LCNF Competition WPD Equilibrium Interrogation Report

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1. PROJECT SUMMARY

WPD state that the deployment of the methods presented in the Network Equilibrium Low Carbon Networks Fund (LCNF) submission will advance the readiness of system voltage control and power electronic based power flow management to a level that will support the wide scale deployment on the 11 kV and 33 kV distribution systems. This deployment will alleviate future voltage and power constraints and provide cheaper, faster connections to Low Carbon Technologies (LCTs) and Distributed Generators (DGs). These technologies will be supported by new planning tools and this work may potentially lead to a relaxation of voltage limits.

It is proposed by WPD that this work is required to support the move to a low carbon economy and it builds on the previous work completed by previous projects. WPD state that completing this project will allow these technologies to be rolled across the GB distribution network using normal business as usual practices in the future. WPD propose three methods that will be trialled as part of the Network Equilibrium project;

1. Enhanced Voltage Assessment (EVA);
2. System Voltage Optimisation (SVO); and
3. Flexible Power Link (FPL)

The EVA method applies academic research, and develops power system modelling tools. In completing the trial of this method Western Power Distribution (WPD) South West aims to:

- understand which network equipment constrains network voltages to +- 6% of system nominal;
- model the impact of relaxing the voltage limits and develop a tool that can be rolled out to other DNOs, which quantifies how close to the operational limits networks are when in operation and how much latent capacity is available for LCTs. This leads to an estimation of any further capacity that may be available should the limits be relaxed;
- champion a change in ENA Engineering Recommendations related to operational voltage limits within 33kV and 11kV electricity networks;

- unlock approximately 81MW of capacity for DG connections, delivering a net financial benefit of £10 million by raising the voltage limits to +/- 7% of nominal system voltage.

This work builds on similar work undertaken by DNOs and aims to increase the Technological Readiness Level (TRL) of the technologies associated with the EVA method from TRL5 to TRL8.

The SVO Method concerns the design, installation and operation of novel wide area voltage management systems across 8 Bulk Supply Points (BSPs). In completing the trial of this method WPD aims to;

- Develop detailed technical specifications and policies for the coordinated control of voltages, as well as design considerations and an implementation guide;
- Demonstrate a wide area voltage control solution and provide guidelines that could easily be rolled out at scale across an entire licence area and to other DNOs;
- Unlock approximately 195MW of capacity for DG connections delivering a net financial benefit of £26 million.

Again this work builds on similar work undertaken in other LCNF projects and aims to increase the TRL of the technologies associated with the SVO method from TRL6/7 to TRL8.

Finally the FPL method concerns the design, installation and operation of a novel power electronic solution to interconnect two electrically distant network areas at 33kV and 11kV. In completing the trial of this method WPD aims to;

- Develop detailed technical specifications and policies for a flexible power link as well as design considerations and an implementation guide;
- Demonstrate the management of power flows and voltages in the two interconnected networks using an artificial intelligence based algorithm to control the set point for the FPL device that could easily be rolled out at scale across an entire licence area and to other DNOs;
- Unlock approximately 48MW of capacity for DG connections delivering a net financial benefit of £10 million.

This work builds on similar work undertaken in other LCN trial projects, and limited commercial deployments and aims to increase the TRL of the technologies associated with the method from TRL6 to TRL8.

This is a 4 year project with a total project cost of £16,400,000. The total project funding request is for £14,420,000 with WPD providing £1,640,000 as their compulsory contribution. WPD state that the EVA, SVO and FPL Methods are expected to release up to 356MW in the trial area, based on the summation of these benefits plus additional benefits from their combination. The net financial benefit of the trial is £45,400,000 which is based difference between the cost of reinforcement and the method costs.

WPD claim that, once fully deployed, the roll-out of the Methods across GB could unlock over 11.8GW of capacity for the connection of low carbon generation and demand technologies.

2. ASSESSMENT AGAINST CRITERIA

The criteria against which each submission will be assessed are outlined in the LCNF Governance Document,

(a) Accelerates the development of the low carbon energy sector and has the potential to deliver net financial benefits to existing and/or future customers;

(b) Provides value for money to distribution customers;

(c) Generates knowledge that can be shared amongst all DNOs;

(d) Involvement of other partners and external funding;

(e) Relevance and timing;

(f) Demonstration of a robust methodology and that the project is ready to implement.

2.1 CRITERION (A): ACCELERATES THE DEVELOPMENT OF THE LOW CARBON ENERGY SECTOR

2.1.1 Key statements

The key statements from the WPD submission are summarised below;

- By solving voltage and thermal issues, Equilibrium facilitates the integration of DG within electricity networks. This project accelerates the development of a low carbon energy sector;
- By deploying the methods detailed above the latent capacity for LCT will be available and reduce the cost of connection when compared to conventional solutions;
- By championing the relaxation of voltage limits further, DG capacity may be released for minimal extra cost ;
- By deploying the FPL and SVO methods detailed above the DG connection process will be accelerated when compared to conventional solutions;
- The Equilibrium Solution will lay the foundation for industry to play a more active role in future energy markets through demand side management and the integration of DG, CHP and Heat Pumps within industrial domestic sites.

The key numerical claims are summarised in Table 1;

Table 1 Key Numerical Claims

Method	Capacity Released in Trial Area (MW)	Decrease in Connection Time (Months)	Net Financial Benefit (£ Million)	Capacity Released in GB Roll out of methods by 2050 (MW)
EVA	81	24	9.9	2700
SVO	195	18	25.9	7100
FPL	48	12	9.6	2000
Total	356*	-	45.4	11800

*The combined EVA, SVO and FPL Methods are expected to release up to 356 MW, in the Trial area, based on the summation of these benefits plus additional benefits from their combination. It is not clear how these additional benefits are accrued or released.

Once fully deployed, it is claimed that the roll-out of the Methods across GB could unlock over **11.8GW** of capacity for the connection of low carbon generation and demand technologies. There are no Carbon Claims articulated in this Network Equilibrium submission only network capacity released for Low Carbon Technologies and DG.

2.1.2 Challenges and Potential Shortfalls

<table>
<tr><th colspan="2">Criterion (A) – Accelerates the development of the low carbon energy sector and has the potential to deliver net financial benefits to existing and/or future customers;</th></tr>
<tr><td rowspan="3">Sub-criterion (a.i) – Ability to facilitate the Carbon Plan through GB wide roll out.</td><td>Challenge 1: How does the submission provide the foundation for a demand side management platform? Will the methods deployed as part of this submission support the control of consumer/industrial loads?</td></tr>
<tr><td>Answer 1:
Q) Will the methods deployed as part of this submission support the control of consumer/industrial loads?

No.

Q) How does the submission provide the foundation for a demand side management platform?

The project methods (EVA, SVO and FPLs) being demonstrated through Network Equilibrium will optimise voltages and power flows across the network, increasing the capacity for additional Distributed Generation connections. The project methods could equally be used to optimise for anything else, including Demand Side Management.

The project will develop one design and one model that could be used to optimise the network capacity, including DG, LCTs and DSM.
The EVA method will demonstrate how existing planning tools will allow DNOs to plan and operate complex networks with more granular information, using historic information to forecast voltages and power flows.
The SVO method will monitor and forecast the network voltage profiles and current flows, using algorithms to issue commands, controlling the target voltage at Primary and Grid substations.
The FPL method will create the ability to flexibly transfer excess power flows between groups (this is useful when there is excesses in both generation and demands within networks); this method supports the dynamic operation of networks.</td></tr>
<tr><td>Conclusion 1: No further comment.</td></tr>
<tr><td></td><td>Challenge 2: The submission states that 11.8GW will be released across the UK based on the roll out of the methods in this submission and this is based on the contribution of the individual methods, as calculated in Appendix A scaled to GB network.

The individual methods, MW capacity contributions (see Table 1) were calculated using power system analysis software. Appendix A does not detail the power system analysis methods used to calculate the MW released for each method only provides a summary of the results. From the information provided the capacity released cannot be substantiated.

Can WPD provide sufficient detail of the methodology used to calculate the capacity released so that the claimed capacity released can be</td></tr>
</table>

substantiated?

Answer 2:

The 11.8GW capacity released in GB rollout by 2050 has been calculated by extrapolating out the capacity released by each method within the trial area as detailed below in table 1. The capacity released in the Trial Area has been calculated using PSS/E modelling; the modelling and the assumptions on extrapolation are described in more detail below.

Method	Capacity Released in Trial Area (MW)	Capacity Released in GB Roll out of methods by 2050 (MW)
EVA	81	2700
SVO	195	7100
FPL	48	2000
Combined	32	N/A[#]
Total	356	11800

Table 1

[#] The combined benefit of the three methods will be quantified as part of the Network Equilibrium trials and has not been used in extrapolating the benefits in GB rollout by 2050.

1. WPD's South-West network models were analysed using PSS/E Version 32. Three network scenarios were investigated in order to identify BSP areas with key constraints: Maximum Generation-Minimum Demand, Maximum Generation-Maximum Demand and Minimum Generation-Maximum Demand. The first scenario (Max Gen-Min Demand) resulted in the highest number of voltage/thermal extremities within the network; therefore it was selected as the basis for further study.

2. Each of the three project methods was modelled across a number of South-West BSP areas within PSS/E to analyse the capacity unlocked. The BSP areas modelled for each method were selected based on their suitability for the respective method (i.e. networks with significant voltage rise or thermal limitations); demonstrated by preliminary modelling (as explained in paragraph 1 above), a study of WPD's constraint maps and local knowledge of the sites gathered through questionnaires/site visits.

3. EVA allowed voltage limits to reach +/-7%, this was modelled in the Bridgwater-Street BSP area and unlocked 16.3MW of network capacity, representing a 10% increase of connected generation. The same methodogy was used at another 9 BSP, unlocking a total capacity of 81MW in the trial area. This had no impact on the LV voltage profiles.

4. SVO was modelled for a range of set-point reductions on BSP grid transformers in order to identify corresponding capacity release values, while monitoring the voltage and loading levels in the network against their limits. The Bridgwater-Street BSP area was modelled

	(among others) and it was concluded that a reduction of the AVC set-point by 2% unlocked 48.9MW of generation capacity, representing a 30% increase of connected generation. The same methodogy was used at another 7 BSP, unlocking a total capacity of 195MW in the trial area. 5. FPLs were modelled transferring both real and reactive power (based on preliminary PSS/E modelling, an operating condition of 50% real power transfer and 50% reactive power support was identified as optimal). This was supported by the RFI responses from FPL manufacturers. The 33kV link was modelled in the South Molton-Exebridge area (among others), where a normally-open point between different grid groups had been identified, unlocking 36.2MW of capacity. A number of potential locations had been identified for the 11kV link, preliminary modelling in PSS/E identified four as the most suitable and further modelling was performed. 12MW of capacity release was calculated as a conservative value for the 11kV FPL, although there were cases where larger amounts of connected generation were unlocked (e.g. Bath Road primary S/S, with 14.8MW). Combining the 11kV and 33kV capacity releases, lead to a total capacity of 48MW being unlocked by the FPL method. 6. Utilising the capacity release values above, the generation increase across the project area was calculated by extrapolating to a size of 10 BSP areas for the EVA method and 8 BSP areas for SVO; the average firm capacity value of participating BSPs and the associated connected generation was used as a conservative way of estimating/normalising the additional capacity unlocked. 7. The results were extrapolated out to the rest of the UK by assuming a modest number of replications across the 14 licence areas in the UK network; i.e. 28 total replications by 2050 for the EVA and SVO methods and 42 replications by 2050 for the FPL method. For the first two methods, a percentage increase in capacity release of 20% and 30% respectively was estimated post 2030, due to further relaxation of voltage limits anticipated by the EVA method. The methodology used has been through a quality assurance processes at WPD.
	Conclusion 2: No further comment.
	Challenge 3: The submission states that by deploying combined equilibrium methods they expect to release up to 356MW capacity in the trial area, based on the summation of these benefits plus additional benefits from their combination. What are the additional benefits above the capacity released from the method identified as 324MW (see Table 1). Can WPD detail the mechanism for releasing the additional 32MW (356-324) and substantiation of the additional benefits claimed?
	Answer 3: As detailed in Challenge 2, the amount of DG capacity unlocked by each method has been calculated individually using the nodal analysis tool, PSS/E v32, at a number of sites within the project area before

	extrapolating out to the project scale of 10 BSP areas for the EVA method, 8 BSP areas for SVO and the installation of a FPL at both 11kV and 33kV. When combining all three methods at a project level, the critical enabler element of the Enhanced Voltage Assessment, demonstrating an enhanced planning tool will unlock additional capacity by better forecasting the critical minimum network demands for each network at the period of maximum DG export. The Strategic Technology Programme (STP), Module 5 Project S5267_2 (Generation Diversity Assessing the Minimum-Load to be used for Solar and Hydro Connections Assessments) Conclusion 5 (C5) states "the minimum demand used for further generation modelling could be increased. As shown from the studies conducted (at BSP level), this increase can range from 1.4-17.3MVA depending of the generator technology and also the network constraints." The learning has been applied to the trial area. The additional 10% headroom account for the conditions where maximum diverse generation sources are not coincident with the minimum network demand. This has allowed us to conservatively estimate the facilitate an additional 32MW of DG capacity within the project area. The additional benefits unlocked at a project level, as with all method benefits will be quantified as part of the project.
	Conclusion 3: DNO response to the challenge seems to suggest that **any** additional capacity release will be quantified as part of the project. It is judged that is optimistic to assume a 10% headroom increase as when the methods proposed as part of this submission are deployed the network will be heavily utilised and an additional 10% capacity increase may not be achievable.
Sub-criterion (a.ii) – Delivers the solutions more quickly than the most efficient existing method	**Challenge 1**: The submission states that by deploying the methods, capacity could be released more quickly (see Table 1) than the most efficient conventional solutions. The submission states that the details regarding the timescales are given in Appendix A. Appendix A provides no details on the timescales. Can WPD provide details of the methodology used to calculate the decrease in connection times so that they can be substantiated? We note that the base case and method timescales are stated in the Full Submission spreadsheet but further detail on how these numbers have been arrived at would aid in the evaluation process.
	Answer 1: The Network Equilibrium submission, page 20, references Appendix A as containing the timescales for releasing capacity, "The detailed outline of the capacities released by each Method and the timescales for release are given in Appendix A." However, we accept this information was accidentally omitted from the submission. This information has now been included below and will be included within the bid during the resubmission phase.

Delivers the solutions more quickly than the most efficient existing method

Section 4.1.4 of the full submission, quickly releasing capacity, details how the Network Equilibrium methods could release capacity quicker than the most efficient method currently in operation on the GB distribution system.

The most efficient methods currently deployed on the GB distribution system for each method detailed in Table 2.

Method	Base case - network reinforcement	Amount	Timescales	Notes
EVA	Rebuilding 33kV OHLs at a higher capacity	176km	36 months	• Reinforcement of 10 BSPs • Each BSP has an Average 8 feeders • Network modelling show 2.2km reinforcement per feeder equates to the EVA benefits
SVO	Installing 33kV cable with a larger capacity	108km	36 months	• Reinforcement of 8 BSPs • Each BSP has an Average 8 feeders • Models show 1.69km reinforcement per feeder equates to the SVO benefits
33kV FPL	Installing two new 132kV Overhead Lines and transformers	2 Tx's 2x13.7km circuits	36 months	• Assumes an average length 132kV feeder and unit ED1 prices • Models show this equates to the 33kV FPL benefits
11kV FPL	Installing two average 33kV Overhead Lines and associated transformers	2 Tx's 2x4.4km circuits	36 months	• Assumes an average length 33kV feeder and unit ED1 prices • Models show this equates to the 11kV FPL benefits

Table 2

The conventional method base case which has been used as the basis for all methods and is based on typical timescales for significant network reinforcement. Due to planning, wayleave consents, land owner consent and resource required for large-scale network reinforcement involved the installing of linear assets, the base case timescales could be significantly

	longer. **EVA** The EVA base case costs has estimated 2.2km of 33kV network reinforcement per feeder using the Ofgem ED1 unit costs for rebuilding 33kV OHLs with a higher capacity. This unlocks the same capacity as the EVA method. It is assumes we would receive permission to rebuild the circuits with a larger capacity. The associated 11kV network reinforcement costs have not been included in the EVA base case costs. **Delivers the solutions more quickly** Section 4.14 states the EVA method could release capacity at least **24 months more quickly** than the EVA Base case. Once the design tools are proven, and the design standards are in place, the critical enabler section of the EVA Method could be replicated by WPD and other DNOs within a 12-month timescale. This builds in time for the tool to be adopted and adapted, assuming six months adaption/testing and six months adoption. The adoption process should be relative short when standards and policies are in place. The amendment of voltage limits allows for a DNO to carryout sufficient diligence in each network area, considering the network equipment and, if appropriate, amending the tap profile of distribution substations across 11kV feeders. **SVO** The SVO method assumes 1.69km of 33kV network reinforcement per feeder using the Ofgem ED1 unit costs for installing larger capacity 33kV cable. This unlocks the same capacity as the SVO method. The associated 11kV network reinforcement costs have not been included in the SVO Base Case Costs. **Delivers the solutions more quickly** Section 4.14 states the SVO method could release capacity at least **18 months more quickly** than the SVO Base case. The deployment of SVO has been estimated as being within an 18 months' timescale, this timescale to deploy SVO based on early adoption. The timescale includes planning, site visits, lead time for ordering equipment, installation and commissioning. Once the SVO control system is in place, new customers could be connected much more quickly (the timescale dominated by the lead time for the customer to purchase their new generation set). **FPL** The FPL methods assumes two average new 132kV (33kV FPL equivalent) and 33kV (11kV FPL equivalent) feeders and transformers using the Ofgem ED1 unit costs are required to unlock the same capacity as the FPLs. This is the minimum cost scheme to unlock additional capacity across different grid groups. **Delivers the solutions more quickly** Section 4.14 states the FPL method could release capacity at least **12 months more quickly** than the FPL Base case. The deployments of FPLs have been estimated as within 24 months, this is heavily dominated by the current worst case lead time for the equipment. It is expected when designs and standards are created for these devices, this timescale

	will reduce. Detailed planning and design can take place in parallel with equipment ordering.
	Conclusion 1: No further comment.
Sub-criterion (a.iii) – The financial benefit of each method compared to most efficient existing method	**Challenge 1**: For the EVA method it is judged that this method will only deliver the financial and capacity benefit if the voltage limits are relaxed. It is judged that there is a significant risk that the voltage limits will not be relaxed. Can WPD clarify how they have captured this risk and if this has been considered in calculating the potential benefits for this project?
	Answer 1: **<u>Will EVA only deliver the financial and capacity benefit if the voltage limits are relaxed?</u>** No. As detailed in the bid Section 2.1.3 (What is the EVA Method) and above (Box 3, Paragraph 2), the EVA has two parts, • Planning and operational tool as a critical enabler to the project • Recommend Changes to voltage limits The critical enabler section of the method, demonstrating an enhanced planning tool will unlock additional capacity by better forecasting the critical minimum network demands for each network at the period of maximum DG export, regardless of the amending of voltage limits. The further headroom created when the coordinated maximum generation is not coincident with minimum network demand will be investigated in more detail. (See Box 3, Paragraph 4). **<u>Risk of changes to 33kV and 11kV voltage limits not being accepted</u>** This risk that voltage limits will not be relaxed has now been added to the Network Equilibrium risk register v1.1. This is a credible risk that has been reduced by the mitigation actions in the development of the bid. The mitigation action (preliminary research) already undertaken, reduces the risk. The preliminary research already undertaken before the project was submitted included reviewing the voltage tolerances of similar distribution networks across the world and a better understanding of the network limiting equipment. During the development of the bid, the team did not identify any technical barriers to amending the statutory voltage limits by 1% (i.e. to +/-7%) provided appropriate control systems are in place in the 11kV network to ensure the LV profile stay within statutory limits. The Network Equilibrium EVA method will identify network limiting equipment types or commercial restrictions at 33kV and 11kV that must be addressed before amended limits can be implemented, identifying this information and sharing with the industry is a key requirement to facilitating the change of voltage limits for both 33kV and 11kV networks. **<u>Calculating benefits</u>** In calculating the potential benefits, considering the risks, the stated

	benefit of 81MVA for the EVA method **only** considers the change in statutory limits on the 33kV networks. If the statutory limits of both the 33kV and 11kV were relaxed, the benefits would be greater than stated. The “likelihood of success” is considered on IFI project benefits, however not on LCNF project benefits. As part of this method, we have stressed the need to identify the operating ranges beyond statutory voltage limits (from a technical/operational point of view). There is a possibility that increasing 11kV voltage limits may also require subsequent regulation on the LV network. There is already a number of LCNF T1 and T2 projects identifying and demonstrating LV voltage regulation solutions. This this outside of the scope of Network Equilibrium as it is already being demonstrated in other projects.
	Conclusion 1: No further comment
	Challenge 2: The net benefit of the EVA, is calculated by comparing the EVA method cost to conventional reinforcement costs This reinforcement includes the installation of 33kV conductor & poles across 10 BSPs to release 10% capacity it includes re-conductoring approximately 352 km (of feeders. WPD state that there will be a net benefit of £9.9 million associated with this method. The net benefit of the SVO is calculated by comparing the SVO method costs to conventional reinforcement costs. This reinforcement includes the installation of 33kV cable circuits across 10 BSPs to release an unknown level of capacity and includes re-conductoring 281.6km of feeders with overhead lines. WPD state that there will be a net benefit of £25.9 million associated with this method. The net benefit of the FPL is calculated by comparing the FPL method to conventional reinforcement costs. This reinforcement includes the installation of 2x132/33kV transformers, 2x33/11kV transformers and the installation of 132kV conductor and towers across 2 BSPs. WPD state that there will be a net benefit of £9.6 million associated with this method. The total benefit is derived by summing the costs of the three methods and comparing to the reinforcement cost to arrive at a net benefit for the project of £45.4 million. The calculated conventional reinforcement costs are based on an average feeder length and 10 Bulk Supply Points, to be representative of the trial area and allow scaling to the license area and the GB network. It is considered that the conventional reinforcement strategy presented in the submission may not represent the most efficient reinforcement solution for the applied methods and there is a possibility that reinforcement of feeders has been duplicated across the methods. Can WPD substantiate that the proposed reinforcement strategy provides the most efficient solution to release 356MW in a 10 BSP area and demonstrate there is no duplication of reinforcement in calculating the cost and therefore benefits?
	Answer 2: **<u>Most efficient solution</u>** Conventional solutions have been used as the most efficient network

	reinforcement; this includes the installation of new overhead lines, underground cables and the installation of new transformers. These are the main solutions currently used by WPD in DR5 as a BaU technique to solve voltage and thermal restrictions. The following Smart Techniques were considered for the most efficient solution: Dynamic Line rating (DLR) – The only BAU use for Dynamic Line ratings is on 132kV tower circuits to increase thermal capacity on lines connecting wind farms, DLR is not a proven conventional solution at 11kV or 33kV on wood pole lines due to the lower construction height. It cannot be used to regulate voltage so is not the efficient reinforcement solution comparison for Network Equilibrium. Statcoms – A 33kV connected Statcom is being trialled on the LLCH project, the technique is expected to reach TRL8 by the end of the project. The combined capital and installation costs results in it not being the most cost effective solution when compared to the EVA and SVO base case, therefore it is not the most efficient reinforcement solution. A Statcom cannot transfer real power, so has not been considered for the FPL base case. Quadrature Boosters – This is not considered a conventional solution and would not be applicable to be installed across a normal open point between different grid groups. It is not the most efficient reinforcement solution. Fault Current Limiters – A number of devices are being trialled and the TRL is expected to reach TRL8 by March 2017. This technology would need to be deployed with other technologies to achieve the same benefits as the FPL. On this basis, it is not the most efficient reinforcement solution. As can be evidenced through the majority of DG connections, the new linear assets often involve the installation of new underground cables as the delays associated with wayleave, planning permission and construction of overhead lines means installing underground cables is often the only viable solution. This has further been evidenced on the Lincolnshire Low Carbon hub project where the project was unable to secure the necessary permission for a new overhead line resulting in a change to the project direction. The project costs have been estimated based on unlocking capacity uniformly across all the BSPs and all feeders, the same way the Network Equilibrium methods will unlock capacity. We have not picked particular circuits and areas to reinforce. Whilst this would be more cost effective, it is not particularly credible as new generation applications could be made in any location. **<u>No duplication of reinforcement</u>** As detailed below, there has not been any duplication in the network reinforcement, the associated costs and subsequent benefits. • The EVA Base case costs has estimated 2.2km of 33kV network reinforcement per feeder using the Ofgem ED1 unit costs for rebuilding 33kV OHLs with a higher capacity. This unlocks the same capacity as the EVA method and assumes we would receive permission to rebuild the circuits with a larger capacity. The

	associated 11kV network reinforcement costs have not been included in the EVA Base Case Costs. • The SVO method assumes 1.69km of 33kV network reinforcement per feeder using the Ofgem ED1 unit costs for installing larger capacity 33kV cable. This unlocks the same capacity as the SVO method. The associated 11kV network reinforcement costs have not been included in the SVO Base Case Costs. • The FPL methods assumes two average new 132kV and 33kV feeders and transformers using the Ofgem ED1 unit costs are required to unlock the same capacity as the FPLs. This is the minimum cost scheme to unlock additional capacity across different grid groups. An error has been found on the Full Submission Spreadsheet, Net Benefits Notes. **EVA Base Case Costs** The EVA base case costs have been calculated assuming re-conductoring 2.2km per feeder to unlock 10% of generation capacity, not 4.4km as stated in the notes. **SVO Base Case Costs** The SVO base case costs have been calculated assuming 1.69km of reinforcement per feeder, not 4.4km as stated in the notes. An amended version of the full submission spreadsheet has been attached. Please note, the only change is to the notes section on the Net Benefits tab.
	Conclusion 2: No further comment, the reduction in feeder length reinforce reduces the total amount of overhead lines and cables to a more reasonable level.
Sub-criterion (a.iv) – The network capacity released and how quickly	**Challenge 1**: See Sub-criterion (a.ii) – Delivers the solutions more quickly than the most efficient existing method. No challenge.
	Answer 1: N/A
	Conclusion 1: N/A
Sub-criterion (a.v) – Potential for replication of the method across the GB	**Challenge 1**: The replication strategy proposed by WPD assumes 36 rollouts across the GB network for the EVA and SVO method by 2050. WPD suggest there may be 48 replications of the FPL method by 2050. The bulk of the deployments are after 2020 and with a gradual roll out to 2050. This will release an average of 320MW per year at this rate of adoption with a proposed total of 11.8GW. WPD have assumed gradual replications, but with regards to EVA the relaxation of the voltage limits is a binary condition (the limits proposed by WPD will be accepted or not). Therefore assuming a gradual rollout of the EVA method does not seem reasonable. Once the limits have been relaxed, other DNOs may choose not to use the EVA network planning

tool, and may choose a tool of their own design, or they may decide that existing tools are fit for purpose.

The proposed adoption rates for the SVO and FPL methods seem to be conservative, if the submission achieves its stated aims and accelerates these technologies to TRL 8 and the delivers the benefits as stated.

Can WPD provide a statement on the limiting factors for the adoption of the methods?

Answer 1:

WPD's gradual replication is conservative; the adoption of new methods has been forecasted based on previous uptake of innovation such as network automation.

EVA

Whilst the amending of the voltage limits is a binary condition, the delivery of benefits comes from applying these changes to networks when applied. The amendment of voltage limits allows for a DNO to carryout sufficient due diligence regarding network equipment at 33kV and 11kV and if appropriate amend the tap profile of distribution substations across 11kV feeders.

The current rollout builds in time for the EVA tool to be adopted and adapted. The WPD EVA planning and design method will be based around PSS/E, however the project will create the functional specifications allowing each DNO to apply the EVA functionality to their planning tools. The project has assumed six months adaption/testing and six months adoption. The adoption process should be relative short when standards and policies are in place.

SVO

The SVO estimate of the timescale to deploy 36 replications each with approximately 8 BSPs. The speed of deployment has factored in installation during summer outage periods, confidence building as the method reaches TRL 9 and where appropriate asset replacement linked to maintenance programmes. Once the SVO control system is in place, expanding to new areas and DG customers could be connected much more quickly.

FPL

This method estimation of 48 replications of FPLs is heavily dominated by the current worst case lead time for the equipment. It is expected as a consequence of the project being awarded funding, further development and competition between FPL manufacturers will stimulate the market, reducing costs and lead times through competitive market forces.

Detailed planning and design can take place in parallel with equipment ordering.

Conclusion 1: No further comment.

2.2 CRITERION (B): PROVIDES VALUE FOR MONEY TO APPLICABLE CUSTOMERS

2.2.1 Key Statements

WPD has completed a benchmarking exercise against similar projects and the cost of the overall Equilibrium project vs MW released is comparable in £/MW terms to other LCNF projects.

Table 2 Cost vs Capacity Comparison

Project	Cost (£m)	Capacity Released (MW)	End TRL Advancement	Cost Per MW Released (£/MW)
Low Carbon Hub	3.5	42	8	£83,300.00
Flexi grid	17	250	8	£68,000.00
Flexible Plug and Play	7	230	7	£30,400.00
Equilibrium	16.4	356	8	£46,100.00

Further analysis of the Equilibrium Methods shows the methods costs, MW released and the £/MW. These numerical metrics are discussed in Section 3.2.2

Table 3 Method Cost vs Capacity Comparison

Method	Cost (£m)	Capacity Released (MW)	End TRL Advancement	Cost Per MW Released (£/MW)
Enhanced Voltage Assessment (EVA);	[redacted]	81	8	[redacted]
System Voltage Optimisation (SVO); and	[redacted]	195	8	[redacted]
Flexible Power Link (FPL)	[redacted]	48	8	[redacted]

2.2.2 Challenges and Potential Shortfalls

Criterion (B) – Provides value for money to applicable customers;	
Sub-criterion (b.i) – Benefits attributable or applicable to the relevant network vs. elsewhere.	**Challenge 1**: This criterion does not seem to be addressed in the submission and cannot be assessed. This criterion should be addressed in the submission No specific challenge.
	Answer 1: **<u>Will this project benefit Distribution Networks (DuoS) or others?</u>** This was addressed in the bid and is detailed below. **<u>Distribution Networks (DuoS customers)</u>** This project methods are only being applied to DNO assets, the primary “quantifiable” benefits resulting from this project are applicable to the distribution network and DuoS customers as outlined in section 3.3.1. **<u>Others</u>** The project will have some secondary, non-quantifiable, benefits include stimulating the supply chain, creating a standard for system wide voltage control, the potential to reduce reinforcement in Transmission networks and cross sector benefits as outlined in Section 3.3.1 and 4.1.2. The project will not benefit retail energy prices.
	Conclusion 1: No further comment.
Sub-criterion (b.ii) – Steps taken to undertaken open, competitive procurement process.	**Challenge 1**: WPD has conducted an RFI to identify suppliers and used market values for costs. No challenge.
	Answer 1: N/A
	Conclusion 1: N/A
Sub-criterion (b.iii) – Other steps taken to ensure that funding request represents good value for money.	**Challenge 1**: WPD has completed a benchmarking exercise against similar projects and the cost of the overall Equilibrium project vs MW released is comparable in £/MW terms to previous LCNF projects but the analysis of the individual methods show that; • The EVA method would potentially be very cost effective, if the voltage limits can be changed and there are no limiting equipment items. • The SVO method is slightly more cost effective than other voltage control based LCNF projects. • The FPL method is an order of magnitude more expensive than the other solutions as, with this method, costs are dominated by hardware costs. The FPL 11kV equipment costs [redacted] million pounds and 33kV equipment costs [redacted] million pounds. These represent the market rates for equipment of this scope and type.

	Given the concerns on calculation of benefits and capacity released as listed in assessment against criteria A, can WPD provide further justification that the FPL method provides value for money in the context of an LCNF project? It is noted that the submission states that Appendix K provides details of the risks associated with the FPL aspects of the project that would prevent it proceeding without LCN funding. Appendix K does not seem to provide this justification - is this available from WPD?
	Answer 1: **FPL method - Value for money** A FPL is the only smart solution that we have identified that can provide both voltage and thermal management to networks at normal open points between different grid groups. We haven't identified another solution which can be installed whilst avoiding either high levels of circulating currents when installed across national grid groups or de couple networks preventing the additional fault level issues. Further evidence as to why the FPLs being demonstrated by Network Equilibrium represents value for money is attached. **Why a FPL requires LCN funding** Further to the information to supplement Appendix K has been included below. A Flexible Power Link at 11kV and 33kV is a new innovative piece of power electronics technology currently estimated at TRL 6. The technology has been installed for industrial and rail applications in Indonesia and Germany. The power electronics components are continually evolving, with increasing reliability and reducing costs. The top two FPL risks are: **Risk** The FPL does not deliver the anticipated network benefits **Mitigation** 1. De risk the method by engaging with manufacturers through issuing a detailed RFI to manufacturers. 2. Trial two different FPL manufacturers under a controlled demonstration to assess the reliability using innovation funding. **Risk** FPL have reliability issues results in an unacceptable availability **Mitigation** 1. 1. De risk the method by engaging with manufacturers through issuing a detailed RFI to manufacturers. 2. 2. Select an established and proven Power Electronics technology

	3. 3. Trial two different manufacturers under a controlled demonstration to assess the reliability
	Conclusion 1: DNO response to the challenge is generally acceptable and we agree that this is the only type of device that meets the objectives of the project and link two sections of the network in the manner proposed by the submission. While the FPL could have reliability issues, from a risk perspective the control of the device is likely to provide more problematic especially if Case Based Reasoning Techniques are used, as proposed in WPDT206 Q&A Answer 29. The FPL technology remains expensive.

2.3

2.4 CRITERION (C) GENERATES KNOWLEDGE THAT CAN BE SHARED AMONGST ALL RELEVANT NETWORK LICENSEES

2.4.1 Key Statements

The EVA Method will generate new knowledge in the following areas:

- Detailing the merits of amending statutory voltage limits for 33kV and 11kV electricity networks, including any technical and procedural restrictions to making the amendments;
- Understanding how to model the SVO and FPL components and evaluate their performance using power system analysis (PSA) software; Updating and/or creating design and operational standards for voltage control; and
- Voltage control models for DG, including the most appropriate control settings.

The SVO Method will generate new knowledge in the following areas:

- How to strategically deploy voltage control technologies at scale to maximise access to the electricity network for DG customers and ensure value for money for demand customers;
- How to operate SVO in the real world, not just in test conditions; and
- How to operate the electricity network to maximise benefits for different types of customers during outage conditions (planned maintenance, new connections and fault restoration) and when communications or control systems fail.

The FPL Method will generate new knowledge in the following areas:

- How to plan, integrate and operate electricity networks with FPL technologies coupling two distribution systems together. For example, this will include the impact of the
- technologies on protection systems, power quality and security of supply to customers; and
- Using artificial intelligence to configure FPL technologies for voltage support and optimum power flows. This will be explored by WPD in Equilibrium, at both FPL deployment sites.

WPD State in Section 4.3.2 Applicability of new learning to other DNOs

The FPL Method would allow different distribution systems to be coupled at 11kV and 33kV, overcoming voltage and power flow management issues at the network peripheries. DNOs border each other; however, there is no significant interconnection between companies. For example, WPD has boundaries with Northern Powergrid, Electricity North West, Scottish Power Energy Networks, UK Power Networks and Scottish and Southern Energy. Each border has a high number of potential points of interconnection. Also, there are boundaries between different licence areas within the same DNO licensee group. For example, WPD West Midlands has boundaries with the East Midlands, South Wales and South West.

Challenges and Potential Shortfalls

<table>
<tr><th colspan="2">Criterion (C) – Generates knowledge that can be shared amongst all relevant Network Licensees;</th></tr>
<tr><td rowspan="3">Sub-criterion (c.i) – The level of incremental knowledge to be provided by the project.</td><td>Challenge 1: The submission postulates that deployment of the equilibrium methods will advance system voltage control, and power electronic based power flow management methods from TL6/7 to TRL 8.

It is considered that the learning from the project will also be an incremental increase, building on the knowledge developed in previous projects.

Can WPD provide a statement on how learning from previous projects will be considered and duplication minimised.</td></tr>
<tr><td>Answer 1:

The detailed learning from previous projects has been taken into account when formulating this project's methods and the project plan such as the scheduled timescales for the SVO method. The learning from other projects has identified the clear gaps that must be filled before these methods can be considered at TRL8.

WPD regularly engages with other DNOs as it is essential that the positive and negative learning from other projects are shared and lessons learnt to maximise learning and the success of projects.

The ENA portal is one of the formal methods used for sharing learning from innovation projects. Knowledge is shared between DNOs during the regular DNO R&D managers meetings and WPD operates a DNO buddy system with a dedicated point of contact capturing and sharing learning between DNOs.

An example of the activities already undertaken to learn from other LCN Fund projects is attached.</td></tr>
<tr><td>Conclusion 1: No further comment.</td></tr>
<tr><td rowspan="2">Sub-criterion (c.ii) – Applicability of new learning to other DNOs.</td><td>Challenge 1: With regards to the FPL Method, WPD states what the FPL method will allow, not what will be applicable with regard to learning for other DNOs

Can WPD provide a statement clarifying what learning will be applicable to other DNOs with regard to the FPL method?</td></tr>
<tr><td>Answer 1:

The applicable learning to other DNOs is set out in the following sections:

Section 4.2.3 - Will create a template for deploying the FPL any position.

Section 4.3.1 – How to plan, integrate and operate electricity networks with FPL technologies coupling two distribution systems together. For example, this will include the impact of the technologies on protection systems, power quality and security of supply to customers;</td></tr>
</table>

<table>
<tr><td></td><td>Section 4.3.1 – Using artificial intelligence to configure FPL technologies for voltage support and optimum power flows. This will be explored by WPD in Equilibrium, at both FPL deployment sites.

Network Equilibrium's Flexible Power Links method will clearly provide knowledge, policies, standard techniques, specifications and operational manuals control and field staff relevant to all DNOs.

The methods and learning is applicable to all GB DNOs, as they like WPD have networks that cannot be meshed due to circulating current and fault level issues. Therefore the learning disseminated by WPD will provide a basis for the other DNOs to consider the FPL method and understand the network capacity it would release.</td></tr>
<tr><td></td><td>Conclusion 1 No further comment.</td></tr>
<tr><td>Sub-criterion (c.iii) – Plans to disseminate learning.</td><td>Challenge 1: Regarding unplanned learning and the lessons learnt as part of the project, the submission states that these will only be distributed to the project team.

Can WPD provide a statement clarifying how they propose to avoid mistakes being repeated by the other DNOs. Have WPD considered presenting the lessons learned as a series of workshops to other DNOs so that any errors, mistakes or errors are not repeated?</td></tr>
<tr><td></td><td>Answer 1:

WPD will share all the relevant learning from Network Equilibrium, both planned and unplanned. This is already standard practice within WPD's innovation projects.

An example of the unplanned learning from the LCNF Falcon project is attached below. This details how this learning has been shared to date.</td></tr>
<tr><td></td><td>Conclusion 1: No further comment.</td></tr>
<tr><td>Sub-criterion (c.iv) – Robustness of the methodology to capture learning.</td><td>Challenge 1: There is no clear linkage between the proposed learning in Section 4.3.1 and Section 5. The strategy as presented is generic and only briefly addresses the proposed learning.

Can WPD provide a statement clarifying knowledge capture methodology which is more specific and detail how the learning outcomes will be achieved?</td></tr>
<tr><td></td><td>Answer 1:
The proposed learning detailed in section 4.3.1 has been re numbered identifying which parent learning topic applies to. Further information on the parent learning topics has been detailed below.

The EVA Method will generate new knowledge in the following areas:

<u>PL1</u> Detailing the merits of amending statutory voltage limits for 33kV and 11kV electricity networks, including any technical and procedural restrictions to making the</td></tr>
</table>

	amendments; **PL2** Understanding how to model the SVO and FPL components and evaluate their performance using power system analysis (PSA) software; **PL4** Updating and/or creating design and operational standards for voltage control; and **PL4** Voltage control models for DG, including the most appropriate control settings. **The SVO Method will generate new knowledge in the following areas:** **PL6** How to strategically deploy voltage control technologies at scale to maximise access to the electricity network for DG customers and ensure value for money for demand customers; **PL7** How to operate SVO in the real world, not just in test conditions; and **PL7** How to operate the electricity network to maximise benefits for different types of customers during outage conditions (planned maintenance, new connections and fault restoration) and when communications or control systems fail. **The FPL Method will generate new knowledge in the following areas:** **PL8** How to plan, integrate and operate electricity networks with FPL technologies coupling two distribution systems together. For example, this will include the impact of the technologies on protection systems, power quality and security of supply to customers; and **PL9** Using artificial intelligence to configure FPL technologies for voltage support and optimum power flows. This will be explored by WPD in ***Equilibrium***, at both FPL deployment sites. Section 5.1.2 details the 10 parent learning topics for Network Equilibrium, each will contain a number of learning outcomes which will be agreed at the start of the project with our suppliers (planned) and recorded as they arise (un planned). The new knowledge EVA will generate will be captured in parent learning topics **PL1** – **PL5**. The new knowledge SVO will generate will be captured in parent learning topics **PL6** – **PL7**. The new knowledge FPLs will generate will be captured in parent learning topics **PL8** – **PL9**. The new knowledge associated with the combination of all methods will be captured in parent learning topics 10. **Parent Learning Topic**

	PL1. Amending 11kV and 33kV voltage limits; **PL2**. Unlocking capacity using amended voltage limits; **PL3**. How to implement enhanced planning tools for planning and operational purposes; **PL4**. Unlocking capacity using enhanced planning tools; **PL5**. Maintaining customer connections using enhanced operations tools; **PL6**. How to implement System Voltage Optimisation (SVO) at a system level; **PL7**. Ability to unlock capacity using SVO; **PL8**. How to implement Flexible Power Links (FPLs); **PL9**. Ability to unlock capacity using FPLs; and **PL10**. Implementing and unlocking capacity (generation and demand) as a combined project. The planned and unplanned learning from each method and the project as a whole will be captured in these areas. The learning from these parent topics will be disseminated in workshops 1-10 and through the reports as outlined in the corresponding SDRC's (Section 9).
	Conclusion 1: No further comment.
Sub-criterion (c.v) – Treatment of IPR.	**Challenge** 1: The submission meets the criteria and the treatment of IPR is as per the LCNF governance documents. No challenge.
	Answer 1: N/A
	Conclusion 1: N/A

2.5 CRITERION (D) INVOLVEMENT OF OTHER PARTNERS AND EXTERNAL FUNDING

2.5.1 Key Statements

Project Partners will be identified after the 2015 LCNF Award, and an initial RFI exercise has been completed to give confidence the market can deliver the project technologies.

2.5.2 Challenges and Potential Shortfalls

Criterion (D) – Involvement of other partners and external funding;	
Sub-criterion (d.i) – Collaborators involved in the project	**Challenge 1**: No specific challenge challenges on this criterion. No partners have been identified at this stage, therefore no challenge as this criteria is not relevant to the particular project.
	Answer 1:
	Conclusion 1:
Sub-criterion (d.ii) – Steps taken to identify potential partners and ideas.	**Challenge 1**: No specific challenge challenges on this criterion. No partners have been identified at this stage therefore no challenge as this criteria is not relevant to the particular project.
	Answer 1:
	Conclusion 1:
Sub-criterion (d.iii) – External funding for the project.	**Challenge 1**: No specific challenge challenges on this criterion. WPD has not received any offers of external funding in the RFI exercise therefore no challenge as this criterion is not relevant to the particular project.
	Answer 1:
	Conclusion 1:
Sub-criterion (d.iv) – How secure external funding is.	**Challenge 1**: No specific challenge challenges on this criterion. WPD have not received any offers of external funding therefore any challenge as this criterion is not relevant to the particular project.
	Answer 1:
	Conclusion 1:

2.6 CRITERION (E) RELEVANCE AND TIMING

2.6.1 Key Statements

It is judged that this criterion has not been addressed by WPD in Section 4.5.

2.6.2 Challenges and Potential Shortfalls

<table>
<tr><th colspan="2">Criterion (E) – Relevance and Timing;</th></tr>
<tr><td rowspan="2">Sub-criterion (e.i) – The relevance of the solution to the move to a low carbon economy</td><td>Challenge 1:
WPD claim that deployment of the methods in this submission will advance system voltage control, and power electronic based power flow management methods from TL6/7 to TRL 8. This advancement in TRL is required to support the move to a low carbon economy and is appropriate for funding now as it builds on the previous work completed by other LCNF projects.

The LCNF governance document states that projects that are at different TRLs will not be considered as unnecessary duplicates. WPD has made an assessment of the TRL of similar LCNF projects, in order to support the claim that the methods proposed are advancing the TRL level of the proposed technologies. It is not clear how the TRLs have been assigned.

The WPD process of assigning TRLs to the technologies and methods developed as part other LCNF projects is unsubstantiated. It is noted that the submission states that Appendix N contains the differentiators from other LNCF projects. It does not seem to contain the differentiators, only a statement of the TRL Levels.

Can WPD provide substantiation of the TRLs claimed?</td></tr>
<tr><td><u>Response to statement in 2.5.1</u>

Clarifications have been added to Section 4.5 to emphasise the relevance and timeliness of Network Equilibrium. The updated Section, as given below, will be included in the revised FSP submission:

4.5 Criterion (e): Relevance and timing
4.5.1 Overcoming current obstacles to a future low carbon economy
The management of voltage is a growing concern with the potential increases in demand, especially localised clusters of low carbon technologies. This was recently highlighted by the IET in their Power Network Joint Vision “Electricity Networks – Handling a shock to the system”. These problems are exacerbated during outage conditions. Large areas of the distribution networks are already limited by voltage rise and thermal restrictions, caused by the high power output from DG during periods of minimum demand. The low carbon capacity trend looks set to continue with DECC and National Grid estimating that an additional 46 – 81 GW will be connected over the next 21 years, based on a recent report “UK Future Energy Scenarios” (published by National Grid in 2014).
The three Methods proposed for trials in Network Equilibrium will overcome voltage and power flow management obstacles by developing alternative solutions to network reinforcement in readiness for Business as Usual roll out by DNOs.

4.5.2 Trialling new technologies that could have a major low carbon impact</td></tr>
</table>

	The system voltage optimisation and power electronics devices being trialled will make a significant difference in areas that have already seen (or expected to see) a large take-up in DG and LCTs. Rather than relying on customer engagement to deliver low carbon benefits, WPD will use Network Equilibrium to demonstrate how electricity networks can evolve to be fit-for-purpose and ready to support a low carbon economy as and when this occurs. For example, the trialling of the innovative technologies will unlock capacity for DG (for example using FPLs to balance high load demand areas with excesses of DG). Once proven, the technologies will facilitate further capacity for Electric Vehicles and Heat Pumps, when these LCTs become more prevalent. 4.5.3 *Demonstrating new system approaches that could have a widespread application* Network Equilibrium has applications in a number of areas including system planning, the development of design standards, system operation and outage scenario planning. The project outcomes will be particularly relevant to other GB DNOs but also of interest to a number of other stakeholders including TSOs, the manufacturers of voltage control and FPL devices, the academic community, and standards / electricity network code developers. Furthermore, the learning and experience will be of interest to international organisations (such as CIGRE, CIRED, the IET and the IEEE). This is evidenced by the recent formation of CIGRE working groups, which are focusing on the control of voltages and application of power electronics to distribution systems. 4.5.4 *Applicability to future business plans (regardless of uptake of LCTs)* WPD has a track record of taking projects to TRL 8 and deploying them into BAU. Equilibrium is the same. The EVA, SVO and FPL Methods will reduce the need for network reinforcement, this will be reflected in the business plan in terms of reduced requirements for conventional asset investment and will contribute to the savings in the Innovation Strategy. If Network Equilibrium proves to be cost effective at releasing latent capacity in electricity networks and lays the foundation for national design / operation standards, it can be reasonably expected to form part of the business plans of other GBs DNO when considering capacity constraints in their EHV and HV networks. **Answer 1**: **<u>Appendix N – No differentiators</u>** There is a typo; this should state both Appendix N & O. **<u>How we decided the TRLs</u>** WPD made an assessment of the TRL of similar LCN Fund projects based on the proposed levels in the “UK Low Carbon Energy Technology Strategy: September 2008” (as given in the table below and referenced in the LCN Fund Governance document v.6).

TRL	Technology status	Description
1	Basic principles observed and reported	Scientific research begins to be translated into applied research and development.
2	Technology concept and/or application formulated	Practical applications of basic key principles can be 'invented' or identified. The application is still speculative: there is not experimental proof or detailed analysis to support the proposal.
3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated: analytical studies to set the technology into an appropriate context, and laboratory-based work to physically validate that the analytical predictions are correct. These should constitute "proof-of-concept" validation.
4	Technology / part of technology validation in a laboratory environment	Following successful "proof-of-concept" work, basic technological elements are integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance. The validation is relatively small scale compared to the eventual technology: it could be composed of ad hoc discrete components in a laboratory.
5	Technology / part of technology validation in working environment	At this level, the reliability / scale of the component being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications can be tested in a 'simulated' or somewhat realistic environment (which is almost always the working environment for energy technologies).
6	Technology model or prototype demonstration in a working environment	A major step in the reliability / scale of the technology demonstration follows the completion of TRL 5. At TRL 6, a prototype going well beyond ad hoc or discrete components is tested in a working environment.
7	Full-scale technology demonstration in working environment	TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in the working environment. The prototype should be near or at the scale of the planned operational system and the demonstration must take place in the working environment.
8	Technology completed and ready for deployment through test and demonstration	In almost all cases, this level is the end of true 'system development' for most technology elements. This might include integration of new technology into an existing system. Represents the stage at which an example of the technology is tried and tested
9	Technology deployed	In almost all cases, the end of last 'bug fixing' aspects of true 'system development' and represents the point at which the technology is proven, but not necessarily yet commercially viable in either a free or supported market. This might include integration of new technology into an existing system. This TRL does not include planned product improvement of ongoing or reusable systems.

As part of the bid preparation, WPD analysed existing projects using information available in the public domain. This included project websites, bid documents and project directions, six monthly reports, SDRCs and other relevant materials. This lead to a detailed qualitative assessment of existing LCN Fund projects. In summary:

- WPD's FlexDGrid is taking fault current limiter technologies to TRL 8. In this case three different types of fault current limiter (pre-saturated core, resistive superconducting and active decoupling) will be tested and demonstrated in a working environment (substations in Birmingham) – TRL 7 – and, by the end of the project, these technologies will be integrated into WPD's existing network management system – TRL 8.

- UKPN's Flexible Plug and Play project is taking voltage control technology to TRL 7. The voltage automatic voltage control of transformer tap changers at a single location (March Grid substation) demonstrates the technology in a working environment but not at full scale across the network. The Quadrature booster element of the project has been classified as TRL7; it is demonstrated in a single location with modest performance data.

- WPD's Lincolnshire Low Carbon Hub is taking voltage control technologies to TRLs 7 (control under steady stated conditions and is being demonstrated on at one substation) and the DStatcom ring network and DStatcom to TRL 8 (due to the learning from this project and other DStatcom and meshed networks in other areas).

- WPD's Falcon project is demonstrating a scenario investment model using existing planning tools and the demonstration of various HV technical and commercial solutions. The SIM and 6

	HV solutions will be at TRL 7. • SSE's NINES project has demonstrated discrete components (1 MW battery for energy storage, domestic demand side response, 130MWh thermal water store and 4MW electrical boiler) in a working environment – TRL 5. When this is controlled through an active network management system, the technology will be at TRL 6. • UKPN's Low Carbon London project is a system level project. The uptake from heat pumps and EV's have been monitored and modelled to statistically derive the cumulative impact on networks, the models are between TRL 6 and 7. The DSM trials are at TRL 7 (a full scale trial across 36 different sites across London). When fully integrated with the control and billing system the method will be at TRL8.
	Conclusion 1: No further comment.
Sub-criterion (e.ii) – How the method will be used as part of future business planning.	**Challenge 1**: No specific challenge. This criterion has not been addressed in the submission. This criterion should be addressed.
	Answer 1: **Methods used in business planning** Section 4.5.2. explains how the projects methods will taken to TRL 8 and subsequently be used within the business plan in the same way as WPDs other large scale demonstration projects. Where appropriate EVA, SVO and FPLs will be used as an alternative to EHV and HV conventional network methods for voltage and thermal reinforcement. Section 8.1 of WPD's innovation strategy details how WPD rolls out learning from our innovation projects into business planning. **Rolling out the learning from innovation projects** 8.1 Rolling out the learning from innovation projects we deliver innovation through an in-sourced model with a small team of specialists using the resources of our operational teams to deliver tools or products onto the network. The Innovation Team is part of the company's Policy department where they interact with equipment specifiers and technical experts of the wider business. Once trials are successfully completed, the outputs are taken forward and replicated across our network. As outputs are delivered, they are developed into new learning that can be taken forward and developed as business as usual. Outputs obtained from other DNO projects are fed into this process to ensure that we gain maximum benefit from LCNF projects. All solutions rolled out from innovation follow the same route as our other policies and techniques introduced into the company. Policies are reviewed by the senior network managers before they are

	introduced. The rollout process includes implementation plans and, where appropriate, training and dissemination sessions. We monitor all the LCNF projects as they develop and make use of learning and outcomes as they are reported. An example of learning that we have used can be seen in our Tier 1 Community Energy Action project where we are using smart commercial agreements from UKPN's Flexible Plug and Play project rather than developing our own agreements. Our RPZ1 project has developed a practical application for Dynamic Line Ratings (DLR) on our 132kV overhead lines. The project results have been embedded into business as usual and are documented in a dynamic line rating policy. On the circuit where the dynamic solution was developed, we have identified 19MVA of capacity that can be offered using DLR. This is a 20% increase on the static capacity values. Similar values will be achieved on circuits which are operated in a dynamic way.
	Conclusion 1: No further comment.
Sub-criterion (e.iii) – How the method will be used as part of future business planning if uptake of LCTs is less than expected	**Challenge 1**: No specific challenge. This criterion has not been addressed into the submission. This criterion should be addressed. WPD should provide a statement on the applicability of the methods should the uptake of LCT be less than expected.
	Answer 1: **<u>If LCTs are less than expected, how will the methods be used?</u>** Section 6.5, states that In the event that the take up of low carbon technologies and renewable energy in the Trial area is lower than anticipated, the Project plan will still deliver learning, detailing the learning for each method. The learning from Network Equilibrium will feed into WPDs future business plan. The trial area already has very high levels of Distributed Generation connected; additional connection of DG to the networks often triggers significant network reinforcement. This is also outlined in the heat map in Appendix C. Voltage profiles have been optimised for passive control. This means in the event of further LCTs <u>or</u> demand growth, network reinforcement will be triggered. Further to the information within the full submission, the learning from each method in the event LCTs is less than expected has been included below: The **Enhanced Voltage Assessment** (EVA) Method would be used in future business planning to increase the precision of network modelling tools, reducing network complexity across networks under abnormal conditions. The **System Voltage Optimisation** (SVO) method would be used in the networks where a maintaining voltage profile with passive control is a limiting factor. This could be triggered by additional demand to networks with existing high LCT penetration. The **Flexible Power Links** (FPL) demonstrations will pave the way for

	cross-border DNO connections, which do not exist at 11kV and 33kV as they would be unmanageable. This could be triggered by additional demand growth.
	Conclusion 1: No further comment.
Sub-criterion (e.iv) – The appropriateness of the timing of the project.	**Challenge 1**: No specific challenge. This criterion has not been addressed into the submission. This criterion should be addressed. WPD should provide a statement why this project is timely.

	Answer 1:
	
	Please also see the response in Box 21. The Full Submission Proforma now addresses this criterion; this information will be included upon resubmission of the Full Submission Proforma.
	
	The 'appropriateness of the timing' criterion has been addressed in the Network Equilibrium bid in a number of ways. For example:
	• Section 2.1 (Aims and Objectives):
	    ○ "Equilibrium is <u>timely</u> because it will build on the learning and technology readiness level (TRL) of other Tier-2 LCN Fund projects (such as ENW's "CLASS" and "Smart Streets", and UKPN's "Flexible Urban Networks" and "Flexible Plug and Play"). These projects have demonstrated the technologies in a network environment but often at lower network voltages. Scaled trials are needed to further advance the technologies, overcoming issues that are preventing the technologies from being rolled out. Equilibrium will deliver the required level of development, needed for critical network infrastructure solutions, in readiness for full business roll-out."
	    ○ "DECC's forecasts predicted that, by now, the UK would see a rapid take up of electric vehicles and other LCTs, such as heat pumps. This has not yet manifested itself but is expected with the continued implementation of the Carbon Plan. The outputs from Equilibrium will be <u>timely</u> in addressing this aspect of the Carbon Plan. The Methods, being demonstrated to accommodate DG in the Trial area, can also be used to solve voltage and thermal issues associated with electricity demand increases."
	
	• Section 3.1 (Reasons)
	    ○ "There are a number of technical constraints (voltage rise, thermal overloads and excessive fault levels), which are a current barrier to the rapid and cost-effective integration of LCTs (in particular, DG). Directly related to this, it is <u>timely</u> to review ENA Engineering Recommendations and GB's statutory voltage limits (which have remained unchanged in 11kV and 33kV systems since 1937) as these were originally developed

	for the passive operation of electricity networks. DNOs need more advanced planning and operational tools (and updated engineering standards) to overcome these technical constraints, integrate increased levels of DG and extract maximum benefits from the existing electricity network infrastructure. WPD avoided unnecessary duplication by not repeating these timeliness reasons in Section 4.5. In addition to this, it is particularly timely to demonstrate FPL technologies at multiple sites. This is because: • The application of power electronic conversion technologies (AC-DC-AC) to distribution networks was identified as being a particularly relevant area by the C6 Study Committee of CIGRE (The International Council of Large Electrical Power Systems) at the Conference Session in Paris 2014. Following the Study Committee meeting on 27th August 2014, two Working Groups are being formed to investigate the application of flexible power links at distribution level voltages (from 33kV to LV). • Power electronics devices are a prominent solution in DECC/Ofgem's Transform model. The industry will benefit from an improved understanding of how the devices can be used and how to build the business case in order to deploy power electronics devices. Furthermore, Network Equilibrium can be reasonably expected to stimulate the market for competition amongst vendors. This will reduce the costs and lead times of technologies through competitive market forces. • In the past 10 years, the voltage rating of power electronic switching devices, such as insulated gate bi-polar transistors (IGBTs), has increased from 1.2kV to 10kV. For higher voltage applications, the topology can be greatly simplified compared to 10 years ago. For example, 11kV AC-DC-AC could be achieved with a three level converter. Network Equilibrium is timely in demonstrating flexible power link technologies due to the availability of power electronic devices (such as IGBTs) at higher-rated voltages. • The increase in power density of semiconductor materials means that power electronics are now more versatile and can be used in high power applications; • The efficiency of power electronic devices has led to a 50% reduction in conversion losses over the past 10 years. In turn, this has reduced the cooling requirements and, hence, the overall footprint of power electronic devices.
	Conclusion 1: No further comment.

2.7

2.8 CRITERION (F) DEMONSTRATE A ROBUST METHODOLOGY AND THAT THE PROJECT IS READY TO IMPLEMENT

2.8.1 Key Statements

The project start date is stated 14 March 2015, the delayed start date is to allow pre-mobilisation, between the funding award date and the planned start of ***Equilibrium***, to ensure there is no conflict when securing specialist Project resource.

The project is phased in to four primary work packages

- Work Package: A Detailed Design including EVO
- Work Package: B SVO Build
- Work Package: C FPL Build
- Work Package: D Trial and Share

WPD states that the project will have not have any Direct Impact on customers, in terms of new charging mechanisms, contractual arrangements or supply interruptions.

The key risks associated with the project have been documented and are listed within the submission and they include;

- R007 Project team does not have the knowledge required to deliver the project
- R003 No suitable SVO system will be available
- R002 Costs of high cost items are significantly higher than expected
- R004 No suitable FPL device will be available
- R009 Selected sites for technology installations become unavailable

The costs of the project are detailed in the Full Submission Spreadsheet, and repeated in Table 4

Table 4 Project costs

Cost Component	£k
Labour	1,374.19
Equipment	8,959.33
Contractors	3,860.92
IT	496.33
IPR Costs	-
Travel & Expenses	169.71
Payments to users & Contingency	1,491.38
Decommissioning	-
Other	53.29
Total	16,405.15

As noted above the equipment cost is dominated by the FPL hardware costs and the AVC equipment for the SVO. WPD labour costs are dominated by project management at £510k and installation of the SVO AVC equipment at [redacted]

Table 5 Project costs per work Package

	WP A (£k)	WP B SVO (£k)	WP C FPL (£k)	WP D (£k)
Labour	[redacted]	[redacted]	[redacted]	[redacted]
Equipment	-	[redacted]	[redacted]	-
Contractors	[redacted]	[redacted]	[redacted]	[redacted]
IT	[redacted]	[redacted]	[redacted]	-
IPR Costs	-	-	-	-
Travel & Expenses	[redacted]	[redacted]	-	[redacted]
Payments to users	-	-	-	-
Contingency	[redacted]	[redacted]	[redacted]	[redacted]
Decommissioning	-	-	-	-
Other	-	-	-	[redacted]

Table 5 details the work package cost from the Full Submission spreadsheet and suggests that contractors are delivering the bulk of the individual work packages. Contractor's costs represent 23% of the total project budget, the dominant cost once equipment purchase and project management has been removed.

Successful Delivery Reward Criteria

There are eight, Successful Delivery Reward Criteria (SDRC)

- SDRC-1 Detailed design of the Enhanced Voltage Assessment (EVA) Method
- SDRC-2 Detailed design of the System Voltage Optimisation (SVO) Method
- SDRC-3 Detailed design of the Flexible Power Link (FPL) Method
- SDRC-4 Trialling and demonstrating the EVA Method;
- SDRC-5 Trialling and demonstrating the SVO Method;
- SDRC-6 Trialling and demonstrating the FPL Method;
- SDRC-7 Trialling and demonstrating the integration of the EVA, SVO and FPL Methods
- SDRC-8 Knowledge capture and dissemination,

2.8.2 Challenges and Potential Shortfalls

Criterion (F) – Demonstrate a robust methodology and that the project is ready to implement;	
Sub-criterion (f.i) – Their project plan, risk management, mitigation and contingency plans, risk register and resources to deliver the project	**Challenge 1**: Project Plan: The breakdown of tasks in the *Whole Cost Breakdown Full Submission Spreadsheet* is not reflected in the project plan. Key tasks such as site surveys, design of the 11kV and 33kV SVO algorithms are not included in the project plan. WPD should produce a project plan that includes all of the tasks indicated in the *Whole Cost Breakdown Full Submission Spreadsheet*?
	Answer 1: Version 1.2 of the project plan is attached clarifying which tasks are linked to the Full Submission Spreadsheet. This was submitted through the Q&A process on Tuesday 26th August.

	Conclusion 1: The DNO response does not include the timescales for the development of the SVO algorithms and FPL artificial intelligence. These activities are software development activities and WPD has not demonstrated that the software development time has been adequately captured.
	Challenge 2 The contingency plan as stated in Appendix F does not seem to fully address the risks. Risk R003: No suitable SVO system will be available, Contingency: Utilise different SVO systems to deliver the project's objectives. This seems to be a circular reference - if an SVO system is not available would there be a different one available? Risk R004: No suitable FPL system will be available, Contingency: Utilise different FPL systems to deliver the project's objectives. This seems to be a circular reference - if an FPL system is not available would there be a different one available? Can WPD produce an updated contingency plan to assist assessment?
	Answer 2: WPD have clarified the circular reference in the answers to Question 32 and 33. Please find attached an updated contingency plan which reflects the answers to Questions 32 and 33. The "No SVO system available" should have said "No SVO available from the contracted supplier". This was a contractual risk, not one of overall availability. The "No FPL available" should have said "No FPL available from the contracted supplier". This was a contractual risk, not one of overall availability. A new copy of the risk register has been attached.
	Conclusion 2 From review of the new risk register it is judged that there is also a significant risk associated with the non delivery/performance of the software component of this submission, considering the significant level of integration required with existing WPD systems and the relative complexity of wide area voltage control algorithms. The updated risk register does contain a series risk associated with the development and integration of the SVO method (RO16 to RO19) and it is judged that the FPL method has similar level and types of risk. The mitigations proposed by WPD are centred around specification and testing, but it is judged that the project would benefit from an early stage de-risking exercise to ensure that all risks can be adequately

	mitigated.
	Challenge 3: The project management costs are very high, approx £500k. Further task cost breakdown is necessary to determine the validity of this cost, particularly as the majority of work package B and C costs relate to the capital cost of equipment.
	Answer 3 These costs consist of both the project management costs and full time programme office. The project management costs account for £350k; this uses the WPD day rates for a full time project manager plus overheads. This is the same as all other innovation and BAU work. The full time programme office will cost £160k over 4 years, the programme office will support the project by managing action logs, RAID logs, and financial performance, support the capturing planned and unplanned knowledge and support the dissemination of learning. The approximate cost of PM cost by work package have are detailed in table 3. **Work Package** / **Costs**: **A** £91k; **B** £94.5k; **C** £94.5k; **D** £70k; **Total** £350k Table 3
	Conclusion 3 No further comment.
	Challenge 4: Whole Cost Breakdown Full Submission Spreadsheet**:** Work Package A contains 130 days of site visits to BSPs and Primaries. What are the benefits of site visits as opposed to desktop reviews? Are there commonalities between the BSPs and Primaries in the trial area that help to reduce/minimise costs? £88k of site survey work is indicated, how does this differ from a site visit?

Answer 4

WPD will use the following three steps when assessing potential sites for Network Equilibrium methods:

1) Desk top reviews
2) Site Visits
3) Site Surveys

As an analogy, this process is very similar to the process of purchasing a house:

1) **Desk top review** - Reviewing a large number of potential properties using estate agent websites and information packs sent by post.

   This allows you to quickly discount certain properties and identify the properties that best fit your specification.

2) **Site visits** – Viewings are arranged for all the suitable properties to gather the information that cannot be gathered from the desk top review.

   This can, on occasion, require a number of viewings to the same property to ensure that all the details have been fully considered, such as to ensure your furniture would fit in the property.

3) **Site Surveys** – After deciding on which house best fits your specification, before purchasing the house you conduct a number of detailed (often expensive) surveys (for example, structural and ground surveys) to ensure you are fully informed and confident to complete the purchase of the house without any unexpected consequences.

The project follows a similar process:

1) The project team will perform a **desk top review** on all the available historic and background information. Where applicable certain sites will be discounted if it is clear the project methods are not suitable. There are 17 BSPs in the project area and 135 primary substations in the project area under normal operation.

2) The project team will undertake site visits to the sub-set of sites identified in the desk top reviews. This will ensure the background information is accurate and to gather information not available from the historic information.

   Pre site visit preparations will be undertaken to minimise the requirement for return visits to sites, however as with the analogy above, this cannot be discounted at this stage.

   By undertaking site surveys, the design of the methods and the installation phase is significantly de risked.

	3) A site survey will be undertaken at 4 substations for the Flexible Power Link Method, two 11kV and two 33kV substations. Site surveys will be undertaken at two separate 11kV and 33kV substations to again de risk the installation of the Flexible Power Link equipment. These site surveys are required to inform civil and electrical design considerations such as ground pressure, soil resistivity and inspection of the existing earthing network. Site surveys are required before any new construction activities are undertaken.
	Conclusion 4 While the answer covered some of the aspects raised in the challenge, £88K seems expensive for 4 site surveys. It remains unclear whether WPD has optimised the costs by carrying out site visits and surveys together, or even whether this was considered. A statement that the project team will optimise the costs of visits etc. during the planning phase of the project would provide assurance to the assessors
	Challenge 5: The key project risk as stated in the submission is that the Project team does not have the knowledge required to deliver the project. WPD to advise if this project will build on previous LCNF project knowledge and lessons learnt from their mitigation strategy project plans? Does the WPD project plan include time to absorb the learning generated by previous LCNF projects to ensure that the knowledge of the project team is as up to date as possible?
	Answer 5 **Will the project build on previous project knowledge?** Yes, as per the answer in box 12 above. **Does the project plan allow enough time to absorb learning from previous LCNF projects?** Yes, both in the pre-project mobilisation and after the tendering process, time has been allowed to ensure all relevant learning has been absorbed from previous projects.
	Conclusion 5 No further comment.
	Challenge 6: Regarding the risks that no suitable SVO or FPL system will be available. These are considered to be significant and are conditions to suspend the project. It would aid the assessment if these key risks were identified and considered in Section 6.6 of the submission.
	Answer 6 Please see box 26.

	The risk register as originally submitted was open to such misinterpretation. Both SVO and FPLs are available. This was confirmed in the RFI responses, provided by suppliers during the FSP preparation. Please find attached an updated version of the risk register, clarifying the risks mentioned above.
	Conclusion 6: As per response to Sub-criterion (f.i) Challenge 2, Conclusion 2
Sub-criterion (f.ii) – The customer impact of the project	**Challenge 1**: No specific challenge. The submission states no customer impacts, this is acceptable.
	Answer 1: N/A
	Conclusion 1: N/A
Sub-criterion (f.iii) – Uncertainties in costs and benefits	**Challenge 1**: WPD have not provided any comments or statements on the uncertainty of costs and benefits associated with the project. The benefits in terms of capacity released, reduction in connection times are assumed to be estimates. Can WPD provide a level of confidence or the associated accuracy levels/ error bands for these figures?
	Answer 1: **<u>Cost uncertainty</u>** The costs are the BAU levels of certainty. WPD's LCNF projects are delivered in the same way. We are sufficiently confident of the cost estimates not to request and protection against cost overruns. **<u>Benefit uncertainty</u>** WPD's best estimates have been used to model the benefits using the method outlined in Box 2. We have not modelled multiple scenarios; this would have taken a disproportionate amount of time and resource. As part of the project, the method benefits will be continually assessed, reviewed and shared (with other DNOs) for each of the networks selected for EVA, SVO and FPL methods.
	Conclusion 1: DNO response to the challenge is acceptable but the panel should note there is significant uncertainty in the estimated benefits as the have been modelled using the South-West BSP area only and may not scale or deliver the same level of benefits in other areas.
Sub-criterion (f.iv) – Project methodology	**Challenge 1**: Section 6 details the project controls, management controls, procurement processes and customer engagement strategy. It does not seem to detail how the design elements of the project, i.e. novel algorithms for the SVO methods and artificial intelligence for the FPL method, will be managed and delivered. Can WPD provide details of the methodology, controls and processes that would ensure that the **design** goals of the project are met?
	Answer 1: The high-level design methodology is outlined below. This process has

	been successfully used by WPD on a number of its other LCN Fund projects (such as FlexDGrid) to manage and deliver the design elements of the project. • Stage 1: Creation of technical specification • Stage 2: Creation of functional design specification • Stage 3: Definition of quality expectations • Stage 4: Definition of acceptance criteria and formation of contract(s) with supplier(s) • Stage 5: Product development • Stage 6: Formal design reviews • Stage 7: Factory / functional acceptance testing • Stage 8: Site acceptance testing (if required) • Stage 9: Demonstration within real world environment • Stage 10: Report on design process, analysis and results The controls of the design process are established at Stage 4, where WPD defines its measureable acceptance criteria against which the product (e.g. algorithm) development is assessed through Stages 5 - 9. The design processes are detailed below: • Stage 1 creates the technical specifications of the design and defines the set of standards (and / or WPD policies) to which the completed product design must comply. • Stage 2 defines what the product is expected to do. In the case of algorithm development, this stage captures the data input requirements, the calculation steps and expected outputs. • Stages 3 and 4 represent qualitative and quantitative design criteria respectively. An example for Stage 3 being ‘the algorithm will be used for forecasting’, an example for Stage 4 being ‘the algorithm will be used for forecasting voltage and load profiles at 8 substations up to 30 minutes ahead’. These criteria are captured in the scope of work of supplier contracts. • Stages 5 and 6 are iterative and formal design reviews take place on a regular basis (for example at a weekly frequency). During this part of the design process, WPD works closely with suppliers to ensure that design goals are met, understood and constantly monitored. Design changes are formally recorded in a design log and design review meetings are formally recorded through meeting minutes. • Stages 7 – 9 represent additional control gateways. For example, the expected performance of a product (e.g. algorithm) is derived from Stage 4 (acceptance criteria) and defined as a series of bench (or functional) tests which are witnessed by two independent WPD personnel. Similar controls are used at Stage 8 (if required) and Stage 9 of the design process. • Stage 10 results in a summary report of the design process. As well as confirming the performance of the product against

	the original specification (and results from acceptance tests), this stage also captures the lessons learnt during the design process. The lessons learnt can then feed into other parts of WPD's business and be shared with other DNOs / product developers. In addition to this, WPD has quality controls in place, whereby design report documents (and resulting products) are produced by one party, independently reviewed by another party and approved by the relevant part of WPD's business (for example, by the Policy Manager or Primary System Design Manager).
	Conclusion 1: From the review of the project plan and risk register and response to this challenge WPD have not demonstrated that software development time has been adequately captured in the project plan. Software development and integration have the potential to significantly delay the implementation of this project.
Sub-criterion (f.v) – Successful Delivery Reward Criteria	**Challenge 1**: The reward criteria detail a number of evidence items that will be used to support the specific measureable criteria of the smart deliverable. For all of the reward criteria the deliverable stated is a report. The Evidence criteria presented seem to be deliverables in the majority of cases. Can WPD detail the format of these deliverables and tie them to the measurable part of the smart objectives.
	Answer 1: The SDRCs in section 9 have been updated to link the evidence to the measurable output.
	Conclusion 1: No further comment.

3. INITIAL FINDINGS

WPD claim that deployment of the methods in this submission will advance system voltage control, power electronic based power flow management and the required planning tools from TL6/7 to TRL8. WPD state that advancement in TRL is required to support the move to a low carbon economy and is appropriate as it builds on previous projects and limited trial data and will allow these technologies to be rolled out as business as usual.

It is considered by the consultant that the methods to advance the TRL and the stated project aims are reasonable and practicable and, if deployed, have the capability to realise significant benefits on the GB distribution networks. However there is further justification work required to substantiate the claimed benefits and costs.

Frazer-Nash Consultancy initial review conclusions with response from WPD in blue;

1. The LCNF governance document states that projects that are at different TRLs will not be considered as unnecessary duplicates. The TRL claims made throughout the submission have not been appropriately substantiated. It is not clear what processes or references have been used to generate the claimed TRL.

2. With regard to the individual methods, the submission does not provide any significant detail on TRLs of the novel voltage control algorithms associated with the SVO method or the artificial intelligence associated with the FPL method. Only generic information or simplified analogies have been provided. It is not clear from the submission what is new, novel, more advanced or more robust than previous deployments.

3. The claims made by WPD with regards to capacity released and the acceleration of timescales and benefits of the particular methods cannot be assessed , as there is very limited information on how these numbers have been generated. Only summary information has been provided.

4. The net benefit of the Network Equilibrium project is calculated by comparing the method costs to conventional reinforcement costs. The calculated conventional reinforcement costs are based on an average feeder length and 10 Bulk Supply points, to be representative of the trial area and allow scaling to the license area and the GB network. It is judged that the conventional reinforcement strategy presented in the submission may not represent the most cost efficient solution. It is not clear in the submission whether the reinforcement of feeders has been duplicated across the methods.

   As a result of the above, WPD has not provided sufficient information to show that the proposed reinforcement strategy provides the most efficient solution to release 356 MW in a 10 BSP area, and demonstrate there is no duplication of reinforcement in calculating the cost and therefore benefits.

5. WPD has completed a benchmarking exercise against similar projects and the cost of the overall Network Equilibrium project vs. MW released is comparable in £/MW terms to previous LCN projects but the analysis of the individual methods shows that;

   The EVA method has a cost of approximately [redacted] per MW released, and would potentially be very cost effective, if the voltage limits can be changed and there are no limiting equipment items.

   The SVO method has a cost of approximately [redacted] per MW released and is more cost effective with regards to costs and capacity released to other voltage control based LCNF projects.

   The FPL method has a cost of approximately [redacted] per MW released and is an order of magnitude more expensive than the other methods as this method's costs are dominated by hardware costs. The 11kV equipment costs [redacted] million pounds and 33 KV equipment costs [redacted] million pounds. These are the market rates for equipment of this type, but given the overall cost and lack of supporting information it is difficult to determine if the FPL solution offers value for money.

For the EVA method it is judged this method will only delivery the financial benefit if the voltage limits are relaxed. As there is a significant risk that the voltage limits will not be relaxed, this risk has not been adequately captured in the project submission.

6. Given the concerns with regard to calculation of benefits and capacity released it is not clear that the FPL method provides value for money in the context of an LCNF project.

7. WPD have not provided any comments or statements on the uncertainty of costs and benefits associated with the project. The benefits in terms of capacity released and reduction in connection times are assumed to be estimates and WPD have not attempted to bound these estimates with error bands or confidence levels.

   It is considered that the learning from the project will also be incremental, increasing and building on the knowledge developed in previous projects. However, it is not clear from the submission how the learning from previous projects will be incorporated into the Network Equilibrium project.

8. WPD has assumed gradual replications, but with regards to EVA the relaxation of the voltage limits is a binary condition, the limits proposed by WPD will be accepted or not. Therefore assuming a gradual rollout of the EVA method does not seem reasonable. Once the limits have been relaxed, other DNOs may choose not to use the EVA network planning tool, and may chose a tool of their own design, or they may decide that existing tools are fit for purpose. WPD should confirm whether this roll out strategy for the EVA method is fit for purpose.

   The proposed adoption rates for the SVO and FPL method seem to be conservative. It is not clear what the limiting factors are for the adoption of the SVO and FPL methods, particularly if the submission achieves its stated aims and accelerates these technologies to TRL8 and delivers the benefits as stated.

9. In a number of areas WPD do not seem to have addressed the LCNF criteria. This has been highlighted in the body of the document and it would assist in the assessment if these criteria were addressed.

4. UPDATED FINDINGS FOLLOWING DNO RESPONSES

From the review of the responses provided by WPD, it is judged that the majority of the challenges raised by Frazer-Nash Consultancy have been addressed. However there are a number of areas where further clarification should be sought.

1. From the submission and the responses provided it is not clear if WPD plan to develop or purchase the novel voltage control algorithms associated with the SVO method or the artificial intelligence associated with the FPL method.

   It is considered that it is the software control of the hardware associated with these methods that will unlock the capacity claimed in the submission. Deployment of the hardware without the software is unlikely to unlock any benefits.

   From this it is judged that there is significant risk associated with the non-delivery/performance of the software component of this submission, considering the significant level of integration required with existing WPD systems and the relative complexity of wide area voltage control algorithms.

   The updated risk register does contain a series risk associated with the development and integration of the SVO method (RO16 to RO19) and it is judged that the FPL method has similar level and types of risk. The mitigations proposed by WPD are centred around specification and testing, but it is judged that the project would benefit from an early stage de-risking exercise to ensure that all risks can be adequately mitigated.

   Of particular concern is RO16. RO16 states that 'The amount of data to be transferred as part of SVO Method means an advancement in the communications system used is required' Deployment of a new communications system has the potential to be expensive and may undermine the cost benefit assumptions in this submission and the ability to replicate the method to other areas.

   From the review of the updated project plan and risk register and responses WPD have not demonstrated that software development time has been adequately captured in the project plan. Software development and integration have the potential to significantly delay the implementation of this project.

2. Frazer-Nash Consultancy challenged WPD to detail the mechanism for releasing the additional MW benefits claimed from the coincident deployment of the three method proposed in the submission.

   The DNO response to the challenge seems to suggest that **any** additional capacity release will be quantified as part of the project. It is judged that is optimistic to assume a 10% headroom increase as when the methods proposed as part of this submission are deployed the network will be heavily utilised and an additional 10% capacity increase may not be achievable.

3. In response to the challenge of the certainty of the estimated benefits, WPD state best estimates have been used to model the benefits using the method outlined based in the use of Power System Analysis software models of the south west area. WPD state that they have not modelled multiple scenarios as this would have taken a disproportionate amount of time and resource. However as part of the project, the method benefits will be continually assessed, reviewed and shared (with other DNOs) for each of the networks selected for EVA, SVO and FPL methods.

   From the review of the modelling methods detailed it is judged that there is significant uncertainty in the estimated benefits as the model will not take into account the physical reality of any particular system. Secondly as WPD have modelled the South-West BSP area only, the claimed benefits may not scale or deliver the same level of benefits in other network areas/DNO licensees.