Question No.	Proforma section	Criteria	Topic	Question	Date question asked	Date response required	Date received	Follow up to Question #	Confidential (y/n)
1	N/A	g) Robust methodology/ready to implement		Is any engagement with the HSE planned and is it anticipated that safety cases for the devices will need to be developed and approved?	16 August 2016	18 August 2016	18 August 2016		
2	N/A	g) Robust methodology/ready to implement		Please explain the approach to ensuring physical security of the mobile units in the event that they are not situated within substation enclosures.	18 August 2016	22 August 2016	22 August 2016		
3	N/A	b) Value for money		The Full Submission Guidance states 'Enough information should be included in this [NPV] summary so that it can be used in conjunction with the data in the Full Submission Spreadsheet to enable the Panel to independently calculate the Net Present Value of each Method.' Please direct us to where you have provided this information in your submission.	25 August 2016	30 August 2016	30 August 2016		
4	N/A	Mulitple		Please provide a breakdown of background IP and its ownership that will be used by the project.	08 September 2016	13 September 2016	13 September 2016		
5	N/A	Mulitple		Please provide a breakdown of the foreground IP that will be developed during the project and its ownership (including IP funded and developed by partners).	08 September 2016	13 September 2016	13 September 2016		
6	N/A	Mulitple		Please indicate which items of background and foreground IP will be required to rollout the solution.	08 September 2016	13 September 2016	13 September 2016		
7	N/A	b) Value for money		Please provide an estimate of the potential financial value of improved CML and CI performance for WPD in the event that the project is rolled out on the Licensee scale as assumed in Appendix 1.	08 September 2016	13 September 2016	13 September 2016		
8	N/A	e) Partners and ext. funding		Please confirm the value of funding that will be spent on each project partner (incl labour and equipment costs).	08 September 2016	13 September 2016	13 September 2016		
9	N/A	e) Partners and ext. funding		Please provide an estimation of potential benefits to project partners in the event of rollout on the GB scale as presented in the benefits estimation in appendix A.	08 September 2016	13 September 2016	13 September 2016		
10	N/A	e) Partners and ext. funding		Please provide a justification of the level of contribution to the project from each project partner. The response should consider partner cost to the project and the potential to benefit post project.	08 September 2016	13 September 2016	13 September 2016		
11	N/A	Mulitple		Please provide details of the difference between the DCU and FCU. In particular, which of the functions in the FCU will also be found in the DCU and will the DCU also self-configure?	08 September 2016	13 September 2016	13 September 2016		
12	N/A	g) Robust methodology/ready to implement		The different phases of the trials follow closely on each other and are set to start one year after the programme start, creating a small window for the development of the system. Please provide further details of your testing programme and how it coordinates with your development programme. Please describe the process for developing the software and systems for the self-configuration of the FCU (and DCU if applicable), the key milestones and how these will be used to trigger the prototyping of the container and the ancillary systems.	08 September 2016	13 September 2016	13 September 2016		
13	N/A	g) Robust methodology/ready to implement		Are there any programme dependencies between the device development and the testing regime and what float is in those dependencies? If the device development is not delivered on time will the tests go ahead with a "reduced" capability system?	08 September 2016	13 September 2016	13 September 2016		
14	N/A	g) Robust methodology/ready to implement		If the Prototype 2 (Beta?) development is incomplete when the test window arrives, will the test be delayed or will an advanced prototype be deployed.	08 September 2016	13 September 2016	13 September 2016		
15	N/A	g) Robust methodology/ready to implement		In the programme "Trial Phase 1 First Prototype only" is shown as starting 12 months after project start. Can you please clarify what these tests will entail (ie. which hardware and software will be tested and which functionality of the system trialled).	15 September 2016	20 September 2016	20 September 2016		
16	N/A	g) Robust methodology/ready to implement		Can you please clarify which of the trials and tests will be simulations, bench tests, lab tests (including test facilities such as PNDC) and tests/trial on the real network.	15 September 2016	20 September 2016	20 September 2016		
17	N/A	g) Robust methodology/ready to implement		A previous response described the configuration and architecture of the system but can you please give a brief summary of the readiness of the software to be implemented for the network analysis, system configuration and system control. If fundamental research is required, how long do you estimate this will take.	15 September 2016	20 September 2016	20 September 2016		
18	n/a	a) Enviro+consumer bens		How much of the capacity and carbon savings are truly NET ADDITIONAL to GB?	20 September 2016	22 September 2016	22 September 2016		
19	N/A	a) Enviro+consumer bens		In calculating the Benefits, what assumption have you made regarding the success of other initiatives including DSM in managing down the growth in maximum demand compared to total units distributed (or put another way, in improving network load factors at the different voltage levels)?	20 September 2016	22 September 2016	22 September 2016		
20	N/A	a) Enviro+consumer bens		How many Proteus boxes are needed for the solution to breakeven (with and without different technical solutions)?	20 September 2016	22 September 2016	22 September 2016		
21	6	g) Robust methodology/ready to implement		As per the Full Submission Guidance, please state the level of protection required against cost over-runs and (if Direct Benefits are identified) unrealised Direct Benefits. This should also be included at the top of Section 6 in your resubmission.	20 September 2016	22 September 2016	22 September 2016		
22	N/A	g) Robust methodology/ready to implement		Have any simulations been undertaken to gain confidence in the Proteus solution?	27 September 2016	29 September 2016	29 September 2016		
23	N/A	Mulitple		The Proteus business case calculates two key areas of benefit from use of the Proteus temporary solutions: the benefit of early solution of network issues, and the benefit of optimising the permanent solution to be implemented. At what year does the business case break even with only the benefit of early solution?	N/A	N/A	04 October 2016		

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	1
Question date	16/08/16	Answer date	18/08/16
Submission section question relates to			
Topic	Safety Considerations		
Question	Is any engagement with the HSE planned and is it anticipated that safety cases for the devices will need to be developed and approved?		
Notes on question			
Answer	All devices developed during the project will be subject to rigourous testing to ensure safe operation and compliance with relevant regulations. A failure mode analysis will be completed early in the project to identify the risks associated with use of the devices. This analysis will inform: • The design of the equipment, • The site selection process, • Policy documentation and technical standards requirements, and • Any further actions that need to be undertaken in order to ensure that the equipment can be used safely. The Project will be undertaken in accordance with the Ricardo Product Development system with an experienced team so that the relevant safety considerations and processes are included. Consultation with Health and Safety respresentatives and policy enginners from WPD will be undertaken throughout the project to ensure specialist network advice is also incorporated. All installations will be undertaken in accordance with WPD's Distribution Safety Rules. Engagement with the HSE is not envisaged at the present time, but will be considered should a specific need arise.		

Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	2
Question date	18/08/16	Answer date	22/08/16
Submission section question relates to			
Topic	Physical security of the mobile units		
Question	Please explain the approach to ensuring physical security of the mobile units in the event that they are not situated within substation enclosures.		
Notes on question			
Answer	Securing mobile, temporary assets is something that WPD have considerable experience in; they have over 300 towable generators which are deployed across the WPD network. The approach taken for securing the Proteus units will be finalised during the initial design stages of the project, but is likely to include: • Locks on doors and openings • Tow hitch locks and wheel clamps, or potentially removal of wheels while onsite • Alarm systems – both audible alarms, and alerts and notifications sent instentaniously through the remote monitoring and management system • GPS tracker – this functionality will be included in the equipment monitoeing anyway, but could be used in case of theft. • Litton type connections, with danger of death notices etc.		
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	3
Question date	25/08/2016	Answer date	30/08/2016
Submission section question relates to			
Topic	b) Value for money		
Question	The Full Submission Guidance states 'Enough information should be included in this [NPV] summary so that it can be used in conjunction with the data in the Full Submission Spreadsheet to enable the Panel to independently calculate the Net Present Value of each Method.' Please direct us to where you have provided this information in your submission.		
Notes on question			
Answer	The details of the assumptions made for the Net Present Value calculations in the business case are explained in Appendix C of the submission. The table below indicates the assumptions made, and indicates the location in the document where they are given. We have also included the detailed assumption data in the attached document.		

Assumption	Value	Reference
Discount rate	As in guidance: 3.5% for the first 30 years and 3.0% thereafter	p53 sec C.2. para 3
First year of roll out	2022	p53 sec C.2. para 1
Roll Out: WPD Scale	8 in the first year in the average scenario, which can be doubled each year up to 180. This is also limited by need.	p54, last para
Roll Out: GB Scale	25 in the first year in the average scenario, which can be doubled each year up to 550. This is also limited by need.	p55, penultimate para
No sites per year per solution	3	p53 sec C.2. para 1
Lifetime of equipment	15 years	p53 sec C.2. para 1

	Forecasted number of substations with Issues	Graph based on results of the Transform model	p50, Fig C.1
	Proportion of GB feeders in WPD	32%	p54, sec 'Licensee Scale', para 2
	Cost of Base case design solution	£ 5,000	p51, table line 4, “Base Case” column
	Cost of temporary solution	£ 10,556	p51, table line 4, “Proteus Case” column
	Saving from early solution	This is estimated to be approximately £14k per issue in 2022, increasing to £26.5k in 2050.	p52, 'Avoided Cost due to Faster Solution of Issue' Section
	Cost of permanent solutions - Base Case	Simple traditional solution: £5k, Substation reinforcement: £30k Cable reinforcement: £70k Complex or high cost solution: £150k	p51, table line 5, “Base Case” column
	Cost of permanent solutions - Proteus Case	Simple traditional solution: £5k Substation reinforcement: £30k Cable reinforcement: £70k Complex or high cost solution: £100k Non-traditional solution: £2k to £60k Doing nothing: £0	p51, table line 5, “Proteus Case” column
	Permanent solution proportions	Chart of the proportions of issues will be solved by each potential permanent solution	p52 Fig C.2
Attachments	Proteus business case NPV assumption data		

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	04
Question date	080916	Answer date	130916
Submission section question relates to	Multiple		
Topic			
Question	Please provide a breakdown of background IP and its ownership that will be used by the project.		
Notes on question			
Answer	The below table summarises the Background IP currently envisaged to be utilised by the project. This will be transferred to an IP regisiter at project set up and reviewed and maintained throughout the project to ensure its accuracy as solutions are developed.		

Ref:	Function/Item	Ownership
B1	Electronic architecture of the existing Power Electronic Devices	TPS
B2	Knowledge and techniques for secure, safe and Functional connection and control of LV power electronic devices	TPS
B3	Simulation, modelling, analysis and design documentation	TPS
B4	Design of Power Electronic Devices including constituent parts such as Silicon Carbide switching devices, cooling and magnetics	TPS
B5	Knowledge of designing controllers and simulation of power electronic devices	Project Consortium

	B6	Knowledge and design of wireless and non-invasive monitoring equipment to measure temperature and complex power in LV substations	Ash Wireless
	B7	Knowledge and systems for online cable measurement using Time Domain Reflectometry.	Ash Wireless
	B8	Knowledge and systems for synchrophasor measurement waveform properties.	Ash Wireless, Ricardo
	B9	Knowledge and systems for wireless, GPRS and meshed local radio communications including over-the-air software and firmware updates.	Ash Wireless
	B10	Understanding and experience of designing for substation and LV systems and environments.	Project Consortium
	B11	Processes & systems for technology integration	Ricardo
	B12	Testing methods for various appropriate technologies	Ricardo
	B13	Existing knowledge & experience of various appropriate technologies	Ricardo
	B14	Various Visualisation tools and algorithms	Ricardo
	B15	Knowledge and design of various Monitoring Solutions	Ricardo, Ash Wireless
	B16	Knowledge and design of real Time Event Monitoring	Ricardo, Ash Wireless
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

<table>
<tr><td>Project code</td><td>WPD NIC 003</td><td>Question Number</td><td>05</td></tr>
<tr><td>Question date</td><td>080916</td><td>Answer date</td><td>130916</td></tr>
<tr><td>Submission section question relates to</td><td colspan="3">Multiple</td></tr>
<tr><td>Topic</td><td colspan="3"></td></tr>
<tr><td>Question</td><td colspan="3">Please provide a breakdown of the foreground IP that will be developed during the project and its ownership (including IP funded and developed by partners).</td></tr>
<tr><td>Notes on question</td><td colspan="3"></td></tr>
<tr><td>Answer</td><td colspan="3">The below table summaries the Foreground IP currently envisaged to be developed by the project. This will be transferred to an IP regisiter at project set up and reviewed and maintained throughout the project to ensure its accuracy as solutions are developed.
<table>
<tr><th>Ref:</th><th>Function/Item</th><th>Ownership</th></tr>
<tr><td>F1</td><td>Low Cost Unified Power Flow Controller (UPFC) transformer design & manufacture.</td><td>TPS, Transformer supplier</td></tr>
<tr><td>F2</td><td>Designs and configurations for Power Electronic converter devices and Magnetics and associated components.</td><td>TPS</td></tr>
<tr><td>F3</td><td>Algorithms for optimal configuration, operation and control of temporary solutions and components.</td><td>Open</td></tr>
</table>
</td></tr>
</table>

	F4	Design of system for determining conductor length and impedance and synchrophasor characteristics using GPS.	Ash Wireless
	F5	Installation and operating procedures.	Project Consortium
	F6	Designs and Specifications related to integrated Proteus temporary solution units.	Ricardo
	F7	Integration methodologies for Proteus temporary solution software.	Ricardo
	F8	Analytical, visualisation and monitoring tools to assess the performance of the Proteus hardware and control algorithms.	Project Consortium
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	06
Question date	080916	Answer date	130916
Submission section question relates to	Multiple		
Topic			
Question	Please indicate which items of background and foreground IP will be required to rollout the solution.		
Notes on question			
Answer	The below table summarises the foreground IP currently envisaged to be required to roll out the project. The background IP and know how used for the Proteus project is likely to be useful to roll out the Proteus solutions, but will not be essential, and could be substituted for an expert level knowledge and experience in the relevent subject areas.		

Ref.	Function/Item
F1	Low Cost Unified Power Flow Controller (UPFC) transformer design & manufacture
F2	Designs and configurations for Power Electronic converter devices and Magnetics and associated components.
F3	Algorithms for optimal configuration, operation and control of temporary solutions and components.
F4	Design of system for determining conductor length and impedance and synchrophasor characteristics using GPS.
F5	Installation and operating procedures.
F6	Designs and Specifications related to integrated Proteus temporary solution units.

	F7 | Integration methodologies for Proteus temporary solution software.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	07
Question date	08/09/2016	Answer date	13/09/2016
Submission section question relates to	b) Value for money		
Topic			
Question	Please provide an estimate of the potential financial value of improved CML and CI performance for WPD in the event that the project is rolled out on the Licensee scale as assumed in Appendix 1.		
Notes on question	Within the business case, it is assumed that the future challenges to the electricity system will cause an increase in CIs and CMLs unless mitigating action is taken. Proteus is a potential mitigation for this. Therefore, Proteus will not decrease the CIs and CMLs from their current values, but will help mitigate the increase of them due to the uptake of LCTs.		
Answer	It was assumed that for any application of Proteus, where the network issue would have caused network outages and therefore CIs and CMLs, that these are prevented once the Proteus temporary solution is in place. It should be noted that one or more outages may have occurred before this point, to trigger the identification of the problem and the deployment of the temporary solution. The table below shows the results of the Proteus business model for the CI and CML benefit of the Proteus solution if it is rolled out on a licencee scale. This is the average of the high and low scenarios from the Transform model, and assumes that the cost of CIs and CMLs remains the same as today. The annual fluctuation of this value is due to the charactoristics of the Transform model, which does not show issues occurring at a steady rate over time, but in an unpredictable manner. While the manifestation of issues are expected to share this characteristic, the details of the pattern are not known. For example, issues may increase or decrease sharply from year to year, but it is unlikely that the pattern will directly match what is shown in the model.		

Potential financial value of avoided CI and CML from Proteus (2016 value, average scenario)	
2022	£ 277,607
2023	£ 548,164
2024	£ 1,082,507
2025	£ 2,137,918
2026	£ 3,420,408
2027	£ 2,904,072
2028	£ 3,254,855
2029	£ 2,833,645
2030	£ 3,741,288
2031	£ 2,765,923
2032	£ 3,077,232
2033	£ 1,248,634
2034	£ 3,216,260
2035	£ 3,145,599
2036	£ 2,607,657
2037	£ 2,614,824
2038	£ 2,805,967
2039	£ 5,039,411
2040	£ 4,419,227
2041	£ 4,927,550
2042	£ 4,873,168
2043	£ 3,389,841
2044	£ 4,178,644
2045	£ 2,357,969
2046	£ 812,996
2047	£ 2,517,387
2048	£ 4,633,962
2049	£ 2,842,004
2050	£ 746,912
Total	**£ 82,421,630**

Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: PROTEUS

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	08
Question date	08092016	Answer date	13092016
Submission section question relates to	e) Partners and ext. funding		
Topic			
Question	Please confirm the value of funding that will be spent on each project partner (incl labour and equipment costs).		
Notes on question			
Answer	The full project budget for the four project partners amounts to £8,450.50k, inclusive of labour, equipment and subcontrators but exclusive of travel & expenses and contingeny.		

Partner	*Total cost £k*
WPD	■■■■■■
Ricardo	■■■■■■
Imperial College	■■■■■■
Turbo Power Systems	■■■■■■

The NIC funding that will be spent on the project partners amounts to £7,086.65k (exclusive of travel & expenses and contingeny).

Partner	*NIC funding £k*
WPD	■■■■■■
Ricardo	■■■■■■
Imperial College	■■■■■■
Turbo Power Systems	■■■■■■

Ash Wireless will participate in the project as a supplier under subcontract to Ricardo. The Ricardo 'Total' budget above includes ■■■■■■ provision for the proposed Ash Wireless subcontract. The Ricardo 'NIC funding' budget includes ■■■■■■ for the proposed Ash Wireless subcontract.

Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	09
Question date	08/09/2016	Answer date	13/09/2016
Submission section question relates to	e) Partners and ext. funding		
Topic			
Question	Please provide an estimation of potential benefits to project partners in the event of rollout on the GB scale as presented in the benefits estimation in appendix A.		
Notes on question			
Answer	The financial benefits included in Appendix B are made up of: • benefits of early mitigation of the network issue (for example reduction in CIs and CMLs), and • benefits of optimised permanent solution, enabled by the additional time and informatopn provided by the temporary solution. Both of these benefits will be to WPD, which can be passed on to customers. In order for the temporary solution to be rolled out following completion of the project, it will need to be commercially produced. The production of this product may be done by project partners and/or other third parties. This will require a seperate agreement between those third parties, the owners of the relevent IP, and WPD. This agreement will enable value to be fed back to customers, through sharing of a proportion of profits up to an agreed value and time cap.		
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	10
Question date	08/09/2016	Answer date	13/09/2016
Submission section question relates to	e) Partners and ext. funding		
Topic			
Question	Please provide a justification of the level of contribution to the project from each project partner. The response should consider partner cost to the project and the potential to benefit post project.		
Notes on question			

Answer

The contribution from the relevent partners are as follows:

Partner	Cost	Contribution
WPD	■■■■■■	■■■■■■
Ricardo	■■■■■■	■■■■■■
Turbo Power Systems	■■■■■■	■■■■■■
Imperial College	■■■■■■	■■■■■■

For consistency with the response to Q8 the costs and contributions presented above exclude T&S and contingency and VAT

The level of contribution from the partners demonstrates commitment to the project whilst balancing the intrinsic risks and commercial uncertainties. The funding contributions of the non-DNO partners, Ricardo, Turbo Power Systems and Imperial College will be in the form of discounted fees.

Partner	Comment
WPD	This is the compulsory contribution from the network licensee
Ricardo	Ricardo is the lead partner within Proteus. This is a significant contribution provided by Ricardo, ■■■■■■. This is provided to demonstrate the commitment to the project and its success. The level of contribution has been informed by consideration of

	<table><tr><td></td><td>- The intrinsic risks and uncertainty in the outcome of innovation of this type (technical challenges and benefits arising) - The large demand on Ricardo resources.</td></tr><tr><td>Turbo Power Systems</td><td>The role of Turbo Power Systems within the project includes development and support of key technologies. This contribution again demonstrates their commitment to the project and its success.</td></tr><tr><td>Imperial College</td><td>Within Proteus, Imperial college will provide the capabilities around diagnostics and control logic. This contribution, provided in a discount on fees, represents their commitment to the project and its success.</td></tr></table>
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	11
Question date	080916	Answer date	130916
Submission section question relates to	Multiple		
Topic			
Question	Please provide details of the difference between the DCU and FCU. In particular, which of the functions in the FCU will also be found in the DCU and will the DCU also self-configure?		
Notes on question			
Answer	The following differences between the DCU and the FCU are envisaged: 1. The Series Transformer will not be present in the DCU; 2. Only 2 Power Electronic devices will be housed, as opposed to the 3 Present in the FCU; 3. Consequently the Flexible LV board and associated network connection requirements will be smaller versions of those found in the FCU. The DCU will be able perform the following functionality: • 2-port SOP; • STATCOM; • Power Electronic Voltage Regulator; and allow • Connection of an Energy Storage device or Diesel Generator. The FCU will be installed in the 'key substation', which is the LV substation which has been identified as being the focus of the solution. The DCU may be installed at link boxes, over head lines, and at other points in the network, which will enable intervention to be input where it is most useful. The Proteus system as a whole will self-configure based on the data provided by the installed dispersed monitoring equipment. Hence the		

	autonomous control system will determine the configuration of the equipment in the FCU and also any connected DCUs.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	12
Question date	08/09/2016	Answer date	13/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	The different phases of the trials follow closely on each other and are set to start one year after the programme start, creating a small window for the development of the system. Please provide further details of your testing programme and how it coordinates with your development programme. Please describe the process for developing the software and systems for the self-configuration of the FCU (and DCU if applicable), the key milestones and how these will be used to trigger the prototyping of the container and the ancillary systems.		
Notes on question			
Answer	The trialling of the Alpha unit starts in September 2018; 21 months after the start of the project. This will trigger the review of the designs of the unit, and the development of the Beta unit, trials of which will begin over 1 year later. There will be "learning on assembly" of the mobile units providing a flexible unit that is safe for transportation and appropriate for deployment, whilst encompassing the "design for manufacture" aspects to allow this to be scaled and sized for different WPD sites in the future. In general, the system sub-components uses proven underpinning technology so most development is in the integration of systems and the interaction of the system components. Ongoing learning will be fed back through formal engineering change requests from manufacture and in-field learnings to improve the overall robustness and reliability of the product. Testing shall be carried out on each individual component that forms part of the final assembly (e.g. power electronics operating in all modes). These		

	validation results provide confidence in the overall assembly of the system in addition to ensuring these validation tests results are representative of WPD on site requirements. The overarching control software, the most novel aspect with the highest degree of leap-technology, shall be tested in a simulation environment (SIL) to provide a high degree of confidence in the algorithm. It will then be deployed in format using a processor in the loop (PIL) approach to ensure the implementation is correct, with the final deployment being tested using hardware-in-the loop (HIL) testing before live operation. Following the component testing, system testing will be performed to ensure the correct interaction between components. Finally, controlled live testing will be performed in a test network to confirm that the system functionality is as espected. By performing this rigorous testing programme the product is expected to have significantly fewer issues during the field trials and provide a test infrastructure that will be utilised to assess, implement and validate changes that results from unpredicted in-field behaviour. This will ultimately lead to faster and more effective updates to the system. The design of the self-configuration system will be completed by running two linked computers and a partitioning of the control and simulation tasks. The first computer will perform network simulations (including load flows) and model the operation of a defined section LV network plus the Proteus hardware including the low level software. It allows Proteus to assess the response of the network to candidate control actions. The second computer is the heart of Proteus controller and will be developed and tested during the project. The Proteus controller consists of three major components: (i) an LV network analysis tool, (ii) a configuration engine and (iii) a supervisory controller for the Proteus hardware (such as power electronic devices). The LV network analysist tool will use information from sensors placed in the LV network (modelled on the first computer) to produce a representation of the LV network and understand the constraints that exist within this network. The configuration engine will determine the configuration of the hardware required to solve the LV constraint and the supervisory controller will send optimal set-points which the Proteus hardware will follow when effecting solutions to the LV network constraint. The milestone based approach of formal hardware and system development will be followed (as shown at a top level in Appendix I), this is a standard waterfall methodology to system engineering and considered best practice for this application. This entails the development of full specifications, simulation and integration activities. Upon completion of a system specification, this will be used to provide component specifications including software functionality specification and overall control approach. Upon acceptance of the specification by suppliers, the detailed system will commence with flexibility or additional capacity where high technical risk or challenges are understood to be present through DFMEA and DFM analysis.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code		Question Number	13
Question date	08/09/2106	Answer date	13/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	Are there any programme dependencies between the device development and the testing regime and what float is in those dependencies? If the device development is not delivered on time will the tests go ahead with a "reduced" capability system?		
Notes on question			
Answer	The ultimate solution, as with all aspects of new technology, needs to be tested as a deployed system by project completion to achieve all of the goals. The software level and included application modules can be grown through the project and managed using rigorous version control. Deployment onto the "in-field" trails will be used to maximise the live time of each function. Hardware modules are currently available in pre-sample form, although upgrades are required to fit the size, weight and thermal needs of the PROTEUS system. Should these upgrades be delayed, there is opportunity between deployments for upgrading the FCU/DCU as needed but deployment of the initial units with reduced power / functionality and or potentially increased weight (and thus larger form factor) could be considered. Engineering judgement will be used to maintain the balance between getting sufficient solution trial time and waiting for the "optimized solution" to be available. Development plans and discussions held between parties to date have given confidence that the proposed overall plan to deliver on-time and budget is suitable, and that proportionate risk mitigation and contingency is included.		

Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	14
Question date	08/09/2106	Answer date	13/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	If the Prototype 2 (Beta?) development is incomplete when the test window arrives, will the test be delayed or will an advanced prototype be deployed.		
Notes on question			
Answer	Engineering judgement will be used to maintain the balance between getting sufficient solution trial time and waiting for the "optimized solution" to be available. If required, an advanced prototype or upgraded Prototype 1 (alpha) will be deployed to maximise the testing duration.		
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	15
Question date	15/09/2106	Answer date	20/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	In the programme "Trial Phase 1 First Prototype only" is shown as starting 12 months after project start. Can you please clarify what these tests will entail (ie. which hardware and software will be tested and which functionality of the system trialled).		
Notes on question			
Answer	The programme displayed in Figures 5.1 & 9.1 show "Trial Phase 1 First Prototype only" beginning in January 2018. Further programme detail is given in the programme provided in Appendix G. From this it can be seen that the initial activities of this trial phase are the site selection process (ID 75) and the documentation design (ID 80). "Trial Phase 1 (Alpha Units only)" (ID 85) is scheduled to begin on Monday the 24th of September 2018, 21 months into the project. This Trial Phase activity represents the use of the initial Alpha units in operational LV networks. As such the complete functionality of the Alpha units will be trialled, with all of the hardware and software developed tested. This will include use of the system to demonstrate Soft Open Points, UPFC, Asset cooling etc. as well trialling the automatic configuration algorithm, remote management and monitoring systems. The trial will involve physically relocating the system between different LV networks to enable the full functionality to be tested.		

	The purpose of this trial is to demonstrate the developed system in real world scenarios and to determine learning for implementation in the Beta Units. Prior to this trial phase there are additional tests on the system and its components which are further discussed in our answer to Question 16. We have noticed that the outline programme used in Figures 5.1 and 9.1 has some discrepancies against the programme provided in Appendix G. These have been corrected on the attached revisions to these diagrams.
Attachments	Outline programme of SDRCs and Dissemination events.pptx

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	16
Question date	15/09/2106	Answer date	20/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	Can you please clarify which of the trials and tests will be simulations, bench tests, lab tests (including test facilities such as PNDC) and tests/trial on the real network.		
Notes on question			
Answer	Initial simulations will be performed during the inception phase of the project, and these will be used to inform the specifications of the various constituent hardware and software. Referring to the programme provided in Appendix G, these simulations will take place in activities 9 (Hardware), 36 (Remote Management System), 45 (Logic and Control algorithms) and 54 (Monitoring System). Individual component testing for each item will be undertaken as part of activities 15 (Alpha Hardware), 27 (Beta Hardware), 38 (Remote Management System), 47 (Logic and Control algorithms) and 56 (Monitoring System). Initial testing of the integrated hardware solutions will be undertaken as part of activities 17 (Alpha) and 29 (Beta). This testing will be to ensure the basic functionality of all of the hardware and that interfacing has been completed correctly. Testing of the complete units in a live but non-operational network environment (for example PNDC or another suitable test network) takes place in activities 72 (Alpha units) and 73 (Beta units).		

	Trials in real LV networks take place in activities 85 (Alpha units only), 87 (Alpha and Beta units) and 89 (Alpha and Beta units, stressed network conditions). We have noticed that the outline programmes used in Figures 5.1 and 9.1 have some discrepancies against the programme provided in Appendix G. These have been corrected on the attached revisions to these diagrams.
Attachments	Outline programme of SDRCs and Dissemination events.pptx

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	17
Question date	15/09/2106	Answer date	20/09/2016
Submission section question relates to	g) Robust methodology/ready to implement		
Topic			
Question	A previous response described the configuration and architecture of the system but can you please give a brief summary of the readiness of the software to be implemented for the network analysis, system configuration and system control. If fundamental research is required, how long do you estimate this will take.		
Notes on question			
Answer	The Proteus hardware consists of six key devices: 1. Soft Open Point 2. UPFC 3. Voltage regulator 4. Battery System 5. STATCOM 6. Asset cooling The control for each of these devices is well established in published literature. The design of the required hardware and the low-level control will be undertaken by the equipment vendor on their preferred platform. An interface between the low-level control and the supervisory controller will be developed at the beginning of the project. The interface will consist of transferred signals such as voltage set-point, power set-point and a number of enable commands to reconfigure the hardware. The project consortium has a strong track record in developing and integrating hardware and software systems from recent experience gained on the FUN-LV and other projects.		

	The Proteus hardware location optimisation algorithm, to solve network constraints and the optimisation of the mode-of-operation of the Proteus hardware, is innovative and has yet to be developed. Optimisation techniques described in published literature will be used and applied to the LV networks (as provided by WPD) and the Proteus hardware. The first 16 months of the project has been allocated to the specification and development of these optimisation algorithms. A commercial load-flow solution for example IPSA or ETAP will be used to support the development and testing of the solution in simulation. The optimisation will continue to be developed throughout the project, with lessons learnt from initial field trial results used to further develop the algorithms. In summary, the design and control of the hardware is documented in published literature and the innovative optimisation techniques derived from existing previously documented techniques. No Fundamental Research is required. A list of reference material can be provided if required.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	18
Question date	20/09/2106	Answer date	22/09/2016
Submission section question relates to	Enviro+consumer bens		
Topic			
Question	How much of the capacity and carbon savings are truly NET ADDITIONAL to GB?		
Notes on question			
Answer	The capacity and carbon savings included in the Proteus proposal are intended to be additional for GB to any other such amounts that arise from other innovations and are directly related to the implementation of the Proteus technology. Hence The methodology used in the Proteus business case is aimed at deriving such additional net benefits to GB. The approach used is described in more detail below. **<u>Capacity Benefits</u>** The **capacity benefits** are derived using the following assumptions: • Three quarters of available units are in service at any time; • Each Proteus deployment creates a temporary capacity increase of 200kVA. This is a prudent assessment of the likely level of capacity increase reflecting the different types of deployment and the benefits that each such type can be expected to bring. For example		

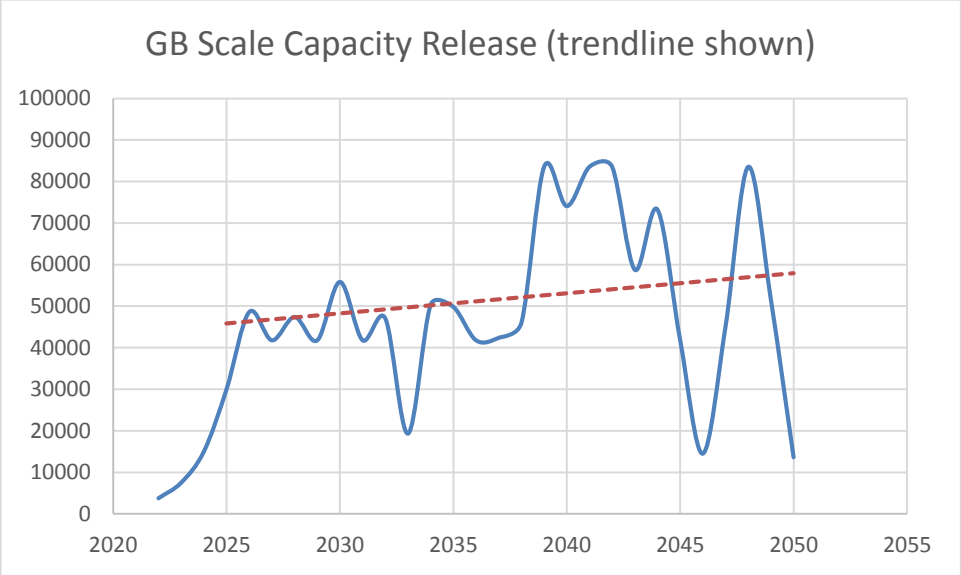
- Asset Cooling is expected to release capacity in the order of a few kVA depending on circumstance;
- Soft Open Points can release capacity up to the rating of the device (which in this instance is 400kVA), but often to a lesser degree according to the individual situation.
- Addition of battery storage or additional generation can provide additional capacity up to the rating of the storage or generation, which may vary depending on application,
- The Unified Power Flow Controller has the potential to release more capacity than the device rating, but once again this is dictated by the situation;
- Easing of voltage constraints on networks, as may be achieved by the UPFC or Voltage regulator functions provides an amount of additional capacity that varies considerably and is determined by detailed assessment of the particular scenario.

- Hence at any one time the average capacity released throughout the lifetime of a single Proteus Temporary Solution is 150kVA

We have noted that the Capacity benefits summary table presented on P17 of the FSP have been presented as cumulative figures, as per the Financial and Carbon benefits. As the Capacity released by the Proteus solution is a temporary increase present only for the period where it is installed this approach is not the most appropriate. A revised table/figure showing the capacity released in each year is presented below.

Capacity Release (kVA)	**2020**	**2030**	**2040**	**2050**
Single Implementation	0	150	0	0
WPD Scale	0	16,114	17,215	18,316
GB Scale	0	48,238	53,565	57,924

Please note that the figures in the table above are taken from the estimated trend of capacity benefits. This is done because the profile of capacity released is uneven across the years, which reflects the 'clumpy' nature of the expected capacity issues caused by clusters of uptake of LCTs as well as influence of other factors such as weather. The graph below shows the estimated capacity release over GB for the average scenario.



The shape of the first part of this graph is dictated by the roll out of the Proteus solution. The trend line shown does not include this roll out, but is representative of the capacity release after 2025.

It was decided that due to the variable nature of the capacity release in time, that providing values for individual years would be misleading, and would not be representative of the true trends in capacity release. Therefore, the numbers provided in the table above use the trend line shown to represent an average trend of annual capacity release.

As per the answer to Question 19, the Proteus Solution is not intended to replace other solutions for increasing LV network capacity. Instead it will reduce the stress on the network between the identification of an issue and its resolution, whilst also informing the selection of the most appropriate capacity increasing solution.

Carbon Benefits

The project will provide direct and indirect **carbon benefits**.

By indirect carbon benefits we mean those that arise from enabling the connection of Low Carbon Technologies on a wide scale. The benefits of this are significant, both to the energy network and to society, but are also particularly difficult to quantify and hence no numeric analysis is included, though they are an important driver of the project.

The direct carbon benefits are derived from the ability of the Proteus Solution to prevent stranded assets, i.e. installing assets which, in the event, are not required. In the absence of Proteus DNO will need to utilise a preventative approach which will inevitably – due to the timescales required for investment and thus the forecasting assumptions that will need to be made - result in situations where network reinforcement has been undertaken in anticipation of an issue, but where ultimately the issue does not materialise. The Proteus approach allows DNOs the opportunity to advance the time at which reinforcement decisions need to be made and thus to more closely target

	reinforcement expenditure at those networks experiencing capacity constraints, rather than relying exclusively on a preventative approach. Our methodology for deriving these benefits initially estimates the embedded carbon associated with the proportion of reinforcement works that, in the absence of Proteus would be stranded. This proportion is set as 5% of total reinforcement expenditure and this is intended to be a conservative assessment of the extent of such stranding and is based on DNO operational experience. Finally, the carbon associated with the manufacture and operation of the Proteus solution has been assessed and is subtracted from the carbon benefits of avoiding stranded assets to produce a small net carbon benefit.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	19
Question date	20/09/2106	Answer date	22/09/2016
Submission section question relates to	a) Enviro+consumer bens		
Topic			
Question	In calculating the Benefits, what assumption have you made regarding the success of other initiatives including DSM in managing down the growth in maximum demand compared to total units distributed (or put another way, in improving network load factors at the different voltage levels)?		
Notes on question			
Answer	Network innovations and management techniques such as DSM are capable of reducing network overloads, and therefore if they are successful, would reduce the number of cases where the Proteus equipment would be necessary. DSM has been trialled in a number of projects including "Low Carbon London" and the "Consumer Led Network Revolution", whilst "My Electric Avenue" investigated consumers' willingness for controlled charging of Electric Vehicles. Each have demonstrated that DSM is a viable technique to varying degrees, though a large level of consumer engagement is required. As a result, DSM is believed to be one technique for the management of future network issues, though not capable of indefinitely deferring reinforcements. The Smart Grid Forum Workstream 7 "DS2030" report reflects this view in assuming a 10% application of DSM which can defer reinforcement by up to 4 years. The assessments of the frequency of required use of the Proteus equipment are based on the TRANSFORM model. This model was an output from the Smart Grid Forum workstream 3 that assessed the changing demands on Distribution Networks and the most cost effective way to reinforce them. Four scenarios are presented with various uptakes of Low Carbon Technologies (in		

	particular Electric Vehicles, Heat Pumps and Photovoltaics) and differing generation mixes to derive upper and lower bounds. The extent to which DSM is adopted by consumers is also varied between the four scenarios so that reasonable views of the demands that the network must meet are presented. The Proteus business case uses the highest and lowest potential network overload profiles as derived from the TRANSFORM model, to reflect the uncertainties of the future energy system. However, even in the lowest profile case, where the highest degree of DSM adoption is assumed, the benefits of the Proteus solution are significant. The other influence that DSM may have on the Proteus business case modelling is its potential as a permanent solution which could be implemented to provide a permanent solution to a network issue after the initial Proteus implementation. The Proteus business case assumes that the base case permanent solutions consist of traditional reinforcement options only, and that the Proteus solution widens this choice to more innovative options. In each case, for the purpose of modelling, a few representative solutions were used to represent the possible range, and DSM would be included in the range of solutions offered. The Proteus temporary solution brings the opportunity to optimise the selection and design of the permanent solution including DSM. It should be noted that the business case modelling is based solely on issues caused by overloaded networks, as this has the clearest cost benefit in today's market. However, the Proteus solution would be capable of supporting the solution of other network issues, such as voltage (including highly dynamic voltages), power factor, and fault level control. Innovative network solutions, such as DSM, and an increased number of LCTs may have other, sometimes unforeseen, impacts on networks, for example producing unexpected load patterns or in other aspects such as voltage (including highly dynamic voltage issues), power factor, fault level etc. The Proteus solution would be suited to supporting the transition to such LCT technologies and managing the issues as they arise.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	20
Question date	20/09/2106	Answer date	22/09/2016
Submission section question relates to	Enviro+consumer bens		
Topic			
Question	How many Proteus boxes are needed for the solution to breakeven (with and without different technical solutions)?		
Notes on question	The question asks for the breakeven analysis to be performed with and without different technical solutions. It is assumed that this refers to the range of permanent solutions, which in the business modelling so far, is different across the Base and Proteus cases. Therefore, the analysis has been done assuming: a) the same assumptions as used and described previously, and b) that the choice and design of permanent solutions will not be impacted by the installation of the Proteus temporary solution, and therefore the benefits gained are purely from the fast solution of the original issue.		
Answer	In order to answer this question, we have undertaken additional breakeven analysis, based on the same project and unit costs and roll out assumptions that have been used for the business case, and described previously. For this modelling, a breakeven year of 2035 was selected as a reasonable breakeven point, which is 15 years after the end of the Proteus project. The modelling shows that, using the same base case and Proteus case assumptions used and described previously, 15 Proteus Temporary Solutions are needed to break even by 2035. Note that this assumes that each solution is deployed on average 3 times per year, at an average duration of 3 months each, beginning in 2022. Therefore, by 2035, Proteus solutions will have been temporarily installed into a total of 630 sites.		

	Modelling assuming that the choice and design of permanent solutions will not be impacted by the installation of the Proteus temporary solution shows that 23 Proteus Temporary Solutions are needed to break even by 2035. An annotated copy of the spreadsheet used to derive these figures can be provided if required.
Attachments	

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	21
Question date	20/09/2106	Answer date	22/09/2016
Submission section question relates to	Enviro+consumer bens		
Topic			
Question	As per the Full Submission Guidance, please state the level of protection required against cost over-runs and (if Direct Benefits are identified) unrealised Direct Benefits. This should also be included at the top of Section 6 in your resubmission.		
Notes on question			
Answer	Requested level of protection required against cost Over-runs – 0% Requested level of protection against Direct Benefits – 0% These figures will be included at the top of Section 6 in our resubmission.		
Attachments			

Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	22
Question date	20/09/2106	Answer date	29/09/2016
Submission section question relates to	Robust methodology/ready to implement		
Topic			
Question	Have any simulations been undertaken to gain confidence in the Proteus solution?		
Notes on question			
Answer	The Proteus solution will demonstrate a range of possible tools, and combinations of these tools, to be applied to resolve a range of LV Network constraints. A high degree of confidence in each of these individual tools is held as a result of: • Field Trial experience in the case of Soft Open Points (SOP) for FUN-LV (UKPN), Battery Systems for FALCON (WPD) and Asset Cooling systems. Direct experience of these is held by project partners on these technologies, through involvement in the FUN-LV, FALCON and Celsius projects. • Operational experience of Voltage Regulators by a number of utilities both in the UK and worldwide. • A number of academic research papers describing simulations and in some cases operational trials of distribution Unified Power Flow Controllers (dUPFC) and distribution STATCOMs (dSTATCOMs are a commercially available solution). These technologies have been		

	shown through the literature to provide support for power factor, reducing phase unbalance, solving voltage constraints (high and low voltage) and harmonic improvement. We have performed some preliminary simulations of dUPFC and dSTATCOM to demonstrate that they will be useful in solving LV Network constraints. These will be examined in greater detail during the initial stages of the project to develop a greater understanding of their impact, both as individual tools and in combinations. One of the project aims is to evaluate and assess the effectiveness of each of the tools and combinations of tools. The dSTATCOM, dUPFC and SOP are each designed using AC-DC converter technology where the design and control is understood in the literature thought both simulation and experimental work. The dSTATCOM consists of a single AC-DC converter connected in shunt to a feeder. The dUPFC consists of two AC-DC converters which have a common DC bus. One converter is connectedto the network in shunt and the second converter is connected in series through a transformer. The SOP is formed by the connection of two or more back-to-back converters where each port is connected in series to a different feeder. The SOP simulations undertaken during the initial stages of the FUN-LV project by Imperial Consultants have subsequently been shown to be accurate in extensive field operations and trials.
Attachments	

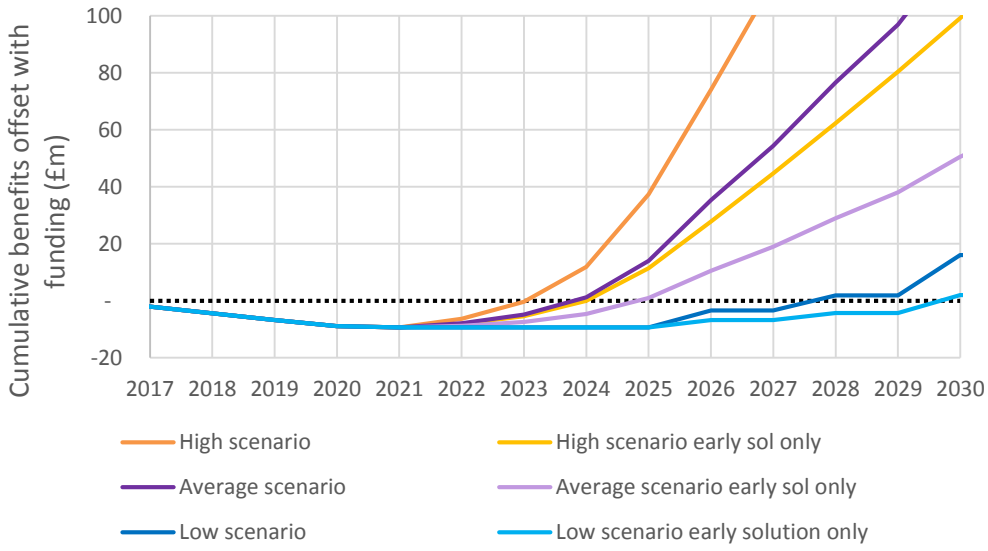
Electricity Network Innovation Competition Full Submission

Supplementary Answer Form

Project: Proteus

Tick if this answer has been provided verbally: ☐

Project code	WPD NIC 003	Question Number	23
Question date	04/10/2106	Answer date	04/10/2106
Submission section question relates to			
Topic			
Question	The Proteus business case calculates two key areas of benefit from use of the Proteus temporary solutions: the benefit of early solution of network issues, and the benefit of optimising the permanent solution to be implemented. At what year does the business case break even with only the benefit of early solution?		
Notes on question			
Answer	The graph below shows the results of the break even analysis on the Proteus business model for the cases with and without the benefit assumptions of optimising the permanent solution. It includes the results of the high, average, and low scenarios.		



The table below summarises the breakeven years of each of the simulations in the graph above.

Scenario Simulated	*Breakeven year*
High scenario with tech solution	2024
High scenario w/o tech solution	2024
Average scenario with tech solution	2024
Average scenario w/o tech solution	2025
Low scenario with tech solution	2028
Low scenario w/o tech solution	2030

Attachments	