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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#1**	**Pro forma section**	**Section 2**
Question date	**18/08/20**	**Answer date**	**20/08/20**
Question summary	**The "Centralised Overarching Software" to be developed By Schneider Electric is a key component of the proposed system and a key deliverable for this project. Please clarify:** **a. What has been developed so far?** **b. Have simulations been carried out to prove the concepts?** **c. Were smaller trials considered, including verification at the PNDC or similar?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

a) There has been no development of the centralised overarching software so far; it will be developed as part of the project.

To-date, none of the associated QUEST software has been developed. This activity will only commence once the algorithms for the QUEST system have been agreed by all parties and designed by the project. The design of the QUEST algorithms is a QUEST project deliverable and forms a key part of the early phase of the project. Once available and published, Schneider Electric will undertake the task of producing the necessary software in the ADMS.

b) The concepts of voltage optimisation are well established and, as such, there have been no simulations carried out to prove these concepts further. The discrete techniques for voltage optimisation already exist, and, based on overall value, QUEST seeks to make a decision as to which of these techniques has priority at any one time. The calibration of the QUEST system, and the development of policy for end-to-end voltage control, will be informed by QUEST field trials and offline simulations.

c) QUEST seeks to deliver whole-system, end-to-end voltage control and voltage optimisation. Small trials would not be sufficient to either prove or disprove the concepts of QUEST. As such, it is necessary to undertake a large-scale project. For these reasons, smaller trials at the PNDC were not considered, and as the discrete techniques, such as ANM, Smart Street and CLASS, are already installed on our network, it is preferable to trial QUEST directly on the real network. QUEST is exploring how whole distribution system voltage management and co-ordination can unlock capacity and maximise the benefits of discrete techniques, and to facilitate this it needs to be trialled across the voltage range of the distribution network.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#2**	**Pro forma section**	**Section 2**
Question date	**18/08/20**	**Answer date**	**20/08/20**
Question summary	**The "Centralised Overarching Software" will "optimise" the network voltages. What does "optimise" mean in this context.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Through dynamically setting the target voltage for all controllable devices and taking a whole distribution system view of the network centrally within the NMS, QUEST will optimise the voltages across the distribution system. This will provide overall maximum value for customers and ensure that potential clashes are avoided.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#3**	**Pro forma section**	**Section 2**
Question date	**18/08/2020**	**Answer date**	**20/08/20**
Question summary	**Which parts of the "centralised overarching software" will be made available to other DNOs for use on other NMS? Please provide details on what will be considered foreground and background IP.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The QUEST centralised overarching software specifications and designs developed during the Project, will be made suitably available such that other DNOs can reasonably take these and work with their NMS providers to replicate the QUEST centralised overarching software in accordance with the default IPR terms of the NIC governance document.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#4**	**Pro forma section**	**Section 2**
Question date	**18/08/2020**	**Answer date**	**20/08/20**
Question summary	**The proposal refers to control of DERs.** **a) Does this apply to demand, storage and generation?** **b) Please clarify if it will apply to existing customers and the proposed mechanisms for enabling such strategies.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

a) Yes – QUEST can be applied to any DER. However, as QUEST is primarily about voltage, we are particularly keen to understand the role of generation (including exporting storage) in providing optimised voltages on the network.

b) We intend to prove the concept that QUEST can be applied to DER through simulation only. Owing to the often complex nature of establishing commercial agreements with third-parties during innovation project delivery, we do not intend to sign any customers up during the project. However, the project does aim to explore the appetite of new and future customers to connect to the network via a voltage dependent connection. The

output of this research could be used to inform the development of a new framework for voltage-managed connections.

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Project Name	**QUEST**		
Question number	**#5**	**Pro forma section**	**Section 3**
Question date	**18/08/20**	**Answer date**	**20/08/20**
Question summary	**AVC relays are already in use on the transmission system. Were they considered for this project?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Initially, QUEST will develop a solution for distribution networks. However, the learning from QUEST will make recommendations on how this may be extended across the ESO/DSO interface for application to transmission networks.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#6**	**Pro forma section**	**Section 2**
Question date	**18/08/20**	**Answer date**	**20/08/20**
Question summary	**What devices and systems will be instructed by this scheme to enable control of voltage. Will it be only transformer tap-changers and existing DNO owned reactive power equipment? Will HV/LV transformers be controlled and, if so, how (i.e. will tap-changers be retro-fitted)?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

We believe this is answered in section 2.2 of the full submission but for the purposes of clarity, QUEST will instruct:

1. intelligent AVC relays to control the transformer tap changers installed at Bulk Supply Points;
2. through the CLASS system, intelligent AVC relays to control the transformer tap changers installed at Primary substations;

3. through the Smart Street system, intelligent Remote Terminal Units and AVCs to control the tap changers at 10 Distribution (HV/LV) substations, enabling LV voltage optimisation on one HV ring. The existing transformers at these sites will be replaced with on load tap changing transformers as it is not possible to retrofit a tap changer;
4. through the NMS, controllable switches to perform network reconfiguration;
5. through the SGS ANM system, intelligent 'Strata' control devices to control a simulated DER.

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Project Name	**QUEST**		
Question number	**#7**	**Pro forma section**	**Section 2**
Question date	**18/08/2020**	**Answer date**	**20/08/20**
Question summary	**Has the impact on transformer tap changers of increased use (if any) been considered and the additional cost of outages, maintenance and repairs been factored into the benefits calculation?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

QUEST is not expected to necessarily increase the number of tap changer operations over what would be expected from non-QUEST operation of the discrete systems. However, appropriate learning from previous innovation projects such as CLASS and Tap Changer Monitoring, and our use of these in BaU over many months, has been factored into the benefits calculation for QUEST.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#8**	**Pro forma section**	**Section 9**
Question date	**18/08/2020**	**Answer date**	**20/08/20**
Question summary	**What deliverable will be provided as part of the ESO collaboration?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Our collaboration with the ESO will explore how QUEST can be used to support ESO network operations. We will work with the ESO to define the relevant use cases and to complete the associated trials using network modelling.

As such, our collaboration with the ESO will feed into a number of our deliverables, including:

1 – QUEST Initial Report – Use Cases

We will work with the ESO to define the use cases and scenarios to be trialled during QUEST, which will be detailed within this document.

2 – QUEST System Design and Architecture Lessons Learned

The ESO will identify their requirements as we design the specification for the network models and modelling regime for QUEST. The lessons learned from this collaboration will be detailed within this document.

3 – QUEST Trials, Design and Specification Report

This report will detail the project progress, including outputs such as functional specifications and trial design. Feedback from the ESO will help to shape these outputs and will be included in the report.

4 – QUEST Interim Report – System Design and Technology Build Lessons Learned

This document will detail all lessons learned from the project thus far, including software development and testing, and system model development, and will include all relevant insight and feedback from the ESO received to date.

7 – QUEST Trials and Analysis Report

This report will detail all project conclusions and lessons learned during the course of the project, including all feedback from the ESO.

Further information about our collaboration with the ESO is provided in the full submission, which we have summarised below:

- Section 2.2 details our collaboration with the ESO. We will explore how we can provide enhanced visibility of the distribution network to enable better management of constraints, and facilitate entry of flexible services providers to the ESO's markets. Additionally, we will explore how we can provide "tuned" responses for demand control and OC6.
- Section 2.3 details the trial design. We will use network modelling to trial the ESO use cases.
- Section 3.6 details the benefits to the ESO. We anticipate that the QUEST functionality could enable more efficient operation of the transmission network, via an enhanced response to system events, improved visibility of embedded active participants on the distribution network, and controllable, whole distribution system voltage management.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#9**	**Pro forma section**	**Section 2.1**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Is it appropriate for Quest to try to help HV customers manage their demand? If the HV volts are low then the HV system losses will be higher than they might otherwise be. Also, managing their consumption and energy efficiency should be the sole preserve of HV customers. Please explain what is behind the last bullet on p5.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

By co-ordinating voltage control techniques across the entire distribution network and optimising voltage profiles accordingly, QUEST will enable us to elicit demand reductions across many areas of our network, providing benefits to all of our customers at all voltage levels.

Given this, the bullet point on page 5 refers to the benefits to all customers obtained through reducing demand. By reducing the voltage, and thereby the demand, we release capacity, facilitating the connection of Low Carbon Technologies and contributing to the Energy System Transition, which delivers benefits for all our customers.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#10**	**Pro forma section**	**Section 2.2**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please explain more about what learning might come from Distributed Restart and how Quest might expect to benefit from this.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Distributed ReStart is investigating using DNO-connected generation to facilitate restoration of supply following a black start.

During discussions with the ESO as part of bid development, it was suggested that QUEST could include for review of other ongoing projects, such as Distributed ReStart, particularly where there is a real-time exchange of data between network operators and the ESO.

The learning from these projects could influence the type and method of data exchange explored as part of the ESO-related use cases in QUEST and on this basis it is appropriate to allow for review and inclusion of relevant learning outcomes where they benefit QUEST.

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Project Name	**QUEST**		
Question number	**#11**	**Pro forma section**	**Section 2.3**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please explain how Quest will avoid the inadvertent disconnexion of DG during emergency conditions. Can this be achieved without fundamentally modifying the LFDD scheme?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Owing to its ability to integrate various discrete systems such as ANM into a larger centralised whole, QUEST can provide enhanced visibility of DG connected on the distribution network. We will explore what benefits could be leveraged from this in addition to those quantified in the business case.

Working with the ESO, we will investigate how QUEST can be used, for example, as part of the current LFDD scheme and any planned enhancement to it. The output of this will be recommendations for future work including how schemes such as LFDD should work for areas of the network with high concentrations of generation, or which are actively managed.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#12**	**Pro forma section**	**Section 2.3**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please explain how the claimed loss reduction benefits will be substantiated in the trials.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The loss reduction benefits will be quantified through modelling work to be carried out by our technical research partner, SGS. A bench-testing regime will create a set of network models (using IPSA, DINIS, analytical scripts, and extensive data sets), DER and load cases/scenarios, and QUEST method/solution configurations, to enable offline analysis of the operation of the QUEST solution.

Initial use of the bench-testing models will inform the design and configuration for the trials. This will include assessment of the prospective benefits, including net loss reductions over an operating period. The net losses outcome is expected to be influenced by the QUEST system configuration, DER and load scenarios, and the operating profiles through time (modelled as a time series of demand, generation, and QUEST/other controls) with variations over time.

SGS will collate the results from the trials and use data cleansing and aggregation methods to provide a bench-testing data set for modelling, comparable to that used in the initial analysis and design phase. The challenge here is to extract granular time series and event-driven data and convert it into appropriate, comparable modelling data for each QUEST trial configuration and operating regime. The outcome will be a robust, pre-trial, trial and analysis of losses, with results reported appropriately in keeping with the QUEST reporting and dissemination objectives.

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Project Name	**QUEST**		
Question number	**#13**	**Pro forma section**	**Section 3.6**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please explain the tuning of the response to protect vulnerable loads. Can this be achieved without fundamentally modifying the LFDD scheme?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Owing to its ability to integrate various discrete systems into a larger centralised whole, QUEST can provide enhanced visibility across the distribution network, which could include the location of vulnerable loads. We will explore what benefits could be leveraged from this in addition to those quantified in the business case.

Working with the ESO, we will investigate how the visibility of vulnerable loads through QUEST can be used, for example, as part of the current LFDD scheme and any planned enhancement to it. The output of this will be recommendations for future work, including how schemes such as LFDD should work whilst maintaining supplies for those vulnerable loads.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#14**	**Pro forma section**	**Section 2**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please explain how the length of the trials were determined and how the information will be extrapolated to seasonal variations not measured.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The trials will run for 12 months; a full year of data capture will provide data for all seasons, incorporating different QUEST solution configurations and a range of operating conditions. A trial of 12 months will provide a wide range of interseasonal effects, which will be measured and analysed. We do not expect to see any significant inter-year effects, and therefore do not believe an extension of 12-24 months, which would incur additional project costs, would yield any material additional benefit.

SGS will assess the benefits of the trial results using modelling techniques, and will extrapolate the data as necessary to ensure that the different seasonal and demand/generation scenarios are covered. The bench-testing modelling regime will be populated with trial data to enable the extrapolation and generalisation of results to the wider

system, and for different load, generation, and low carbon technology implementation cases. By validating the bench models to the operational trial results, we can address a much wider set of questions (including various scale-up cases) and remove the requirement and expense of extended trials.

As QUEST will be implemented in the NMS, it is relatively straightforward to switch between trial modes and deliver a streamlined but highly effective set of trials. If necessary, we will consider making adjustments to the trial regime, for example, by changing the operating modes throughout the year, to ensure that we deliver the maximum learning. The 12-month trial period with any alternate QUEST configurations will allow important architecture, design, decentralisation, and co-ordination questions to be addressed without an unnecessarily lengthy project.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#15**	**Pro forma section**	**Section 2**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**The previous voltage projects (CLASS, etc.) provided learning on customer behaviour as far as voltage and losses are concerned. Which customers were identified as voltage sensitive? What additional learning about behaviour do you hope to gather through QUEST.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Previous Electricity North West innovation projects, including CLASS, have established that the majority of customers do not discern voltage control. However, it is recognised that some atypical customers, usually I&C, such as heavy industry, may operate equipment that is especially sensitive to routine voltage variations, either by design or by configuration, even though supply voltage levels are within statutory limits. These customers may configure their equipment based on the supply voltage characteristics they would traditionally expect to receive from our network.

However, we are aware of a need to change the way in which we control voltage, for instance, by operating more widely within the permissible voltage range thereby realising considerable benefits for customers.

During QUEST we will engage with several customers that we could expect to be representative of voltage-sensitive customers, to learn more about how they operate their systems and configure their equipment. This understanding will allow us to produce recommendations for them to review their strategies, based on how our system will operate going forward.

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Project Name	**QUEST**		
Question number	**#16**	**Pro forma section**	**Section 3**
Question date	**25/08/20**	**Answer date**	**28/08/20**
Question summary	**The Base Case that is presented here assumes increase in capacity based on traditional reinforcement or flexible services. However, that allows other interventions already funded (such as those from CLASS) to be counted as part of the benefit of the current proposal. Why was the base case not taken as that using the voltage management tools already available and the method case as the benefit when the QUEST method is applied in addition to the tools already available?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

A key benefit of QUEST is that it "boosts" the performance of existing voltage management techniques, thereby providing additional capacity release and benefits to customers. Currently, we could only obtain the equivalent amount of "boosted" capacity released by QUEST from our

use of traditional reinforcement and flexible services, and therefore it is entirely appropriate to use these as the Base Case for QUEST.

However, it is correct that existing voltage management techniques, such as CLASS, do provide benefits to customers already, and that in assessing the value of QUEST due consideration of these benefits must be made. Given this, we have accounted for these existing techniques by appropriately discounting the Method case benefits of QUEST by the amount gained from existing voltage management techniques.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#17**	**Pro forma section**	**Section 4**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**While the text of the proposal states that the GB benefit will only start in 2028 there is already benefit shown by 2030 in the benefits table and graphs. How was this benefit derived?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The benefits presented out to 2030 comprise the combination of benefits from:

- The Electricity North West roll-out of QUEST, which starts from 2025. At the end of the project, we will be in the position to begin our roll-out using the models, processes and learning gained from the project.
- The roll-out of QUEST across the rest of the GB DNOs, assumed to deliver benefit starting in 2028, allowing DNOs the necessary time to incorporate learning from the QUEST project within their systems. The cost of developing and integrating software solutions is spread over the first four years of roll-out. Consequently, not all of these costs are included in the 2030 numbers.

The 2030 benefits include the considerable benefits from incorporating several 'quick win' networks into QUEST, thereby releasing capacity where it is needed most, first. The early stages of our roll-out incur the highest cost due to our needing to establish and integrate the models and solution. By 2030, less than 30% of roll-out costs have been incurred compared to the cumulative total in 2050. For this reason, the cumulative benefits in 2030 outweigh the costs.

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Project Name	**QUEST**		
Question number	**#18**	**Pro forma section**	**Section 3**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**It appears that the Quest system will be business ready by the end of the project. As this is the case (rather than moving the solution from a lower TRL to that for a fits implementation) why was QUEST not considered for BaU deployment.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

In developing the project proposal we worked closely with our Project Partners, including with Schneider Electric on the centralised software. After discussion, it became clear that building the QUEST system directly into the NMS production system, as opposed to maintaining it separately as a trial system and then later building it into our NMS after successful completion of the trials, would save considerable time and cost, representing the best value for money for customers.

However, whilst the central QUEST software can be considered as business ready upon completion of the QUEST project, the full benefits of QUEST can only be obtained through the

associated deployment of enhanced voltage control equipment at substations. The QUEST roll-out is assumed to happen in an organic manner, with field devices installed as capacity release is required across the network or as existing non-QUEST ready controllers are replaced with QUEST-enabled (i.e. modern standard) devices.

As the business case for QUEST is not yet proven – a specific output of the QUEST project – it would be premature for inclusion in our ED2 business plan. However, we expect QUEST to prove the business case, which will allow for a roll-out after the project is complete.

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Project Name	**QUEST**		
Question number	**#19**	**Pro forma section**	**Section 3**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**What percentage of the current ENWL demand is fixed impedance rather than fixed power and how is that expected to change in the future? Has the present ratio been quantified and together with the future changes taken into account in the change benefit calculations.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

In common with many UK DNOs, we have not undertaken any analysis regarding the percentage of fixed impedance and fixed power demands on our network, and therefore we have no specific expectations around how this might change in future.

The voltage demand relationship used in the business case calculations was developed by the University of Manchester during our CLASS project, and is now well established across the industry. The Kp (voltage/demand ratio) values were determined by measurement at the 60 substations in the CLASS trial areas.

The substations were categorised as Domestic, Industrial and Commercial using the Elexon profile classes 1-8, and the measured Kp values were averaged for each respective category. The CLASS trials were carried out after the significant demand change associated with the banning of incandescent light bulbs.

In our BaU operation of CLASS the intelligent AVC relays re-calculate the Kp in real-time, and these values have not varied since the trials. QUEST will use these intelligent relays and will have access to the real-time values to enable accurate assessment of the demand reduction.

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Project Name	**QUEST**		
Question number	**#20**	**Pro forma section**	**Section 2**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**The scheme seems to focus on demand driven voltage issues on the network. While it may not yet be an issue on the ENWL network, other networks in GB face considerable overvoltage issues. For the benefit to be replicated the scheme will therefore have to be able to accommodate both types of network and be able to swap between modes (import/export) as the networks go through these swings on a daily /seasonal basis. Is it the intention to develop a control hierarchy that will also cope of the overvoltage conditions typical with net export conditions in networks.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

At its core, QUEST is a voltage constraint management tool that uses distributed network voltage controllers to increase or decrease the voltages in the network. On this basis, QUEST can be used to solve a range of voltage-related network constraints.

Our business case has been constructed around using QUEST to deliver voltage optimisation specifically.

However, the suitability of QUEST to address overvoltage constraints will feature as a part of the project; albeit, owing to the absence of any specific occurrences of overvoltages on our network, we will likely use our modelling work to capture the appropriate learning.

Furthermore, the QUEST Industry Steering Group, which comprises representatives from all UK DNOs and the ESO, will be actively involved in shaping the project's use cases including, if appropriate, overvoltages.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#21**	**Pro forma section**	**Section 4**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**Please provide day rates for the project resources.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Average day rates as follows:

[redacted]

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Project Name	**QUEST**		
Question number	**#22**	**Pro forma section**	**Section 4**
Question date	**25/08/20**	**Answer date**	**28/08/20**
Question summary	**Which of the project partners were selected through a competitive process and what is the reason for the approach. How is value for money ensured?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Where practicable we have used competitive processes to select Project Partners.

As there are several third parties that could provide the necessary support, the technical and customer research and analysis consultants, SGS and Impact Research respectively, were selected following a short, procurement-led tender. To ensure value for money, responses to the tender were evaluated against the criteria of relevant experience and expertise, cost, and Partner contribution.

In addition, we've selected two Project Partners which Electricity North West had previously appointed following an open tender process (i.e. chosen from our incumbent suppliers). This covers our partnering with Schneider Electric (SE) and Fundamentals Ltd.

SE are our incumbent NMS provider, and our partnering with them ensures value for money in several key areas. We have previously established their technical and delivery competence, leveraging both their extensive and existing delivery logistics and testing infrastructure, our own integrated project delivery teams, their role as a key supplier of control room systems to network operators, and their expertise in the development of advanced real-time applications for smart grid operations.

Partnering with Fundamentals Ltd allows us to build upon existing, industry-leading know-how in the development, manufacture, and installation of advanced voltage controllers. This technology plays a key role in delivering QUEST into substations, and partnering with Fundamentals thus ensures that QUEST does not have to pay to establish the requisite test and development systems, which are specific to the advanced, integrated nature of the voltage control systems. Furthermore, we can leverage the existing, appropriately authorised and trained installation teams.

The selection of SGS to deliver the ANM functionality is owing to their unique role within the industry as a lead supplier of ANM solutions, and their extensive knowledge about distribution network control. We consider that their partnering us on QUEST will ensure replicability of the method for other DNOs, thus adding further value for customers.

Finally, through partnering with the ESO we aim to ensure the QUEST solution and all associated designs are appropriately cognisant of the wider, whole-system aims in respect of voltage control at the boundary of the ESO and DNO (DSO).

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Project Name	**QUEST**		
Question number	**#23**	**Pro forma section**	**Section 3**
Question date	**25/08/20**	**Answer date**	**28/08/20**
Question summary	[redacted]		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#24**	**Pro forma section**	**Section 9**
Question date	**25/08/20**	**Answer date**	**27/08/20**
Question summary	**What will the minimum successful centralised solution look like for the project to be assessed as a success?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The software will be considered a success if we can reliably use it to prove the business case for QUEST: that by co-ordinating the real-time operation of currently discrete voltage control techniques we can deliver additional benefits to consumers. At minimum, it must be able to show that a centralised solution can deliver capacity release, as this is central to the business case.

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Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#25**	**Pro forma section**	**Section 10**
Question date	**25/08/20**	**Answer date**	**28/08/20**
Question summary	**The risk register submitted with the proposal mitigates several of the risks by allowing for additional expenditure. In most cases this mitigation has had a modest impact on the overall risk. For the key risk (the progress and success of development of the overarching algorithm and software), a number of stage gates could significantly reduce the impact (and hence the risk), for example, by timeously terminating the parts of the project that is not innovative. Can you please set out your strategy for managing the large risks related to the progress and success of the algorithm development. Did you or would you consider alternate strategies?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Our risk register contained several different risks. There are risks that we have identified during the course of our developing the submission and that we have mitigated through decisions factored into the bid, thus reducing either their likelihood or impact, or both.

Other items on the register have been constructed around their triggering a requirement for release of contingency funding. These risks are primarily mitigated by a need for additional time for completion of an associated activity, such as design, and in the event that the risk manifests, we may seek to apply for contingency release. We believe this approach is consistent with the Governance in place for contingency.

In situations where the realising of a risk is not binary (i.e. where in its manifesting there is not a subsequent 'go' / 'no go' outcome but instead there is need for alternative action), stage gates create uncertainty and their use in projects often necessitates non-parallel working, for example, where passing through a stage gate is a prerequisite to commencing a subsequent piece of work. This approach is not efficient when applied to this type of work and is likely to increase time and cost. We therefore do not believe that use of stage gates is appropriate for mitigation of the type of risks identified in QUEST.

Furthermore, our use of regular project review meetings to assess project progress and outcomes is considered to be a suitable project management technique to manage risks – an approach agreed with all Project Partners.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#26**	**Pro forma section**	**3**
Question date	**08/09/20**	**Answer date**	**10/09/20**
Question summary	**Do your estimates for reduction in losses and reduction in consumption assume a constant voltage:current relationship to 2050? If they do, please illustrate how these benefits might be moderated by change in that relationship resulting from new LCTs on the network.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Our approach to estimating the reduction in losses and consumption associated with our use of QUEST differs for HV and LV connected customers.

For HV customers, we use the voltage demand relationship initially developed in the CLASS LNCF project. The relationship is described by the following equation:

$$P = P_0 \left(\frac{V}{V_0}\right)^{k_p}$$

- where P_0 and V_0 are the power and voltage before the voltage reduction, P and V are the power and voltage after the voltage reduction and k_p is the voltage exponent of real power.

During the CLASS project trials, a range of values of k_p were calculated using network measurements, depending on seasonality and the mix of customer type as presented in table 1.

As this as HV, in our assessment of QUEST benefits, we have selected the 'mainly non-domestic' seasonal average k_p values (highlighted in blue) and assumed they remain constant out to 2050.

Table 1: k_p values calculated in the CLASS trials

	Mainly domestic			Mainly non-domestic			Mixed		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Spring	0.83	1.86	1.32	1.02	1.80	1.39	0.8	1.68	1.20
Summer	0.72	2.11	1.25	1.02	1.97	1.52	0.7	1.58	1.20
Autumn	0.67	1.91	1.31	0.95	1.98	1.53	0.71	1.8	1.23
Winter	0.87	1.93	1.33	0.86	1.85	1.47	0.7	1.91	1.23

Our estimates for the reduction in losses and consumption for LV customers used the 'CVR factor' first calculated in the Smart Street LCNF project. This produced a range between 0.97 and 1.09.

To illustrate how QUEST benefits might be moderated by changes in the relationship between voltage and demand, we have examined sensitivities on the k_p and CVR factor values used. The results are presented in table 2 with the QUEST bid assumption highlighted in blue:

Table 2: k_p 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

		Minimum	Lower Quartile	Average - Base Case	Upper Quartile	Maximum
	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)		28.00	30.22	32.62	34.38	36.32
2050 NPV at GB Scale (£m)		218.58	243.12	266.71	282.75	300.73

This reveals that QUEST maintains a positive NPV (both for ENW and GB scale) even with significant reductions to the Base Case k_p and CVR values, thus providing increased confidence in the validity of this assessment.

Furthermore, the intelligent AVC relays deployed as part of the CLASS roll-out and proposed for QUEST calculate the k_p value in real time, sharing the results with our central systems via SCADA. The relay measures the voltage and current on tap-change initiation and again on tap-change completion, and the equation above is used to determine the k_p value. A recent review of this data shows that the k_p values remain broadly consistent with the range obtained during the CLASS trials in 2015.

While the voltage-demand relationship has not changed over the proceeding 5-years, we acknowledge that there is uncertainty as to how this might change out to 2050. Given this, we will now include for an additional deliverable in the QUEST project, undertaking research on how and by what degree this relationship might change in this period. We will fund this research through an increase in our project contribution, thereby ensuring that the project cost to customers remains unaffected. We expect to conduct a competitive tender in the early stages of the project to recruit the most appropriate organisation to assist us with this research.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#27**	**Pro forma section**	**Section 4, p20**
Question date	**10/09/20**	**Answer date**	**14/09/20**
Question summary	**How will Quest be integrated with other DNOs' NMS and ANM schemes, considering that ANM deployments differ as do NMS? To what extent will this project investigate this?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

The ability to integrate QUEST functionality across the full range of NMS and ANM schemes of other DNOs, thereby ensuring its applicability and transferability beyond ENWL, is essential, and has informed our choice of supporting partners.

To ensure it is readily applicable to all UK DNOs known to have adopted different approaches in implementing NMS and ANM, QUEST aims to tackle several essential questions concerning interoperability, modularity, functional abstraction and, ultimately, vendor competition. To enable the key elements of platform openness and interoperability, which are core to the design of QUEST, it is necessary to bring together key technology partners with diverse experience with system integration to produce answers to these and other questions.

In support of this, QUEST seeks to define, develop and test whole system voltage optimisation at a functional level so that a UK DNO could, using the output of the project, contract for the implementation of QUEST on any NMS or third party system. QUEST will prepare and publish appropriate functional requirements (i.e. not those specific to SE's implementation of QUEST) with which a competent vendor could reasonably deliver the same or a similar functional solution.

In the years since its first adoption, ANM has faced similar challenges in interoperability, modularity, portability, integration, architectures and multiple use cases. Our partner, SGS, has established itself as a leader in this area, gaining vast, relevant experience in the development of sector-wide solutions to many of these challenges; and, in addition to providing the ANM needed for the QUEST trials, is ideally placed to support the development of similar solutions for whole system voltage optimisation.

To-date, ANM largely resides outside of the NMS with multiple vendor solutions. Crucially, defining the QUEST functionality (i.e. the data requirements, the tools used, etc.) in the way proposed, will allow adoption agnostic of choice of vendor and architecture. The project will explore and comment on implementation issues associated with centralised, decentralised and hybrid architectures.

Additionally, to further ensure interoperability, and as required for a 'system of systems' DSO future, NMS and ANM products are designed around open-standards. QUEST will use the latest developments in open standards, NMS and ANM capabilities (e.g. interfaces between the customer's NMS, other DSO systems, the ESO, ANM, etc.), ensuring that QUEST is as widely applicable as possible to other NMS, ANM and similar systems.

QUEST deliverables include: vendor-agnostic specifications for QUEST functionality, open-standard interfaces, crucial and timely learning on technology, and customer value. These will be captured in appropriate detail and shared at a DSO functional level, rather than a specific, proprietary systems level.

Finally, the integration from the NMS-based QUEST central platform to field devices and ANM components will use standard protocols and interfaces (many already used across DNOs), and these are known to be fully portable to other DNOs and system vendors.

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Project Name	**QUEST**		
Question number	**#28**	**Pro forma section**	**Section 3.4**
Question date	**10/09/20**	**Answer date**	**14/09/20**
Question summary	**For the counterfactual, why have all available solutions (such as soft open points, etc.) not been considered, instead only considering "the least cost option between flexible services and traditional reinforcement"?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

For the QUEST business case we have selected a counterfactual that offers a similar alternative solution to network operators, i.e. a whole distribution network solution to provide capacity release.

Currently, flexible services is the only alternative to traditional reinforcement applicable to the whole system solution. For this reason, we have assessed the least cost option between flexible services and traditional reinforcement as a counterfactual.

The "FUN-LV" solution trialled power electronic devices as soft open points within the LV network, and "Active Response" is investigating power electronics and remote switching on

both LV and HV networks. They provide localised solutions, through local management of power flows and load equalisation, to address constraints on the network in the immediate vicinity of the equipment. As such, they are not seen as appropriate counterfactuals to QUEST, which provides benefits across the whole network.

Implementing QUEST will not prevent the application of other solutions; implementing the solutions together will bring about enhanced benefits, providing the opportunity to leverage additional flexibility and optimisation.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#29**	**Pro forma section**	**Section 2**
Question date	**10/09/20**	**Answer date**	**14/09/20**
Question summary	**Understanding how voltage optimisation affects voltage sensitive customers is an important part of the project, with page 7 stating that QUEST will deliver "guidance for customers with voltage sensitive equipment." However the specification for the trial area (page 10) states it "should include at least one voltage-sensitive customer." How will a trial area with potentially just one voltage sensitive customer give you sufficient assurance that you can discharge these project aims?**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

Based on learning from the CLASS trials, we already understand that voltage optimisation affects a small number of what we describe in the QUEST bid document as "atypical" customers who operate voltage sensitive equipment, and is normally a result of how their equipment is configured. QUEST looks to take our use of voltage optimisation further, by making more extensive use of the permissible voltage range where this can be shown to deliver benefits to customers. While it is our experience that these customers are very few in number, it is our knowledge of them that prompted us to include for this in the QUEST project.

The intention of the customer research element of the project is in part to work with 50 of these atypical, voltage-sensitive customers (some of whom we may have contacted previously through past work, including LCNF) from across Electricity North West to develop customer guidance explaining how we propose to operate our network, the possible effects of this on system voltages, and how they can re-configure their existing equipment to avoid any issues.

We want to include at least one voltage sensitive customer in the trial area to give us the opportunity to conduct more detailed monitoring and testing, in order to further improve our understanding of how such equipment operates in response to variations in system voltage. However, it is important to note that the results of our wider engagement with the 50 atypical customers will not depend on this, but rather is complementary, in that the scope of the one could be reasonably informed by the outcomes of the other.

Network Innovation Competition 2020 Supplementary Answer form

Project Name	**QUEST**		
Question number	**#30**	**Pro forma section**	**3**
Question date	**29/09/20**	**Answer date**	**01/10/20**
Question summary	**In your response to SQ26, you stated you "will now include for an additional deliverable in the QUEST project, undertaking research on how and by what degree this relationship might change in this period." Please could you provide more information on the scope and method of this additional deliverable.**		

Answer (please retain document formatting and do not exceed 2 pages unless otherwise agreed with Ofgem)

We will conduct a targeted tender exercise during project delivery to ensure value for money, during which the precise methodology for this research will be confirmed. We would seek suggestions from tenderers on how they might best approach the research question.

However, we consider that the scope and method for the additional deliverable can be split into three key areas:

1. Research and stakeholder engagement

A literature review of projects and academic research into the voltage demand relationship will be conducted. Working alongside our partners, we will consult equipment vendors of low carbon technologies (e.g. ASHPs, EV chargers, LED lighting, battery inverters, PV inverters) to understand the electrical characteristics of these technologies and how they respond to changing voltages both today and in future.

We will consult a relevant company with expertise in econometric forecasting, such as Delta-EE, to get data on household load profiles which include EVs and heat pumps. Delta-EE maintain an ongoing database detailing the type of chargers expected to make up the approximately 2.9 million home charging devices predicted for the UK by 2030, as well as other types and locations of EV chargers, and also monitor the roll out of heat pumps across the UK, recording details of the various manufacturers' market shares and their respective heat pump types. As part of the Demand Scenarios project, Delta-EE conducted load forecasting work for ENWL which considered the impacts of the evolving loads and profiles resulting from the electrification of mobility and heat and understand the breakdown of typical residential loads and the extent to which each type of load (inductive, resistive, etc.) might be modified using voltage control.

2. Review network data to determine today's voltage demand relationship

The intelligent relays deployed as part of CLASS and QUEST measure the voltage demand ratio (k_P), and this data will be assessed to understand if it is changing over time. This value is captured from the relays at 15 minute intervals and stored in the NMS data historian which gives access to up to 3 years of data currently.

This will be supported by data from the LCTs (see 1, above) connected to each of the substations; for example, EV charge points, heat pumps, storage, and distributed generation connection over time.

3. Assess the future voltage demand relationship

The future uptake of LCTs is uncertain, but there are several established forecasts that provide insight and uptake scenarios we would expect to use:

- National Grid's Future Energy Scenarios (FES) to provide a national view of LCT uptake and the future characteristics of the power system in GB.
- ENWL's Distribution Future Energy Scenarios (DFES) to provide a more focused view of the future load and uptake of LCTs in a distribution network.

This data will be used in conjunction with the findings of the network data analysis (see 2, above), literature review, and stakeholder engagement (see 1, above) to estimate the future energy mix. Using methods consistent with the CLASS research, we will conduct power system modelling to determine the voltage demand relationship.

The various scenarios within the DFES will be used to perform a sensitivity analysis within the modelling and demonstrate how the voltage demand relationship is affected by factors such as seasonality, customer type, load type, and low carbon technology type.

The output of this modelling will deliver the expected voltage demand relationship and associated k_p values along a future trajectory out to 2050, to be used in the update of the project cost benefit analysis.