PPA Energy
1 Frederick Sanger Road
Surrey Research Park
Guildford, Surrey
GU2 7YD, UK
www.ppaenergy.co.uk
Tel: +44 (0)1483 544944
Fax: +44 (0)1483 544955

PPA energy
Planning Energy
for a Sustainable World

Ofgem LCNF Tier 2 Evaluations

FLEXGRID – Advanced Fault Level Management in Birmingham

WPD

Final Report

Submitted to: Ofgem

Date: 2 November 2012

CONTENTS

Explanatory Note

This report, including the "traffic light" indicators that reflect issues of concern identified during the evaluation process, (other than Section 9) is based on:-

- the original full submissions that were received from the DNOs in August 2012;

- subsequent question responses through the formal written question process; and

- discussions held at meetings between the DNOs and the Expert Panel and/or PPA Energy.

In October 2012 the DNOs were given an opportunity to submit revised proposals. The traffic light indicators and the metrics shown in Sections 1 to 8 have not been changed to reflect any changes made by the DNOs in these revised submissions.

Section 9 of this report contains an addendum, which summarises changes made between the original and revised submissions, and the impact this has on the evaluation of the project against the criteria. Any significant changes to figures/metrics are noted in this addendum.

Project Summary

Full name:	FLEXGRID – Advanced Fault Level Management in Birmingham	Short name:	FLEXGRID
		Total cost:	£17.600 million
DNO group:	WPD	LCNF funding request:	£13.881 million

The Problem(s): Fault level is a measure of electrical stress that results when faults occur on the network. Fault level is a growing issue in the connection of DG, particularly in urban areas. In locations where fault level is at or close to its limit, there are constraints connecting DG as DG contributes to fault level. Conventional solutions to reduce fault level often require significant capital costs and long lead times. Fault level estimates are currently based on unmonitored network environments - could be conservative.

The Method(s): Three methods have been identified to be tested:

- Method Alpha: Enhanced Fault Level Assessment - develop a fault level quantification methodology using a probabilistic approach.
- Method Beta: Real-time Management - Install fault level measurement devices, gather fault level data and verify Method Alpha.
- Method Gamma: Fault level mitigation - Install five fault level mitigation technologies (to be selected).

The Trial(s):

- Use historic data based on connection applications to understand how the Method Alpha could have been applied; develop "Enhanced Fault Level Assessment" processes; apply method to new connection applications to determine difference between and benefit over traditional approach; consider longer term development of the method (DECC 2050 pathways analysis scenarios); consult stakeholders on Method Alpha.
- Install real-time Fault Level measurement devices at 10 primary substation sites; model the sites (with real-time input, includes modelling fault level mitigation technologies); assess contribution of new DG to fault level using modelling and measurement;

design network management logic.

- Five (demonstration ready) fault level mitigation technologies will be chosen for network installation at five separate primary substations in Birmingham; assess their merits (including allowing different substation operating arrangements that could reduce CMLs and CIs); quantify benefits (connections that can be made).

The Solution(s): Defer / avoid capital investment due to fault level issues and associated lead times; expedite time to connect DG and reduce cost of connections; reduce CIs and CMLs through "solid network configuration"; "facilitate sustainable and affordable electricity prices".

Key strengths and weaknesses against the criteria

Strengths

- The project has considerable potential to contribute to the development of the low carbon energy sector, through the facilitation of the connection of greater quantities of low carbon generation at the distribution level by the mitigation of fault level increases.

- The benefits of this project are clearly attributable to distribution customers, through the cost reductions that would arise from reduced network reinforcement costs to cater for increasing fault levels and any improvements that are achieved in connection application assessment.

- Trials of new methods for calculating and measuring fault levels, and reducing them, are proposed which, if successful, could directly improve the ability of DNOs to connect generation, particularly CHP, in areas where fault levels are a constraint.

- The project partners have the capability to investigate the subject area comprehensively.

- Costs of major equipment items will be contained through a competitive tendering process.

- The project methodology consists of related activities which taken together have the potential to increase learning in an important technical area affecting distribution network customers.

Weaknesses

- The assumptions behind the figures presented for total carbon savings assume a high level of CHP take up in cities in the UK, which is dependent on a variety of factors beyond simply the configuration of the electricity network.

- It appears questionable whether the 10% increases in permissible fault level claimed for Methods Alpha and Beta would be achievable.

- The project management and programme for the project are defined at a high level and there is insufficient visibility of the detailed tasks and interdependencies between them that will need to be taken into account to ensure the success of the project.

- A number of the defined outcomes of the project relate to activities outside the deployment of the trials that are more connected with the adoption of revised practices into WPD's business as a consequence of the project than related to the project itself.

1 Summary of Assessment against Evaluation Criteria

Criteria	Overall Assessment	
(a) Low carbon and benefits		The project has considerable potential to contribute to the development of the low carbon energy sector, through the facilitation of the connection of greater quantities of low carbon generation at the distribution level by the mitigation of fault level increases. The assumptions behind the figures presented for total carbon savings assume a high level of CHP take up in cities in the UK, which is dependent on a variety of factors beyond simply the configuration of the electricity network. Insufficient evidence is presented of the basis for the estimates of capacity released, and it appears questionable whether the 10% increases in permissible fault level claimed for Methods Alpha and Beta would be achievable. The timescales over which capacity would be released, particularly in Methods Alpha and Gamma, are potentially somewhat optimistic, given the time that it would take to gain acceptance of new methods of carrying out fault calculations and gaining acceptability of proposed range of fault level mitigation technologies on the network.
(b) Value for money		The benefits of this project are clearly attributable to distribution customers, through the cost reductions that would arise from reduced network reinforcement costs to cater for increasing fault levels and any improvements that are achieved in connection application assessment. Competitive tendering processes are understood to have been applied to the selection of the academic partner, and will also be used in the selection of fault level mitigation technology. At present however the cost of the fault level

		mitigation measures for the project comprises the largest area of uncertainty. It is unclear whether further supplier selection is proposed for the fault level monitoring equipment. Parsons Brinckerhoff's involvement in the project has been an evolving collaboration rather than in response to a call for expressions of interest. Contractor costs are generally reasonable, although a relatively large proportion of these is associated with management of contractor inputs and general project support. A larger amount of resource is being directed at this project by WPD than might be expected, although the daily charge rates for the staff involved appear reasonable.
(c) Generates knowledge		The knowledge generated by the project is relevant to all DNOs, since rising fault levels on systems with distributed generation seeking to connect to them are a well known problem. There are no deviations from the default IP arrangements requested for this project. The principles of learning dissemination are clearly defined, however a more detailed plan would be beneficial.
(d) Partners and Funding		The partners selected for the project are appropriate and have relevant experience, however the depth of experience of Warwick University in the specific area of fault level measurement is unclear. A procurement process was run for the identification of an academic partner, however this is understood to have received limited response. The bulk of the external funding to be provided is shown as being provided by equipment suppliers that have yet to be identified, and is

		presumably therefore subject to negotiation.
(f) Relevance and timing		Increasing system fault levels are a well known barrier to the integration of distributed generation into the distribution network. Proving the operation of fault level mitigation equipment and enhancing the accuracy with which fault levels are understood and limits are applied could have a significant impact in reducing fault levels and creating additional headroom for new generation. The potential for any of the methods proposed to gain acceptance and be approved for use in normal network planning and operation may be dependent on achieving the necessary approvals from the Health and Safety Executive, depending on the extent of the changes to existing standards and practices that are proposed. From a technical perspective, however, the technologies proposed offer the potential to have significant low carbon impact if they are successful in permitting larger penetrations of DG from low carbon sources to connect to the distribution networks.
(g) Methodology		The project appears technically feasible in that it proposes a step by step approach to evaluating complementary methods for increasing the fault level head room on the distribution network. Relatively limited information is available regarding the details of the project methodology. Method Alpha is not clearly defined, however WPD have stated that this will use existing standards and fault level modelling/design principles combined with probabilistic techniques and focus on exploring and refining the underlying assumptions that feed into the calculation of fault levels. Method Beta relates to the application of fault level monitoring technology that has been

		developed to the level of laboratory tests through an LCNF Tier 1 project, and is reasonably well defined and self-contained. Previous attempts to measure fault level accurately are understood to have met with limited success, and a key issue on this project therefore concerns the extent to which the proposal for Method Beta is likely to prove more successful. Results presented by WPD from laboratory tests of the effectiveness of equipment of the type proposed for the trial indicate an accuracy of 4.5%, which gives a reasonable basis from which to proceed to field trials. Method Gamma is clearly defined at a conceptual level, in that it consists of the installation of specific fault level mitigation technologies at five different substation sites. The basis for the selection of the technologies, whether they are expected all to be different, and the criteria against which locations for their deployment are to be selected, are yet to be fully defined, however. Methods Alpha and Beta are expected to feed into this process, however the project plan is insufficiently clear as to the interactions and interdependencies between the three methods.
Successful Delivery Reward Criteria		Eight SDRCs are defined. These are not all clearly linked to the project programme or the deliverables described, in that whilst some of the outcomes relate to activities shown in the programme, others refer to activities outside the deployment of the trials that are more connected with the adoption of revised practices into WPD's business as a consequence of the project.

The "traffic light" system used in the table above gives an indication of PPA Energy's assessment of the information provided by the DNO in support of the project in respect of its detail, alignment with the LCNF evaluation criteria, identification and management of project risks and other aspects for each of the criteria. This is not intended to suggest whether projects should be funded or not but to point out those areas which PPA Energy believes merit particular scrutiny or consideration. Thus:-

	• Seems to be generally in line with the objectives and requirements of the LCN Fund evaluation criteria, • Whilst there are some areas where additional information would be useful, that provided is generally comprehensive and provides no immediate cause for concern.
	• Some indication that the project is in line with the objectives and requirements of the LCN Fund evaluation criteria. However further scrutiny is required to ensure this, • There are some gaps in the information provided, • Further assurance is needed to confirm that the project is viable and that risks are appropriately managed.
	• Significantly more assurance is required that the project is in line with the objectives and requirements of the LCN Fund evaluation criteria, • There are some major gaps in the information provided, • Considerable scrutiny is needed to confirm that that the project is viable and that risks are appropriately managed, • Potential major risks to the viability of the project.

In the following evaluations against the criteria, if the project is addressing various problems and/or trialling several methods and solutions, separate analysis of metrics and sub-criteria will be provided, if appropriate, for relevant criteria.

2 Criterion (a) Low Carbon and Benefits

Criterion:	Accelerates the development of the low carbon energy sector and has the potential to deliver net financial benefits to future and/or existing consumers
Overall assessment:	The project has considerable potential to contribute to the development of the low carbon energy sector, through the facilitation of the connection of greater quantities of low carbon generation at the distribution level by the mitigation of fault level increases. The assumptions behind the figures presented for total carbon savings assume a high level of CHP take up in cities in the UK, which is dependent on a variety of factors beyond simply the configuration of the electricity network. Aspects of the proposed financial savings would benefit from further clarification, since these are based on differing assumptions about the scale of application of the three Methods during the trials. Since the benefits arising from Method Gamma dominate in the calculations, however, this is not considered a significant issue. Insufficient evidence is presented of the basis for the estimates of capacity released, and it appears questionable whether the 10% increases in permissible fault level claimed for Methods Alpha and Beta would be achievable. The timescales over which capacity would be released, particularly in Methods Alpha and Gamma, are potentially somewhat optimistic, given the time that it would take to gain acceptance of new methods of carrying out fault calculations and gaining acceptability of proposed range of fault level mitigation technologies on the network.

Metrics (where available):			
	Method Alpha	Method Beta	Method Gamma
Net financial benefit (£)[1]:	£72,000	-£3.000 million	£38.400 million
Network capacity released (kW)[2]:	28,000 kW	28,000 kW	138,500 kW
Base case time to release capacity (months)[3]:	12	0	108
Method time to release capacity (months)[4]:	8	24	36
Potential for replication[5]:	Yes	Yes	Yes

[1] The financial benefit of each method (at the trial scale) compared to the most efficient existing method; **Net financial benefit = Base case costs** (the lowest cost of delivering the Solution (on the scale outlined as part of the project) which has been proven on the GB Distribution Systems) **– Method costs** (the costs of replicating the method at the trial scale once it has been proven successful)

[2] The network capacity released by each method (the additional headroom released on the distribution system following implementation of the Method)

[3] The time it would take in months to deliver the capacity shown in "Network capacity released" under the Base Case

[4] The time it would take in months to deliver the capacity shown in "Network capacity released" using the replicated Method

[5] The estimated number of sites or % of the GB Distribution System where the method could be rolled out, up to 2040

Sub-criteria	Assessment
Carbon claims (including quantitative, if provided)	Carbon reductions of 5.05 $MtCO_2$ per annum are claimed for the roll out of the three Methods across GB as a whole. This is based on the connection of some 6GW of Combined Heat and Power (CHP) generation at an assumed 140 UK substations, assuming that fault level mitigation technologies are in place. Carbon savings are estimated by comparison with the production of electricity from the standard UK generation mix and the production of heat from conventional gas boilers. The carbon claims are directly related to calculations of the amount of headroom that is created on the distribution networks for the connection of CHP generation, which, although being low carbon, contributes fault current through its utilisation of conventional synchronous generation technology. These are described in more detail under "Capacity Released" below.
Quantitative analysis	The quantitative analysis put forward is based on a bottom-up calculation of the assumed carbon benefits, based on the assumption that all of the connection headroom generated by the project is utilised by CHP generation. The calculations assume that the fault level mitigation techniques would be applicable to 5 substations in each of two cities with each of the 14 DNO areas. This assumption is somewhat simplistic, as the likelihood of finding cities in each DNO area that are appropriate for the high level of CHP take-up that is assumed is limited in some cases. The carbon reduction claims presented would be relevant in situations where other forms of generation, e.g. wind generators, are connected to the system, however the magnitude of the benefits achieved would require revision.
Robustness of financial benefits	The financial benefits claimed for the project are related to the Base Case costs which are defined for each of the three Methods as follows: Method Alpha: the costs of conventional connection studies carried out by WPD are estimated to amount to £216,000 per year, based on a reasonable set of assumptions as to the cost per connection study. The benefits accrue from a 33% saving in study execution time using new modelling techniques. This

	may be an optimistic assumption for studies of 3 days' duration currently, which it is assumed can be reduced to 2 days each using the new analytical methods. Method Beta: there is no directly comparable Base Case for this method, as no monitoring of fault levels is currently carried out. Consequently the analysis contains only costs for this Method, amounting to £3.000 million for the installation of fault level monitoring technology at 10 substations. Method Gamma: the benefits stated assume the application of fault mitigation technology at 5 WPD substations. These are then compared with the costs of conventional switchgear and cable reinforcements required to accommodate higher fault levels. The quantities of equipment assumed for the Base Case seem high, in terms of the amount of equipment per substation requiring replacement, and the unit costs adopted are at the upper end of the ranges quoted by WPD in their Statements of Connection Charges; this could therefore tend to overstate the savings from this method. The three methods have been evaluated on different bases, in that connection application processing cost savings are evaluated for WPD as a whole, fault level monitoring is applied at ten substations, and fault level mitigation measures are applied at five substations. Since the benefits arising from Method Gamma dominate in the calculations, however, this is not considered a significant issue.
Capacity released (and how quickly)	The project expects to release 42.79MW of connection capacity per substation, based on the application of the three Methods. The split between these is stated as: Method Alpha: 5.6MW Method Beta: 5.6MW Method Gamma: 27.7 MW Plus what is stated to be a conservative margin for applying the methods together of 10%. The way in which these figures relate to the total capacity released shown in the Net Benefits calculations submitted by WPD requires further clarification. These are based on an assumed increase in the fault level

	capacity of each substation of 10% in each of Methods Alpha and Beta and 50% in Method Gamma. These estimates are based on assumed levels of reduction that would be achievable in existing margins that are currently incorporated into calculation methods and the application of fault level calculations in practice, as per IEC 60909 and ER G74. Testing the validity of these assumptions will be a core part of the learning delivered by the project. The timescales over which capacity would be released, particularly in Methods Alpha and Gamma, are somewhat optimistic, given the time that it would take to gain acceptance of new methods of carrying out fault calculations and gaining acceptability of proposed range of fault level mitigation technologies on the network. It is unclear whether the project programme has taken sufficient account of the role of the Health and Safety Executive in approving the proposed methods and technological developments for use on the distribution network.
Replication (applicability of technology, dependence on specific network characteristics)	The proposed methods could be widely replicable on the GB distribution networks, due to the widespread nature of fault level issues arising from the increased penetration of distributed generation. The project focuses specifically on the example of inner city networks where it may be particularly appropriate to decarbonise through the application of CHP, however all networks are suffering from the significant increase in fault levels over time. This is reflected in the findings of the DTI Study “The Contribution to Distribution Network Fault Levels from the Connection of Distribution Generation”, which notes that “Whilst ... the connection of distributed generation to urban 11 kV and 33 kV networks is most likely to result in fault level issues, there will also be instances of large-scale distributed generation connections to both rural and urban networks which provide sufficient contribution to fault levels to exceed the fault level headroom available at that particular location.”

3 Criterion (b) Value for Money

Criterion:	Provides value for money to distribution customers
Overall assessment:	The benefits of this project are clearly attributable to distribution customers, through the cost reductions that would arise from reduced network reinforcement costs to cater for increasing fault levels and any improvements that are achieved in connection application assessment. Competitive tendering processes are understood to have been applied to the selection of the academic partner, and will also be used in the selection of fault level mitigation technology. At present however the cost of the fault level mitigation measures for the project comprises the largest area of uncertainty. It is unclear whether further supplier selection is proposed for the fault level monitoring equipment. Parsons Brinckerhoff's involvement in the project has been an evolving collaboration rather than in response to a call for expressions of interest. Contractor costs are generally reasonable, although a relatively large proportion of these is associated with management of contractor inputs and general project support. A larger amount of resource is being directed at this project by WPD than might be expected, although the daily charge rates for the staff involved appear reasonable.
Metrics (where available):	
Size of benefits to distribution system[6]	£1.085 billion over ten years

[6] Size of benefits attributable or applicable to the Distribution System versus elsewhere

Sub-criteria	Assessment
Proportion of benefits attributable to distribution system (as opposed to elsewhere on supply chain)	All of the benefits claimed in the project are attributable to the distribution system, either through: • reduced connection study costs associated with new generation applications; or • reduced reinforcement costs that would be required to accommodate higher fault levels on the network. These costs are socialised through Distribution System Use of System (DUOS) charges and levied on all distribution network users.
How learning relates to the distribution system	The learning generated through this project is highly relevant to the distribution system, as it investigates ways in which the increasing number of connection applications from low carbon and other distributed generation sources can be accommodated given the problem of rising fault levels.
Approach to ensuring best value for money in delivering projects	During the development of the project, it is understood that a competitive procurement process was undertaken for academic institutions to participate. Requests for information were sought from suppliers of fault level mitigation equipment, fault level monitoring equipment and voltage conditioning equipment and it is proposed that technology vendors will be selected through a competitive process for the delivery of the different components of the project. At present however the exact cost of the fault level mitigation measures for the project comprises the largest area of uncertainty. Parsons Brinckerhoff's involvement in the project is understood to have been of a collaborative nature in bilateral discussion with WPD rather than through a process of inviting expressions of interest in participation.
Identify and review major cost items, examine justification for relevant costs,	The costs of the project are dominated by the fault level mitigation equipment, which has been broken down by WPD into £6.750 million for equipment and £0.743 million for installation, i.e. a total of £7.493 million. This is based on a capital cost of £1.350 million per substation for a five

assess choice of discount rates	substation trial. Figures were presented in discussions with the Consultant showing a range of fault level mitigation equipment with indicative costs in the range £0.5 to £2.5 million. The assumed average equipment cost per substation adopted by WPD is not unreasonable, therefore, although the outturn cost will be highly dependent on which specific technologies are selected for the trials. Other key areas of equipment cost relate to the procurement and installation of fault level monitoring equipment and to optimise system voltages in the event that network reconfiguration is required as part of the reduction of fault levels. The fault level monitoring equipment is understood to build on the products that were tested in WPD's LCNF Tier 1 Project, "Implementation of an Active Fault Level Management Scheme", however the basis for the budgetary costs presented for this equipment in Method Beta requires clarification. The role that the Voltage Conditioning Units will play in the trial is unclear however. Contractor costs totalling £2.180 million are included, associated with inputs from Parsons Brinckerhoff and the University of Warwick. Generally the breakdown of these is reasonable, however the costs of project management of contractor services and general project support appears high and requires further justification. Total labour costs for the project amount to £2.011 million. This is a large amount of resource which appears to be difficult to justify, particularly in tasks relating to the investigation of substations and the technologies to be deployed. The daily charge rates are generally based on a reasonable set of cost assumptions.

4 Criterion (c) Generates Knowledge

Criterion:	Generates knowledge that can be shared amongst all DNOs
Overall assessment:	The knowledge generated by the project is relevant to all DNOs, since rising fault levels on systems with distributed generation seeking to connect to them are a well known problem. There are no deviations from the default IP arrangements requested for this project. The principles of learning dissemination are clearly defined, however a more detailed plan would be beneficial.
Metrics (where available):	
Conforming to default IPR arrangements:	Yes

Sub-criteria	**Assessment**
Potential for new/incremental learning to be generated by the project	Incremental learning has been identified in the areas of developing novel connection processes, accelerating the Technology Readiness Level (TRL) of fault level management technologies, and developing the business case for generators to adopt flexible solutions rather than network reinforcement. New learning is being claimed in relation to gaining in-depth understanding of assumptions that underpin fault level calculations, enhancing network knowledge and allowing assumptions to be refined, and then testing these against measured values. These appear to be valid claims, given the range of methodologies and equipment types that are under investigation in the project.
Applicability of learning to other	WPD have provided indications of potential CHP development in GB, from which England looks to be the area most affected by potential growth in CHP generation. All GB DNOs have at

DNOs	least one district heat scheme developing, however, and it is reasonable to assume therefore that most DNOs would benefit from the specific learning from this project. Furthermore, all all DNOs have issues with increasing fault levels to some extent. WPD present useful analysis of the percentage of DNO substations with fault levels > 80% of switchgear rating @33kV, which shows figures ranging from 1-50%, with an average of 20%. Figures presented for DNOs' fault level related capital investment also illustrate increased expenditure in this area. The learning proposed in this project is therefore highly relevant to DNOs.
Proposed IP management and any deviations from default IP principles	No deviations from default IP principles.
Credibility of proposed methodology for capturing learning from the trial and plans for disseminating	WPD have identified some key items relating to knowledge dissemination (e.g. audiences, broad ways of disseminating to different groups) however there is little evidence of a detailed knowledge dissemination plan at this stage. The company has a LCN funding projects website, which is informative, and has been involved in previous Lower Carbon Networks Fund projects, however, and may therefore be expected to be familiar with the requirements. "Learning reviews" are proposed on the agenda at monthly project steering review meetings. WPD states that learning capture will be based on the method applied in existing Future Networks projects, however no details of this methodology are provided. Key "knowledge capture outputs" have been identified, which it is stated will disseminate knowledge via websites through which they will share reports, publications and updates. Stakeholder inputs are envisaged through a process of DNOs peer reviewing Method Alpha, generation customers attending workshops, the publication of academic papers and knowledge dissemination events being held for the wider industry. These proposals appear adequate for ensuring that the learning

	from the project will be appropriately disseminated.

5 Criterion (d) Partners and Funding

Criterion:	Involvement of other partners and external funding		
Overall assessment:	The partners selected for the project are appropriate and have relevant experience, however the depth of experience of Warwick University in the specific area of fault level measurement is unclear. A procurement process was run for the identification of an academic partner, however this is understood to have received limit response. The bulk of the external funding to be provided is assumed to come from equipment suppliers that have yet to be identified, and is presumably therefore subject to negotiation.		
Metrics (where available):			
Total cost of project (£):	£17.600 million	LCNF support (£):	£13.881 million
Costs met by DNO (£):	£1.561 million	Costs met by others (£):	£1.700 million
LCNF support (% of total cost):	78.9 %	Costs met by DNO (% of total cost):	9.0 %
Costs met by others (% of total cost):	9.7 %	Number of consortium members:	3 Project partners (including DNO) 2 Identified suppliers, other suppliers to be identified during project

Sub-criteria	Assessment
Appropriateness of collaborators (including experience,	This project involves a relatively small number of collaborators. Parsons Brinckerhoff is widely experienced in power systems engineering and is an appropriate partner for providing network planning, design and procurement/project

expertise and robustness of commitments)	management support. The University of Warwick was identified as a collaborator for this project through a competitive process of inviting participation from universities, which is understood to have received limited interest from other parties. WPD have advised that Warwick has recently recruited an academic from Durham University with expertise in the relevant aspects of power engineering. Given the extent of work that has been carried out in the area of fault level monitoring in previous studies, it is not clear whether the University of Warwick have sufficient expertise to make a substantial contribution to this aspect of the project. Further information submitted regarding the technical role of the university suggests that this will focus on network simulation for addressing control and protection issues, which should however represent fairly mainstream power system analysis activities. The proposed research into the social and economic impact of enabling DG to connect to the distribution network to be conducted by Warwick appears to offer marginal benefits to the project as a whole.
Level of external funding (presented on a comparable basis with other Projects)	The level of external funding that is proposed amounts to £1.700 million, or 9.7% of the total project cost. This is dominated by an assumed £1.308 million of funding from equipment suppliers that are to be identified during the course of the project, and will presumably therefore be subject to negotiation. Parsons Brinckerhoff and the University of Warwick are contributing £167,000 and £80,000 respectively, which amounts to some 11% of the corresponding contractor payments to these organisations and is not unreasonable. In view of the potential benefits to manufacturers of fault level mitigation technology downstream from successful demonstrations in this project, the level of contribution being sought from them is appropriate.
Effectiveness of process for seeking and identifying new project partners and ideas	The selection of Parsons Brinckerhoff is understood to have been made on the basis of collaborative discussions, rather than an open tendering process. A procurement process was run for the identification of an academic partner, however it appears that this received limited interest from the key universities with experience in relevant areas.

	There will be a competitive tendering process run for the selection of fault level mitigation technologies. The range of technologies to be deployed has yet to be decided however.

6 Criterion (f) Relevance and Timing

Criterion:	Relevance and timing		
Overall assessment:	Increasing system fault levels are a well known barrier to the integration of distributed generation into the distribution network. Proving the operation of fault level mitigation equipment and enhancing the accuracy with which fault levels are understood and limits are applied could have a significant impact in reducing fault levels and creating additional headroom for new generation. The potential for any of the methods proposed to gain acceptance and be approved for use in normal network planning and operation may be dependent on achieving the necessary approvals from the Health and Safety Executive, depending on the extent of the changes to existing standards and practices that are proposed. From a technical perspective, however, the technologies proposed offer the potential to have significant low carbon impact if they are successful in permitting larger penetrations of DG from low carbon sources to connect to the distribution networks.		
Metrics (where available):			
Start date:	1 December 2012	Elapsed time of project:	4 years 4 months

Sub-criteria	**Assessment**
Significance in the project in: (a) overcoming current obstacles to a low carbon future	Increasing system fault levels are a well known barrier to the integration of distributed generation into the distribution network. WPD illustrate the impact of increasing portions of DG at a substation on fault level in their submission for levels of DG penetration up to 50% of primary substation capacity. As substations near their fault level limit, this impact becomes a significant barrier to the adoption of greater levels of DG, particularly that based on convention synchronous generator technology such as CHP. WPD illustrate that fault level is an issue at most of their primary substations in and around Birmingham. At a national level, expenditure on fault-level related capital for UK DNOs

	has increased from £41.3m to £131.6m from DPCR4 to DPCR5. Proving the operation of fault level mitigation equipment and enhancing the accuracy with which fault levels are understood and limits are applied could have a significant impact in reducing fault levels and creating additional headroom for new generation. The scale of fault level reduction available from the fault current limiters being considered by WPD for possible application on the network as part of the trials is typically in the range 50% to 90%, which is substantial.
(b) trialling new technologies that could have a major low carbon impact	WPD have indicated that it is the integrated nature of the trials proposed in this project that will unlock the full potential of the methods and equipment involved, through: • the development of a methodology for calculating fault current more accurately; • cross checking this against fault level measurements based on equipment that has been identified under its Tier 1 Project "Implementation of an Active Fault Level Management Scheme"; and • combining this information to target the placement of trials of fault current limiters, soft normally open points and other equipment. The potential for any of the methods proposed to gain acceptance and be approved for use in normal network planning and operation may be dependent on achieving the necessary approvals from the Health and Safety Executive, depending on the extent of the changes to existing standards and practices that are proposed. From a technical perspective, however, the technologies proposed offer the potential to have significant low carbon impact if they are successful in permitting larger penetrations of DG from low carbon sources to connect to the distribution networks.
(c) demonstrating new system approaches that could have widespread	All of the approaches described in the three methods have the potential for widespread application, subject in the case of the fault mitigation technologies to there being sufficient space at the relevant substations for the equipment to be installed. This could be an issue in some city centre locations, which, given the focus of the project on areas with a high penetration of

application	CHP, could limit its applicability. The ability to calculate fault levels more realistically and to measure fault levels on the network accurately would be widely applicable on distribution networks generally, subject to gaining the acceptance of the HSE and other bodies responsible for ensuring the safety of network users.
Applicability of the project to future business plans, regardless of uptake of Low Carbon Technologies (LCTs)	The primary driver for this project is the increasing uptake of CHP generation, which because of its utilisation of conventional synchronous generation technology contributes greater fault current than plant such as converter-connected wind farms. Nevertheless the project is relevant to the increasing penetration of generation as a whole, and situations where the increasing application of motors associated with pumps, heating systems, etc., will tend to increase fault levels. Methods Alpha and Beta, relating to the calculation and measurement of fault levels, will also be relevant to DNOs even if the widespread deployment of fault level mitigation techniques does not proceed.

7 Criterion (g) Methodology

Criterion:	Demonstration of a robust methodology and that the project is ready to implement
Overall assessment:	The project appears technically feasible in that it proposes a step by step approach to evaluating complementary methods for increasing the fault level head room on the distribution network. Relatively limited information is available detailed aspects of the project methodology. Method Alpha is not clearly defined, however WPD have stated that this will use existing standards and fault level modelling/design principles combined with probabilistic techniques and focus on exploring and refining the underlying assumptions that feed into the calculation of fault levels. Method Beta relates to the application of fault level monitoring technology that has been developed to the level of laboratory tests through an LCNF Tier 1 project, and is reasonably well defined and self-contained. Previous attempts to measure fault level accurately are understood to have met with limited success, and a key issue on this project therefore concerns the extent to which the proposal for Method Beta is likely to prove more successful. Results presented by WPD from laboratory tests of the effectiveness of equipment of the type proposed for the trial indicate an accuracy of 4.5%, which gives a reasonable basis from which to proceed to field trials. Method Gamma is clearly defined at a conceptual level, in that it consists of the installation of specific fault level mitigation technologies at five different substation sites. The basis for the selection of the technologies, whether they are expected all to be different, and the criteria against which locations for their deployment are to be selected, have yet to be fully defined, however. WPD have stated that this process will include consideration of: • the required fault level headroom; • space availability and other practical issues at relevant substations; • the lead time for fault level mitigation equipment delivery

	in relation to the overall project programme; and • value for money considerations. Methods Alpha and Beta are expected to feed into this process, however the project plan is insufficiently clear as to the interactions and interdependencies between the three methods.

Metrics (where available):			
Requested level of protection against cost over runs (default 5%) (%):	0	Requested level of protection against direct benefits (default 50%) (%):	0

Sub-criteria	Assessment
Feasibility of project proposal	The project appears technically feasible in that it proposes a step by step approach to evaluating complementary methods for increasing the fault level head room on the distribution network. The trialling of new methods of calculating fault levels is the least well defined area of the project, and it is also unknown at this stage which specific fault level mitigation techniques will be included in the trial phase. The proposed methodology is split into three clear Methods. Method Alpha is primarily analytical and can be implemented relatively easily in practical terms, however there are questions around the technical approach that is to be adopted for these studies, which is not clear. Method Beta requires monitoring equipment to be installed. The submission indicates that the technology to be deployed already exists and consists of the combination of two existing products in a configuration that has been investigated in a WPD Tier 1 project. Method Gamma consists of the deployment of technologies that are at least at a stage of demonstration readiness, though in some cases these represent relatively established technologies. Previous attempts to measure fault level accurately are understood to have met with limited success, and a key issue on this project therefore concerns the extent to which the proposal for Method Beta is likely to prove more successful. Results presented by WPD from laboratory tests of the

	effectiveness of equipment of the type proposed for the trial indicate an accuracy of 4.5%, however, which gives a reasonable basis from which to proceed to field trials.
All risks, including customer impact, exceeding forecast costs and missing delivery date	A small number of project risks are identified by WPD, most of which are considered to have a relatively low likelihood of occurrence. One risk, that of the project delivery team having insufficient knowledge to deliver the project, is considered to have a 50/50 probability of occurrence. The likelihood of this arising will depend to some extent on the selection of equipment providers to undertake the field trials of fault level mitigation equipment, but the ability to secure adequate resources from within the project partners to address key technical issues will be crucial. In response to detailed questioning, WPD has indicated that there will be no adverse customer impact as a result of the connection of a 20 ohm inductance to the circuit under investigation for a period of 10 ms. A key issue here will concern the frequency with which the switching is to be carried out and whether there is the potential "flicker" on system voltages to be detectable. WPD has advised that voltage disturbances of a magnitude large enough to cause a re duction in supply quality to customers will not be seen and has submitted a report confirming this, based on laboratory test results, but highlighting that the permissible repetition rate of the tests requires further investigation. WPD have not commented on overall probability of gaining HSE approval for the outcomes of the project. Whilst this could affect the final acceptance of the project, it would seem reasonable for the project to proceed to a further stage of proving the likelihood of the proposed methods contributing significantly to fault level reduction, were such approvals to be gained.
Whether items within project budget provide value for money	See Criterion (b) and in particular Sub-Criterion "Identify and review major cost items..."
Project methodology (including depth	Relatively limited information is available regarding the details of the project methodology. Method Alpha is not clearly defined, however WPD have stated that this will use existing

and robustness of project management plan)	standards and fault level modelling/design principles and focus on exploring and refining the underlying assumptions that feed into the calculation of fault levels. Method Beta relates to the application of fault level monitoring technology that has been developed to the level of laboratory tests through an LCNF Tier 1 project, and is reasonably well defined and self-contained. The project cost build-up allows for substation surveys to investigate the practicality of installing the equipment at the most relevant sites. Method Gamma is clearly defined at a conceptual level, in that it consists of the installation of specific fault level mitigation technologies at five different substation sites. The basis for the selection of the technologies, whether they are expected all to be different, and the criteria against which locations for their deployment are to be selected, are yet to be defined. The project plan is insufficiently clear as to the breakdown of subtasks within key activities, and the interdependencies between them. Four phases of the project are identified, where Phases 1, 2 and 3 are broadly in alignment with the technical scope of methods Alpha, Beta and Gamma respectively, and the trials phase encompasses the monitoring of the performance of methods and equipment in each of the other three phases. Given the intention to spread the trials of Method Beta over ten substations and the trial of fault level mitigation techniques over five substations, it will be important for resource planning purposes to have a clear understanding of the timing of the installations. In particular, the connection between trials of the fault level monitoring equipment and any dependency on the results of these for the installation of mitigation equipment needs to be understood. Given the procurement lead times for the fault level mitigation equipment, it appears that the procurement process for this is proceeding ahead of the commencement of the fault level monitoring equipment being commissioned. This requires further investigation in terms of the extent to which the outcomes of the project are dependent on the interconnectedness of the trials of these methods. WPD has proposed gateway reviews of the project at key

	stages in its development, comprising: • Output of Phase 1 – Enhanced Fault Level Assessment; • Output of Phase 2 – Monitoring commissioning • Output of Phase 3 – Mitigation commissioning It is stated that the outcome of these reviews will determine whether or not the project can progress to the next stage; in reality, the overlapping nature of the phases of the project makes it hard to see how the gateways can effectively control the project.
Appropriateness of Successful Delivery Award Criteria (SDRC)	See Section 8.

8 Successful Delivery Reward Criteria

Criterion:	Appropriateness of the SDRC definitions and timing and adequacy of links to key project milestones.
Overall assessment:	Eight SDRCs are defined. These are not all clearly linked to the project programme or the deliverables described, in that whilst some of the outcomes relate to activities shown in the programme, others refer to activities outside the deployment of the trials that are more connected with the adoption of revised practices into WPD's business as a consequence of the project.
Review:	Eight SDRCs are defined. These are not all clearly linked to the project programme or the deliverables described, however. Some of the outcomes and deliverables referred to relate to activities shown in the programme, however others refer to activities outside the deployment of the trials that are more connected with the adoption of revised practices into WPD's business as a consequence of the project. SDRC 9.1 relates to a clearly measurable deliverable, that of the Enhanced Fault Level Assessment Process, which appears to form part of the project design phase shown in the project programme and is due for completion by 1st June 2013 (a date which does not relate directly to the programme). This appears to be a subset of the broader SDRC 9.3, for delivering the overall project design. SDRC 9.4 refers to the development of novel commercial frameworks with generation and demand customers. From the clarification process with WPD it has become apparent that this represents the development of the commercial mechanism by which customers could opt for an alternative connection offer based on the trial Method learning and outputs. WPD note, however, that developing this framework is highly useful for the project, but is not core learning. This activity does not appear in the project programme, and seems inappropriate as an SDRC. SDRC 9.5 and 9.6 relate to the "open loop" testing of the fault level monitoring and fault level mitigation equipment. These are understood to align with the delivery of Method Beta and Method Gamma respectively.

	SDRC 9.7, however, is a more broadly based criterion which refers to the "closed loop" testing of the fault level monitoring and mitigation equipment. It is unclear how this criterion will be applied, since although there is an implied interaction between the trials of the three methods, the methodology for this is not clearly defined.

9 Addendum: Changes made in resubmission

9.1 Summary of changes

9.1.1 Labour inputs and rates

In response to concerns expressed about the value for money of the project as a whole, WPD have reduced their labour inputs and associated costs by 10%, and reduced the time to be spent by PB on Project Management support by 20%. The reduction in WPD costs has been achieved by a combination of a reduced average day rate and a reduction in the number of person days of their input. The PB average day rate has remained unchanged, but with 20% fewer days' input. This has led to a reduction in the overall project cost from £17.600 million to £17.147 million. As a consequence of the reduced input from PB however, the external funding for the project has decreased from £1.700 million to £1.670 million. The overall result of these changes however is a reduction in the overall Second Tier Funding request from £13.881 million to £13.514 million.

9.1.2 Academic Partners

In response to concerns expressed about the depth of academic expertise available in the project, WPD have recruited the University of Southampton and the University of Manchester as project supporters. The level of input that these universities will provide during the course of the project, if any, is unclear, however they have indicated broad support for the technical approach that is proposed.

The Resubmission also contains an additional Appendix providing background information relating to a literature view that has been carried out to identify the current "state of the art" in fault level measurement techniques. This gives reasonable support for the conclusion that the trials proposed in the FLEXGRID project are a logical step to build on previous work.

9.1.3 Technical Clarifications

The other changes made by WPD in their resubmission largely consist of technical clarifications in response to issues raised by the Expert Panel and the Consultants. The additional information provided includes:

- correction of the "capacity released" figures shown in the Full Submission Workbook for Methods Alpha and Beta to 5.6MW in each case, reflecting the application of each method to ten substations and further information about the technical justification for these figures has been provided;

- confirmation from a health and safety perspective that each of the fault level reduction technologies to be trialled in Method Gamma will be designed to "fail safe";

- the adoption of ±5% as the target accuracy for Method Beta, which appears reasonable;

- acknowledgement that the level of carbon benefits claimed is dependent on the widespread adoption of CHP across the UK;

- the suggestion that the integrated nature of the project is such that Methods Alpha and Beta inform Gamma, but also that Gamma informs Alpha and Beta. Whilst the way in which Alpha and Beta can feed into Gamma, in terms of providing information about the optimum locations where fault level mitigation equipment could be installed, is clear, it is less obvious how the results of Method Gamma can usefully inform the approaches take in Methods Alpha and Gamma. Nevertheless, there are clearly benefits to be gained from the integration of all three project methods;

- clarification of the stage at which the HSE would be involved in the project, noting that this would occur as necessary to enable new equipment and/or working practices to be adopted on the distribution network. The precise timing of these inputs will be determined during the project design phase.

9.2 Impact on LCN Funding Application

9.2.1 <u>Criterion (a) Low Carbon and Benefits</u>

Nothing in the Resubmission changes significantly the low carbon benefits or financial benefits associated with the project. The questions remain as to the level of capacity release that will be achieved by Methods Alpha and Beta, however it is recognised that part of the objective of the trial is to demonstrate what is achievable.

9.2.2 <u>Criterion (b) Value for Money</u>

In response to the concerns expressed regarding the amount of input from PB on project management and the WPD resource input, WPD have reduced both inputs by a reasonable amount, which improves the assessment of the project's value for money.

9.2.3 <u>Criterion (c) Generates Knowledge</u>

The potential for knowledge generation remains high, supported by the views expressed by the Universities of Manchester and Southampton in the Resubmission.

9.2.4 <u>Criterion (d) Partners and Funding</u>

The issue of Warwick University's depth of experience is to a degree mitigated by the involvement of the Universities of Manchester and Southampton as "supporters". It would however be desirable to ensure that these universities remain actively involved in the reviewing the project on an ongoing basis – this may be what WPD envisages in their assertion that “expert challengers” will be involved in the stage gate reviews during the project. It would clearly be desirable to include the other academics in this role, however their involvement in the project as supporters improves the project’s overall academic credentials.

9.2.5 Criterion (f) Relevance and Timing

The relevance and timing for the project remain clear and appropriate.

9.2.6 Criterion (g) Methodology

The concerns expressed about the lack of clarity in the detail of Method Alpha and the way in which the methods are integrated in the overall project plan remain, although it is recognised that there is a limit to the extent to which these issues can be addressed until the results of investigating the methods themselves become clearer.

9.2.7 Successful Delivery Reward Criteria (SDRC)

Minor changes have been made to the wording of the SDRC to clarify terminology points, however no additional information has been provided to tie these into the detailed work plan.