QUEST
An overarching control system

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OVERARCHING CONTROL SYSTEM
QUEST

Network Innovation Competition 2020

Project Partners

nationalgridESO FUNDAMENTALS Schneider Electric
smarter grid solutions IMPACT FROM INSIGHT TO INFLUENCE

Network Innovation Competition: Full Submission Application (ENWEN03)

1. Project Summary

1.1 Project Title	QUEST		
1.2 Project Explanation	Using a novel application of proven technology combined with innovative software, QUEST will build an overarching system which operates a holistic voltage control methodology. This will co-ordinate existing and future voltage management techniques, establishing efficient network operation, promoting low-cost connection and use of LCTs, to deliver significant customer benefits.		
1.3 Funding Licensee	Electricity North West Ltd. (ENWL)		
1.4 Project Description	1.4.1. *The Problem:* to cater for the increased uptake of LCTs, and subsequent increase in demand on our network, ENWL has deployed a number of discrete voltage management techniques. These techniques have been successful in helping us to manage the network but have some limitations, as they are not currently co-ordinated. 1.4.2. *The Method:* QUEST will identify and trial novel Methods to holistically integrate the techniques in use across the network into an overarching control system. It will explore co-ordinated operation to enable a reduction of the built-in operating margins, creating capacity for our customers. 1.4.3. *The Solution:* QUEST will build upon learning and outputs from previous Projects to deliver a business-ready solution to co-ordinate multiple voltage management techniques, enabling whole distribution system voltage optimisation. It will develop and introduce a distribution network-wide, fully co-ordinated, voltage control system, with an appropriate balance between centralised and decentralised control hierarchy. 1.4.4. *The Benefits:* QUEST will produce a new holistic voltage control methodology, optimising the system voltage and minimising losses. This new methodology will boost the benefits available from existing voltage management techniques, facilitate the increased connection and use of LCTs, and maximise benefits to customers through energy reductions.		
1.5. Funding			
1.5.1. NIC Funding Request (£k)	£7,946,019	1.5.2. Network Licensee Compulsory Contribution (£k)	[redacted]

1.5.3. Network Licensee Extra Contribution (£k)	[redacted]	1.5.4. External Funding – excluding from NICs (£k)	[redacted]
1.5.5. Total Project Costs (£k)	£9,674,900		
1.6. List of Project Partners, External Funders and Project Supporters (and value of contribution)	Project Partners: National Grid ESO [redacted] Schneider Electric [redacted] Fundamentals Ltd [redacted] Smarter Grid Solutions [redacted] Impact Research [redacted]		
1.7. Timescale			
1.7.1. Project Start Date	January 2021	1.7.2. Project End Date	April 2025
1.8. Project Manager Contact Details			
1.8.1. Contact Name and Job Title	Dan Randles, Head of Network Innovation	1.8.2. Email and Telephone Number	Dan.Randles@enwl.co.uk 07917658031
1.8.3. Contact Address	Electricity North West Ltd, Innovation Forum, 51 Frederick Road, Salford, M6 6FP.		
1.9. Cross Sector Projects (only complete this section if your project is a Cross Sector Project, ie involves both the Gas and Electricity NICs).			
1.9.1. Funding requested the from the [Gas/Electricity] NIC (£k, please state which other competition)			
1.9.2. Please confirm whether or not this [Gas/Electricity] NIC Project could proceed in the absence of funding being awarded for the other Project.			
1.10. Technology Readiness Level (TRL)			
1.10.1. TRL at Project Start Date	6	1.10.2. TRL at Project End Date	8

2. Project Description

QUEST will create an overarching control system by designing a holistic voltage control methodology to co-ordinate discrete techniques, optimising their use and facilitating the increased use of LCTs.

2.1. Aims and objectives

The Problem

Effective control of system voltages by network operators is crucial to the safe and efficient operation of distribution networks, and to providing optimum voltage to connected customers.

Methods for controlling system voltages on distribution networks have evolved over time based largely on the historic passive nature of power flows – whereby power flows in one direction, from the transmission network through to demand customers connected to the distribution network – together with the predictable nature of customer demand profiles.

The passive nature of the network meant that the design and operation of voltage control solutions, typically via use of transformer tap settings, could be kept simple, with local solutions acting independently with minimal need for overall co-ordination.

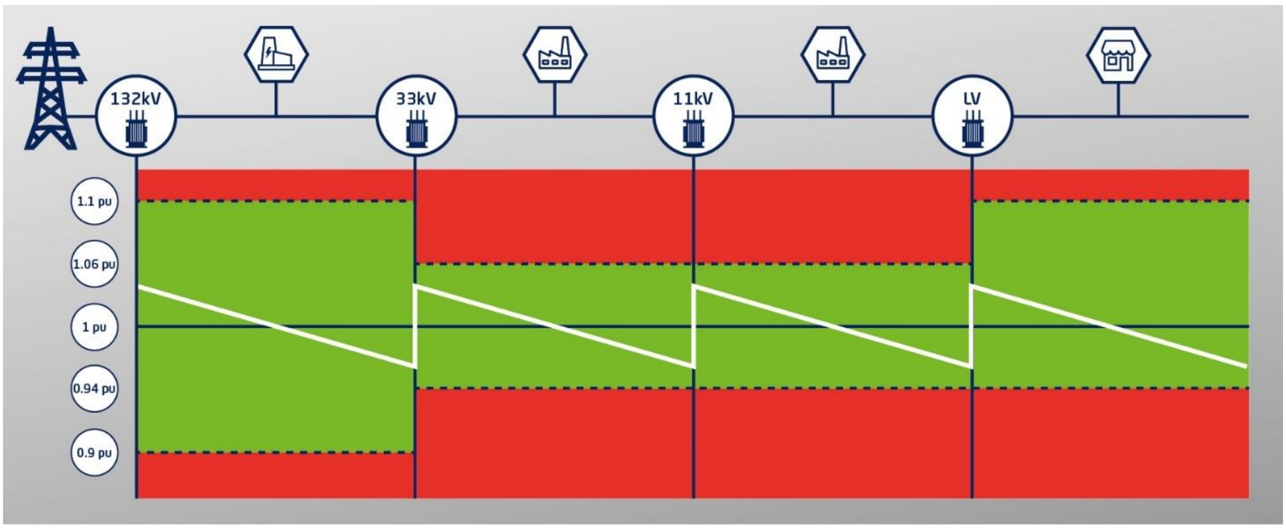
This type of voltage control is applied at discrete layers on the distribution network. Many of the voltage control solutions are fixed systems, with local, manual adjustment of transformer tapping equipment, while others are fitted with Automatic Voltage Controllers (AVCs), which vary the voltage dynamically in response to local measurements.

These traditional voltage control solutions have been designed based on three main concepts:

- Locally measured voltage and current.
- Assumed voltage change along the network.
- 'Time grading' and 'dead banding', where the transformer tap changer closest to the voltage issue responds first and voltage hunting is prevented.

This type of basic voltage control and the voltage profiles typically delivered are illustrated in Figure 2.1. The voltage profile is shown in per unit (or percentage) values, with the green areas demonstrating the permissible range, as stipulated in the Electricity Safety, Quality and Continuity Regulations, for the different voltage levels. The illustration shows the voltage

Figure 2.1: Passive voltage control profiles



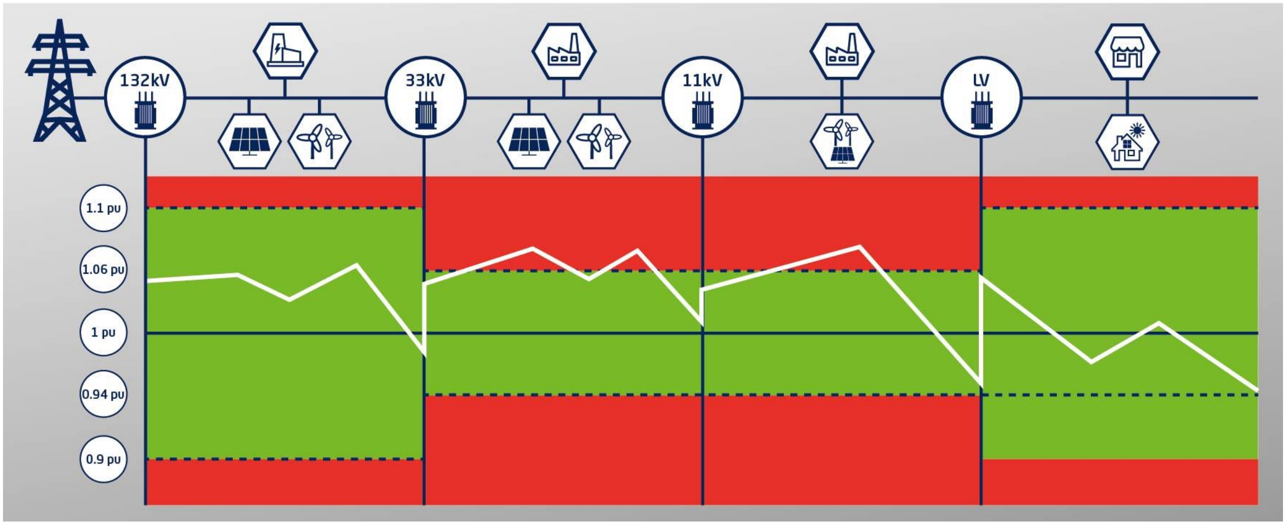
reducing along the network due to the connected demand; the voltage is then boosted at each transforming point using the voltage control solution at that substation. This approach worked well for the passive "fit and forget" system operated by Distribution Network Operators (DNOs) for many years.

In response to government decarbonisation targets and societal trends, customers have been encouraged to lead more sustainable lifestyles and are choosing to adopt Low Carbon Technologies (LCTs) such as Heat Pumps (HPs), Electric Vehicles (EVs) and Photovoltaic (PV) generation, in place of traditional options.

The adoption of these LCTs is affecting networks, including changing their operation from passive to active, whereby power flows are increasingly bi-directional in nature, and customer demand profiles are much more difficult to predict with the required certainty.

Figure 2.2 shows the rise in voltage caused by Distributed Generation (DG) and the more significant reduction caused by increased demand. As illustrated, these changes result in highly variable voltage profiles across the network, constraining the ability of traditional voltage control solutions to provide the optimum voltage to consumers.

Figure 2.2: Illustration of challenges with today's voltage control profiles



In recent years, DNOs have introduced voltage optimisation and Conservation Voltage Reduction (CVR) to provide customers with optimum system voltages. Intelligent network devices and central software are used in combination to change system voltages dynamically. Furthermore, Active Network Management (ANM) has also been deployed to efficiently manage the connection of demand and generation on constrained networks. In some instances, the ANM solution has been designed to manage voltage constraints instead of the usual thermal constraints.

Crucially, as with the AVCs associated with traditional network voltage control, these modern voltage management techniques are not yet fully co-ordinated, instead relying on similarly basic forms of co-ordination.

In June 2019, government targets changed from an 80% reduction to net zero greenhouse gas emissions by [2050](). Some local authorities went even further, with the Greater Manchester Combined Authority (GMCA) stipulating its aim to achieve net zero emissions by [2038]().

This means that the landscape of distribution network operation is expected to change further as more customers switch to electrical forms of heat and transport, as demonstrated by our [Distribution Future Electricity Scenarios]() (DFES).

This changing landscape will result in more areas of the network becoming constrained due to voltage issues. Without significant reinforcement, historic solutions for distribution network voltage control are not well-suited to addressing these needs. Therefore, more economic techniques such as voltage optimisation and ANM will be deployed.

This increased proliferation of discrete voltage management techniques could introduce problems; i.e., when active at the same time and on the same part of the network, it is possible that one technique could counteract another. To mitigate this, we currently design, configure and deploy these techniques with built-in safety margins that provide an operating 'buffer'. This could lead to a reduction in the effectiveness of each technique.

Changes to power flows and the unpredictability of demand, together with the proliferation of independent voltage management techniques, require DNOs to review their approach to delivering safe and effective voltage control.

To ensure that all techniques are operated optimally, it is necessary to investigate ways of integrating the various, discrete techniques to create a flexible and co-ordinated system.

Using a modern Network Management System (NMS) and intelligent relays, coupled with innovative software deployed in the control room, QUEST can provide a more optimal way to manage system voltage. Full use of the permissible voltage range is key to QUEST providing a more economic system of electricity distribution than is currently possible using conventional voltage control solutions.

This improved optimisation of system voltage provides significant benefits to customers and the environment through increased capacity for new connections, energy savings for customers, and reduction in network losses.

The QUEST Method

QUEST will identify and trial novel methods to holistically integrate multiple, concurrent system voltage control and optimisation techniques across the whole distribution system. The Method will be integrated into the NMS, thus providing the full co-ordination needed to unlock the available benefits.

In addition, the new holistic voltage control methodology will:

- Ensure the network operates as efficiently as possible, optimising the system voltage to connected customers and minimising losses.
- Further boost the benefits available from existing voltage management techniques.
- Facilitate the increased connection and use of LCTs.
- Maximise benefits to all customers through demand reduction at High Voltage (HV) and Low Voltage (LV).

By providing a means of command arbitration, QUEST will ensure that potential clashes are avoided and overall benefits are maximised through co-ordination of previously discrete techniques. Furthermore, QUEST provides a solid foundation upon which issues associated with conflict resolution, i.e. independent activation of Distributed Energy Resources (DERs), can be addressed.

QUEST will explore the co-ordinated operation of voltage management techniques to enable a reduction of the built-in operating margins, creating capacity for our customers.

QUEST will develop and introduce a distribution network-wide, fully co-ordinated, overarching system to manage voltages, with an appropriate balance between centralised and decentralised control hierarchy.

Through its co-ordinated design, QUEST will unlock greater overall capacity and will allow DNOs greater control of equipment connected to the network.

The Method will integrate discrete voltage management techniques into an overarching, co-ordinated and optimised system, enabling voltage optimisation for the whole distribution system, from the National Grid intake to the interface with the domestic customer. By viewing and controlling the distribution system as a whole, QUEST will co-ordinate the often competing objectives of the various, discrete techniques to ensure optimised operation whilst maximising benefits for our customers.

In addition, the Method will examine how demand and generation can automatically self-adjust in response to changes in system voltage, potentially creating the world's first inherently self-regulating distribution network.

QUEST will also explore how to unlock benefits for National Grid Electricity System Operator (ESO) by providing improved visibility of real-time, embedded generation exporters and other forms of DER, and allowing "tuned" responses for demand control and OC6.

Throughout the Project QUEST will engage with customers, particularly those with voltage sensitive equipment, to understand how optimising voltage may affect their operations and to identify any special requirements they may need to consider.

The Development/Demonstration being undertaken

QUEST will build upon learning and outputs from previous projects to deliver a business-ready solution for the co-ordination of multiple voltage management techniques, enabling the deployment of whole distribution system voltage optimisation.

A key area of development will be the innovative, overarching control software. When combined with the novel application of proven technology, this software will allow DNOs to more actively manage voltage profiles across the entire network to remove voltage constraints and optimise operation.

QUEST will necessitate the creation of rules for command arbitration, or "trade off" decisions. The output of these decisions will need to reflect the variation in network conditions between different areas, and at different times, to create a highly sophisticated decision-making matrix.

This development presents significant challenges that justify the use of innovation funding. The Project will develop the overarching software and holistic voltage control methodology from Technology Readiness Level (TRL) 6, and progress it to a business-ready solution (TRL 8). The final stages of the Project will produce the plan for transitioning the solution to Business as Usual (BaU).

The Solution

QUEST will explore the additional benefits that can be obtained from whole distribution system co-ordination of voltage management techniques. Informed by our understanding of the trajectory of network operations, and the increase in use of automatic voltage-dependent solutions, we see significant value in the introduction of command arbitration within the control room, ensuring that previously discrete systems are operated in an optimised manner.

QUEST will reduce the overall costs of accommodating increased load on our network. These savings will be available to all customers across Great Britain (GB). The Method will enable DNOs to defer reinforcement, releasing **2,236.7MVA** of capacity, resulting in a saving of around **£266.7 million by 2050**. This will reduce costs for customers and facilitate the connection of LCTs.

QUEST will deliver:

- Technical reports detailing the architecture required to effectively co-ordinate existing and future voltage management techniques.
- A functional specification for the new, holistic voltage control methodology, to enable management of the DNO system voltages at all levels.
- Recommendations for a new voltage control and optimisation standard that could be adopted by all DNOs and Distribution System Operators (DSOs).
- Reports detailing our engagement with customers, including:
  - Customer feedback to revalidate the hypothesis that customers will not discern any changes in their electricity supply when operating across the permissible voltage range.
  - Guidance for customers with voltage sensitive equipment connecting to networks with highly optimised control of system voltages.
  - Customer feedback on the appetite and acceptability of voltage-managed connections.

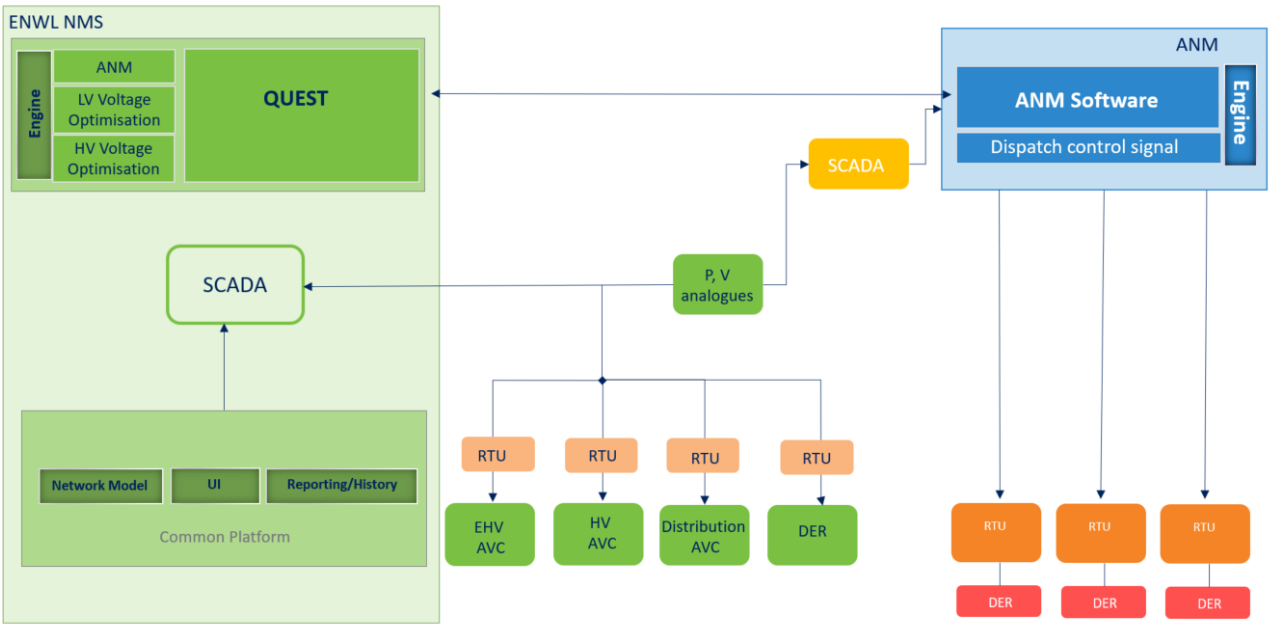
The new voltage control methodology and recommended standard could be extended to include its application to the transmission network. It is anticipated that as part of the BaU transition we will, along with the ESO, establish the future trajectory of this work.

2.2. Technical description of Project

The Method will use a combination of enhanced functionality within the NMS, combined with intelligent control units deployed on site, to actively co-ordinate the operation of various, discrete techniques and adapt to changing conditions in real-time.

Our current view on the proposed architecture is as per Figure 2.3.

Figure 2.3: Proposed QUEST Architecture



Centralised overarching software

QUEST will be enabled through the addition of a new, innovative software module within the NMS. This module will perform the overarching command arbitration necessary to deliver the whole distribution system voltage optimisation required.

This will be developed in conjunction with our Project Partners, including our NMS provider, Schneider Electric (SE). We will examine a range of use cases and architecture options to design the overarching, co-ordinated and optimised system.

We will consult with other network operators, as part of an Industry Steering Group (ISG) established specifically for QUEST, to ensure the holistic voltage control methodology is replicable and considers all appropriate use cases.

The QUEST software module will take an overview of the network, in conjunction with forecasted loadings, to control both new and existing intelligent voltage control devices at substations. The software will also create a dispatch schedule for connected DERs that compliments this optimal running arrangement.

QUEST will use the various voltage management techniques available to balance outputs and adjust voltages to meet user-defined objectives. The software will be designed to enable objectives to be applied to the distribution system as a whole, or to be configured to meet local needs on specific subsets of the system.

The QUEST software module will continuously monitor the network and adjust its decisions in real-time as conditions change. A high-level functional specification for this software module is described in Appendix B.1.

Active Network Management

Working with Project Partner Smarter Grid Solutions (SGS), QUEST will deploy the intelligent 'Strata' control devices at points on the network. These devices will interface with the centralised QUEST software module, which will provide network data and an allowable operating envelope. Whilst the devices will act within operating parameters provided by the centralised software, the technology will provide a degree of decentralised intelligence, allowing for continued operation of ANM in the event of a communications issue and thereby improving overall resilience.

Intelligent AVC relays at BSP and Primary substations

Building on the successful use of the SuperTAPP SG relay in the BaU roll-out of CLASS, a Low Carbon Network (LCN) Fund Project, we will partner with Fundamentals Ltd to add further functionality to the relay to facilitate the requirements for QUEST. Using the learning from CLASS and Enhanced AVC, our Network Innovation Allowance (NIA) Project, we will develop new software for the relays to enable integration with the QUEST software module.

The relays will take in measurements from DERs connected on the local network to take appropriate account of their effect on voltage. The relays will be designed to communicate with any ANM solutions fitted locally to provide a more resilient service.

On those sites, particularly Bulk Supply Points (BSPs), where the CLASS relay has not been deployed, we will upgrade the existing, 'dumb' voltage control relays for the new, intelligent devices, and will install communications equipment as required.

Intelligent voltage control equipment at Distribution substations

As part of the QUEST deployment we will install intelligent Remote Terminal Units (RTUs) and AVCs at ten Distribution substations, enabling LV voltage optimisation on one HV ring. These will work with the centralised software module to manage the voltage at LV and will be capable of operating independently. The intelligent RTUs will allow the option for autonomous operation of LV voltage optimisation similar to that at HV, and will ensure that the system continues to operate should the communications link to the centralised software module fail.

Modelling

We will use offline modelling and bench-testing to allow assessment of a wider range of operating conditions (including overvoltage constraints) and devices than would be possible on a live network.

Along with outputs from the offline modelling, network measurements captured during the trials will be assessed to fully quantify the benefits of the holistic voltage control methodology.

ESO functions

Working in collaboration with the ESO, we will explore how QUEST might be used to support ESO network operations. By providing enhanced visibility of the distribution network, the ESO will have a better understanding of the current operating conditions. This could enable better management of constraints and could make it easier for flexibility service providers to enter the ESO's markets.

Additionally, this enhanced functionality could improve our ability to respond to high-impact, low-probability events, such as an OC6 voltage reduction or a Low Frequency Demand Disconnection (LFDD). By providing real-time visibility of the network and DERs, along with a finer degree of control, QUEST would allow the required demand reductions to be carried out without inadvertently shedding generation.

These questions will be explored as part of the desktop modelling exercise to fully understand the benefits that can be achieved using the QUEST approach.

Throughout the Project, the QUEST team will monitor the learning generated from the ESO's Distributed Restart Network Innovation Competition (NIC) Project, along with the ongoing NIA projects detailed in Appendix C. This learning will be used to inform discussion around the QUEST emergency response philosophy.

Voltage demand relationship research

The capacity release element of QUEST is based upon the premise that a reduction in voltage elicits a reduction in demand. Whilst this relationship was proven in CLASS and has not changed in the intervening years, we acknowledge that there is uncertainty as to how this might change out to 2050. Therefore, we will undertake research on how and by what degree this relationship might change in the future.

Business as Usual

The Project will create all the necessary documentation, including a transition plan, to ensure the outputs can be deployed as BaU on our network. This will be made available to all stakeholders.

2.3. Description of design of trials

The trials to demonstrate the Method will take place on a section of the distribution network fed from one Grid Supply Point (GSP), and will explore how whole distribution system voltage management and co-ordination can unlock capacity and maximise the benefits of discrete techniques.

QUEST will achieve this by testing the following hypotheses:

- Using a novel application of proven technology, combined with the development of highly innovative control software, QUEST will remove voltage constraints and defer reinforcement, thereby reducing costs for customers and facilitating the connection of LCTs.

- Through innovatively managed network voltages, QUEST will reduce energy consumption and losses delivering financial and carbon benefits. The loss reduction benefits will be substantiated using modelling and bench testing.
- Customers will not discern the operation of QUEST.
- QUEST will support simultaneous and highly optimised operation of discrete voltage management techniques, ensuring each is used to its maximum at all times whilst avoiding conflicts.
- QUEST will deliver an improved demand response during emergency conditions by avoiding inadvertent disconnection of embedded generation and providing the ESO with improved visibility of available response.

Site selection and trial size methodology

To demonstrate the benefits of QUEST it is considered necessary to optimise the voltage across the full permissible range on the distribution network.

To fulfil this requirement, we reviewed the GSPs on our network and assessed each against the following criteria:

1. *Overlap with existing techniques:* the trial area should include existing voltage optimisation and ANM systems.
2. *Types of networks:* the trial area should include a mix of urban, suburban and rural networks.
3. *Types of demand:* the trial area should include a mix of demand types, including domestic, Small and Medium sized Enterprise (SME), commercial, light industrial, heavy industrial.
4. *Presence of generation:* the trial area should include significant connected generation.
5. *Presence of sensitive customers:* the trial area should include at least one voltage-sensitive customer.

From this assessment we have initially selected Whitegate GSP, which will be reviewed and validated during the Project. Whitegate GSP supplies 4 BSPs, 21 Primary substations and 1279 Distribution substations. The trial area extends from Manchester City Centre out towards the Peak District, and is therefore considered to be representative of the full range of connected customers. Statistical data on Whitegate GSP can be found in Appendix B.2 along with a map and diagram of the trial area.

For the incremental cost of including all four BSPs, we can evaluate different modes of operation on different parts of the network and test how the system responds if we transfer load from one Primary or BSP to another. Additionally, it will ensure that all network and customer types are included.

Should any unforeseen operational work prevent the application of QUEST here, it may be necessary to find an alternative GSP.

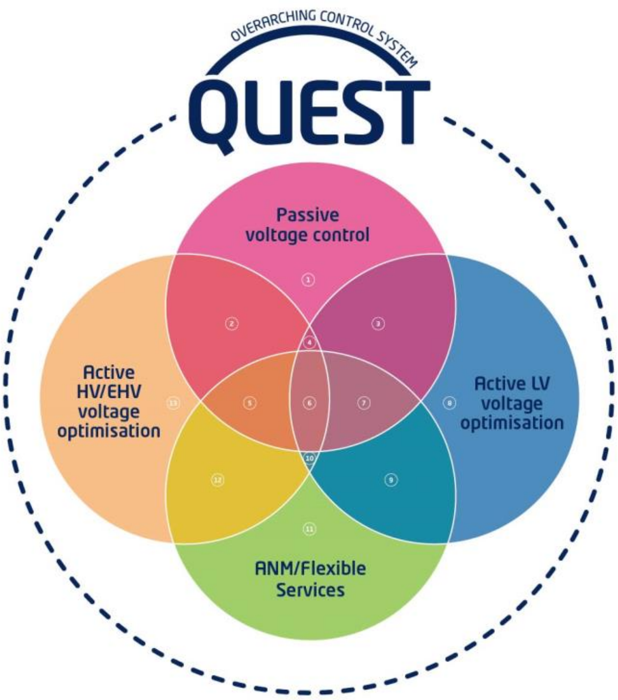
QUEST trials

The trials will be run over a period of 12 months to allow testing of the different modes of operation and a full year of data capture which provides for a wide range of interseasonal effects. During this phase, QUEST will optimise voltage profiles across the trial area of the network, from the 132kV intake down to the domestic customer.

The trials, illustrated diagrammatically in Figure 2.4 below, will be carried out to determine how the command arbitration in QUEST will work for the 13 potential combinations of the following voltage management techniques:

- *Passive voltage control:* traditional methods of voltage control either responding to local measurements or fixed at the time of commissioning. No centralised overview.
- *Active LV voltage optimisation:* the use of centrally controlled devices to actively optimise the voltage profile on the LV network.
- *Active EHV/HV voltage optimisation:* the use of centrally controlled devices to actively optimise the Extra High Voltage (EHV) and HV parts of the network.
- *ANM/flexible services:* the controlled use of DERs to alleviate constraints on the network.

Figure 2.4: QUEST trials



These combinations will be trialled on subsets of the Whitegate GSP network to demonstrate the benefits of using QUEST.

We will run each trial regime for a sufficient duration to gain the necessary learning; however, it is envisaged that each will run for around three months. At the start of each trial we will run the software in "open loop" mode for a short period, which allows the optimisation algorithm to run and produce suggested actions without sending commands to network assets. This is to ensure that commands will not have an adverse effect on customer supplies before the software is switched into "closed loop" mode, where the system can autonomously adjust the voltage profiles.

The trials regime and methodology will be developed fully prior to the start of the trial period.

There will be some use cases and scenarios that we will be unable to deliberately trial on a live network, such as:

- How QUEST responds to fault situations.
- How voltage managed connections can be used to provide further benefits.

- How QUEST can provide benefits to the ESO.
- How QUEST manages nested ANM schemes.

For these use cases we will employ modelling techniques carried out by our technical research Project Partner, SGS.

The models and modelling techniques will also allow initial analysis of the software algorithm prior to live trials, thus guaranteeing confidence that the software will respond as designed. It will also allow for comparison of the trial results to the modelled results to provide further confidence in the benefits calculations.

2.4. Changes since Initial Screening Process (ISP)

As we have moved forward from the ISP stage, we have made necessary adjustments to the overall scope of the Project. These changes have been made to ensure overall Project deliverability and value to customers.

We have now secured the ESO as a Project Partner, along with technical and customer research partners, namely SGS and Impact Research.

Following detailed discussions with our Project Partners, we have extended the Project length by 12 months to account for the complexities associated with the algorithm development element of the Project. This has resulted in an increase to the Project costs due to the extension of the Project and the additional level of resource required. The overall cost of the Project is now £9,674,900, but we have secured [redacted] in contributions from our Project Partners. We are therefore seeking £7,946,019 in NIC funding.

3. Project Business Case

QUEST will provide new, significant financial and carbon benefits as well as maximising and extending the benefits from existing techniques.

3.1 Background

As government and regional decarbonisation targets become more ambitious, there is likely to be an increase in the adoption of LCTs by customers. In turn, the connection at scale of LCTs is expected to cause additional voltage constraints on the electricity distribution network.

To avoid or defer investing in carbon intensive and costly traditional network infrastructure, DNOs have deployed voltage management techniques to optimise network voltages as part of a portfolio of alternative solutions.

Typically, these techniques are installed independently of one another (i.e. discrete applications without direct means of co-ordination). This means that they are not always able to work collectively to provide voltage optimisation benefits to the whole distribution system.

Additionally, as the solutions are not fully co-ordinated, there is potential for them to counteract one another, resulting in reduced overall effectiveness.

Our DFES suggests that the requirement for these voltage management techniques as alternatives to traditional solutions is set to rise over the next 5-10 years. Therefore, to ensure optimised outcomes and to deliver value to customers, the need for their co-ordination becomes necessary.

3.2 QUEST benefits summary

QUEST delivers voltage optimisation benefits to customers across the whole distribution system by:

- *Extending voltage optimisation* to areas of the network that are not covered by existing techniques.
- *Maximising the benefits of existing techniques*, such as voltage optimisation and ANM, by co-ordinating their operation and minimising clashes.

The benefits of QUEST have been translated into avoided network costs, customer savings, and carbon benefits, and these are compared with the costs of deploying QUEST. The high-level benefits and the benefits calculation process are summarised in this section and described in more detail in Appendices A.1 and A.2 respectively.

3.3 Quantified financial benefits

The benefits quantified in the business case focus on extending voltage optimisation, and are divided into:

- *Release of network capacity:* owing to the relationship between current and voltage, identified in the CLASS and Smart Street LCNF projects, reducing system voltages reduces demand on the network, which can result in a reduction in peak loads at critical sites. This releases latent thermal capacity, allowing DNOs to defer or mitigate the need for reinforcement or, where available, other capacity creating methods such as flexible services. QUEST will release over **2,200MVA** of capacity, delivering a financial benefit of **£266.7m across GB by 2050**.
- *Reduction in system losses:* reducing demand reduces the total energy required to flow through the network and consequently the system losses attributable to that energy flow. This reduction in losses provides a financial benefit of **£65.4m across GB by 2050**.

- *Financial benefits for customers associated with the reduction of energy consumption:* as QUEST reduces voltages on the network, the energy consumed by customers is also reduced. By fully co-ordinating the operation of voltage management systems across the whole distribution system, QUEST provides additional voltage optimisation benefits, for example, by providing benefits to areas of the network not included in Smart Street. This boost in benefits provides a direct saving on customer bills, totalling over **£3,385.5m for LV customers** and over **£932.8m for HV customers across GB, up to 2050**. Although these benefits have been calculated, they are not included as part of the main Project benefits as they are not network focussed, and are highly dependent on the customer's tariff arrangement.

3.4 Financial modelling methodology

The financial costs and benefits of QUEST are shown in Figure 3.1 and have been calculated using the following methodology.

Calculation of capacity release

The capacity release from QUEST comes from two sources: HV loads and LV loads. Each of these are aggregated at the relevant Primary or BSP substations to give the total capacity release for each HV substation.

CLASS provides capacity release benefits for the HV network, where fitted. Therefore, we have discounted the Method case benefits of QUEST by the amount gained from CLASS to avoid double-counting of benefits.

Smart Street provides significant capacity release benefit to the LV network, where fitted. QUEST will provide limited, but not insignificant, capacity release benefit to all LV networks. Therefore, as we are starting to roll out Smart Street across the network, we have identified the number of LV networks expected to be included in the roll-out up to 2050 and have excluded these to avoid double-counting of benefits.

Capacity release is calculated using the following methodology:

- *Reduction of HV loads at the ENWL scale:* The voltage demand relationship developed in CLASS was used to estimate the reduction in peak load for each HV load connected to our network. To allow for diversity between peaks at different customer sites the minimum monthly peak load within the year was used. This reduction in peak load was then assigned to the relevant Primary substations or BSPs.
- *Reduction of LV loads at the ENWL scale:* The reduction in peak load for LV transformers, not included in the Smart Street roll-out, on our network was calculated using the voltage demand relationship developed in Smart Street. This capacity release was spread out evenly among the Primary substations.

The proportional number of Primary and BSP substations in ENWL compared to that in GB was derived using the DNOs' Long-Term Development Statements (LTDS), giving a scaling factor of 13.4. This scaling factor has been used to calculate the GB scale benefits.

Calculation of capacity release benefits

Benefits are gained where the capacity released through QUEST either defers or mitigates the need for alternative capacity release methods. Examples include flexible services, if available, or traditional reinforcement. The benefit is calculated by comparing the Base Case and Method case as follows:

Base Case

1. Using demand forecasts from our DFES, the year that each Primary and BSP substation is expected to reach its firm capacity is identified.
2. The cost to solve the capacity constraint (referred to here as intervention cost) is identified. This is chosen from the least cost option between flexible services and traditional reinforcement.
3. The total intervention costs are then aggregated for each year to 2050.

Method case

1. The MVA capacity released through QUEST is calculated for each Primary or BSP substation to determine the additional capacity.
2. The additional capacity is added to the firm capacity.
3. As per the Base Case, the year the substation is forecast to reach the new 'firm + additional' capacity is identified, and the total intervention costs are calculated, with the least-cost option being selected.

The Method case results in a delay and/or reduction in the overloading of the substation, deferring (and in the case of flexible services, reducing) costs.

Calculation of losses reduction benefits

Due to the reduction in the total energy consumed by customers, there is an associated reduction in network losses.

This is calculated for HV and LV customers.

QUEST roll-out costs

It is assumed that the overarching software module will be business ready for ENWL by the end of the Project. QUEST is compatible with existing intelligent voltage control devices, such as the enhanced AVC relays used in Smart Street and CLASS, and this equipment is expected to be standard for DNOs. Any existing intelligent devices not in the trial area can be incorporated into QUEST through a software upgrade, which is assumed will be carried out over 4 years following completion of the Project.

It is assumed that other DNOs will begin to adopt QUEST from 2028, in line with the start of RIIO-ED3. Additional equipment will be integrated to QUEST as a low-cost capacity release method for overloaded substations, or following routine asset replacement/reinforcement.

Figure 3.1: Financial NPV cost and benefits of QUEST

Scale	Benefit or Cost	£m NPV 2020 Prices		
		2030	2040	2050
Project/ ENWL Scale	QUEST benefits	[redacted]	[redacted]	[redacted]
	QUEST roll-out costs	[redacted]	[redacted]	[redacted]
	Total NPV	**21.3**	**29.8**	**32.6**
GB Scale	QUEST benefits	[redacted]	[redacted]	[redacted]

Scale	Benefit or Cost	£m NPV 2020 Prices		
		2030	2040	2050
	QUEST roll-out costs	[redacted]	[redacted]	[redacted]
	Total NPV	**51.0**	**165.1**	**266.7**
Additional Benefit – Energy Consumption Reduction	The energy consumption reduction for customers will directly reduce bills and is highly dependent on the tariff structure for each customer. Based on the proportion of the bill related to the wholesale cost of electricity, this has an estimated NPV benefit of over **£4,300m across GB by 2050**.			

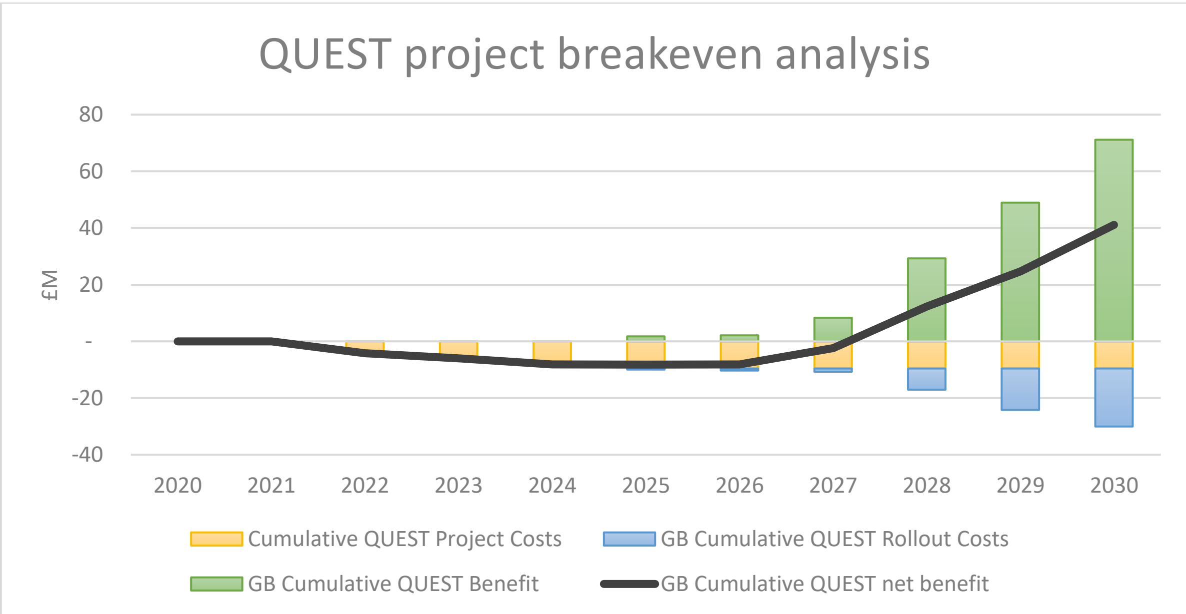
The results demonstrate a strong business case for QUEST, both at ENWL scale (with a total benefit of over £32m by 2050) and at GB scale (with a total benefit of over £266m by 2050).

The energy consumption reduction benefits are much larger, estimated at over £4,300m by 2050, which highlights how QUEST will bring tangible, significant benefits directly to customers.

QUEST break-even analysis

Figure 3.2 shows the break-even analysis which compares the QUEST Project and roll-out costs with the benefits up to 2030. Figures are shown in real terms based on 2020 prices.

Figure 3.2: Break-even analysis for QUEST



This shows an estimated roll-out cost for GB of [redacted]. In the first few years of adoption, the roll-out costs of QUEST are covered by ENWL benefits, meaning that the estimated break-even year for the QUEST Project is 2027 (with installation at an additional 23 ENWL HV substations over and above the CLASS deployment), after which the benefits climb quickly. Although there are fluctuations in the net benefit owing to the expected need for traditional reinforcement, QUEST continues to deliver a significant net benefit well into the future.

Sensitivity analysis

To illustrate the impact that different assumptions have on the overall benefits at GB scale, a sensitivity analysis was carried out. This included sensitivity on the approach to and results of voltage optimisation through QUEST, the future electricity scenario used to estimate where network equipment might be overloaded, and the assumed cost of flexible services. This analysis and the results are described in Appendix A.2.

3.5 Additional financial benefits

QUEST will deliver the following additional benefits, which have not been quantified as part of the business case:

- *Maximising benefits from a combination of discrete voltage techniques:* the holistic voltage control methodology developed in QUEST will integrate the functionality of the existing, discrete voltage management techniques, and optimise them to maximise their individual benefits. Opportunities for this optimisation will be explored in the Project and have not been quantified for the business case.
- *Lower cost connection of LCTs*: QUEST optimises network voltage to release capacity where it is needed and provide lower cost connections, thus facilitating LCT uptake. This will result in additional benefits for QUEST. Additionally, QUEST provides a platform for ENWL to be able to offer alternative connection options, such as voltage managed connections. This will be explored in the Project and has not been quantified for the business case.
- *Greater visibility and dynamic control of the network:* QUEST will provide a system-wide view of voltage profiles and enable the co-ordination of multiple control points (including, where connections require, customers). This releases benefits such as wider system awareness, speed of identifying and reacting to issues, and visibility of the system for other stakeholders such as National Grid ESO.

3.6 Benefits to the ESO

Several of the functions provided by QUEST are considered as being of value to the efficient operation of the transmission network by achieving more effective co-ordination at the ESO/DSO interface.

Enhanced response to major events

QUEST gives DNOs more flexibility to respond to major events such as that experienced on 9th August 2019. For example, it could provide additional benefits to both DNOs and the ESO in respect of demand control and OC6 by "tuning" the response based on the presence of vulnerable loads (e.g. hospitals) and the overall effectiveness. Alternatively, QUEST could take into account any connected generation or ANM response contracts to optimise the response for minimal customer impact. Visibility through a dashboard of the forecast demand response could present further benefits to the ESO.

Although these events are rare, the impact is significant, and there are notable benefits to system resilience and recovery if the response can be more flexible.

Improved visibility of embedded active participants

QUEST can provide improved visibility of energy flexibility providers connected to the distribution network, for example, flexible generation, storage, and smart EV charging. QUEST could be used to forecast their impact on the transmission network and wider system. This could be used by the ESO to optimise the dispatch of embedded contracted services.

Transmission network high volts control

QUEST provides for highly controllable, whole distribution system voltage management. The ability to adjust voltage dynamically in such a manner offers the potential for QUEST to provide relief to the ESO during times of transmission network high volts (e.g. periods of low demand). The opportunity exists for QUEST to communicate to the ESO the availability of distribution network-embedded reactive power support or control.

3.7 QUEST carbon benefits

The assessment of the carbon benefits of QUEST is based on the reduction in distribution losses associated with reduced energy consumption. The reduction in carbon emissions associated with avoided reinforcement was not included, as reinforcement is generally only deferred rather than avoided, resulting in no significant carbon reduction.

The reduction in energy consumption results in carbon benefits. While these are not part of the main QUEST business case benefits, they have been quantified. Figure 3.3 summarises the carbon benefits for each of these categories at ENWL and GB scale.

Figure 3.3: Carbon benefits of QUEST

Scale	Carbon Benefit	Cumulative Carbon Benefit tCO_2e		
		2030	2040	2050
ENWL Scale Benefits and Costs	Losses reduction (main business case benefits)	2,161	5,286	8,373
	Energy consumption reduction (additional benefits)	70,217	172,617	275,022
GB Scale Benefits and Costs	Losses reduction (main business case benefits)	4,088	22,090	51,498
	Energy consumption reduction (additional benefits)	82,461	451,901	1,070,380

The carbon benefits from losses is significant, saving over 51,000 tonnes of CO_2e across GB by 2050.

The carbon benefits obtained from the reduction in energy consumption are much larger, with over 1m tonnes of CO_2e saved.

There are significant additional carbon and environmental benefits beyond those quantified in the use cases. As these are more difficult to define, they have not been included as part of the business case, but are driven by increased visibility, co-ordination, and adaptability of the system (see Appendix A.1 for further information).

4. Benefits, Timeliness, and Partners

QUEST will maximise and extend the benefits of discrete voltage management techniques to provide value for money to customers.

(a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing customers

According to our DFES, over the next 5-10 years greater numbers of customers will support government decarbonisation plans by increasing their use of LCTs. This increase in the volume of LCTs connected to the network will result in an increase in voltage-related constraints. To facilitate this, DNOs have begun to deploy discrete innovative techniques, such as voltage optimisation and ANM.

QUEST will enable whole distribution system voltage optimisation by integrating these discrete, innovative techniques. Further, QUEST will maximise the use and overall system efficiency of these techniques, facilitating increased use of low carbon generation on constrained networks.

Contributing to the Carbon Plan

QUEST will contribute towards the aims set out in the Government's Carbon Plan, and the more recent Ofgem Decarbonisation Action Plan, for example, the aim to efficiently transform the power sector through system balancing and the facilitation of low carbon generation and demand.

QUEST will support government aims to decarbonise heating and transportation industries by releasing network capacity to facilitate the low-cost connection of LCTs such as HPs and EVs. This ambition is now more urgent than ever before, after the recent acceleration of the ban on the sale of internal combustion engine vehicles, with the government citing an urgency to cut carbon emissions further to reach their target of net-zero carbon emissions for GB by 2050.

GMCA is even more ambitious, with a decarbonisation target of 2038. In their Spatial Framework, GMCA have specified the requirement that all new building developments will be net-zero carbon from 2028, achieved by utilising on-site generation and greater energy efficiency measures. They have also outlined plans for investment in low carbon energy.

In addition, the Carbon Plan outlines the Government's prediction of more than 100GW of low carbon generation needed by 2050 to support growing electricity demand, and the Decarbonisation Action Plan emphasises the need for investment in network infrastructure to accommodate this necessary increase.

QUEST will help to achieve this goal by maximising the use of existing low carbon generation and by allowing DNOs to provide faster, cheaper connections to customers, facilitating further uptake.

Our benefits calculations demonstrate carbon savings of **8,373tCO_2e across ENWL by 2050**, and **51,498tCO_2e across GB by 2050**.

QUEST deployment

As QUEST comprises central software and uses industry standard equipment installed on the network, the Method can be deployed in response to voltage constraints across GB much more rapidly (see Figure 4.1) and cost-effectively than alternative methods. This will help to accelerate the connection of more LCTs.

The quoted delivery times (comprising planning and installation time) are based on ENWL's experience, assuming that the QUEST software module is already in place, and will be comparable for similar methods employed by other DNOs. QUEST will be able to deliver additional capacity up to four times faster than alternative methods for the HV and EHV networks.

Figure 4.1: Comparison of installation times for QUEST and alternative methods

Method	Description	Delivery Time
Traditional Reinforcement	BSP/Primary substation transformer replacement	40-52 weeks
Flexible Services	Agree contract, install control equipment	26 -52 weeks
QUEST	Install intelligent AVC and integrate to software	12 weeks

Delivering significant financial and network capacity benefits

QUEST will maximise and extend the benefits of existing voltage management techniques by fully co-ordinating their operation and thereby minimising potential clashes when these systems are operating at their upper range. Having this co-ordinated operation will enable us to reduce the built-in operating margins and conservative planning assumptions, releasing capacity for our customers.

The financial and network capacity benefits that QUEST could provide are quantified in the sections below as well as in Appendices A.1 (Benefits Tables) and A.2 (Method and Base Case methodologies). These benefits are then extrapolated across GB.

QUEST Project/ENWL benefits

QUEST will develop a DNO-scale solution as the software developed during the Project will be applicable to the whole distribution system. Therefore, it is not appropriate to represent the benefits on a project-scale.

Once the software is developed and integrated, new sites can be added incrementally as they are upgraded with intelligent voltage control devices or where there is an identified benefit to customers.

Using an organic roll-out methodology, QUEST will deliver net benefits, inclusive of direct costs and the cost of network losses, of **£32.6m** across our network by 2050 and will provide asset capacity release of up to **211.2MVA** across our network by 2050.

Great Britain benefits

The Method is readily replicable by all DNOs owing to its use of industry standard equipment in substations and, on the basis that all DNOs have an NMS and SCADA system, can be applied to 100% of GB distribution networks. Additionally, the holistic voltage control methodology could be extended to include its application to the transmission network.

As the ENWL benefits are calculated based on the number of HV substations on our network, the benefits for GB have been scaled proportionally based on the number of HV substations at GB level compared with the number on the ENWL network.

Application of the Method to GB will provide a net benefit of **£266.7m** by 2050 and will release up to **2,236.7MVA** of network capacity for the HV and EHV distribution networks, which will help to facilitate LCT load growth.

Customer benefits

The Method optimises system voltage, which will result in an energy consumption reduction for customers. This will lead to a direct reduction in the number of units consumed by customers, and hence their bill. Based on the proportion of the bill related to the wholesale cost of electricity, this reduction has an estimated NPV benefit of **£3,385.5m** for LV customers and over **£932.8m** for HV customers across GB up to 2050.

(b) Provides value for money to electricity distribution/transmission Customers

Potential for Direct Impact

QUEST will have a Direct Impact on the distribution network by releasing capacity at a lower cost and significantly more quickly than alternative methods. This will enable customers to transition more quickly to new LCTs, speeding up the move to a net zero carbon economy.

QUEST will research the architecture and software design required to optimise voltage profiles across the whole distribution system. As per Section 2.3, the Project will trial the Method on an area of the network fed from one GSP, which will allow integration of the discrete techniques. The area selected, fed from Whitegate GSP, covers different network and customer types and is considered to be of representative size to demonstrate the learning.

We anticipate that the learning from QUEST will produce the recommendations for a new voltage control standard and architecture, which will be applicable to all DNOs and have the ability to be further developed for application to the transmission network. This could unlock additional benefits.

Processes to ensure competitive cost

QUEST is a highly technical Project, integrating several discrete voltage management techniques to deliver new, and maximise existing, benefits to customers. To ensure we have the necessary technical knowledge working on QUEST, we sought support in Project delivery from industry leading experts in the area of voltage control, optimisation and active network management: SGS and Fundamentals Ltd. As part of the bid process we engaged with each of these providers to develop a fully-costed proposal, which was reviewed and scrutinised to ensure that it delivered value for money.

Additionally, we engaged with SE, our incumbent NMS provider (appointed following competitive tender), to support development of the centralised software module. By using SE, we can avoid third party integration costs and, as they have been appointed as a Project Partner, their contribution will reduce their cost to the Project.

For the other areas of the Project, during the bid development phase, we conducted a tender for the technical and customer research. ENWL had recently conducted an open tender seeking this type of support for other areas of the business. Whilst the bid team took advantage of this work to select participants for the tender, some candidates were added to the list based on awareness of their expertise in the required areas.

Responses to the tender were evaluated against the criteria of relevant experience and expertise, cost, and Partner contribution. Impact Research and SGS were assessed as offering the best overall package and selected as Partners for delivering QUEST. Selecting SGS to perform the technical research ensured further value for money as they were already a delivery Partner.

Costs for the substation equipment have been taken from our BaU framework agreements. These contracts are awarded based on open competitive procurement exercises compliant with EU procurement regulations and the utilities directive.

Figures 4.2 to 4.4 illustrate the total cost split by Project stage, the split of total personnel cost by Project Partner and Project stage, and the staffing and equipment costs by Project stage. These costs are all pre-contribution.

Figure 4.2: Total cost split by Project stage

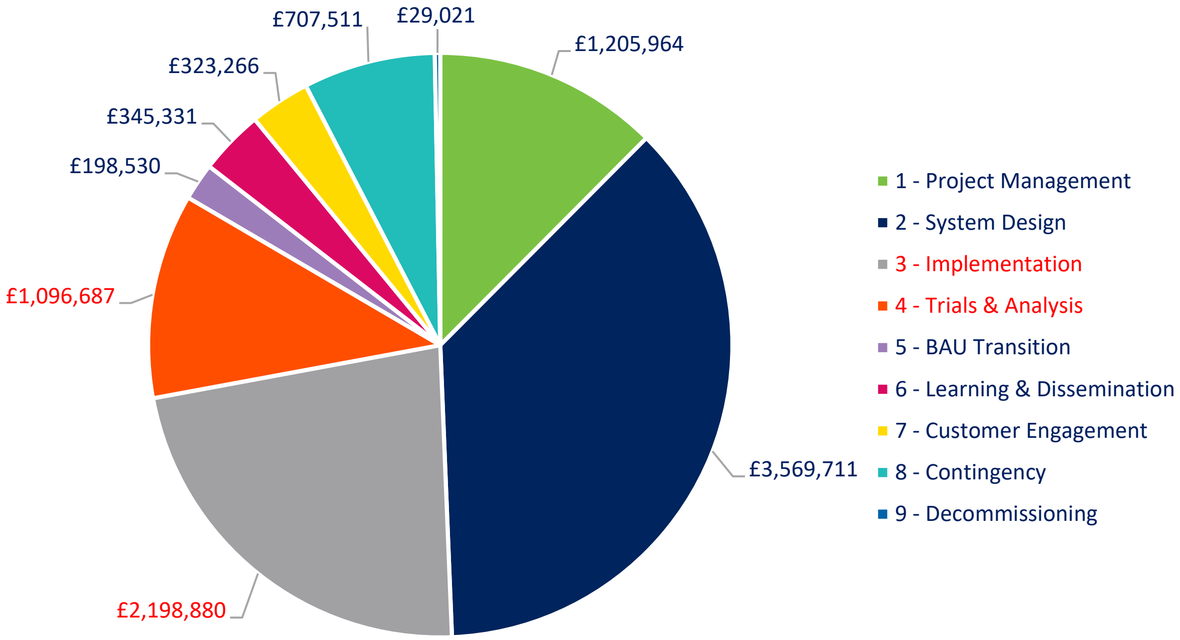


Figure 4.3: Personnel cost split by Project stage and Partner (before contribution)

[redacted]

Figure 4.4: Staffing and equipment cost by Project stage

[redacted]

Figure 4.5: Project participant day rates

[redacted]

Planned Supply Interruptions

Wherever possible, the QUEST team will seek to install the technology using live working techniques, thereby avoiding Planned Supply Interruptions (PSI) affecting customers wherever possible.

The reliability and incentives impact has been assessed using the following assumptions:

- All BSP and Primary AVC schemes can be installed with no shutdown.
- Eight of the ten Distribution substations can use either backfeed from another transformer or temporary generation for the duration of any installation or decommissioning activities.
- Where a PSI is anticipated, the expected duration, as advised by our operational engineers, is eight hours.

Using the 2020/21 planned interruptions values and an average number of 249 customers connected to each distribution transformer, it is anticipated that the impact may be around [redacted] and we will not seek protection to this value.

Direct Benefits

The potential Direct Benefits resulting from undertaking the QUEST Project would appear in the following areas:

1. The replacement of AVC schemes in BSP and Primary substations and Distribution transformers in the trial area.
2. The deferment of network reinforcement in the trial areas.

The list of pre-selected sites was compared to our current investment plans, and the value of the Direct Benefits has been calculated as [redacted] We will not seek to offset our contribution by this value.

Additionally, the new AVCs in Primary substations could be used to provide services to the ESO. We can confirm that this service provision will not take place during the lifetime of the Project.

(c) Generates knowledge that can be shared amongst all relevant network licensees

The criterion for 4.(c) is evaluated in Section 5: Knowledge Dissemination. This is in line with Ofgem's guidance notes for completion of the full submission documents.

(d) Is innovative (ie not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

At its core, QUEST contains three highly innovative, and as yet untested, aspects:

1. For the first time ever, network operators will have the ability to resolve voltage constraints at one voltage level through the action of voltage controllers at other voltage levels.
2. Further, network operators will have the ability to look holistically at the total network, determine and deploy voltage profiles that deliver optimised outcomes for both network operation (including potentially the ESO) and connected customers.
3. By fully co-ordinating the operation of previously discrete systems, QUEST will boost their effectiveness to provide a fully optimised system.

QUEST is seeking to achieve something entirely new, and therefore untested, for the effective management of system voltages across GB distribution networks. By integrating discrete voltage management techniques into one overarching voltage control and optimisation system, QUEST will give network operators the ability to manage system voltages more efficiently by using the full range of voltage control available across all levels in a holistic manner.

QUEST will take inputs from various sources, including information on connected customers, DERs, and AVCs, along with the real-time network model and an electrical equivalent representation of the transmission network. Using these inputs in conjunction with real-time measurements and forecast data, QUEST will forecast and assess the network conditions in near real-time.

The aim is to determine the optimal configuration for the network in order to achieve specified objectives, such as minimising losses or energy consumption, ensuring at all times that the network operates within its technical and operational limits.

Where possible, QUEST will look to stack benefits across the voltage levels, for example, by raising the voltage at one level to reduce losses, whilst still maintaining head room at other levels for energy consumption reduction.

QUEST is a highly ambitious Project with significant technical complexities and risk. To achieve the benefits from effective co-ordination and management of voltage as described, QUEST will need to design, develop and introduce into the live network control environment untested, and as yet unproven, software for the holistic voltage control methodology. This needs to be done in such a manner so that it does not adversely affect the performance of any of the discrete techniques, but instead boosts them. Without NIC funding this would not be possible.

(e) Involvement of other partners and external funding

We endeavour to make it as simple as possible for stakeholders to interact with the Innovation team and suggest ideas. There are various channels by which our stakeholders can make contact, including our Customer Contact Centre, the Innovation page on our website, our Innovation email inbox, and our social media channels.

Our Future Networks Steering Group (FNSG), chaired by the Engineering and Technical Director, assesses all Project suggestions and makes a decision about which to take forward.

The idea for QUEST was generated internally to address the limitations of voltage management techniques deployed on the network. It was recognised that whilst these techniques help us to manage the network and have demonstrated benefits to customers, they are not co-ordinated. This means that in their current configuration one technique could prevent another from operating effectively or efficiently. It is important to develop a solution to this problem to mitigate the risk of restricted functionality, which could impact benefits to customers.

The Project concept has been reviewed by our Project Partners, who recognise that we are addressing an area of key challenge by looking at integration of multiple systems with different zonal approaches, objectives, and constraints. The FNSG selected and approved this innovation idea as the basis for the 2020 submission to the NIC. Project Partner selection is determined in part by the FNSG, where Project Partners have previously demonstrated experience, ability or interest in this area, and in part through a competitive tender process, in cases where more than one potential Project Partner could fulfil the Project requirements.

Selection of the Project Partners and suppliers is dependent on experience, skills, cost, and ability to commit resources to deliver the Project and disseminate the learning to other GB DNOs and stakeholders.

There are five Project Partners on QUEST: SE, SGS, Fundamentals Ltd, National Grid ESO, and Impact Research. The Project Partners will make a combined contribution to the Project of [redacted] Figure 4.6 below outlines each Partner's role on the Project and confirms their individual contribution, and Appendix G provides further details.

Figure 4.6: Project Partner details

Prior Experience	Role on Project	Contribution
Schneider Electric (SE)		
Design of our new NMS, which will replace our current, bespoke NMS.	Overarching control system will form part of new NMS: Will specify, design, and develop the overarching system. Will assist with implementation of system.	[redacted]
Smarter Grid Solutions (SGS)		
Have valuable knowledge about operation of software systems such as ANM and have worked with a number of DNOs on this technique.	Will help to define use cases and architecture. Will implement voltage control strategy in their system. Will conduct technical research, involving modelling, to inform control methodology and trial design. Will participate in trials. Will analyse trial data to identify benefits and update business case and carbon plan.	[redacted]
Fundamentals Ltd		
Have expertise in end-to-end voltage control and management, desire to be at the leading edge of approaches, and have previously worked on the roll-out of CLASS.	Will help to define both hardware and software architecture and use cases. Will help to design control methodologies. Will implement voltage control strategy in their AVC relays.	[redacted]
National Grid ESO		
ESO – experience interacting with DNOs and using services such as CLASS.	Will help to explore the expected benefits of QUEST for the transmission system, including real-time visibility of our network and dynamic adjustment of interface voltage parameters, for both steady state and emergency conditions.	[redacted]

Prior Experience	Role on Project	Contribution
Impact Research		
Have worked on the customer element of previous innovation projects, such as CLASS, Smart Street, Celsius, and VoLL2.	Will assist with customer research, including engagement via surveys, interviews, and focus groups. Will support customer communications strategy.	[redacted]

QUEST will use standard distribution substation equipment as well as existing, off-the-shelf equipment provided by Project Partners Fundamentals Ltd and SGS. Once the overarching system has been developed and proven there may be an increase in demand for this existing equipment. However, QUEST will not create a new market as this equipment is already available to, and in use by, other DNOs.

There may be a marginally increased opportunity for Schneider to sell their centralised software module. However, it is likely that competitors will develop and sell their own equivalent solutions, especially as learning will be shared and disseminated.

There will, therefore, be a limited opportunity for Project Partners to exceed a reasonable return on their financial contribution. This potential first-mover advantage is not believed to be significant enough to warrant a profit-sharing arrangement.

(f) Relevance and timing

In recent years, DNOs have demonstrated the value of targeted voltage optimisation techniques when resolving constraints at specific levels of the network (e.g. CLASS, Smart Street, Network Equilibrium, and Customer Lead Network Revolution). These techniques have been successfully used to avoid or defer the need for traditional forms of network reinforcement. Several of these techniques now form BaU activities within DNOs, typically deployed in response to specific network constraints or where, through assessment, a credible business case can be established.

As of July 2020, 64% of our network is fitted with CLASS, and it is expected that other DNOs will follow with their own roll-out of CLASS-like functionality during RIIO-ED2. In addition, following the award of the Innovation Rollout Mechanism (IRM) for Smart Street, we have started, and will continue, to fit our network with LV voltage optimisation. Further, flexible services are becoming increasingly prevalent, 274.5MW as of the end of 2019, including the provision of actively managed customer connections with autonomous modes of operation.

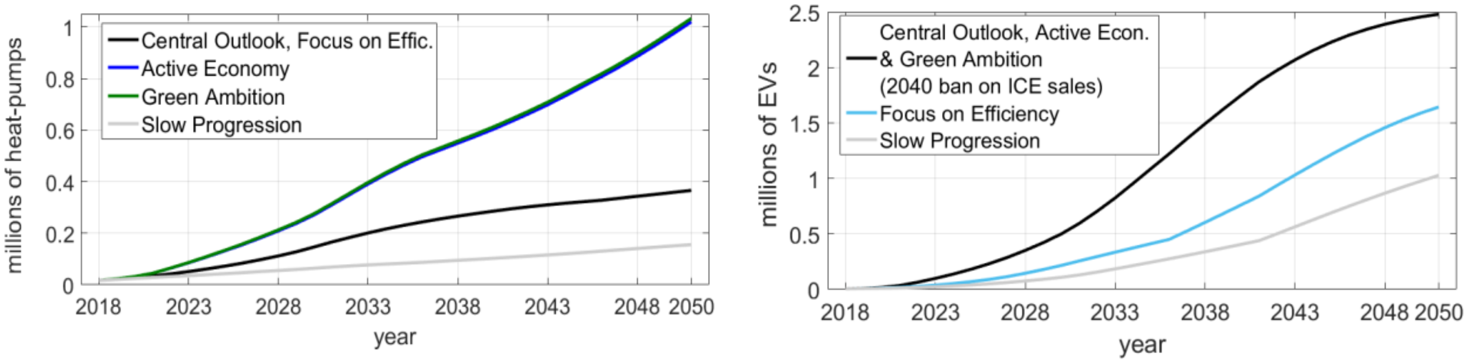
These techniques have been successful in helping DNOs to manage the network and have demonstrable benefits for customers; however, they do have limitations. This is because the techniques are deployed in isolation, are not currently co-ordinated, use worst case planning assumptions, and are reliant on a robust communications infrastructure. To overcome these limitations, it is necessary to integrate the various, discrete techniques for voltage management, creating a flexible and co-ordinated system which operates within the full range of availability and, through enhanced autonomous modes of operation, with much less reliance on communications.

QUEST will co-ordinate the discrete voltage management techniques to ensure that they work together to deliver maximum benefits to customers and DNOs. By installing elements of these techniques at other voltage levels, QUEST will extend their reach to cover areas of the network that cannot currently benefit, thus delivering benefits to customers.

In addition, QUEST will build upon the carbon benefits of these techniques by enabling further reductions to energy consumption and system losses, which would not be achievable using the techniques in isolation. This aligns with the increasingly ambitious targets many local authorities are setting for a reduction in emissions.

Forecasts across GB show an increasing use of LCTs by customers; Figure 4.7 shows the growing trend for ENWL. This will place even greater demand on increasingly saturated and heavily-loaded networks.

Figure 4.7: LCT uptake across ENWL



In response, we expect DNOs to deploy more voltage optimisation techniques as an alternative to traditional network reinforcement. By developing the Method now, we can prove the concept, identify the appropriate architecture for deployment, and demonstrate the benefits of this co-ordinated approach, thereby enabling integration into the ongoing roll-out of these techniques. This will ensure that all associated benefits are realised in as timely a fashion as possible.

5. Knowledge Dissemination

QUEST will generate learning applicable to all licensees which will be shared as early as possible.

5.1. Learning generated

QUEST will build on the learning from previous LCN Fund Projects on voltage management to develop and demonstrate a new, end-to-end voltage control and optimisation standard. This will be implemented using industry standard hardware, and will produce and publish the required software algorithms.

An analysis of relevant projects can be found in Appendix C, and all key deliverables for the Project are outlined in Figure 5.1 below.

Figure 5.1: QUEST deliverables

Project Deliverable	Evidence	Responsible
QUEST Initial Report - Use Cases	Document introducing the Project and detailing the use cases and scenarios.	ENWL, Fundamentals Ltd, SGS, SE
QUEST System Design and Architecture Lessons Learned	Document explaining Project progress including the following outputs: • Review of architecture options • Specification for the network models and modelling regime	ENWL, Fundamentals Ltd, SGS, SE
QUEST Trials, Design and Specification Report	Document explaining Project progress including the following outputs: • Functional specification for chosen architecture • Functional specification for voltage control methodology • Trial design • Detailed site design	ENWL, Fundamentals Ltd, SGS, SE
QUEST Interim Report - System Design and Technology Build Lessons Learned	Document detailing Project progress to date including lessons learned from: • QUEST software development and testing • Power system model development • Site installation for the voltage control and ANM equipment	ENWL, Fundamentals Ltd, SGS, SE

Project Deliverable	Evidence	Responsible
QUEST System Integration Lessons Learned Report	Document detailing the lessons learned from the installation and commissioning of the QUEST system including system integration and the results of site acceptance testing.	ENWL, Fundamentals Ltd, SGS, SE
Customer Research Findings Report	Document detailing the outputs from the customer research.	ENWL, Impact
QUEST Trials and Analysis Report	Document detailing: • Final results from network trials • Final results from modelling trials • Output from research into the voltage demand relationship • Any adaptation required to voltage control methodology	ENWL, SGS
QUEST Final Report	Report on the conclusion of the QUEST Project including all the lessons learned and detailing the next steps, including BaU transition.	ENWL
Comply with knowledge transfer requirements of the Governance Document.	Annual Project Progress Reports which comply with the requirements of the Governance Document. Completed Close Down Report which complies with the requirements of the Governance Document. Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	ENWL

There is significant potential for QUEST to provide benefits to the GB distribution system as a whole. To ensure that this potential is maximised, we have assembled an ISG, see Appendix I for our letter of invitation, which will provide input to the Project at its early stages to help shape the use cases. The ISG will convene on a quarterly basis thereafter for the duration of the Project, to inform the Project direction, review trial designs and conclusions, and help to construct a plan to transfer the Solution to BaU.

The ESO and each DNO have nominated one representative to take part in the ISG, which will help to ensure that the Method and all associated benefits are applicable to the GB distribution system as a whole.

5.2. Learning dissemination

The detailed project plan, which can be found in Appendix E, incorporates timely dissemination of the learning and knowledge that QUEST expects to generate.

Stakeholder groups

QUEST will generate a wealth of knowledge that will be of interest and benefit to various stakeholder groups. It is important to identify and understand these groups to ensure that our chosen knowledge-sharing and dissemination methods meet their individual requirements. Our history of the successful delivery and Close Down of LCN Fund Projects has enabled us to develop a consistent approach to capturing and sharing learning effectively.

Our main stakeholder audiences fall broadly into the following categories:

Network operators: including DNOs, the ESO, Transmission Network Operators (TNOs), Independent Distribution Network Operators (IDNOs), Ofgem and BEIS. Network Operators will be keen to understand how QUEST can maximise efficiency of discrete voltage management techniques to delay network reinforcement and reduce customer costs. Information for this audience will focus on the holistic voltage control methodology used to co-ordinate these techniques, and how it can influence network investment and reduce costs for customers whilst maintaining quality of supply and network reliability. This will assist in decision-making for future strategies, price control reviews, and industry regulation.

Industry groups: this includes organisations such as the Energy Networks Association (ENA), who will be interested in any potential impact on network design and operation. Manufacturers of distribution equipment and/or voltage control devices will be keen to ascertain any operational effects of the holistic voltage control methodology and to explore possible opportunities for product development and potential market opportunities.

Academic institutions: including universities and higher education establishments who are likely to access the raw data generated in QUEST to support wider research in the area of voltage management on the electricity distribution network. Knowledge dissemination with this stakeholder group presents a unique opportunity to invite alternative conclusions.

Local authorities and customers: these groups will be interested in the customer benefits to be gained from the roll-out of QUEST, such as reduced network operation costs, lower disruption associated with reinforcement activities, and potential reduction in energy bills. It is also possible that they will be interested in the results from customer engagement undertaken as part of QUEST.

Electricity North West: colleagues from across the organisation have been highly engaged and interested in the innovation programme and the Project team will be proactive in disseminating to this key stakeholder group. Close links with the Customer Contact Centre, those responsible for Policy and Standards, and the Commercial and Procurement departments will help with successful Project delivery. The ENWL community has a vested interest in working together to establish how learning and knowledge will be incorporated into BaU in the future.

Dissemination activities

Knowledge-sharing and dissemination activities are designed around the Project deliverables. In addition to planned learning, our experience has shown that unplanned learning is also likely. Timely dissemination of all planned and unplanned learning is crucial to keeping stakeholders engaged. To facilitate this, a designated knowledge and dissemination workstream will capture all learning and promote simple, targeted, and pragmatic dissemination activities.

We will leverage learning from previous innovation Projects to use appropriate dissemination methods that support direct feedback from our stakeholders to enable Project responsiveness and further incremental learning. These are outlined in Figure 5.2 below.

In previous Projects we have used advertorials in magazines, such as the IET magazine, to disseminate Project learning. We have decided not to continue with this approach in QUEST because, based upon our experience, we believe it is unlikely to generate sufficient customer or wider stakeholder engagement.

Figure 5.2: QUEST Project dissemination activities

Dissemination Method	Description	Audiences
Website	We will set up a page for QUEST on our website, providing an easily accessible platform to share knowledge and materials generated during the Project.	All stakeholder groups
Seminars, conferences and workshops	Certain dissemination activities may be delivered in this traditional manner, allowing for valuable time with stakeholders and stimulating active participation from the audience. Events may be filmed and added to the webpage or YouTube to reach a wider audience.	All stakeholder groups
Industry Steering Group	Quarterly ISG meetings will provide targeted stakeholder engagement. These will take place throughout the Project to inform the Project direction and help to construct a plan to transfer the Solution to BAU.	ESO/DNOs
Annual knowledge sharing event	Annual engagement sessions will be held either online or in person to provide Project updates and maximise accessibility to stakeholders.	All Stakeholders
Social media	Social media channels such as Twitter, LinkedIn and YouTube will be used as appropriate to promote learning from the Project.	Customers, local authorities, DNOs, IDNOs
Press releases	Issued during the course of the Project by an in-house press officer, these articles will be designed to publicise QUEST activities and events throughout the industry and will be published online.	All stakeholder groups

Dissemination Method	Description	Audiences
Internal communications	This will include articles in the company magazine, 'Newswire', the weekly email bulletin, and The Volt intranet site, which will communicate the Project's aims and objectives across ENWL, as well as providing updates to prepare the company for BaU once the methodology is proven.	ENWL
Reports, documents and training material	Milestones and deliverables will be agreed to govern when these documents are produced and ready to share with stakeholders.	DNOs, IDNOs, Ofgem, BEIS, academic institutions, equipment manufacturers, ENWL

Figure 5.3 below shows the knowledge dissemination activities planned throughout the course of the Project.

Figure 5.3: Dissemination programme

2021	2022	2023	2024	2025
QUEST webpage	QUEST webpage updates	QUEST webpage updates	QUEST webpage updates	QUEST webpage updates
Internal communication	Internal communication	Internal communication	Internal communication	Internal communication
Annual report	Annual report	Annual report	Annual report	Close Down Report
Knowledge sharing event	Knowledge sharing event	Knowledge sharing event	Knowledge sharing event	
ISG	ISG	ISG	ISG	
LCNI Conference	LCNI Conference	LCNI Conference	LCNI Conference	

5.3. IPR

ENWL intends to conform to the NIC default Intellectual Property Rights (IPR) arrangements. All Partner contracts will include the standard NIC default IPR clause.

6. Project Readiness

QUEST has been planned using a robust methodology and the Project is ready to commence.

We have a proven track record of delivering innovation Projects to time and budget. We have developed a robust project plan in line with our proven process, and together with our chosen Partners we are confident that we can deliver the Project learning and benefits.

Requested level of protection required against cost over-runs (%): 0%
Requested level of protection against Direct Benefits (%): 0%

6.1 Measures taken to ensure the project can start in timely manner

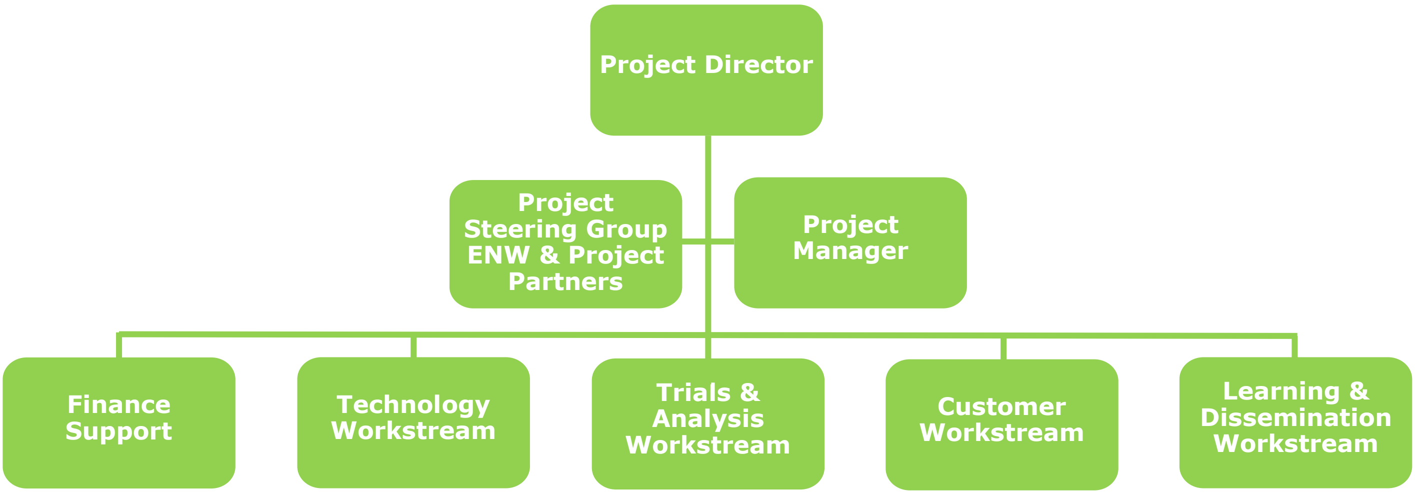
We are confident that, if funding is awarded, QUEST will be able to start in a timely manner due to the significant amount of preparatory work that has taken place prior to the Full Submission. In addition to producing a comprehensive project plan, we have established relationships with all Project Partners, taken steps to set up our Project Steering Group (PSG), and completed our site selection and pre-work surveys. We also have well-established, dedicated teams within the Innovation department who will build on past experience from previous successful submissions to deliver the Project. Furthermore, we have opted to use readily available equipment to minimise potential delays.

In recent years we have trialled and proven a number of voltage management techniques on our network. Now that we have started to roll these techniques out across the network, a risk of potential operational conflicts has been highlighted. It is, therefore, vital that we develop strategies and the architecture necessary to resolve these potential conflicts now to ensure that the benefits of these techniques are maximised ready for the continued roll-out to our network, as well as the GB distribution system as a whole.

Project management and governance

QUEST will use the programme management and governance approach employed for the delivery of our Celsius, CLASS, Smart Street, and Respond Projects. Following the successful Close Down of these Projects, our proven Project governance methodology will ensure that QUEST meets all defined milestones and Project deliverables. Enhancements to the methodology identified in the delivery of previous and ongoing Projects can be easily transferred into QUEST. The philosophy to be open and collaborative, with the commitment to get it right first time to achieve delivery success, will be embedded in the Project team. The Project management structure is shown in Figure 6.1.

Figure 6.1: Project management organogram



Project Partners and contractual arrangements

Project Partners and suppliers have been carefully selected dependent on experience, cost, and their ability to commit skilled resources to deliver the Project and disseminate learning to other GB DNOs. The process by which Partners are selected is described in Section 4.(e).

We have established a dedicated consortium and confirmed with each Partner that they will have sufficient resource available to meet the requirements of the project plan. We have also confirmed contributions, costs, roles, and responsibilities, which will form the basis of our contractual agreements. The key outcome of this approach is to minimise time spent on contractual agreements and ensure that QUEST can be mobilised very quickly if funding is awarded.

Defined roles and responsibilities and financial costing and contributions for the provision of services and/or products are included in the Full Submission workbook (see Appendix L).

6.2 Minimising the possibility of cost overruns or shortfalls in direct benefits

Project costs and Direct Benefits

The costs and Direct Benefits have been compiled by a management accountant. Inputs were generated by our internal and external Project Partners/suppliers and have been approved through ENWL's internal investment appraisal process. The cost information included in the proposal has an accuracy of between 5% and 7%, and within the overall cost calculation we have added an additional 7.4% as contingency against any potential changes to costs as the Project progresses.

A management accountant, responsible for managing all costs and constructing and delivering the reporting requirements, will be embedded in the Project team along with the Project Management Office (PMO) to manage the budget. ENWL runs a robust financial tracking and reporting system in line with current internal policies and frameworks. The Project finances will be held in a separate Project bank account as required by the NIC Governance Document. This will meet the following requirements:

- Show all transactions relating to QUEST only.
- Be capable of supplying a real-time statement (of transactions and current balance) at any time.

- Accrue expenditures when a payment is authorised (and subsequently reconciled with the actual bank account).
- Accrue payments from the moment the receipt is advised to the bank (and then subsequently reconciled with the actual bank account).
- Calculate a daily total and the interest on the daily total according to the rules applicable to the bank account within which the funds are held.

In addition, our auditors will be made aware of our responsibilities should funding for QUEST be awarded.

6.3 Verification of all information included in proposal

Assurance and sign off

We have undertaken various assurance activities throughout the bid preparation process to substantiate our financial costings and benefits, including:

- Developing detailed internal cost models to evaluate the required Project resources, with proposals from third parties subject to fixed price contracts.
- Documenting and challenging all contributions by Partner organisations individually.
- Collating all costs and contributions for review by the Project's management accountant.
- Compiling our benefits estimate with independent third-party support from Ricardo Energy and Environment.

We have also conducted an internal process audit for the submission. This audit found no material errors or issues and will form the basis of a report to be presented to the responsible director.

A review of this nature represents the most appropriate form of challenge for this type of submission. Our final submission has been reviewed and approved by our Head of Innovation, Dan Randles, our Engineering and Technical Director, Steve Cox, and our Chief Executive Officer, Peter Emery.

Project plan

The Project will be delivered via six workstreams: Mobilisation, Technology, Trials and Analysis, BaU Transition, Customer, and Learning and Dissemination. The project plan outlines our approach by defining the activities required within each workstream and identifying who has been assigned to undertake each, and when.

A high-level plan is shown in Figure 6.2 and a more detailed version can be found in Appendix E.

Mobilisation: the mobilisation of both internal and external teams, as well as the retention of those individuals across the Project delivery lifecycle, is crucial to the successful start and continued delivery of the Project. We have identified delegate resources to deliver QUEST, managed by a full time Project manager. The team will also receive significant help from within the wider Innovation team. Furthermore, the Project Partners have identified resources that will be dedicated to QUEST.

Technology: the technology workstream will be undertaken with support from Project Partners Fundamentals Ltd, SGS, and SE, and will be split into two phases. During the System Design phase, we will develop the use cases, design the hardware and software architecture, and create the models for the simulations. During the Implementation phase we will complete the trial design and detailed site design, procure equipment, and complete installation of equipment and IT.

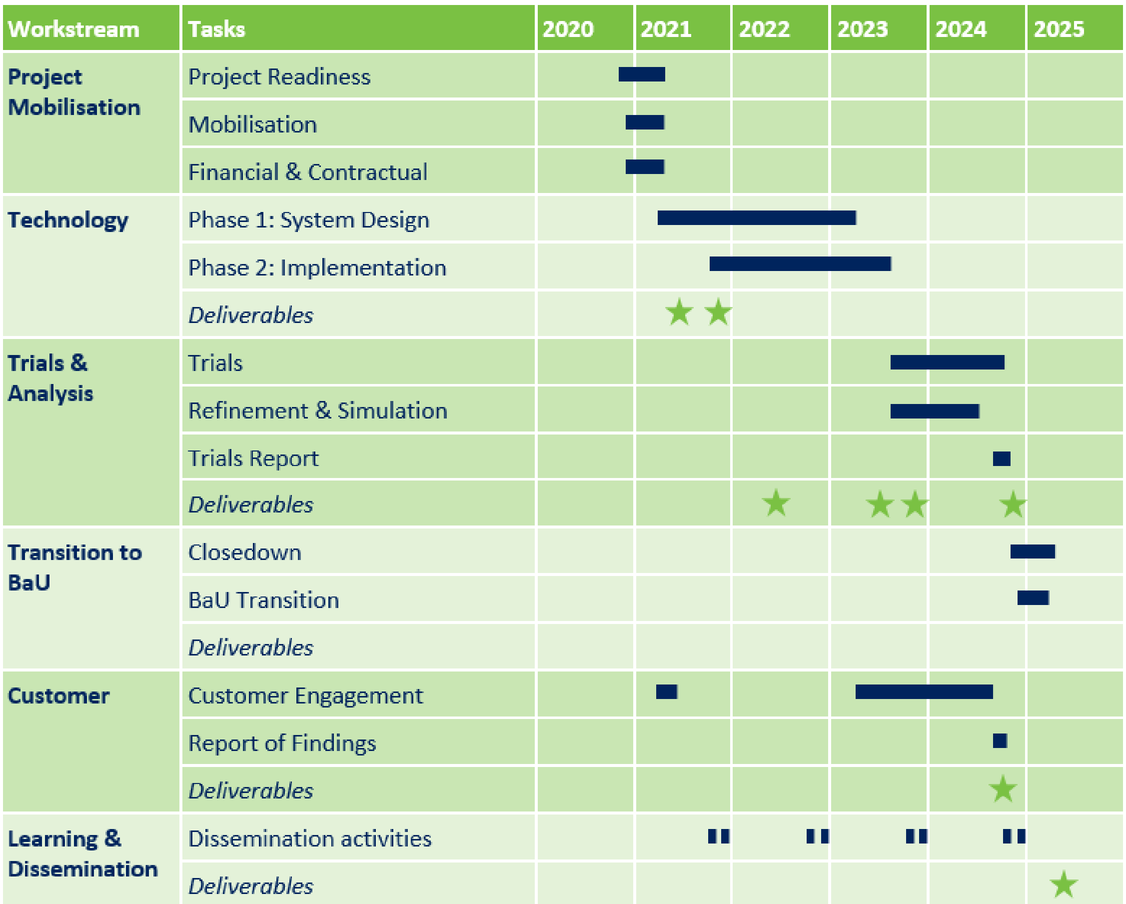
Trials and analysis: the Project delivery team will spend one year trialling QUEST on the network, whilst monitoring and refining the system as necessary. During this phase we will complete the modelling simulations. The results will be analysed to generate a final trial report which will be disseminated to other DNOs.

BaU Transition: this workstream will see the Close Down of the Project, during which we will analyse the costs and benefits of QUEST and produce a Close Down Report for dissemination. We will also develop the process for transition of the Solution into BaU, provide training to internal planners and operational engineers on all new codes of practice, and publish our holistic voltage control methodology.

Customer: the customer workstream runs in parallel with the other Project workstreams and a detailed Customer Engagement Plan (CEP) will be published on the QUEST website in early 2021. Further details about the planned customer engagement can be found in Section 8.

Learning and dissemination: this workstream will incorporate all learning and dissemination activities and will run throughout the Project in line with our Deliverables, to ensure timely dissemination of all learning. We will make best use of all available channels to ensure maximum reach, including online resources such as our website, social media, and online engagement sessions, as well as knowledge sharing events, ISGs, and presentations at the LCNI conference. These activities are defined in more detail in Section 5.

Figure 6.2: High-level project plan



The project plan provides a clear roadmap to steer and support the Project delivery team in achieving the relevant milestones and Deliverables on time and within budget.

6.4 Project will deliver learning if LCT uptake is lower than anticipated

The Project scope is designed to deliver learning and develop outputs without the need for further low carbon or renewable energy uptake on the trial networks.

Our methodology will be applicable to any distribution network, regardless of load type, to understand how different voltage management techniques can be co-ordinated.

In addition, the Project benefits will remain relevant even if there is minimal LCT uptake. For example, for the distribution system, the capacity release benefits will support load growth from any source and a reduction in system losses will still provide carbon and financial benefits. The ESO will also gain many of the same Project benefits, such as enhanced visibility of the distribution system, which will enable better management of constraints and an improved response to system events.

6.5 Processes to identify circumstances in which to suspend the Project

Risks, mitigation and contingency plans

A key aspect of our Project delivery methodology is the identification and management of risks and issues. We have employed ENWL’s well-established risk model which has been refined to better reflect the increased significance of impacts at Project level.

Appendix F contains our Risks and Issues Register, including mitigating and contingency actions. We have used the format and scoring matrix from our risk model to evaluate the likelihood and impact of an identified risk or issue and to re-evaluate the controlled risk or issue following mitigating activity. Tables showing the scoring matrix and associated description have been included in Appendix F, for reference.

The definition and creation of mitigating and contingency activities form a key part of our risk management strategy. The Project management team and PSG will use this methodology to continually identify and review the Project risks, mitigating actions, and contingencies to ensure that risks are managed in priority order. When a risk is raised the Project management team will be responsible for creating a mitigating action that can be brought into play should the risk be realised. Standard considerations in the risk identification process include the monitoring of cost management, specifically cost overruns or shortfalls in Direct Benefits.

During the course of the Project we will hold regular PSG meetings at which the Risks and Issues Register will be reviewed. In addition to the Project team and Partners, this group will include a Project director and a federated management accountant from the finance directorate, to drive delivery to budget.

The PSG will identify the circumstances in which the Project is either suspended until sufficient risk mitigation has taken place to enable ongoing management of the risk or issue, or halted with further commitment deferred until agreement on how to proceed has been reached with Ofgem.

7. Regulatory Issues

QUEST will have a positive impact on the future design and operation of distribution networks and will reduce costs for customers.

It is not expected that the QUEST Project will require any derogation, licence consent, or licence exemption for its delivery.

QUEST will trial whole distribution system voltage optimisation to increase the utilisation and flexibility of existing networks whilst maximising the benefits of existing voltage management techniques. QUEST could have profound implications on the operation of both transmission and distribution networks.

QUEST will prove that network operators can optimise voltage profiles on their networks to have a positive effect on operational carbon through a reduction in losses and customers' energy consumption.

Long term regulatory impact

Learning from the trials will deliver a new voltage control and optimisation standard that will be put forward as a basis for a new industry standard. Additionally, this learning will allow the QUEST Project team to consider recommendations for delivering OC6 responses.

The longer-term impact on the regulatory regime applied to network operators is significant and positive with the following areas potentially seeing change:

- Voltage control regime in the Distribution and Grid Codes.
- Common connection and use of system charging methodologies applied by DNOs.
- Regime for the provision of connections.
- National Terms of Connection within Distribution Connection and Use of System Agreement (DCUSA).
- Future DSO operational management.

The additional monitoring equipment installed to facilitate QUEST will support the more granular view of charging being considered in Ofgem's Charging and Access Review.

8. Customer Impact

QUEST will ascertain that customers continue not to notice any impact to their supply when the network is operated more dynamically.

QUEST will trial the Method at one GSP, from the National Grid intake through the network and down to the domestic customer at LV. The trial area supplies electricity to approximately 158,000 customers.

The trial will involve making adjustments to the network voltage to deliver benefits to customers. At all times these changes will remain within the statutory limits. Previous innovation research has established that most customers do not discern voltage changes associated with our use of CLASS and Smart Street, which also made voltage adjustments. This understanding provides confidence in our ability to deliver whole distribution system voltage optimisation without disruption to customers. However, as this will represent a new way of managing network voltages, seeing us operate more fully within the permissible range, we believe it is appropriate to revalidate this view as we move towards a more dynamic network operation.

As such, we will survey 300 of the customers served by the 10 distribution networks in the QUEST trial area. This survey population represents a statistically robust sample, approximately 10%, of the LV customers that will experience the full extent of whole distribution system voltage optimisation.

Whilst we do not expect the majority of customers to notice QUEST, we are aware that there are a small number of atypical customers who operate voltage sensitive equipment. As QUEST will allow operation within the full permissible voltage range, we plan to engage directly with these customers. We will explore how they set up their equipment, how they might be impacted by other adjustments in system voltage, and what information we could provide that will assist these customers in making the necessary adjustments to their systems as we transition to this new method of operation.

QUEST could provide the facility to offer customers a new type of managed connection. A voltage dependent connection would complete our portfolio of managed connection offerings to accompany demand-side flexible connections, developed in the LCN funded Capacity to Customers Project. We will also leverage learning from the LCN funded Respond Project's exploration of fault-level managed agreements. QUEST will explore the appetite of new and future customers to connect to the network in such a manner. The output of this research could be used to inform the development of a new framework for voltage-managed connections.

Impact Research have been appointed as the customer research Project Partner through a competitive tender process. We will work together to produce the CEP and Data Privacy Statement (DPS), which will set out how we intend to engage with customers in QUEST. This will document the communication strategy and customer research methodology, from recruitment of participants to reporting and analysis. The outline scope for this plan is included in Appendix H.

As part of the CEP we will segment customers into groups and identify which will be involved in the research. The three key areas of focus for the customer research are set out in Figure 8.1.

QUEST will engage with a sufficient number of customers in each of the research areas to demonstrate representative results at scale. Customers will be identified using available network, property specific, or customer data. Recruiting customers into the research will be subject to a stringent data privacy impact assessment, and the explicit consent of participating customers.

The Project will use proven engagement methods and channels to ensure customers participating in the research fully understand the benefits and requirements of participation. Suitable communications materials will be generated to support customers that participate in the three distinct areas of research. All materials generated as part of the Project will be developed collaboratively with Impact Research and guided by customer and stakeholder feedback. These materials will confirm that ENWL is the research sponsor and will highlight any potential implications and benefits of QUEST.

Feedback received from customers and stakeholders may be used to revise research plans in order to continually improve the customer research and engagement strategy. The Project team will consult Ofgem in advance of any significant changes from the original approach.

The following summarises the customer engagement and research approach in QUEST, by customer type.

Figure 8.1: Research objectives

Area	Customer Segment	Objective
Area 1 *Customer experience*	• Relevant domestic and SME customers connected in the QUEST trial area. • Survey aligned to technology trials.	Revalidate, via a small, targeted study, the currently held view that customers do not discern voltage change as the industry moves towards a more dynamic operating model for system voltage.
Area 2 *Sensitive customers*	HV & EHV connected customers from across the North West that operate sensitive equipment or who may have designed their equipment assuming narrow system voltage bands.	• Establish the expectations of voltage sensitive customers, from a range of sectors. • Evaluate how they set up and operate their own equipment. • Explore potential impact and the guidance they require. • Develop guidance materials • Endorse guidance materials with customers.
Area 3 *Voltage managed connections*	HV & EHV connected customers (focussed on generators but including a sample of large demand customers) from across the North West.	Assess technical ability and customer appetite for voltage managed connections.

Customers in the QUEST trial area

There is no active involvement from the wider community in QUEST and no customer impact is anticipated. Therefore, the Project will not involve a large scale general customer awareness campaign in advance of the trials. This rationale leverages learning from previous research.

Planned supply interruptions

There is a remote possibility that some customers may experience PSIs associated with the technology installation. We will take all practicable steps to mitigate this risk and will use mobile generation and backfeeds from adjacent networks to avoid interruption in supply. Where a PSI is unavoidable, we will manage these impacts through BaU processes and provide standard written notification, in accordance with Guaranteed Standard procedures. It has been assessed that the maximum impact of any PSI will not exceed eight hours and the number of customers affected will be minimal. As per the calculations in Section 4.(b), the reliability and incentives impact has been assessed at [redacted] and we will not seek protection to this value.

Unplanned supply interruptions

Customers will not be affected by an unplanned supply interruption as a result of QUEST.

Customer engagement

Relevant domestic and SME customers

We will revalidate the finding from previous research that voltage management techniques remain imperceptible to customers. This area of research will engage a broad and representative sample of 300 domestic and SME customers from within the trial area. These customers will experience the full range of optimisation and will be surveyed during the technical trials, to reliably demonstrate that they continue to not discern voltage change within the permissible limits.

Sensitive HV & EHV connected customers

We recognise that there are atypical customers served by our network that have designed their systems assuming a narrow deviation from the nominal voltage. This small subset of customers, typically hospitals and heavy industry operating embedded systems, will be engaged in research area 2. This research will provide a detailed understanding of expectations and the potential impact associated with voltage management for sensitive customers. The output will be clear guidance for customers to ensure they are able to accommodate the wider band of voltage change required to deliver benefits for all customers. This will comprise three distinct stages:

Stage 1: Identify needs & expectations
Qualitative research with 50 large voltage sensitive customers to establish how their systems are set up and how operation of system voltage within the full permissible range may impact these organisations.
Stage 2: Develop guidance
Develop information and guidance materials to support customers who may need to modify their systems as voltage control across our network changes.
Stage 3: Evaluate guidance
Qualitative research to evaluate and endorse guidance materials developed in stage 2.

Stage 1 will answer the following questions:

- Are the operating characteristics of various sensitive customers affected by voltage management; and, if so, how and in what circumstances?
- Are there any special requirements in respect of the supply voltage for certain customer types?

Learning from this initial stage of engagement will be used to develop guidance for sensitive customers, to inform their own resilience strategies. This guidance will be evaluated by a broad sample of atypical customers in stage 3, and refined based on feedback. The final version will be publicly available through a variety of easily accessible channels and will enable customers to act appropriately to ensure their systems continue to work harmoniously with the network.

HV & EHV connected customers

QUEST will maximise the use of existing low carbon generation and allow network operators to provide faster, cheaper connections to their customers, facilitating further uptake. Generators typically have an effect on voltage, and their ability to respond to voltage signals by dynamically changing their output could provide commercial benefits and quicker, lower cost connections.

This research builds on learning from Capacity to Customers, which explored the requisite commercial arrangements for demand-side response and is now a standard BaU offering. Additionally, new commercial arrangements associated with a fault level response were explored in Respond. QUEST will complete the exploration across the full portfolio of potential commercial offerings by establishing the appetite for voltage-driven, self-managed connections.

Research area 3 will explore the ability of large customers to respond to voltage signals and will identify any technical constraints that introduce barriers to managed connections of this type. We will use modelling to trial this, and measure customer response. QUEST will not, therefore, necessitate the installation of any type of equipment at customer premises.

Our learning will underpin a potential connections offering and inform how DNOs can best include customers in the operation of their networks.

Managing customer enquiries

To ensure the impact of QUEST on customers is fully evaluated, a robust strategy will be embedded to manage customer enquiries and complaints. This will ensure that any communications are captured and thoroughly investigated. Should customers on the trial networks report any notable effect associated with the Method, the matter will be managed by the Project team, in line with the risks and issues process, and all possible mitigation explored. In the unlikely event that a resolution cannot be achieved, we may consider halting or suspending certain aspects of the trials on a specific part of the network.

Our aim is to maintain a positive customer experience throughout the duration of QUEST. This upholds ENWL's core value of putting our customers at the heart of our business. This commitment will be achieved by employing a number of communication channels so that customers will find it simple to raise any questions or concerns at a time convenient for them.

9. Project Deliverables

Reference	Project Deliverable	Deadline	Evidence	NIC funding request (%, must add to 100%)
1	QUEST Initial Report - Use Cases	31/07/21	Document introducing the Project and detailing the use cases and scenarios.	5%
2	QUEST System Design and Architecture Lessons Learned	31/12/21	Document explaining Project progress including the following outputs: • Review of architecture options • Specification for the network models and modelling regime	10%
3	QUEST Trials, Design and Specification Report	30/06/22	Document explaining Project progress including the following outputs: • Functional specification for chosen architecture • Functional specification for voltage control methodology • Trial design • Detailed site design	10%
4	QUEST Interim Report - System Design and Technology Build Lessons Learned	30/06/23	Document detailing Project progress to date including lessons learned from: • QUEST software development and testing • Power system model development • Site installation for the voltage control and ANM equipment	20%

Reference	Project Deliverable	Deadline	Evidence	NIC funding request (%, must add to 100%)
5	QUEST System Integration Lessons Learned Report	30/12/23	Document detailing the lessons learned from the installation and commissioning of the QUEST system including system integration and the results of site acceptance testing.	20%
6	Customer Research Findings Report	31/10/24	• Document detailing the outputs from the customer research.	5%
7	QUEST Trials and Analysis Report	30/12/24	Document detailing: • Final results from network trials • Final results from modelling trials • Output from the voltage demand relationship research • Any adaptation required to voltage control methodology	10%
8	QUEST Final Report	30/04/25	Report on the conclusion of the QUEST Project including all the lessons learned and detailing the next steps, including BaU transition.	20%
9	Comply with knowledge transfer requirements of the Governance Document.	End of Project	Annual Project Progress Reports which comply with the requirements of the Governance Document. Completed Close Down Report which complies with the requirements of the Governance Document. Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	N/A

10. List of Appendices

Appendix number	Title
A.1	Benefits Tables
A.2	Base Case Method and Solution (Business Case)
B.1	High-Level Functional Specification for Software
B.2	Trial Area Details
C	Review of Forerunner Projects
D	Organogram
E	Project Plan
F	Risks and Issue Register and Contingency Actions
G	Project Partner Details
H	Customer Engagement
I	Invitation to Industry Steering Group
J	Letters of Support
K	Glossary
L	Full Submission Spreadsheet

Appendix A.1: Benefits Table

A.1.1 Financial benefits

Figure A.1.1 summarises the results as calculated by the QUEST financial business case model.

Figure A.1.1: QUEST financial benefits

Scale	Method	Method Cost (£m)	Base Cost (£m)	Benefit (£m NPV 2020 prices)			Cross References	Notes
				2030	2040	2050		
Project / ENWL Scale	QUEST	[redacted]	[redacted]	21.3	29.8	32.6	Appendix A.2.4	1 & 2
GB Scale	QUEST	[redacted]	[redacted]	51.0	165.1	266.7	Appendix A.2.4	3 & 4
Additional Benefits - Quantified	The Method reduces the supply voltage, resulting in an energy consumption reduction for customers. This leads to a direct reduction in the number of units paid for by customers. This benefit is highly dependent on the tariff structure and the approach to fixed costs, such as use of system charges. Based only on the proportion of the bill related to the wholesale cost of electricity, this has an estimated **NPV benefit of over £4,300m up to 2050**.							
Additional Benefits - Not Quantified	• Lower cost connection of LCTs • Maximising benefits from a combination of existing voltage technologies.							

Explanatory notes:

1. *Project scale benefits have not been calculated for QUEST* because it will develop a DNO scale Solution. The software module will be applicable to the entire distribution network; however, we will demonstrate the optimisation and co-ordination benefits on a clearly defined area.
2. *ENWL scale benefits include capacity release and loss reduction,* together with the ENWL roll-out costs for QUEST. The Base Case costs include the lowest cost method to reach a similar level of capacity release for each overloaded substation, taking into account traditional methods and flexible services. The cost to reduce losses is not included in the Base Case cost. However, as this is an additional benefit of the Solution, it is included in the benefits totals. The methodology is described in more detail in Appendix A.2.1.
3. *GB scale financial benefits are scaled from the ENWL models using modified assumptions:* GB scale benefits are assumed to be proportional to the number of Primary and BSP substations in GB compared to the number on ENWL's network (i.e. a factor of approximately 13.4 is used to convert ENWL scale benefits to GB benefits), and it is assumed the profile across GB will be smoothed compared to the ENWL profile. It is assumed that the other GB DNOs will roll-out the Solution from 2028, in line with the beginning of RIIO-ED3. It is also assumed that, outside of ENWL, there are no existing substations with advanced relays capable of being integrated into the Solution at the beginning of this roll-out. This is

conservative, as modern relays are compatible with QUEST and it is likely they exist on other DNO networks (note: ENWL has a high proportion installed as a result of other Projects).

4. *The sensitivity analysis shows significant variation in results, but generally shows a good benefits case:* the central assumptions are stated in Appendix A.2.5. The sensitivity analysis found that the most influential factors are the assumed level of voltage reduction and the future electricity scenario used to predict future load.
   - Using the voltage reduction sensitivity range of 1.5% to 3.5% (central assumption: 2.5%), the NPV of the GB benefits in 2050 range from £155.6m to £361.1m.
   - The range of benefits was even more varied for the selected future electricity scenario. Using our DFES, the lower growth and prosperity scenarios show a significantly reduced business case, which is only just positive, whereas the higher prosperity and growth scenarios reach an NPV benefit of over £330m in 2050, across GB. The Central Outlook scenario was selected as the central assumption because it is a balanced view and is our current view of how demand will increase to facilitate the net zero carbon transition.

A.1.2 Capacity benefits

Figure A.1.2 summarises the capacity benefits as calculated by the QUEST business case model. Further explanation is provided in the notes below the table.

Figure A.1.2: QUEST capacity benefits

Scale	Method	Benefit (cumulative MVA)			Cross References	Notes
		2030	2040	2050		
Project / ENWL Scale	QUEST Solution	162.3	191.2	211.2	Appendix A.2.1	5
GB Scale	QUEST Solution	490.1	1,517.0	2,236.7	Appendix A.2.1	6
Additional Benefits	• Optimisation of existing voltage management techniques.					

Explanatory notes:

5. *ENWL scale capacity release benefits are driven by the reduction in peak load on the network due to voltage reduction:* the reduction in losses will release a marginal level of capacity, but this has not been included in the benefits case as it is assumed to be negligible.

6. *GB scale capacity release benefits are scaled from the ENWL models using modified assumptions:* the GB scale benefits are assumed to be proportional to the number of Primary and BSP substations in GB compared to the number on ENWL's network (i.e. a factor of approximately 13.4 is used to convert ENWL scale benefits to GB benefits), with a roll-out starting in 2024 for ENWL and 2028 for other DNOs. It is also assumed that the profile of benefits across GB will be smoothed, compared to that across ENWL.

A.1.3 Carbon benefits

Figure A.1.3 summarises the carbon benefits as calculated by the QUEST business case model. Further explanation is provided in the notes below the table.

Figure A.1.3: Carbon benefits of QUEST

Scale	Method	Benefit (cumulative tCO_2e)			Cross References	Notes
		2030	2040	2050		
ENWL Scale	QUEST Solution	2,161	5,286	8,373	Appendix A.2.7	7
GB Scale	QUEST Solution	4,088	22,090	51,498	Appendix A.2.7	8 & 9
Additional Benefits - Quantified	QUEST will deliver an energy consumption reduction for customers by reducing the supply voltage. This has a significant carbon benefit, resulting in cumulative carbon benefits of approximately **275ktCO_2e across ENWL by 2050,** and **1,070ktCO_2e across GB by 2050.**					
Additional Benefits – Not Quantified	QUEST will also lead to substantial indirect carbon and environmental benefits through enabling lower-cost connection of distributed generation, EV charging infrastructure, and other LCTs. This will reduce the barriers to establishing this infrastructure at scale.					

Explanatory notes:

7. *ENWL scale carbon benefits are driven by the reduction in network losses* and are quantified using the forecasted grid carbon intensity up to 2050, from the '2 degrees' scenario data in National Grid's 2019 Future Energy Scenarios.

8. *GB scale carbon benefits are scaled from the ENWL models using modified assumptions:* the GB scale benefits are assumed to be proportional to the number of Primary and BSP substations in GB compared to the number on ENWL's network (i.e. a factor of approximately 13.4 is used to convert ENWL scale benefits to GB benefits), with a roll-out starting in 2025 for ENWL and 2028 for other DNOs. It is assumed that the profile of benefits across GB will be smoothed, compared to that across ENWL.

9. *The sensitivity analysis shows a good carbon benefits case throughout the ranges:* the central assumptions used are stated in Appendix A.2.5. The sensitivity analysis determined that the assumptions for voltage reduction and percentage of the network voltage reduction is applied to has an impact on the carbon case. The analysis found that GB scale carbon benefits up to 2050 ranged from 30,518tCO_2e to 72,990tCO_2e.

Appendix A.2 Quantified Business Case Methodology

The QUEST quantified business case model is reflective of the benefits and drivers for QUEST, tangible and measurable, and is based on validated data and credible assumptions. In general, conservative assumptions have been chosen in recognition of the uncertainty of future benefits forecasts, and a sensitivity analysis has been carried out to explore the impact of those assumptions.

The quantified business case is derived from the benefits of whole distribution system voltage optimisation, to reduce both customer energy consumption and peak demand.

The business case is made up of two main benefit categories:

- *Network capacity release:* reducing the peak network load releases thermal capacity in connected assets. This additional capacity can then be used by network operators to defer the need for reinforcement or other capacity release methods.
- *Network losses reduction:* reducing the energy carried on the network results in a reduction in the associated losses.

The benefits associated with energy consumption reduction have been calculated, but are not included as part of the main Project benefits.

The benefits case avoids overlap with discrete voltage management techniques. As such, the benefits included in the QUEST business case are considered new benefits, and use the following assumptions:

- QUEST aims to optimise voltage reduction to release capacity whilst remaining within statutory limits. CLASS previously demonstrated the benefits from a voltage reduction of 1.5% for limited durations at Primary transformers. As implemented, CLASS is a discrete solution with local visibility and control, and it is not currently possible to implement a larger voltage reduction for longer periods. Therefore, to calculate the QUEST business case, we assumed a voltage reduction of 2.5% (i.e. a 4% reduction through QUEST, minus the 1.5% already proven through CLASS), with a sensitivity analysis of between 1.5% and 3.5%.
- Smart Street provides voltage optimisation when installed on LV networks fed from GMTs, whereas QUEST will provide whole distribution system voltage optimisation. To avoid double-counting, the QUEST business case only includes LV networks not expected to be included in our Smart Street roll-out up to 2050. For the purposes of this assessment, it is assumed that the roll-out of Smart Street will be 60 substations per year, continuing the rate proposed in the IRM submission, meaning that by 2050 an estimated 1800 substations will be included in Smart Street. These have, therefore, been removed from the model.
- Innovations such as Smart Street and Celsius provide methods of releasing capacity and deferring reinforcement of LV equipment. Though QUEST will provide these benefits, the business case focusses on the deferment of reinforcement for HV equipment.

A.2.1 Network capacity release benefits

Network load is forecasted to grow between now and 2050, and, alongside it, the necessity to release additional capacity on the network. Voltage optimisation delivered by QUEST will reduce the substation loading, which will defer or mitigate the need for alternative solutions to release network capacity, resulting in substantial financial benefits.

The capacity release benefits were calculated by comparing the Method case to the Base Case, as described below. The assumptions used to calculate the network capacity release benefits are listed in Figure A.2.1.

Base Case

The Base Case uses the Central Outlook scenario from our DFES to identify the year that each Primary and BSP substation is predicted to reach its existing firm capacity, and require intervention. The other four DFES scenarios are used in the sensitivity analysis.

The intervention requirement is then addressed by either traditional reinforcement or flexible services, whichever results in the lowest NPV cost.

Method case

The Method case uses the same approach as the Base Case; the forecasted substation load is compared with the firm capacity. In this case, the capacity released by QUEST is added to the firm capacity, which in many cases results in a delay to the year an intervention is required. Notwithstanding the need to replace substations due to other factors, this leads to a deferment in the cost to reinforce or employ flexible services. Additionally, when flexible services is the preferred solution, using QUEST will reduce the requirement to procure services on an ongoing basis, further reducing the Method case costs.

Calculation of capacity release

The capacity release from QUEST includes two elements; HV loads, and LV loads. These elements are aggregated at the relevant Primary or BSP substations to give total capacity release per substation. This capacity release is calculated using the following methodology:

Reduction of HV loads: using the voltage demand relationship developed in CLASS, along with monthly peak demand data for each load, the reduction in peak load was estimated. To allow for diversity between peaks at different customer sites, the minimum monthly peak load reduction over the year was selected for each customer load. This reduction was then assigned to the relevant Primary or BSP.

Reduction of LV loads: using the voltage demand relationship developed in Smart Street, the reduction in peak load for LV load was calculated. This capacity release was spread out equally among the Primary substations.

Using this methodology and the central assumptions, we observed the following:

- Many substations will not be overloaded before 2050.
- 147 substations are forecast to reach their firm capacity between 2025 and 2050, including:
    - 19 substations where reinforcement cannot be deferred, though deployment of QUEST will reduce the need for flexible services.
    - 19 substations where reinforcement is deferred by 1 year.
    - 75 substations where reinforcement is deferred by 2-4 years.
    - 14 substations where reinforcement is deferred by 5 or more years.
    - 20 substations where reinforcement is deferred beyond 2050.

A.2.2 Losses reduction

Reducing the voltage directly reduces the amount of electrical energy used by customers, which leads to a corresponding reduction in network losses.

The losses reduction has been estimated using the following methodology:

- *The annual energy consumption of HV customers* was calculated using the monthly consumption data for all HV customers in the ENWL area, and assumes that energy consumption will not change over the duration of the model.
- *The energy consumption of LV customers* was estimated using the average rating and an estimated average loading.
- *The energy consumption reduction possible through QUEST* was calculated as per the Capacity Release Benefits modelling.

Losses reduction will occur when a voltage reduction is applied. It is unlikely that all areas will have a voltage reduction applied at all times, as the optimum voltage may change between different areas of the network and at different times of the day, week or year. QUEST will investigate what the optimal voltages will be across the network, and how much of the network will benefit from voltage reduction at any one time. For the business case, a central assumption of 50% of the network was selected.

Figure A.2.1: Assumptions used in the network benefits analysis

Description	Central Assumption	Notes
Voltage reduction	2.5%	• Based on 4%, minus the 1.5% already proven in CLASS. • Sensitivity analysis: between 1.5% and 3.5%.
Peak reduction and energy consumption reduction calculation parameters for HV and LV loads	Power exponent values of between 1.39 and 1.53 for HV and 1.03 for LV. Values from CLASS (for HV industrial and commercial loads) and from Smart Street (for LV loads). For energy consumption reduction it is assumed that voltage reduction is applied on average to 50% of the QUEST enabled network.	• Peak consumption reduction calculated for each HV customer for each month; minimum monthly values over the year used for the model. • Sensitivity analysis: between 30% and 70% of the network can experience voltage reduction.
Future network peak load	Central Outlook scenario	• Based on our DFES. • Sensitivity analysis: based on all scenarios.
Current Primary and BSP substation capacity	ENWL LTDS	• Firm capacity for each substation, matched to substations in DFES data.

Description	Central Assumption	Notes
Costs to release capacity in the Base Case - traditional reinforcement	[redacted]	• Primary substation with transformers smaller than 20MVA – upgrade each transformer on site. • Primary substation with a 20MVA transformer or higher – install additional transformer and associated equipment. • BSP substation with transformers smaller than 50MVA – upgrade each transformer on site. • BSP substation with a 50MVA transformer or higher – install additional transformer and associated equipment.
Costs to release capacity in the Base Case - flexible services costs	[redacted]	• The current market is not fully mature, and there is significant uncertainty about the level of availability and the likely price. However, it is assumed that the market will be fully operational and service providers will be available where needed. • Sensitivity analysis: [redacted]
Existing peak demand across HV connected loads	Half-hourly metering data for HV customers in the ENWL area, and their network arrangement data.	• Monthly peak consumption data is used to take into account seasonal variations.
Existing peak demand across LV connected loads	PMT loads: calculated assuming an average rating of 50kVA, and an average peak load of 40%, across 17,308. GMT loads: calculated assuming an average rating of 598kVA, and an average peak loads of 53%, across 17,767 transformers.	• Rating data is taken from asset databases. • Peak load data is based on maximum demand readings of ground mounted sites.

Description	Central Assumption	Notes
Existing energy consumption by HV and LV connected loads in the ENWL area	Half-hourly metering data for HV customers. LV PMT loads: assumed average rating of 50kVA, and average load of 21.9% across 17,308 PMTs. LV GMT loads: assumed average rating of 598kVA and average load of 30%, across 17,767 transformers.	• It is assumed that the annual energy consumption does not change for the duration of the model. • For LV average load assumption based on data collected in the Celsius Project.
Losses reduction due to reduced HV and LV loading	Loss associated with HV loads - 1.22%. Loss associated with LV loads - 5.41%.	• Figures from ENW's 2015 Loss Strategy.
Value of losses	£40.56 per MWh.	• Based on Ofgem CBA methodology.

A.2.3 QUEST roll-out

The Solution comprises a centralised software module, to optimise the voltage profiles across the whole distribution system, and intelligent devices at Primary and BSP substations, to make changes to system voltages.

At the conclusion of the Project in 2025, the QUEST software module will be business ready for ENWL, and it is assumed that other DNOs will adopt the Solution from 2028, in line with the start of RIIO-ED3.

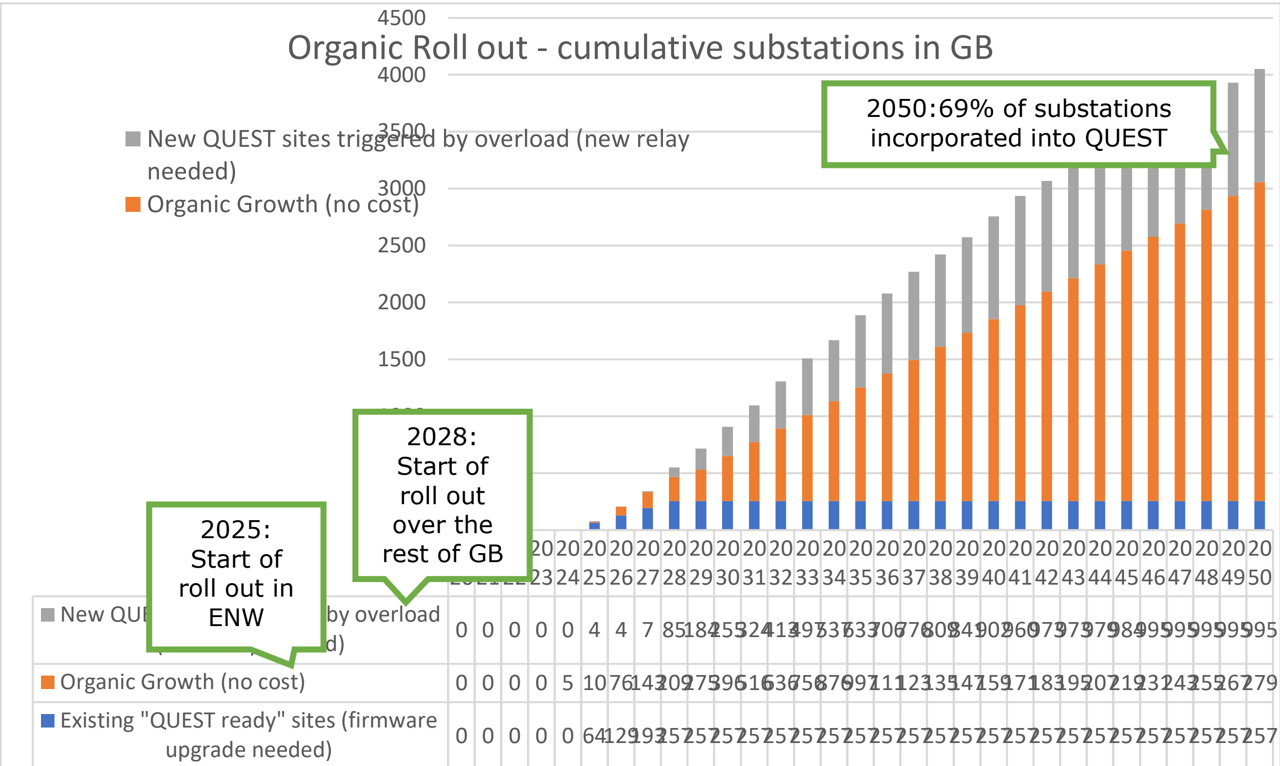
The GB scale benefits are assumed to be proportional to the number of Primary and BSP substations in GB compared to the number on ENWL's network (i.e. a factor of approximately 13.4 is used to convert ENWL scale benefits to GB benefits). It is assumed that the profile of benefits across GB will be smoothed, compared to that across ENWL.

Figure A.2.2: QUEST roll-out assumptions

Type of Site	Assumptions: ENWL	Assumptions: Other DNOs
Existing "QUEST ready sites": Sites with advanced relays that can be converted to QUEST sites with a firmware upgrade.	Approximately 60% Primary substations. Sites will be upgraded over four years, starting in 2025.	No QUEST ready sites. A conservative assumption made due to the lack of data.
Asset Replacement: As equipment is replaced, it will be incorporated within QUEST.	50% between now and 2050, based on historic and predicted replacements. Proportion of network under QUEST reaches 80% in 2050.	50% of all sites will undergo a replacement by 2050. Proportion of network under QUEST reaches 50% in 2050.

Type of Site	Assumptions: ENWL	Assumptions: Other DNOs
New QUEST sites where capacity release is needed.	Sites identified starting from 2025. Proportion of network under QUEST reaches 88% in 2050.	Starting at 2028, benefits scaled to the number of Primary and BSP substations. Proportion of network under QUEST reaches 69% in 2050.

Figure A.2.3: Cumulative number of Primary and BSP substations that are incorporated into the QUEST Solution in GB



The costs to roll-out QUEST are summarised in Figure A.2.4, indicating the ENWL scale costs, and the costs assumed for other DNOs. The GB scale costs are calculated by combining these.

Figure A.2.4: Equipment costs associated with the QUEST roll-out

[redacted]

[redacted]

A.2.4 Results of financial business case modelling

The cumulative benefits for the central scenario assumptions are presented in Figure A.2.5, which also includes the benefits due to reduction in losses. This is a much smaller benefit, but it does increase over time.

Figure A.2.5: Cumulative network benefits for GB scale, NPV in 2020 prices

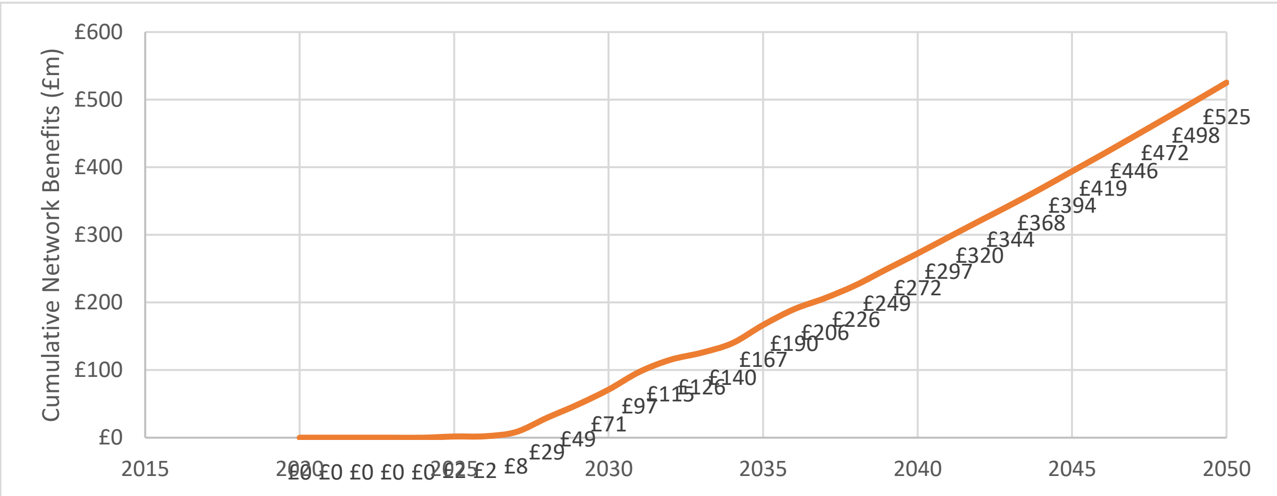


Figure A.2.6: Costs and benefits of the QUEST Solution using central assumptions

Scale	Benefit or Cost	Benefit (£m NPV 2020 prices)		
		2030	2040	2050
ENWL Scale Benefits and Costs	Network Capacity Release	[redacted]	[redacted]	[redacted]
	Loss Reduction	[redacted]	[redacted]	[redacted]
	QUEST Roll-out Costs	[redacted]	[redacted]	[redacted]
	Total NPV	**21.3**	**29.8**	**32.6**
GB Scale Benefits and Costs	Network Capacity Release	[redacted]	[redacted]	[redacted]
	Losses Reduction	[redacted]	[redacted]	[redacted]
	QUEST Roll-out Costs	[redacted]	[redacted]	[redacted]
	Total NPV	**51.0**	**165.1**	**266.7**

Figure A.2.6 shows that the benefits case is driven by capacity release, which makes up 91% of the GB benefits by 2050. However, the losses reduction benefits would continue to grow, as they are cumulative over time, with the benefits being realised year after year.

The results show that there is a strong business case for the Method, with a total benefit of over **£32m across ENWL by 2050**, and over **£266m across GB by 2050**.

A.2.5 Financial benefits sensitivity analysis

A sensitivity analysis was carried out using the following parameters to illustrate the impact that different assumptions have on the overall benefits. The sensitivities used are described in Figure A.2.1. In the following charts, '*' denotes the central assumption.

Voltage reduction and percentage of the network under voltage reduction

Figure A.2.7 presents the results of the sensitivity analysis on the voltage reduction by percentage of network to which the voltage reduction is applied.

Figure A.2.7: Sensitivity analysis of voltage reduction/percentage of network voltage reduction

	GB scale benefit 2050 £m NPV 2020 prices		
Reduction in voltage / % network	**1.5%**	**2.5%***	**3.5%**
30%	154.8	265.4	359.2
50%*	155.6	266.7	361.1
70%	156.4	268.0	362.9

The value of voltage reduction has a large impact on the business case performance, with an increase in benefits of more than double, between a 1.5% and 3.5% reduction. The lower end of the analysis, which is considered unlikely, produces a benefit of £155m; the central assumption of 2.5% is considered conservative.

The percentage of network under voltage reduction affects the losses throughout the network. Since the losses reductions form a smaller part of the benefits, changes in this assumption have only a marginal impact on the business case.

Future network load

The future load forecast is based on the DFES, which contains the following five scenarios:

- *Green Ambition:* High prosperity partnered with strong green policies
- *Active Economy:* High prosperity with weak green policies
- *Central Outlook:* Average assumptions across the other scenarios
- *Focus on Efficiency:* Strong green policies with low prosperity
- *Slow Progression:* Weak green policies with low prosperity

The QUEST business case uses all five of these scenarios to produce a sensitivity analysis, using the Central Outlook scenario as the central assumption. The results of the sensitivity analysis are in Figure A.2.8.

Figure A.2.8: DFES scenario sensitivity analysis

DFES Scenario	GB scale benefit 2050 £m NPV 2020 prices
Green Ambition	328.3
Active Economy	334.5
Central Outlook*	266.7
Focus on Efficiency	67.4
Slow Ambition	37.6

The choice of scenario has a significant impact on the projected benefits, with the lower growth and prosperity scenarios showing a significantly reduced business case. The Central Outlook scenario is selected as the central assumption because it reflects a balanced view of the future scenarios.

Cost of flexible services

The central case assumption is that services will be available for [redacted]. Due to the uncertainty in this assumption, a sensitivity analysis was performed for services between [redacted] and a further sensitivity model was generated for the case where the flexible services market is not used. The results are shown in Figure A.2.9.

Figure A.2.9: DSR cost sensitivity analysis for QUEST Solution network benefit

Cost of DSR services (per MVA per year)	GB scale benefit 2050 £m NPV 2020 prices
[redacted]	230.4
[redacted]	266.7
[redacted]	326.9
No DSR service market	234.6

The cost of flexible services directly affects the method of intervention for capacity release in the Base Case. A lower cost makes it more competitive, which increases the assumed number of substations using flexible services instead of traditional reinforcement. A higher cost will increase the benefit of deferring and reducing the need for reinforcement through QUEST. In the case with no flexible services market, all substations that become overloaded are reinforced by traditional methods.

The benefits case varies moderately based on the varying cost of flexible services. However, even at the lower end of the assumed cost, the business case for QUEST remains strong.

Voltage demand relationship

The capacity release benefit is based upon the premise that a reduction in voltage elicits a reduction in demand. Whilst this relationship was proven in CLASS and has not changed in the intervening years, we acknowledge that there is uncertainty as to how this might change out to 2050. Therefore, we have undertaken sensitivity analysis to demonstrate that changes to the HV (k_p) and LV (CVR factor) relationship values do not adversely affect the financial and carbon benefits. Figure A.2.10 presents the results of this sensitivity analysis.

Figure A2.10: Voltage demand relationship sensitivity analysis

		Minimum	Lower Quartile	Average - Base Case	Upper Quartile	Maximum
HV k_p	Spring	1.02	1.215	1.39	1.605	1.80
	Summer	1.02	1.2575	1.52	1.7325	1.97
	Autumn	0.95	1.2075	1.53	1.7225	1.98
	Winter	0.86	1.1075	1.47	1.6025	1.85
LV CVR Factor		0.97	1.00	1.03	1.06	1.09
2050 NPV at ENW Scale (£m)		28.0	30.2	32.6	34.4	36.3
2050 NPV at GB Scale (£m)		218.6	243.1	266.7	282.8	300.7

	Minimum	Lower Quartile	Average - Base Case	Upper Quartile	Maximum
2050 Carbon benefits at ENWL scale (tonnes of CO_2eq)	7,295	7,807	8,373	8,822	9,321
2050 Carbon benefits at GB scale (tonnes of CO_2eq)	45,009	48,063	51,498	54,245	57,228

A.2.6 Additional benefits

In addition to the network benefits, QUEST will deliver a reduction in the energy consumed by customers, directly leading to a reduction in their bills. This benefit has been quantified and the results are presented in Figure A.2.11. The approach to calculating these benefits is summarised below:

The energy consumption reduction for HV and LV customers was calculated using the method described for calculating losses reduction in A.2.2.

Tariff assumptions for HV and LV customers was calculated using the following methods:

- HV customers have widely varying tariff arrangements. As a conservative estimate, it was assumed that the proportion of the tariff related to consumption was equal to wholesale costs, assumed to be £58.6 per MWh.
- LV customer tariff was taken from the average unit prices of electricity for 2020, published by BEIS, of 16.6p per kWh. However, as the changes to the use of system and other fixed charges are not predictable, and may be re-distributed if there is a large-scale reduction in consumption, only the wholesale-related costs were used, estimated to be 5.6p/kWh.

Figure A.2.11: Customer benefits of the QUEST Solution at ENWL scale and GB scale

Scale	Benefit	Benefit £m NPV 2020 prices		
		2030	2040	2050
ENWL Scale Benefits and Costs	HV energy consumption reduction	30.4	89.9	137.8
	LV energy consumption reduction	115.2	334.4	505.7
	Total NPV	145.6	424.3	642.8
GB Scale Benefits and Costs	HV energy consumption reduction	83.7	466.0	932.8
	LV energy consumption reduction	316.2	1,724.1	3,385.5
	Total NPV	399.9	2,190.1	4,318.3

The results demonstrate that QUEST will result in very large additional benefits for customers across GB, which will be directly passed on through reduction in their bills.

As with the network benefits, these results are impacted by the sensitivity analysis and, in particular, the level of voltage reduction assumed as well as the percentage of the network assumed to have voltage reduction applied. Using the sensitivities described above, the energy consumption reduction NPV benefits range from over £2,650m to over £6,560m across GB, up to 2050.

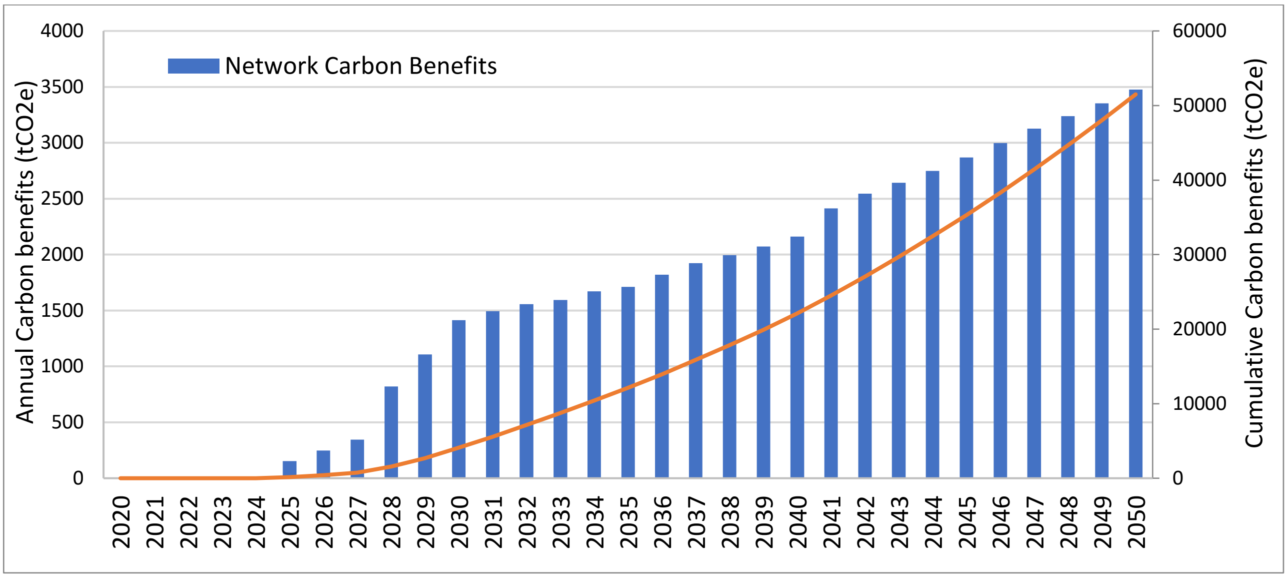
A.2.7 Carbon impact

The carbon impact of QUEST was assessed based on the reduction in distribution losses. The carbon emissions associated with avoided reinforcement were not assessed, as reinforcement was generally deferred, rather than avoided, resulting in no significant carbon reduction.

The losses reduction was translated into carbon emissions reduction based on the forecasted grid carbon intensity up to 2050, taken from National Grid's 2019 Future Energy Scenarios using the '2 degrees' scenario data.

Figure A.2.12 presents the annual and cumulative carbon benefits up to 2050, and shows that the carbon benefits rise as the Solution is rolled out and the losses reduction benefits grow year on year. As the carbon intensity of the grid decreases, this trend slows.

Figure A.2.12: Annual and cumulative carbon emissions reduction, up to 2050



In addition to the losses benefits described above, the carbon benefits of the reduction in energy consumption were also quantified and are presented as additional benefits. Figure A.2.13 summarises the carbon benefits for each of these categories at ENWL and GB scale.

Figure A.2.13: Cumulative carbon benefits from QUEST at ENWL and GB scale

Scale	Carbon Benefit	Cumulative Carbon Benefit tCO_2e		
		2030	2040	2050
	Losses reduction (main business case benefits)	2,161	5,286	8,373

Scale	Carbon Benefit	Cumulative Carbon Benefit tCO_2e		
		2030	2040	2050
ENWL Scale Benefits and Costs	Energy consumption reduction (additional benefits)	70,217	172,617	275,022
GB Scale Benefits and Costs	Losses reduction (main business case benefits)	4,088	22,090	51,498
	Energy consumption reduction (additional benefits)	82,461	451,901	1,070,380

The carbon benefits from losses reduction are significant, saving over 51,000tCO_2e across GB, by 2050. The carbon benefits due to energy consumption reduction, which make up the 'additional benefits', are even larger, with over 1m tCO_2e saved.

The sensitivity analysis also impacts the carbon case results, in particular the different voltage reduction levels and percentages of the network to which voltage reduction has been applied. This analysis found GB scale carbon benefits up to 2050 ranged between 30,518tCO_2e for the lower assumptions, and 72,990tCO_2e for the higher assumptions. Whilst this is a significant range, it demonstrates that in all cases QUEST has significant carbon benefits.

Appendix B.1: High-Level Functional Specification for Software

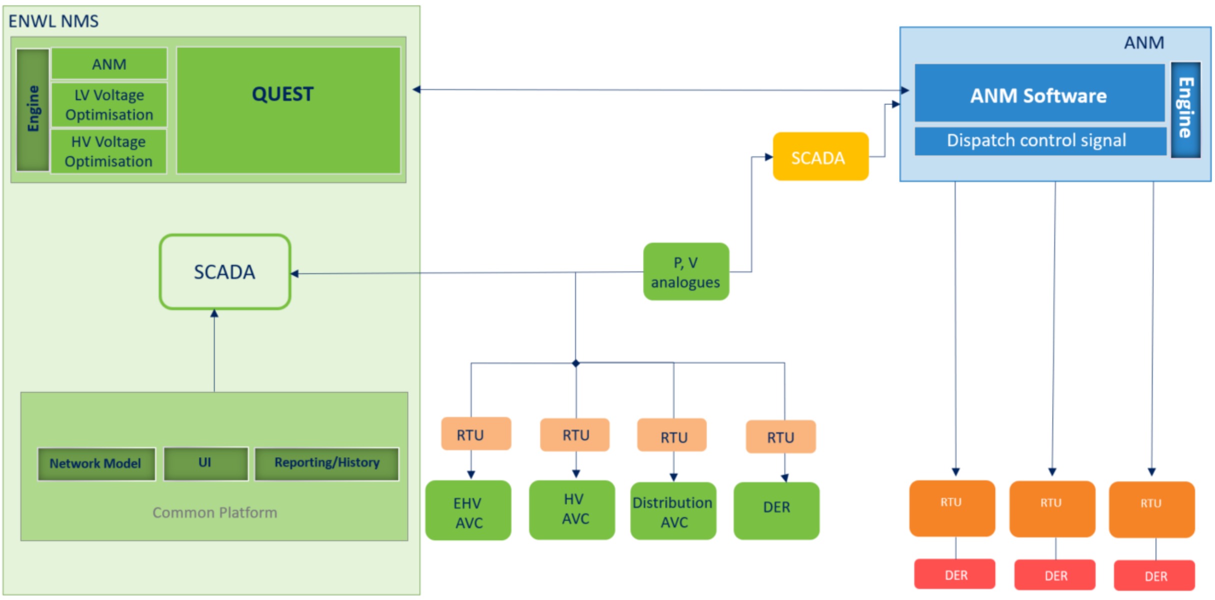
QUEST will develop an overarching centralised software module that will co-ordinate and control discrete voltage management techniques to provide an optimal whole distribution system voltage profile.

The centralised software module would be required to interact with discrete voltage management techniques, such as CLASS, Smart Street, ANM and flexible services, to deliver whole system voltage optimisation and co-ordination. This will include the combining or 'stacking' of benefits to maximise the delivered outputs.

Proposed Platform Overview

The overarching centralised software will be built on the NMS platform and will utilise several new and existing components. These are subdivided into four distinct areas, the common platform, the SCADA system, the calculation engine, and the NMS applications. The current proposed architecture for this is as shown in Figure B1.1.

Figure B.1.1: Proposed QUEST Architecture



The common platform will comprise the User Interface (UI), which allows an operator to interface with the system and adjust parameters, and the network model which provides the connectivity and electrical data for the trial network.

The SCADA system collects telemetered data from all monitored points and sends commands to the installed devices.

The calculation engine carries out state estimation and load flow studies to allow the system to assess the current state of the network. These are carried out automatically on change of state or at a predefined interval.

Finally, the NMS application area will interface with the discrete voltage management techniques, e.g. Smart Street and ANM.

Technical Description

The software module will take inputs, such as:

- Real-time analogue measurement of system current and voltage
- Network constraint limits
- Information on connected customers and relevant DER
- Settings for voltage control equipment
- Schedules for flexible services
- Forecasted levels of demand and generation

The software module will use these to assess the network conditions at predefined intervals and create a sequence of operations to optimise the voltage profile across the all levels of the network, whilst taking into account the potential outputs of CLASS, Smart Street and flexible services dispatch provided by ANM.

QUEST will then autonomously send out the appropriate controls to the various devices to achieve this optimal voltage profile

The aim will be to determine the optimal configuration of the discrete voltage management techniques in order to achieve the objectives by specified priority, ensuring at all times that the network operates within its technical and operational limits.

As a minimum, QUEST will consider the following objectives and determine the optimum balance between them:

- Network demand reduction
- Customer energy consumption reduction
- Loss reduction
- DER customer network access

Where possible, QUEST will look to stack benefits across the voltage levels, for example, by raising the voltage set point at a higher voltage to reduce losses, whilst still maintaining the headroom required for techniques at lower voltages to operate.

Appendix B.2: Trial Area Details

The preliminary subset of the network identified for trialling QUEST is a region fed from Whitegate GSP, where our network takes an infeed from National Grid’s 275kV network via three 240MVA Supergrid transformers.

Whitegate GSP feeds around 6% of our total connected customers. Geographically, this network covers a diverse area ranging from the north-east side of Manchester City Centre out towards the Pennines.

This provides a range of demand types: from highly commercial to dense urban, suburban and semi-rural areas. In addition to the usual domestic and commercial customers, there a number of larger HV connected customers, such as hospitals and a large semiconductor factory. Further technical details of the network are contained in Figure B.2.1 below.

Figure B.2.1: Technical overview of Whitegate GSP

Peak demand	340MVA
Number of BSPs	4
Number of Primaries	21
Number of connected customers	158,000
Connected generation	2 x 20MW at 33kV
Length of underground cable	744km
Length of overhead line	13.9km
Total connected network	758km

Figure B.2.2: Map of trial area

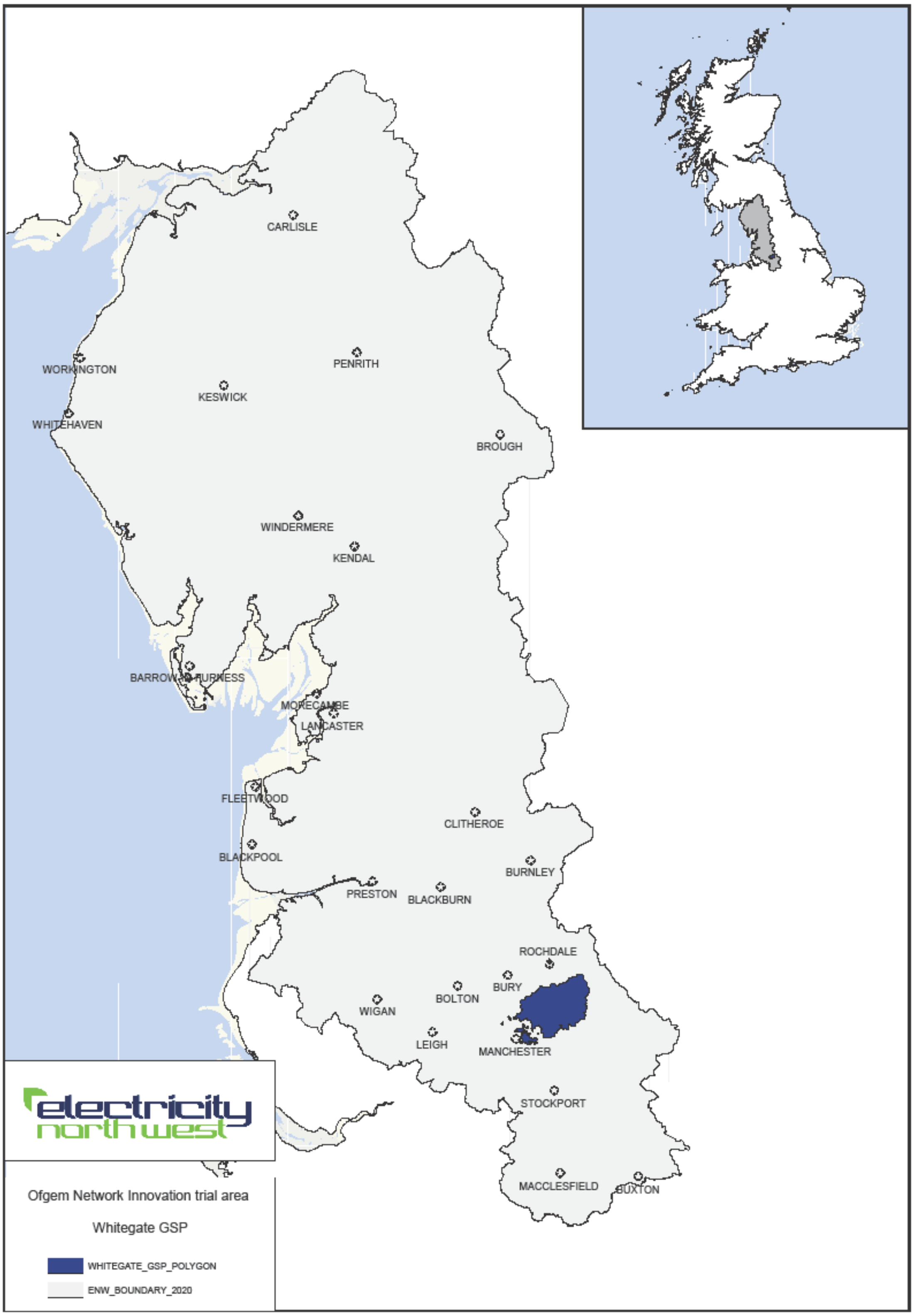
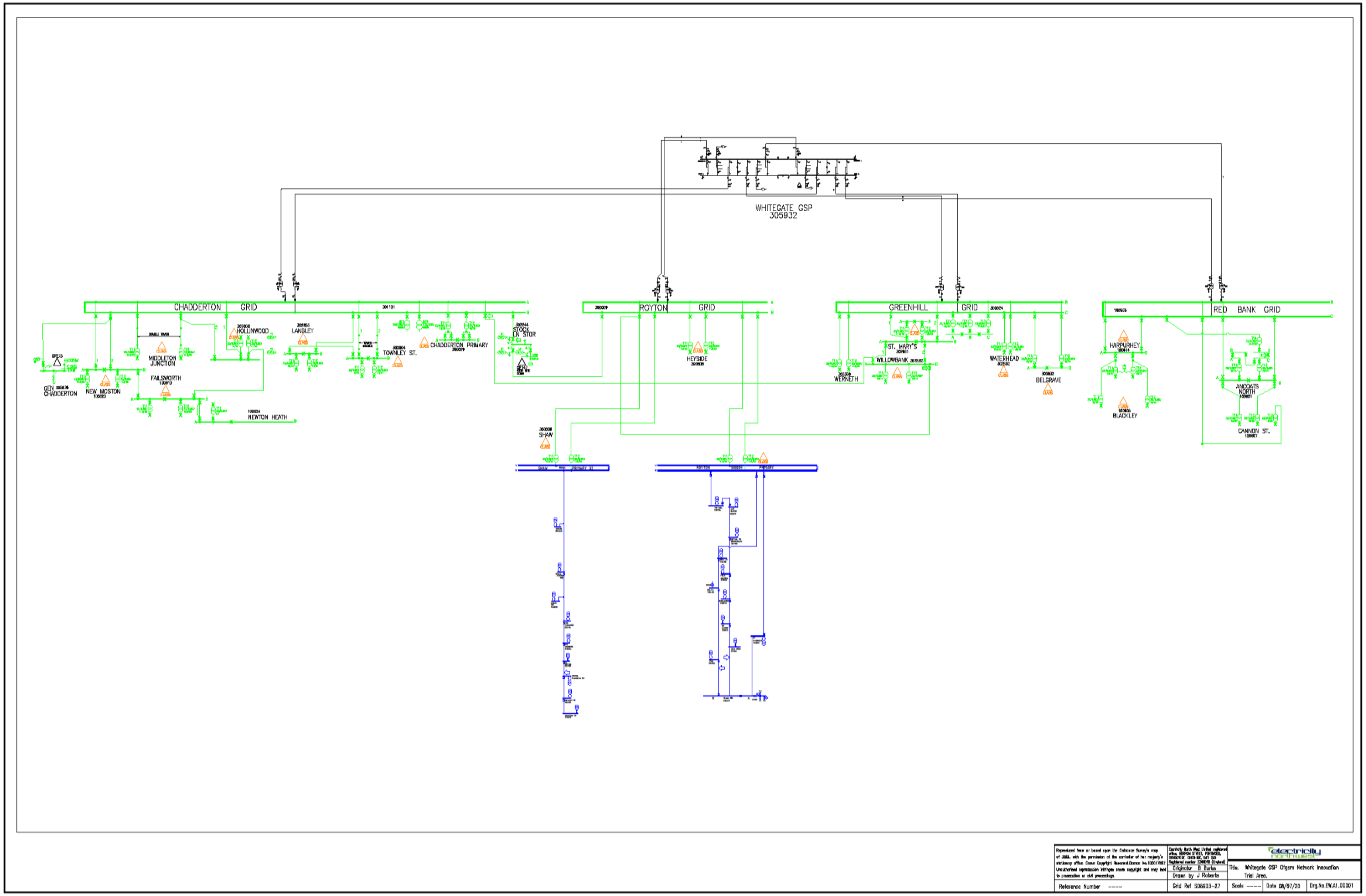


Figure B.2.3: Network diagram



Appendix C: Review of Forerunner Projects

QUEST builds on the learning from previous Projects focussed on solving voltage constraints which have been undertaken through LCN Fund Projects. Figure C.1 provides an overview of the related Projects and the incremental learning that is relevant to QUEST.

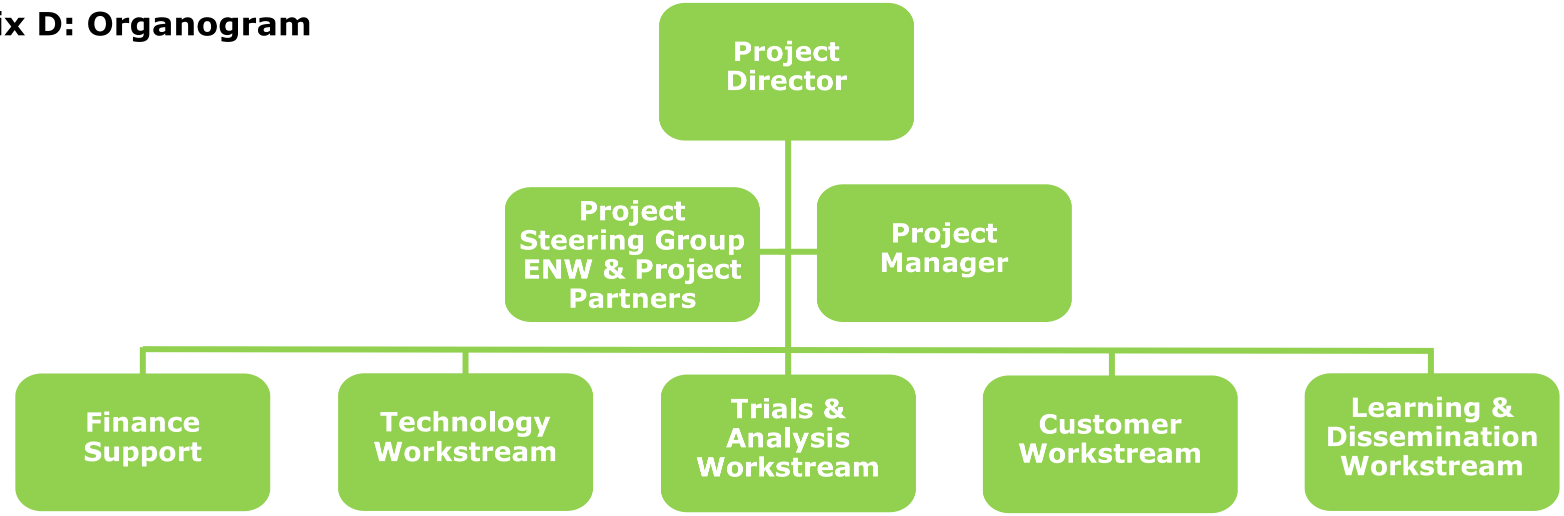
Figure C.1: Incremental learning

Innovation Funding Mechanism	Project Name	Delivering DNO	Learning
Second Tier	CLASS – Customer load active system services	ENWL	Investigated the voltage/demand relationship for HV networks; uses voltage to provide demand response. The equipment installed to facilitate CLASS will be used in QUEST to facilitate whole distribution system optimisation. In the trials, this equipment will be used for EHV / HV voltage optimisation.
Second Tier	Smart Street	ENWL	Investigated the application on CVR for LV networks. The equipment installed to facilitate Smart Street will be used in QUEST to facilitate whole distribution system optimisation. In the trials, this equipment will be used for LV voltage optimisation.
NIA	Enhanced Automatic Voltage Control	ENWL	Developed new AVC settings which allowed effective voltage control at substations with significant generation connected; modelling work to understand if alternative connection methods could be used to address voltage constraints. QUEST will assess the technical ability and customer appetite for the voltage managed connections modelled in this Project.
Second Tier	Network Equilibrium	WPD	Investigated reducing voltage to create headroom for DG to connect. The reduction was applied at discrete points to achieve one objective. The learning will be used as one of the QUEST use cases and used when defining the software objectives for co-ordination.

Innovation Funding Mechanism	Project Name	Delivering DNO	Learning
Second Tier	Lincolnshire Low Carbon Hub	WPD	This Project tested an early form of local dynamic voltage control with predefined logic. The voltage control learning in this Project led to the advancement of voltage control and voltage control relays. These new relays will be used in QUEST.
Second Tier	Flexible Plug and Play	UKPN	Investigated the adoption of Flexible Connections - the first use case deployed under the ANM banner. Mainly focussed on real power constraints but did implement a voltage constraint management solution coordinating threshold based real-time control with AVC relays. This learning will be used when designing use cases and defining the software objectives for co-ordination.
Second Tier	Customer Led Network Revolution	NPG	This Project tested an early form of enhanced automatic voltage control using remote setpoints. The voltage control learning in this Project led to the advancement of voltage control and voltage control relays. These new relays will be used in QUEST.
Second Tier	Accelerating Renewable Connections	SPEN	Investigated a number of use cases for flexible DG connections, including DG connections in voltage constrained 11kV feeders, co-ordinating DG/DER response to transmission network constraints and assessing the impact of ANM actions on ESO system balancing actions. This learning will be used when designing the use cases and defining the software objectives for co-ordination.

Innovation Funding Mechanism	Project Name	Delivering DNO	Learning
NIC	Power Potential	NG ESO	An ongoing Project investigating the ability to dispatch reactive power from DG to support voltage stability on the transmission system. It does not address other voltage optimisation objectives, and so illustrates the remaining questions over end-to-end co-ordination of voltage for customer connection, DSO and ESO objectives. The learning, when available, will be used when designing the use cases, particularly for the ESO.
NIC	Distributed ReStart	NG ESO	An ongoing Project investigating commercial mechanisms, system management processes and technical capabilities/trial/design of black start from DER. The design process for Distributed ReStart Zone controller includes the use of an ANM technology platform. QUEST will use the same ANM platforms to trial the co-ordination of techniques and the objectives of this Project will be used when designing the use cases.
NIC	Enhanced Frequency Control Capability	NG	Trialled and proved the benefits of a co-ordinated response to frequency issues. The learning will be used when designing the use cases, particularly for the ESO.
NIA	Optimal co-ordination of active network management schemes and balancing services	NG ESO	This is a new NIA Project scheduled to finish in June 21 (ENWL are a supporting partner) to identify and define solutions that will optimise the co-ordination of ANM schemes with the balancing services market. The learning, when available, will be used when designing the use cases, particularly for the ESO.
NIA	SHEDD – System HILP Event Demand Disconnection	NG ESO	This is a new NIA project scheduled to finish in May 22 (ENWL are a supporting partner) to design and test a new LFDD scheme to take into account decarbonisation, increased DG, and decreasing system inertia. The learning, when available, will be used when designing the use cases, particularly for the ESO.

Appendix D: Organogram



Technical Workstream

- System Design – develop use cases and system architecture
- Implementation – detailed site design and surveys
- Procurement of equipment
- Installation – on site and IT

Trials and Analysis Workstream

- Site Selection and trials Design
- Trials on system for one year
- Trials analysis and refinement
- Simulation of specific use cases
- Publish report on trials

Customer Workstream

- Develop CEP and design comms
- Customer engagement
- Publish report of findings
- Publish guidance for sensitive customers

Learning and Dissemination

Learning generated by QUEST will be published in a series of documents detailing the following: use cases; lessons learned from system design and architecture; trials, design and specification; interim lessons learned from system design and technology build; system integration; trials and analysis; and customer research findings. We will also publish a final project report.

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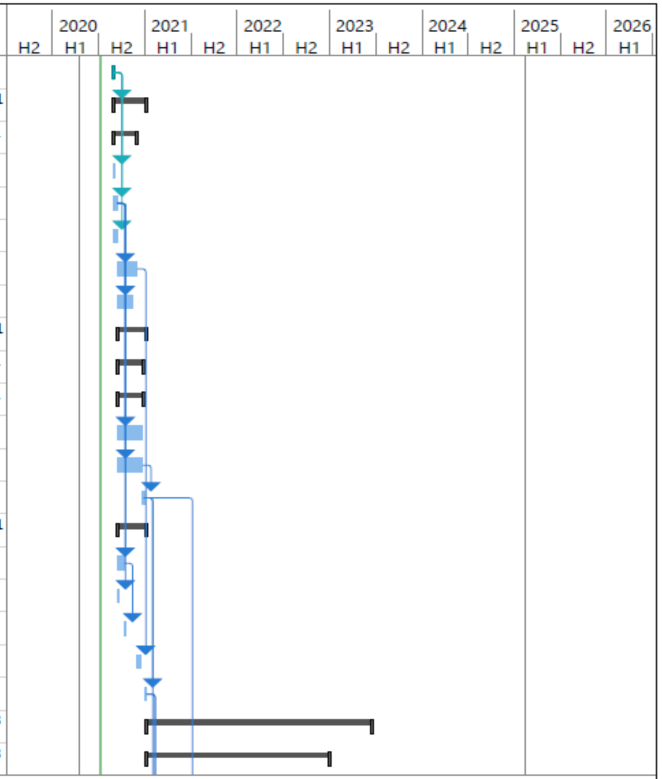
Appendix E: Project Plan

ID	Task Name	Duration	Start	Finish
1	**NIC Fund Award Announcement**	1 day	Fri 27/11/20	Fri 27/11/20
2	**Workstream - Project Mobilisation**	**82 days**	**Mon 30/11/20**	**Wed 07/04/21**
3	**Project Readiness**	**55 days**	**Mon 30/11/20**	**Mon 01/03/21**
4	Project Governance embedded into existing Governance structure	5 days	Mon 30/11/20	Fri 04/12/20
5	Review and agree Project Direction	10 days	Mon 30/11/20	Fri 11/12/20
6	Develop and send out partner contracts	10 days	Mon 30/11/20	Fri 11/12/20
7	Review and negotiate contracts	45 days	Mon 14/12/20	Mon 01/03/21
8	Design, develop and issue the Project Implementation Document	30 days	Mon 14/12/20	Mon 08/02/21
9	**Mobilisation**	**72 days**	**Mon 14/12/20**	**Wed 07/04/21**
10	**Project Management Office Start-Up**	**65 days**	**Mon 14/12/20**	**Mon 29/03/21**
11	**Identify & Mobilse Project Management Office**	**65 days**	**Mon 14/12/20**	**Mon 29/03/21**
12	Identify & mobilise Project team	60 days	Mon 14/12/20	Mon 22/03/21
13	Partner resourcing	60 days	Mon 14/12/20	Mon 22/03/21
14	Project Management Office and Partner resources mobilisation m	5 days	Tue 23/03/21	Mon 29/03/21
15	**Financial & Contractual**	**72 days**	**Mon 14/12/20**	**Wed 07/04/21**
16	Identify and implement project budget controls with ENW	9 days	Mon 14/12/20	Fri 08/01/21
17	Set up project bank account	5 days	Mon 14/12/20	Fri 18/12/20
18	Financial controls established	3 days	Mon 11/01/21	Wed 13/01/21
19	Partnership relationship discussions	10 days	Tue 02/03/21	Mon 15/03/21
20	Contractual agreement signed	7 days	Tue 30/03/21	Wed 07/04/21
21	**Workstream - Technology**	**615 days**	**Thu 08/04/21**	**Mon 18/09/23**
22	**Phase 1 System Design**	**495 days**	**Thu 08/04/21**	**Mon 03/04/23**

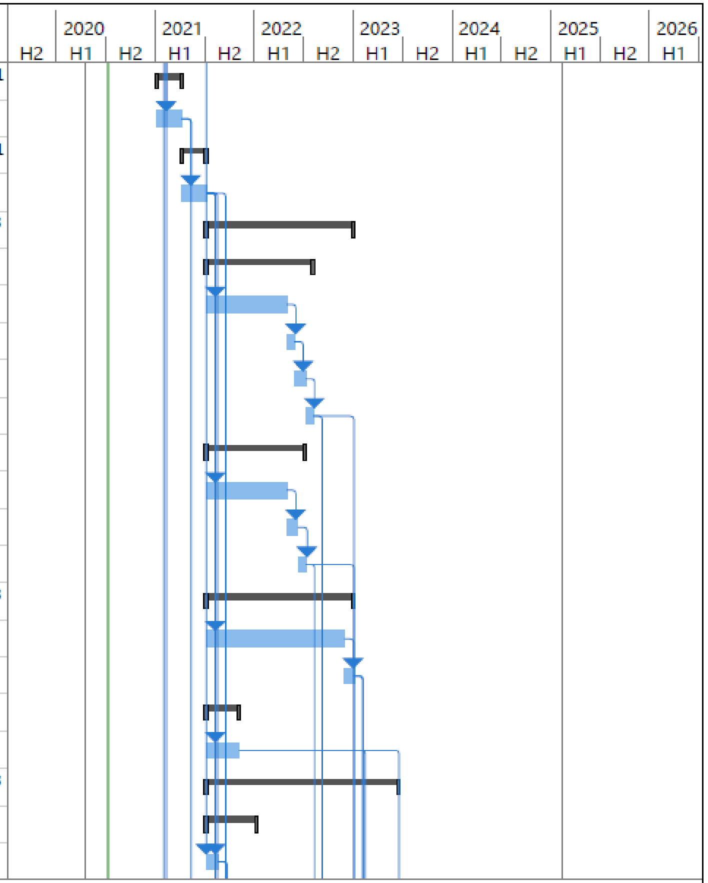


Project: QUEST Project Plan v.4
Date: Tue 06/10/20

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

Page 1

ID	Task Name	Duration	Start	Finish
23	**Develop Use Cases**	**65 days**	**Thu 08/04/21**	**Wed 07/07/21**
24	Define use cases	65 days	Thu 08/04/21	Wed 07/07/21
25	**Hardware Architecture Design**	**65 days**	**Thu 08/07/21**	**Wed 06/10/21**
26	Review all architecture options and agree solution	65 days	Thu 08/07/21	Wed 06/10/21
27	**Software Architecture Design**	**365 days**	**Thu 07/10/21**	**Mon 03/04/23**
28	**BSP and Primary AVC**	**270 days**	**Thu 07/10/21**	**Fri 04/11/22**
29	Discuss and develop new voltage control algorithms for SuperTAF	200 days	Thu 07/10/21	Fri 29/07/22
30	Lab testing of algorithm	20 days	Mon 01/08/22	Fri 26/08/22
31	Refine algorithm	30 days	Mon 29/08/22	Fri 07/10/22
32	Factory Acceptance Testing	20 days	Mon 10/10/22	Fri 04/11/22
33	**ANM**	**250 days**	**Thu 07/10/21**	**Fri 07/10/22**
34	Co-ordination and optimisation methods development & impleme	200 days	Thu 07/10/21	Fri 29/07/22
35	System configuration and build	30 days	Mon 01/08/22	Fri 09/09/22
36	ANM FAT testing	20 days	Mon 12/09/22	Fri 07/10/22
37	**NMS**	**365 days**	**Thu 07/10/21**	**Mon 03/04/23**
38	Algorithm build	340 days	Thu 07/10/21	Mon 27/02/23
39	NMS FAT testing	25 days	Tue 28/02/23	Mon 03/04/23
40	**Modelling**	**75 days**	**Thu 07/10/21**	**Fri 04/02/22**
41	Trial simulation and PPT environment development	75 days	Thu 07/10/21	Fri 04/02/22
42	**Phase 2 Implementation**	**485 days**	**Thu 07/10/21**	**Mon 18/09/23**
43	**Site Selection and Trial Design**	**120 days**	**Thu 07/10/21**	**Fri 08/04/22**
44	Finalise site selection	30 days	Thu 07/10/21	Wed 17/11/21



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

Task		Inactive Summary		External Tasks	
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Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

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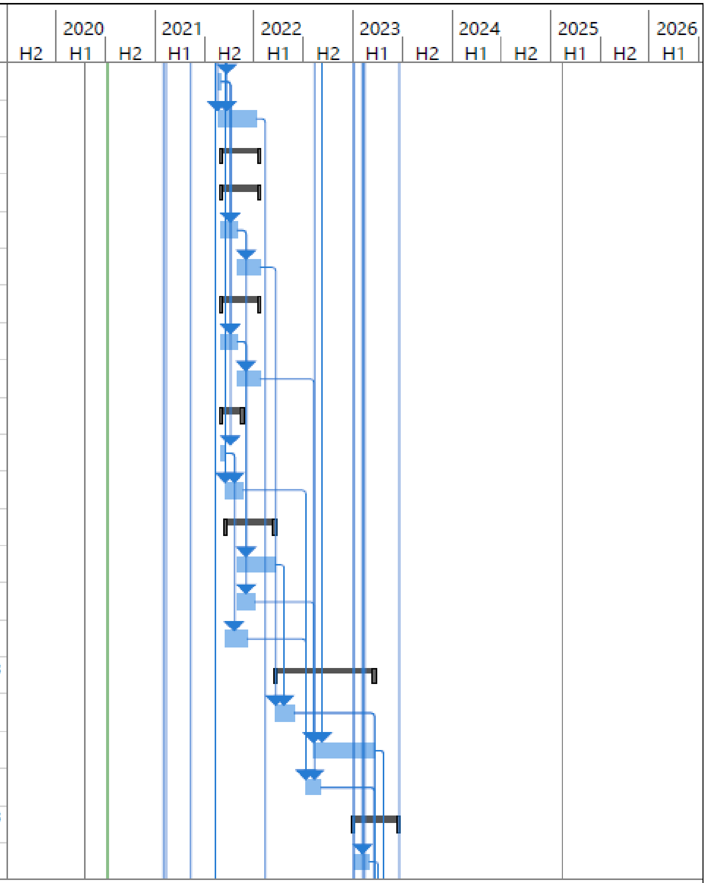
ID	Task Name	Duration	Start	Finish
45	Define installation plan (schedule)	10 days	Thu 18/11/21	Wed 01/12/21
46	Finalise trial design	90 days	Thu 18/11/21	Fri 08/04/22
47	**Detailed Site Design**	**90 days**	**Thu 02/12/21**	**Fri 22/04/22**
48	**Distribution AVC**	**90 days**	**Thu 02/12/21**	**Fri 22/04/22**
49	Conduct site surveys	30 days	Thu 02/12/21	Fri 28/01/22
50	Design transformer replacement schemes	60 days	Mon 31/01/22	Fri 22/04/22
51	**BSP & Primary AVC**	**90 days**	**Thu 02/12/21**	**Fri 22/04/22**
52	Conduct site surveys	30 days	Thu 02/12/21	Fri 28/01/22
53	Design new retrofit AVC schemes	60 days	Mon 31/01/22	Fri 22/04/22
54	**ANM**	**45 days**	**Thu 02/12/21**	**Fri 18/02/22**
55	Conduct site surveys	10 days	Thu 02/12/21	Wed 15/12/21
56	Design ANM installations	35 days	Thu 16/12/21	Fri 18/02/22
57	**Procure Equipment**	**120 days**	**Thu 16/12/21**	**Fri 17/06/22**
58	Distribution transformers	100 days	Mon 31/01/22	Fri 17/06/22
59	Primary & BSP AVC	45 days	Mon 31/01/22	Fri 01/04/22
60	ANM	45 days	Thu 16/12/21	Fri 04/03/22
61	**Site Installation**	**250 days**	**Mon 20/06/22**	**Mon 19/06/23**
62	Distribution AVC	50 days	Mon 20/06/22	Fri 26/08/22
63	BSP & primary AVC	150 days	Mon 07/11/22	Mon 19/06/23
64	ANM	40 days	Mon 10/10/22	Fri 02/12/22
65	**IT Installation**	**120 days**	**Tue 04/04/23**	**Mon 18/09/23**
66	System configuration/build	40 days	Tue 04/04/23	Mon 29/05/23



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

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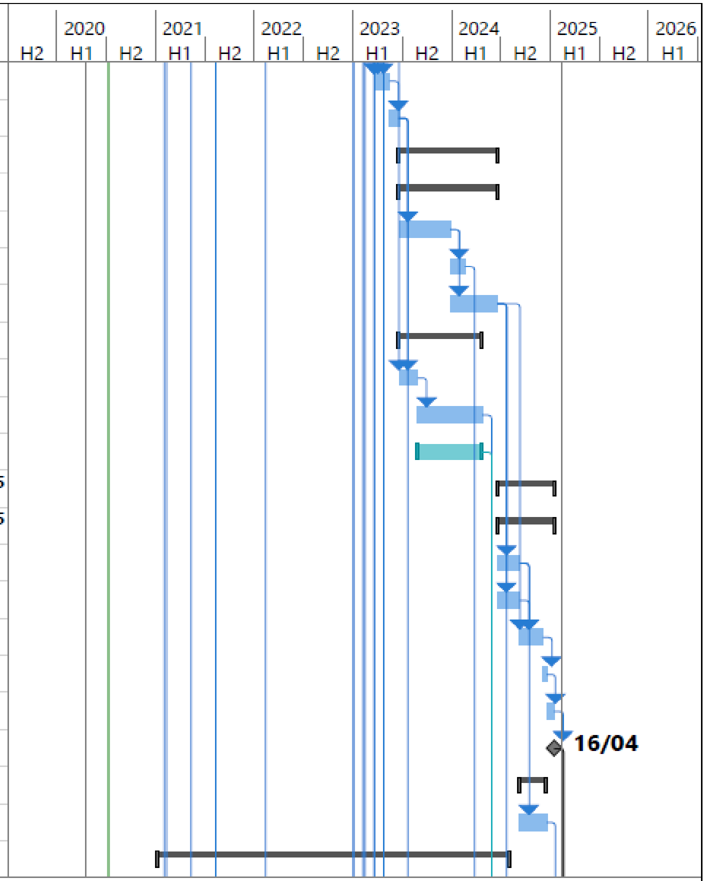
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

Page 3

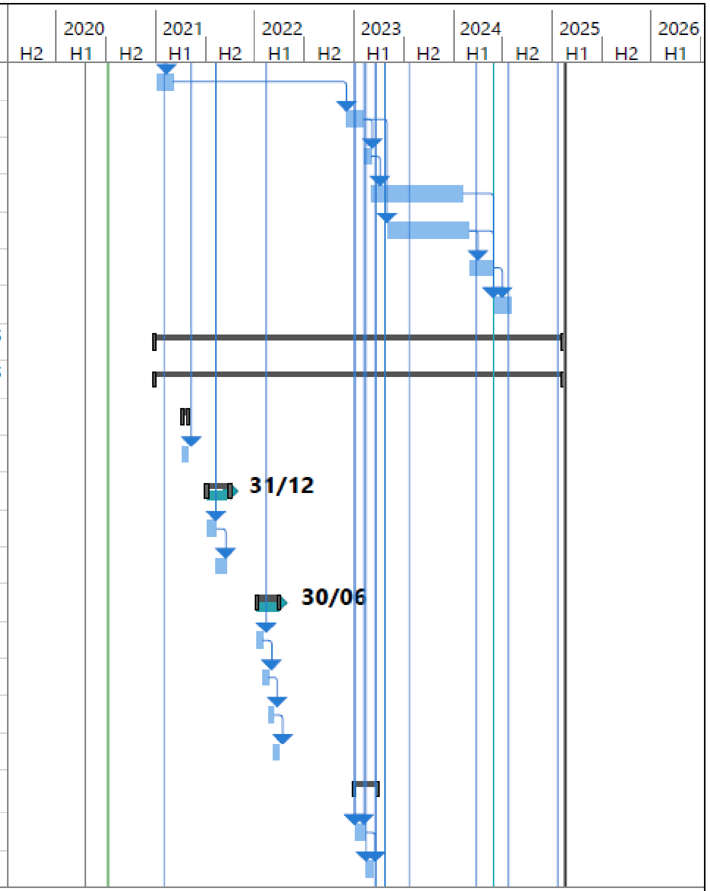
ID	Task Name	Duration	Start	Finish
67	System integration	40 days	Tue 20/06/23	Mon 14/08/23
68	Site Acceptance Testing	25 days	Tue 15/08/23	Mon 18/09/23
69	**Workstream - Trials & Analysis**	**250 days**	**Tue 19/09/23**	**Tue 17/09/24**
70	**Phase 3 Trial**	**250 days**	**Tue 19/09/23**	**Tue 17/09/24**
71	Trial phase 1	125 days	Tue 19/09/23	Tue 26/03/24
72	Refine the methodology if required	40 days	Wed 27/03/24	Tue 21/05/24
73	Trial phase 2	125 days	Wed 27/03/24	Tue 17/09/24
74	**Simulation**	**210 days**	**Tue 19/09/23**	**Tue 23/07/24**
75	System refinement	50 days	Tue 19/09/23	Mon 27/11/23
76	Simulated trials and analysis	160 days	Tue 28/11/23	Tue 23/07/24
77	Research into voltage demand relationship	160 days	Tue 28/11/23	Tue 23/07/24
78	**Workstream - BAU Transition**	**141 days?**	**Wed 18/09/24**	**Wed 16/04/25**
79	**Closedown**	**141 days?**	**Wed 18/09/24**	**Wed 16/04/25**
80	Analysis of the costs and benefits of QUEST	60 days	Wed 18/09/24	Tue 10/12/24
81	Carbon Impact Assesment	60 days	Wed 18/09/24	Tue 10/12/24
82	Development of Close Down Report	50 days	Wed 11/12/24	Tue 04/03/25
83	Peer Review of Close Down Report	10 days	Wed 05/03/25	Tue 18/03/25
84	Finalise Close Down Report	20 days	Wed 19/03/25	Tue 15/04/25
85	Close Down Report issued to Ofgem and published on QUEST website	1 day?	Wed 16/04/25	Wed 16/04/25
86	**Phase 4 BAU Transition**	**60 days**	**Wed 11/12/24**	**Tue 18/03/25**
87	Development of BAU process	60 days	Wed 11/12/24	Tue 18/03/25
88	**Workstream - Customer**	**897 days**	**Thu 08/04/21**	**Thu 31/10/24**



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

ID	Task Name	Duration	Start	Finish
89	Develop Customer Engagement Plan and Data Privacy Statement	40 days	Thu 08/04/21	Wed 02/06/21
90	Design customer materials	45 days	Mon 06/03/23	Fri 05/05/23
91	Customer contact centre training and briefing	20 days	Mon 08/05/23	Fri 02/06/23
92	Domestic customer surveys	230 days	Mon 05/06/23	Mon 06/05/24
93	Sensitive/I&C customer engagement	205 days	Tue 01/08/23	Tue 28/05/24
94	Voltage managed connections engagement	60 days	Tue 04/06/24	Mon 26/08/24
95	Produce customer research findings report	48 days	Tue 27/08/24	Thu 31/10/24
96	**Workstream - Learning & Dissemination**	**1030 days**	**Tue 30/03/21**	**Mon 12/05/25**
97	**External Learning & Dissemination**	**1030 days**	**Tue 30/03/21**	**Mon 12/05/25**
98	**D1 QUEST Initial Report - Use Cases**	**17 days**	**Thu 08/07/21**	**Fri 30/07/21**
99	D1.1 Document introducing Project and detailing use cases and scen	17 days	Thu 08/07/21	Fri 30/07/21
100	**D2 QUEST System Design and Architecture Lessons Learned**	**53 days**	**Thu 07/10/21**	**Fri 31/12/21**
101	D2.1 Review of architecture options	26 days	Thu 07/10/21	Thu 11/11/21
102	D2.2 Specification for the network models and modelling regime	26 days	Fri 12/11/21	Fri 17/12/21
103	**D3 QUEST Trials, Design and Specification Report**	**59 days**	**Mon 11/04/22**	**Thu 30/06/22**
104	D3.1 Functional specification for chosen architecture	14 days	Mon 11/04/22	Thu 28/04/22
105	D3.2 Functional specification for voltage control Methodology	15 days	Fri 29/04/22	Thu 19/05/22
106	D3.3 Trial design	15 days	Fri 20/05/22	Thu 09/06/22
107	D3.4 Detailed site design	15 days	Fri 10/06/22	Thu 30/06/22
108	**D4 QUEST Interim Report - System Design and Technology Build Lessons Learned**	**64 days**	**Tue 04/04/23**	**Fri 30/06/23**
109	D4.1 QUEST software development and testing	30 days	Tue 04/04/23	Mon 15/05/23
110	D4.2 Power system model development	20 days	Tue 16/05/23	Mon 12/06/23



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

Task		Inactive Summary		External Tasks	
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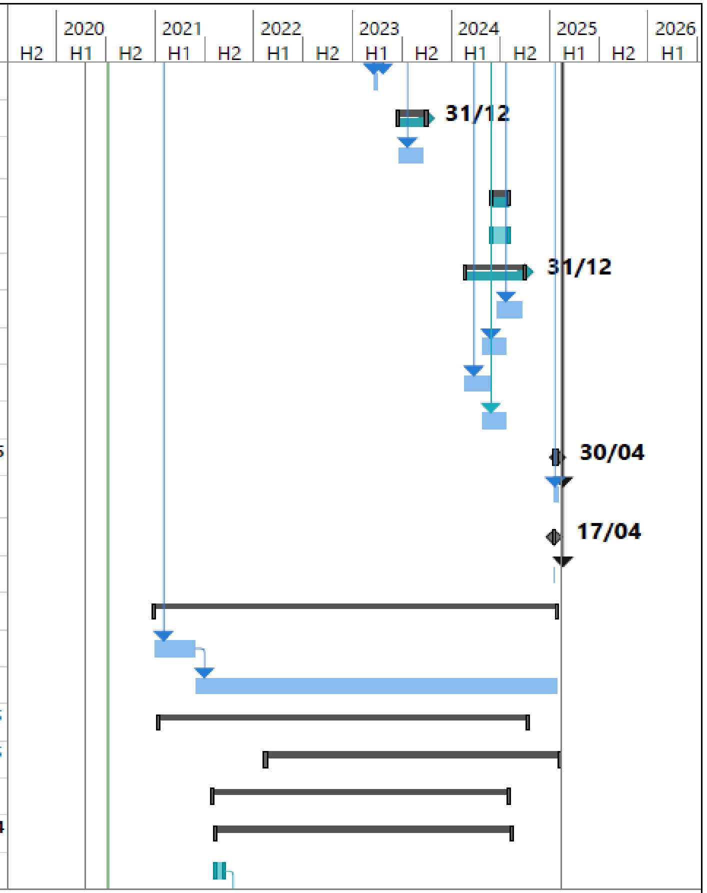
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

ID	Task Name	Duration	Start	Finish
111	D4.3 Site installation for the voltage control and ANM equipment	9 days	Tue 20/06/23	Fri 30/06/23
112	**D5 QUEST System Integration Lessons Learned Report**	**68 days**	**Tue 19/09/23**	**Sun 31/12/23**
113	D5.1 Document detailing lessons learned from installation and commissioning of QUEST system	65 days	Tue 19/09/23	Mon 18/12/23
114	**D6 Customer Research Findings Report**	**48 days**	**Tue 27/08/24**	**Thu 31/10/24**
115	D6.1 Document detailing the outputs from the customer research	48 days	Tue 27/08/24	Thu 31/10/24
116	**D7 QUEST Trials and Analysis Report**	**154 days**	**Wed 22/05/24**	**Tue 31/12/24**
117	D7.1 Final results from network trials	65 days	Wed 18/09/24	Tue 17/12/24
118	D7.2 Final results from modelling trials	65 days	Wed 24/07/24	Tue 22/10/24
119	D7.3 Any adapatation required to voltage control Methodology	65 days	Wed 22/05/24	Tue 20/08/24
120	D7.4 Output from research into the voltage demand relationship	65 days	Wed 24/07/24	Tue 22/10/24
121	**D8 QUEST Final Report**	**10 days**	**Thu 17/04/25**	**Wed 30/04/25**
122	D8.1 Report on the conclusion of QUEST Project including all lessons learned and detailing next steps, including BaU transition	10 days	Thu 17/04/25	Wed 30/04/25
123	**D9 QUEST Close Down Report**	**1 day**	**Thu 17/04/25**	**Thu 17/04/25**
124	D9.1 Publish QUEST Close Down Report	1 day	Thu 17/04/25	Thu 17/04/25
125	**QUEST Website**	**1022 days**	**Tue 30/03/21**	**Tue 29/04/25**
126	Design, build, install, test and commission QUEST website	109 days	Tue 30/03/21	Fri 27/08/21
127	Support & maintenance of QUEST website	913 days	Mon 30/08/21	Tue 29/04/25
128	**Industry Steering Groups (quarterly)**	**936 days**	**Mon 12/04/21**	**Mon 13/01/25**
145	**Annual Knowledge Sharing Events**	**748 days**	**Mon 16/05/22**	**Mon 12/05/25**
150	**Conference Attendance**	**750 days**	**Mon 01/11/21**	**Fri 01/11/24**
155	**Ofgem Annual Reports**	**754 days**	**Mon 08/11/21**	**Wed 13/11/24**
156	Preparation of Annual Report 1	25 days	Mon 08/11/21	Fri 10/12/21



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

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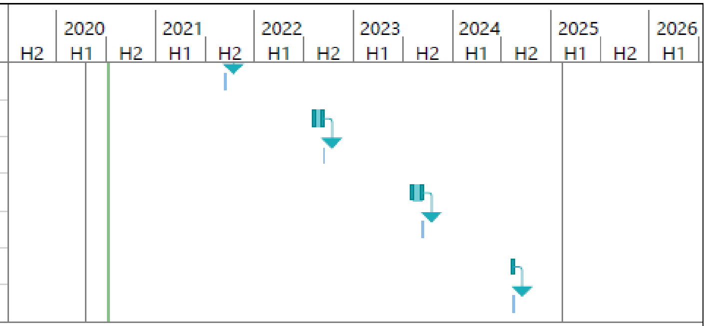
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

ID	Task Name	Duration	Start	Finish
157	Issue Annual Project Progress Reports and publish on the QUEST we	1 day	Mon 13/12/21	Mon 13/12/21
158	Preparation of Annual Report 2	25 days	Mon 07/11/22	Fri 09/12/22
159	Issue Annual Project Progress Reports and publish on the QUEST we	1 day	Mon 12/12/22	Mon 12/12/22
160	Preparation of Annual Report 3	25 days	Wed 08/11/23	Tue 12/12/23
161	Issue Annual Project Progress Reports and publish on the QUEST we	1 day	Wed 13/12/23	Wed 13/12/23
162	Preparation of Annual Report 4	1 day?	Tue 12/11/24	Tue 12/11/24
163	Issue Annual Project Progress Reports and publish on the QUEST we	1 day	Wed 13/11/24	Wed 13/11/24



Project: QUEST Project Plan v.4
Date: Tue 06/10/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Appendix F: Risks and Issues Register and Contingency Actions

The risk model employed by ENWL in the delivery of NIC projects looks at risks in much the same holistic manner as the well-established risk model employed by ENWL at a corporate level. However, using previous experience, the risk and issues register has been refined to better reflect the increased significance of impacts at a project level. In this model, risk impact areas have been categorised into time, cost and scope/quality which are given a score of 1 to 5 along with the likelihood of occurrence. The resulting product of these two ratings is used to score and rank the risks on the project. The format of the ENWL NIC risk scoring matrix is below.

Risk impact descriptors

RISK AREA	1 Negligible	2 Minor	3 Moderate	4 Significant	5 Serious
Time	There will be no impact on deliverables. No re- planning necessary.	Any delays are likely to be small ie <one week and manageable. Minor re- planning necessary.	Some delays likely to project/programme milestones, but the overall project/programme delivery date will not be affected. An element of re-planning will be necessary.	There is likely to be a delay which causes the overall project/programme delivery end-date to slip. Significant re-planning will be essential.	There is likely to be a delay which causes the overall project/programme delivery end-date to slip. Serious re-planning will be essential.
Cost	£0	<£10k	<£20k	<£50k	>£50k
Scope/ Quality	There will be no impact on the overall quality of the deliverables in the project/programme. All requirements will still be met.	There will be negligible impact (if any), on the overall quality of the deliverables in the project/programme. Most, if not all requirements will still be met.	Some requirements will not be met, or a small number of business process(es) will need to be modified to accommodate shortcomings in the delivery.	A significant number of requirements will not be met, or business process(es) will need to be modified to accommodate shortcomings in the delivery.	Major requirements, key to the success of the delivery, are not likely to be delivered as planned.

Risk probability descriptors

5	Almost certain	>80%
4	Likely	60-80%
3	Moderate	30-60%
2	Low	10–30%
1	Rare	<10%

Risk score

Impact						
Impact	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Probability				

The following potential risks have been identified. These risks have been based on the scoring matrix set out above and linked to the Project phase or workstream in which they will occur.

Project Phase/ Workstream	**Description**	**Probability Score**	**Impact Score**	**Mitigating Action/ Contingency Action**	**Revised Probability Score**	**Revised Impact Score**
Delivery	There is a risk that COVID-19 restrictions will impact Project delivery. This is especially true should we experience a second wave or a regional lockdown. This could have a significant effect due to the location of one of our Partners, potentially causing delays to Project completion.	3	4	We will monitor government advice both in the UK and Europe to identify any risks to travel as early as possible. ENWL are implementing improved IT functionality to enable more effective remote working for Projects.	2	3
Mobilisation	There is a risk that the Project Partners are not able to mobilise their resources in time because of other commitments leading to a delay in achieving potential milestones which could have a Project reputational and financial repercussion.	3	4	Suitable partnership agreements that ensure collaborative working, value for customers' money and achievement of learning objectives in a timely manner have been identified for all Partners. A project initiation document will be issued to the Project Partners to ensure that all parties are ready. *Contingency: ENWL will seek new Project Partners should existing Project Partners fail to mobilise.*	2	4

Project Phase/ Workstream	Description	Probability Score	Impact Score	Mitigating Action/ Contingency Action	Revised Probability Score	Revised Impact Score
Technology	There is a risk of delay in development/integration of the overarching software, which leads to an overall Project delay.	3	4	We have selected an appropriate Project Partner with relevant experience to deliver this element of the Project and have ensured that the scope of work is clear and deliverable. Regular development meetings will be held to track progress against the plan. *Contingency: Budget allocated to cover additional resource for a possible Project extension.*	1	4
Technology	There is a risk to transformer delivery due to Brexit. Should no deal be reached between the UK and EU, World Trade Organisation import tariffs could be imposed on equipment sourced from the EU. Additional cross-border requirements may impact the lead times for taking delivery of electrical equipment.	3	3	ENWL has a Brexit working group in place which draws together key business streams from across the company to assess Brexit implications. The working group will monitor developments during the transition period, which ends on 31st December 2020. *Contingency: updates shared periodically with ELT and board. Increased stock holdings currently being maintained and ongoing dialogue with key suppliers.*	2	3

Project Phase/ Workstream	Description	Probability Score	Impact Score	Mitigating Action/ Contingency Action	Revised Probability Score	Revised Impact Score
Technology	There is a risk of delay in procurement/delivery of the trial equipment leading to a delay in implementation.	2	4	Project plan specifies that a purchase order will be raised to procure the equipment, giving time for manufacture. QUEST will use equipment already available on the market. *Contingency: flexibility built into project plan.*	1	4
Technology	There is a risk that the final architecture design may be more complex than originally anticipated leading to an increase in cost and delivery timescales.	3	5	Proposed architecture in bid has been developed using experience of Project Partners. *Contingency: budget allocated to cover potential changes.*	1	5
Technology	There is a risk that customers may experience an outage during installation of the distribution substation equipment.	2	2	Pre-site surveys to identify suitable means of installation which avoid customer outages whether via backfeeds or generators. *Contingency: budget allocated for generators.*	1	2

Project Phase/ Workstream	Description	Probability Score	Impact Score	Mitigating Action/ Contingency Action	Revised Probability Score	Revised Impact Score
Technology	There is a risk of increased cost for installation of BSP and Primary AVC schemes due to unforeseen issues such as increased cabling, etc.	3	5	Preliminary site surveys to be conducted. *Contingency: budget allocated for extra works.*	1	5
Technology	There is a risk that there is a need for unforeseen additional work during commissioning, leading to a requirement for additional resource to attend site to fix or replace.	2	4	Pre-installation surveys to identify commissioning requirements. *Contingency: budget for additional resource.*	1	4
Trials and Analysis	There is a risk that the QUEST software does not perform as intended leading to a requirement for additional resource to carry out debugging/ development.	3	4	We have selected a Project Partner who is familiar with our existing systems and software and whom has appropriate experience and technical expertise to perform this task. *Contingency: budget for additional resource.*	2	4

Project Phase/ Workstream	Description	Probability Score	Impact Score	Mitigating Action/ Contingency Action	Revised Probability Score	Revised Impact Score
Trials and Analysis	There is a risk that implementation of the holistic voltage control methodology may have an impact on the network which leads to disruption or outage.	1	5	The holistic voltage control methodology uses a combination of proven techniques. We will run the methodology in open loop to understand the actions it would take before allowing operation on the live network. *Contingency*: *if any issues occur, then the software would be disabled.*	1	4
Customer	There is a risk that customers could be adversely affected by implementation of the holistic voltage control methodology. This risk might result in a breakdown in customer relationship and reputation.	2	3	We will engage with a variety of customers to understand how optimising voltage may affect their operations and identify any special requirements. We will adapt the Method to incorporate the needs of these specific users. To ensure that there is no public or reputational damage to ENWL, QUEST will embed a process to quickly and appropriately manage any customer impacts. *Contingency: Work with customers to adapt methodology.*	1	2

Project Phase/ Workstream	Description	Probability Score	Impact Score	Mitigating Action/ Contingency Action	Revised Probability Score	Revised Impact Score
Learning dissemination	There is a risk that attendance at events may be low due to other dissemination events/current restrictions preventing attendance. Learning may be inhibited due to stakeholders having different interests and learning styles.	2	3	ENWL will choose dissemination channels optimised to achieve maximum reach and coverage. *Contingency: dissemination will be carried out through multiple communication channels including use of online resources.*	1	2
Close Down	There is a risk that new obligations and guidance will be released on key deliverables, such as the Close Down Report leading to a longer preparation and review period required.	3	3	Communication channels from Ofgem will be monitored and any updates to such requirements identified as early as possible. *Contingency: additional time allowed for Close Down reporting*	1	3

Appendix G: Project Partner and Supplier Details

Name	Experience	Contribution	Contractual Relationship	Role of Project Partner	Funding Benefits to Project
Schneider Electric (SE)	Design of our new NMS, which will replace ENWL's current, bespoke NMS.	[redacted]	Terms & Conditions, contract drafting, and work schedules required	• Specification, design, development of overarching system. • Will assist with implementation of system. • Supply, install and configure the optimisation hardware and software.	Discount on day rates
Smarter Grid Solutions (SGS)	Have valuable knowledge about operation of software systems such as ANM and have worked with a number of DNOs on this system function.	[redacted]	Terms & Conditions, contract drafting, and work schedules required	• Will help to define architecture and use cases. • Will conduct technical research, involving modelling to inform holistic voltage control methodology and trial design. • Will participate in trials. • Will analyse trial data to identify benefits and update business case and carbon plan.	Discount on day rates
Fundamentals Ltd	Have experience in voltage control and production of relays.	[redacted]	Terms & Conditions, contract drafting, and work schedules required	• Will assist with design of holistic voltage control methodology and customer interface. • Learning & Dissemination Support.	Will fund software algorithm development for their AVC relays

Name	Experience	Contribution	Contractual Relationship	Role of Project Partner	Funding Benefits to Project
National Grid ESO	The ESO operates the GB transmission network and has experience interacting with DNOs, managing voltages and emergency events.	[redacted]	Terms & Conditions, contract drafting, and work schedules required	• Will help to explore the expected benefits of QUEST for the transmission system, including real-time visibility of our network and dynamic adjustment of interface voltage parameters, for both steady state and emergency conditions.	Discount on day rates
Impact Research	Impact Research is a specialist marketing research organisation	[redacted]	Terms & Conditions, contract drafting, and work schedules required	• Will assist with customer engagement via surveys and focus groups. • Learning & Dissemination Support	Discount on day rates

Appendix H: Scope for Customer Engagement Plan

This appendix summarises the scope of the CEP and accompanying DPS that will be developed as part of QUEST. The CEP will outline all the planned interaction with Relevant Customers or their premises and any potential customer impacts.

The CEP will fully set out how we intend to interact, engage with and impact upon customers and will outline the customer research methodology and what each phase of engagement will entail. It will provide a framework for all engagement with customer groups that directly participate in the three areas of research. The CEP will set out the activities and tools that we will draw upon to maximise customer outcomes. It will include, but is not limited to the following:

- Establishing which customers need to be engaged;
- Developing and implementing engagement plans;
- Planning customer selection, recruitment and approach for interviews, survey participation and focus group participation;
- Bringing customers into the Project;
- Keeping customers engaged in the Project – retention and incentivisation; and
- Managing customers' issues, enquiries and complaints.

Data and ethics

Recruiting customers into the research will be subject to a stringent data privacy impact assessment, and the explicit consent of participating customers. Some personal data, which is already held by ENWL, for legitimate interests, will be used to identify and recruit customers into the research. The DPS will provide details of the data that we will use, store and process in QUEST, and demonstrate how the Project will comply with the requirements of the Data Protection Act 2018 and Electricity North West's Privacy Policy.

Customer protection requirements

There will be no visits made to the premise of any Relevant Customer for sales or marketing activities in connection with, in the context of, or otherwise under the guise of QUEST.

Care will be taken in all aspects of the research to ensure there is no confusion with the smart meter roll-out and all QUEST activities will be conducted in a manner so as not to disrupt or impede the smart meter programme in any way. There will be no acquisition or use of smart meter data in QUEST.

Customer impact

The CEP will include all details on customer impact, including risk of interruptions, contractual and charging arrangements, technology installation at customer premises & customer safety, and vulnerable customers.

Customer segmentation

The CEP will reinforce our commitment to ensure best practice in engagement and customer communication and will specify how the following five distinct customer groups will be engaged in QUEST:

1. Customers on trial networks.
2. Customers on trial networks who may experience PSIs for the installation of the network equipment.

3. Relevant Customers (domestic or micro-business customers) and SME customers on trial networks who will be engaged in surveys for research area 1.
4. Sensitive HV & EHV connected customers taking part in research area 2.
5. HV & EHV connected customers taking part in research area 3.

Communications strategy

The customer engagement strategy will require targeted communications for the five separate groups of customers identified in QUEST. The CEP will specify how we intend to:

- Engage with the various groups to ensure that the customer experience remains a positive one.
- Pay regard to the experience of vulnerable customers (including those identified on the Priority Service Register).
- Consider the needs of customers during planned interruptions and look to mitigate impacts.

Tailored communications, developed as part of QUEST (which may be a combination of written, audio and visual mediums) will be informed by learning from previous research and feedback from customers and stakeholders.

Customer relations - Managing customer enquiries

Our aim is to maintain a positive customer experience throughout the duration of QUEST. The CEP will explain how this commitment will be achieved by employing several communication channels for customers and other stakeholders to obtain information or assistance about any aspect of the QUEST Project.

Our partners

We have selected Project Partners with consideration for their strong credentials in the area of customer engagement and approach to customer relations. Project Partners responsible for any form of customer contact will ensure their codes of practice include guidance on ensuring that customer contact is appropriate and will adhere to the key principles outlined in the CEP and DPS.

Feedback and review

This CEP will be a starting point for our communication with customers throughout the QUEST Project. However, there may be a requirement to review the plan on an ongoing basis to reflect feedback and lessons learned as we progress along the QUEST journey. The CEP will document how we will engage, communicate and incorporate feedback from customers and other key stakeholders.

Analysis and reporting

The CEP will specify the analytical methodologies that will be used, and will detail how we will use the technical data from the trial and the quantitative survey data to test the customer hypothesis. It will also provide details of how lessons learned from the three areas of research will be reported at key stages of the Project.

Learning and dissemination

The CEP will outline the extensive knowledge dissemination programme in QUEST and the range of communication methods and channels that will be employed to engage with and impart information to our customers and other stakeholders.

Appendix I: Invitation to Industry Steering Group

QUEST
Network Innovation Competition 2020

electricity north west
Bringing energy to your door

Dear Elizabeth,

Our submission to this year's Network Innovation Competition is a project called QUEST, which will develop an overarching control system to co-ordinate current and future voltage control techniques.

Now that QUEST has passed the Initial Screening Process, we would like to ensure that we capture the thoughts and expectations of other network operators as we develop our solution. In order to achieve this, we are planning to assemble an Industry Steering Group (ISG).

At this stage we are still working on the structure of the group and its precise objectives. However, we are anticipating that the ISG will provide input to the project at its early stages to help shape the use cases, and thereafter to convene on a quarterly basis for the duration of the project to inform the project direction, review trial designs and conclusions, and help to construct a plan to transfer the solution to business as usual.

At this stage we are still working on the structure of the group and its precise objectives. However, we are anticipating that the ISG will provide input to the project at its early stages to help shape the use cases, and thereafter to convene on a quarterly basis for the duration of the project to inform the project direction, review trial designs and conclusions, and help to construct a plan to transfer the solution to business as usual.

We would like to invite you to take part in this steering group, and at this stage are looking for a commitment from each DNO to nominate one representative to participate.

QUEST will build an overarching control system which operates a holistic voltage control methodology to coordinate both existing and future voltage control techniques. This will establish highly efficient network operation and promote the low-cost connection and use of LCTs, thus delivering significant benefits to customers.

If funding is awarded, we are expecting the project to run from 1 April 2021 until 31 April 2025.

We look forward to your response.

Kind Regards,

Dan Randles
Head of Network Innovation
Electricity North West Ltd
Technology House
Lissadel Street
Salford
M6 6AP
Tel: 07917658031
Email: Daniel.Randles@enwl.co.uk

For any further information, please contact the Innovation Team.

Appendix J: Letters of Support

FUNDAMENTALS

Tel: +44 (0) 1793 847163
Web: www.fundamentalsltd.co.uk

Dan Randles
Head of Network Innovation
Electricity North West Limited
Technology House
Lissadel Street
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M6 6AP

Our Ref.:

Your Ref.:

7th July 2020

Dear Dan

Electricity North West 2020 NIC bid – QUEST

I am writing this letter in support of your bid for Network Innovation Competition (NIC) funding in the 2020 competition.

Your QUEST bid encapsulates the future network challenges as we continue the network transition needed to support the net-zero objectives: a more flexible electricity network in a DSO-orientated environment. Voltage management is at the heart of this and you have identified some of the key challenges to be addressed, particularly in the integration of multiple systems all with different zonal approaches, objectives and constraints.

Fundamentals prides itself in having expertise in end-to-end voltage control and management, with a desire to be at the leading edge of approaches. We are delighted to play our part in this project and believe that we can offer unique insights to support successful delivery of the project: network wide and zonal considerations, optimal control and management of on-load tapchangers (OLTCs) and management of the tapchangers themselves to ensure cost-effective and efficient delivery of voltage management.

From a personal perspective, I have been closely involved with several of your voltage-related innovation projects stretching back for almost 20 years, during my time with various organisations. Having seen the development of several of your initiatives through to deployable commercial practices, I can confirm that successful delivery of this project would provide a useful blueprint on best practice approach to integration of multiple techniques in a coherent and strategic manner.

I would therefore like to offer Fundamentals support to this project, both in our collaboration and expertise, and through in-kind contribution of our resource to the project. I wish you every success with your bid and you can be assured of our support at each step on the way.

Yours sincerely,

Dr. Vincent Thornley
BD and Technology Director

Dan Randles
Head of Network Innovation
Electricity North West
Technology House
Lissadel Street
Salford
M6 6AP

Optima Building
58 Robertson Street
Glasgow
G2 8DU

29th July 2020

REF: QUEST Network Innovation Competition Letter of Support

Dear Dan,

Further to our recent discussions I am pleased to confirm our full support, as a project partner and with board approval, to Electricity North West in its bid for Network Innovation Competition for the QUEST project. The value of the project to GB is very significant and it tackles major hurdles to wider adoption of already proven innovations; we commend you on bringing the project forward.

Smarter Grid Solutions has seen a number of successful innovation trials over the years that have struggled to reach their full potential through roll-out. There are a number of reasons for that, but one of the largest is the lack of understanding as to how multiple solutions or 'methods' can operate together and avoid counteracting each other's business case. We believe that understanding these 'whole system' challenges, and demonstrating that they can be addressed through good engineering process, is vital to realising the benefits for bill payers. The QUEST project specifically addresses this challenge bringing together flexible connections, flexibility services, CLASS voltage optimisation, LV voltage optimisation (SMART STREET), and other Electricity System Operator (ESO) use cases to show how a truly flexible and interactive system can operate reliably.

Smarter Grid Solutions has been at the forefront of innovation over the last decade addressing network optimisation use cases using Distributed Energy Resources, such as Flexible Connections and Flexibility Services. We have also invested £ms of private capital to develop the technologies, products and team capability to deliver these solutions. We have actively participated with the broader industry, dissemination events and working groups to help mature these innovations from trials through to business as usual adoption. In doing so we have worked closely with all other UK DNOs. Our role in the QUEST project is in part therefore, to ensure that the QUEST solution maps to the use cases, architectures and methods applied by other DNOs and ensure replicability / transferability. We believe we are uniquely positioned to perform that role and help facilitate the industry transfer process into other DNOs.

Over the last months we have collaborated with the Electricity North West team, and the other partners, to design a project that we believe delivers the benefits described above. Our track record, and that of our other partners, in delivering successful innovation outcomes is first class and we believe the outcome from this project will accelerate the GB industry to realise the full benefit of multiple innovations.

Yours sincerely,

Alan Gooding
UK and Europe General Manager

Life Is On | Schneider Electric

Tom Naul
Schneider Electric
123 Jack Lane
Leeds
LS10 1BS

30th July 2020

Dan Randles
Head of Network Innovation
Electricity North West Ltd.
Technology House
Lissadel Street
Salford
M6 6AP

Re. Support for QUEST – NIC 2020 Entry

Dear Dan,

This letter is to confirm our support for Electricity North West's application to Ofgem's Network Innovation Competition to fund the QUEST project.

QUEST will build a holistic, centralised optimisation engine that will demonstrate the use of an overarching optimisation function to co-ordinate and control existing systems, such as CLASS, Smart Street, ANM, Respond and flexibility services, to provide an optimum whole distribution system voltage profile at all times. Thus, facilitating concurrent operation of discrete voltage-dependent applications across the network.

Schneider Electric has been selected to partner with Electricity North West to develop the centralised software module, which will use some of the NMS functionality, which would be expanded, to enable envisioned QUEST functionality. The centralised software is required to interact with discrete voltage management solutions to deliver the whole distribution system optimisation and co-ordination. This will include the combining or 'stacking' of benefits to maximise the benefits delivered.

We have worked alongside Electricity North West on previous innovation projects and have recently designed the new NMS, which will replace the current, bespoke NMS.

We are looking forward to assisting Electricity North West as they address this significant network challenge in the move towards a zero-carbon future.

Yours sincerely,

Thomas Naul

Tom Naul
Sales Lead - Utilities
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07967 587438

Schneider Electric

schneider-electric.com

nationalgridESO

Dan Randles
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Carolina.tortora@nationalgrideso.com
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27 July 2020

Support for ENW NIC 2020 bid - QUEST

Dear Dan,

I am writing this letter in support of your bid for the 2020 Network Innovation Competition, for your project QUEST.

As we work towards our target of being able to operate a zero-carbon electricity system by 2025, we must overcome many challenges. Many of these challenges relate to visibility and coordination issues across the whole electricity system.

QUEST is the development of a whole-system, central co-ordinated network voltage control method for UK distribution networks, which allows for optimised configuration of distribution network voltages. There are several applications where we believe QUEST can offer value to the ESO:

1. Improved visibility of DER
2. Enhanced demand control during system frequency or voltage events
3. Whole electricity system voltage management

We are excited to test these theories with ENW and the QUEST partners as part of this important innovation project. As a minor partner in the project, we will be providing expert resource as well as data to the project.

Yours sincerely

Carolina Tortora

Head of Innovation Strategy and Digital Transformation

IMPACT
FROM INSIGHT TO INFLUENCE

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21 July 2020

Dear Dan,

LETTER OF SUPPORT FOR ELECTICITY NORTH WEST LIMITED - NIC PROJECT 'QUEST'

Impact Research is delighted to have been selected to be part of the consortium of partners working in collaboration with Electricity North West on the Quest project.

Impact Research is an independent market research agency specialising in obtaining and analysing customer and stakeholder feedback.

Using a novel application of proven technology combined with innovative software, QUEST will build an overarching control system which operates a holistic voltage control methodology. This will coordinate existing and future voltage control techniques, establishing efficient network operation and promoting low-cost connection and use of LCTs, thus delivering significant customer benefits.

This is an exciting and innovative project with real potential to drive sustainable networks.

Impact Research has a strong track record in the design, management, analysis and dissemination of innovation funded customer engagement activities. We pride ourselves on the rigour of our research methodologies, our sector expertise and the smart application of customised techniques.

We have worked on the customer element of previous innovation projects, such as Celsius and VoLL2 and we look forward to our role in the customer research elements of the project. This will include engagement via surveys and Engaged Customer Panels, as well as support for the customer communications strategy.

We are fully committed to achieving the project success criteria and I have full confidence in the team at Impact Research to deliver a high quality, robust and innovative project.

Yours sincerely,

Dr David Pearmain
Board Director

Appendix K: Glossary

ANM	Active Network Management
AVC	Automatic Voltage Controller
BaU	Business as Usual
BSP	Bulk Supply Point
CBA	Cost Benefit Analysis
CEP	Customer Engagement Panel
CLASS	Customer Load Active System Service
CVR	Conservation Voltage Reduction
DCUSA	Distribution Connection and Use of System Agreement
DER	Distributed Energy Resource
DFES	Distribution Future Electricity Scenarios
DG	Distributed Generation
DPS	Data Privacy Statement
DNO	Distribution Network Operator
DSO	Distribution System Operator
EHV	Extra High Voltage (voltage of 33kV and above)
ENA	Energy Networks Association
ENWL	Electricity North West Limited
ESO	Electricity System Operator
EV	Electric Vehicle
FNSG	Future Networks Steering Group
GB	Great Britain
GMCA	Greater Manchester Combined Authority
GMT	Ground-Mounted Transformer
GSP	Grid Supply Point

HP	Heat Pump
HV	High Voltage (voltages over 1kV up to, but not including, 22kV)
IDNO	Independent Distribution Network Operator
IET	The Institution of Engineering and Technology
IPR	Intellectual Property Rights
IRM	Innovation Roll-out Mechanism
ISG	Industry Steering Group
ISP	Initial Screening Proposal
LCN	Low Carbon Networks
LCNI	Low Carbon Networks & Innovation
LCT	Low Carbon Technology
LFDD	Low Frequency Demand Disconnection
LTDS	Long Term Development Statement
LV	Low Voltage (voltages of 1kV and below)
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
NMS	Network Management System
NPV	Net Present Value
PMO	Project Management Office
PMT	Pole-Mounted Transformer
PSG	Project Steering Group
PSI	Planned Supply Interruption
PV	Photovoltaic
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SE	Schneider Electric

SME	Small to Medium sized Enterprise
SGS	Smarter Grid Solutions
TNO	Transmission Network Operator
TRL	Technology Readiness Level

Appendix L: Full Submission Spreadsheet

All changes in the cost submission spreadsheet are shown as follows:

1. Removal of cost is shown as red highlighted cell.
2. Addition of cost is shown in red text.