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BANDING OF CONNECTION STANDARDS FOR DISTRIBUTED GENERATION

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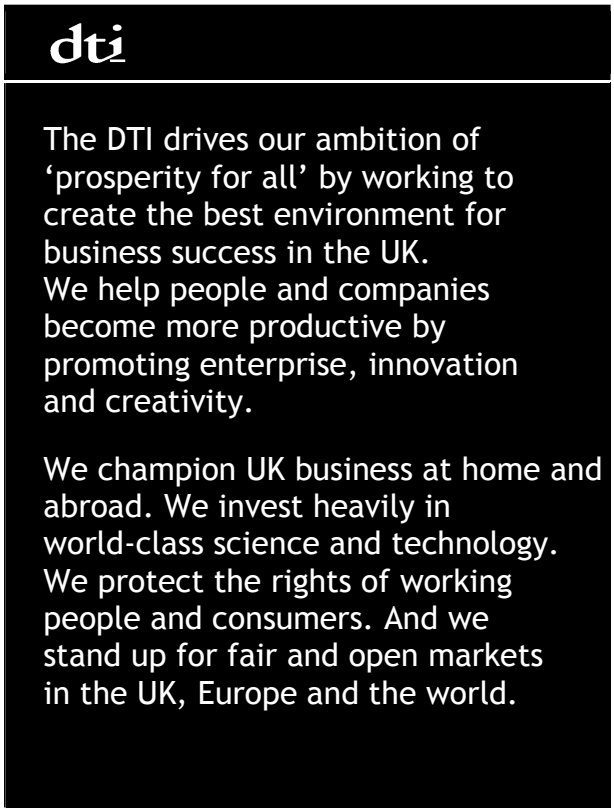
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Banding of Connection Standards for Distributed Generation

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URN NUMBER: 06/647

Contractor
Econnect Ltd

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1 Introduction

Econnect have been commissioned by the Department of Trade & Industry (DTI) to review the current banding of distributed generation (DG) in the context of connection "standards"/ recommendations, and assess the "fitness for purpose" of these documents – i.e. to identify whether the current suite of recommendations or standards require a review in order to accommodate the growing range and network densities of distributed generation.

The documents covered in this review, classed either as an Engineering Recommendation (ER) or Engineering Technical Report (ETR) and published by the Energy Networks Association, are:

- ER G59/1: 1991 (Amd 2 1995) – Recommendations for the Connection of Embedded Generating Plant to the Public Electricity Suppliers' Distribution Systems
- ER G75/1: 2002 – Recommendations for the Connection of Embedded Generating Plant to Public Distribution Systems above 20kV or with Outputs over 5MW
- ER G83/1: 2003 – Recommendations for the Connection of Small Scale Embedded Generators (up to 16A per Phase) in Parallel with Public Low-voltage Distribution Networks
- ETR 113/1: 1995 (Amd 2 1995) – Notes of Guidance for the Protection of Embedded Generating Plant up to 5MW for Operation in Parallel with the Public Electricity Suppliers' Distribution Systems

In the interests of brevity, these documents are referred to as G59, G75, G83[1] and ETR 113 throughout this report.

To deliver this review it was considered appropriate to create a project team, including Econnect staff with experience in a broad range of DG connection issues. An external consultant, W J S (Bill) Rogers, was also included on the project team, bringing in a wealth of experience both as a Distribution Network Operator (DNO) protection specialist for almost 40 years, and as an independent consultant specialising in DG Issues. Bill also chaired the latest reviews of G59 and ETR113.

In order to assess the "fitness for purpose" of the G59, G75 and G83 recommendations it was necessary to establish how they are currently being applied in practice within the industry. Hence a questionnaire was developed by the project team and sent out to consultees within the industry in order to engender feedback on the actual application of the recommendations. This also provided an opportunity for the consultees to provide suggestions as to how the recommendations may be amended in future. A list of consultees forms Appendix 1 of this report.

The consultee list was designed to include a wide spectrum of stakeholders with a variety of experience of these recommendations, and included Distribution Network Operators (DNOs), Trade Associations (and their members), Developers, Generation Equipment Manufacturers, Consultants, Protection Manufacturers, and Academics. Specific responses from the project team are classed as "Other".

[1] It is noted that G83 refers to Small-Scale Embedded Generation (SSEG) rather than DG, a distinction that may indicate that the technical issues concerning the connection of SSEG and DG could differ.

The purpose of this final report is to summarise the responses received from the consultees, to draw the relevant conclusions from those responses, and to broadly outline proposals for the future development of the G59, G75, and G83 connection recommendations.

2 Summary of Consultation Responses

Seventeen completed responses were received to the questionnaire, covering all the consultee groups targeted except the Protection Manufacturers and the Trade Associations themselves. These responses have been collated by question and by consultee group for reference in Appendix 2 of this report. The responses are summarised below into the broad topic areas identified in the questionnaire.

2.1 How are the recommendations applied in practice?

2.1.1 Is current document framework correct?

This question sought to ascertain whether the current document framework, including the links between documents, the number of documents, and the remit and purpose of the individual documents (as represented in Figure1) governing the connection of distributed generation was correct or needed reviewing.

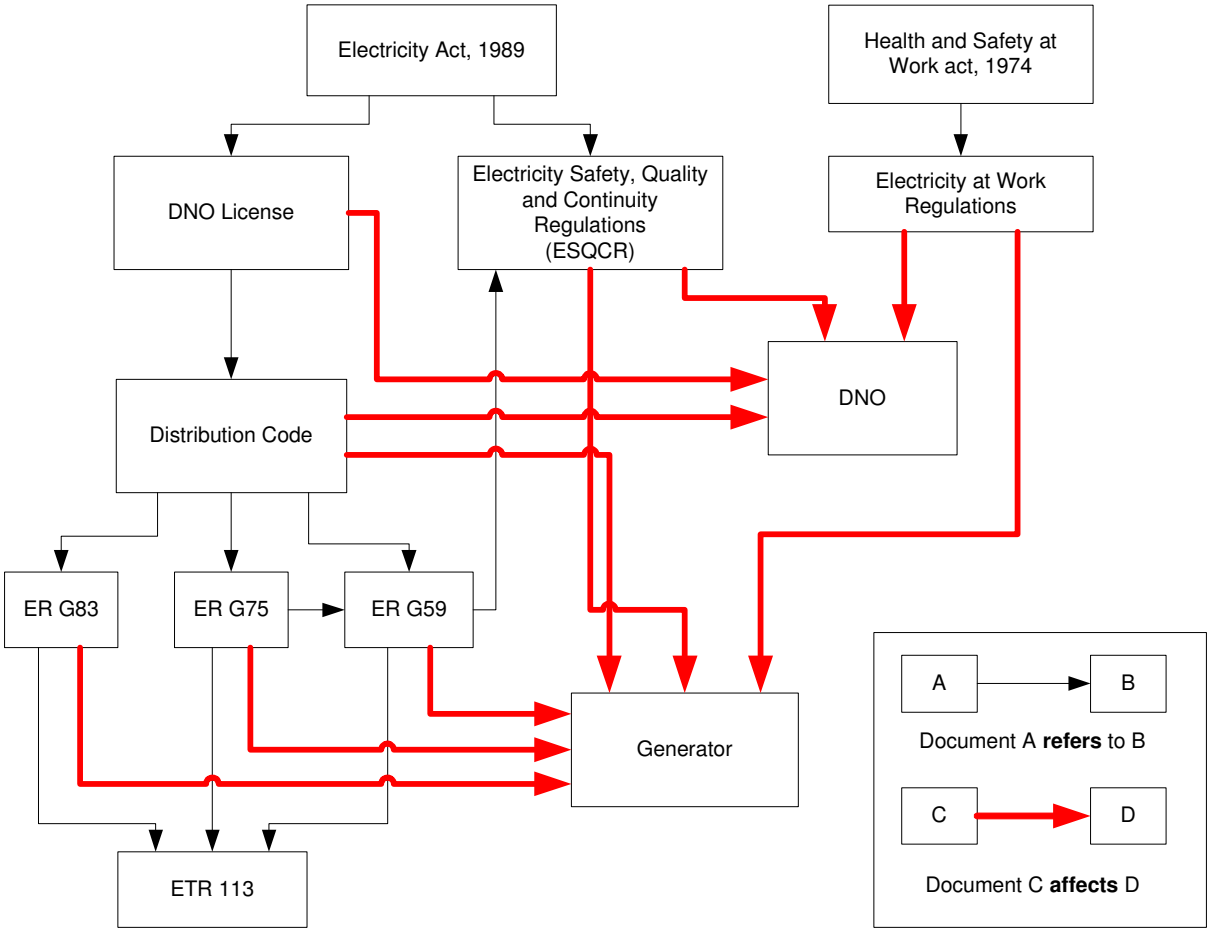

Figure 1: Legislative and Regulatory framework

Distributed Network Operators (DNOs) (Utilities)[2]

The DNOs broadly felt that the framework was correct although the diagram did not take account of the technical conditions imposed on DG by the Grid Code or the Connection Agreement. They also felt that G59/75/83 significantly affected both the generator and the DNO.

Developers

The developers also felt that the requirement to comply with many of the aspects of the recommendations is enforced by the connection agreement, and that to prevent different interpretations between DNOs and ensure direct governance, that the connection requirements should be in the Distribution Code.

Equipment Manufacturers

One respondent felt that the current framework lacked transparency with poor communication of the connection requirements from the DNO.

Other

Again it was highlighted that G59/75/83 also have an impact on the DNO. One respondent also felt that there should be a wholesale reassessment of the framework, with the elimination of ETR113, and a revision to the content and purpose of the Distribution Code and the Recommendations.

2.1.2 Should G59/75/83 be recommendations or standards?

DNOs

The consensus amongst DNOs was that G83/59/75 should remain as recommendations because they are being applied across a variety of technical areas and need to cater for different technical practices across different DNOs as well as site-specific issues. Whilst they acknowledged that the recommendations should be applied in a non-discriminatory way, a number of DNO respondents felt that the documents were recommendations for the DNO to consider whilst establishing the mandatory requirements for each DG scheme. Some elements of the documents could become standards, especially G83.

Developers

The consensus was to keep G59/75/83 as recommendations and that any mandatory aspects that are currently enshrined in the recommendations should be transferred into the Distribution Code and subject to proper governance. The developers also felt that the DNOs have been applying some aspects of the recommendations as standard requirements, which they considered inappropriate for all situations.

Equipment Manufacturers

The equipment manufacturers felt that G59/75/83 should be standards so that they are implemented equally across all DNOs. One respondent also felt that the recommendations were currently being applied in a mandatory way and were not open to negotiation.

Consultants

The consultants felt that as G59/75/83 were now referenced by the Distribution Code they had become mandatory requirements and therefore effectively standards.

[2] Note responses were only received from DNOs out of the Utilities consultee group, hence from here on in this section will be labelled DNOs.

Other

Again it was felt that G83 could become a standard with the mandatory aspects of G59/75 being devolved into the Distribution Code. One respondent also made the point that standards are not always mandatory and can be applied with discretion.

2.1.3 Have larger capacity connections than 16A / phase been allowed under G83?

DNOs

The consensus was that 5kW to 6kW connections have been allowed under the remit of G83, however this may be reviewed if there were a significant number of similar generators on the local LV network.

Equipment Manufacturers

Also report some flexibility, with 36A single-phase connections being allowed under G83 without objection.

Consultants

Also report a 5.2kW PV system being connected under G83.

2.1.4 Is the 16A / phase G83 limit reasonable?

It appears that the 16A limit originates from an alignment with European EMC standards.

DNOs

The DNOs were broadly happy with the 16A/phase limit.

Developers

The developers raised the issue of whether G83 should be amended to cover all potential domestic generation devices such as wind turbines.

Equipment Manufacturers

The equipment manufacturers felt that the limit should be raised to 32A / phase, or even that it could possibly be aligned with the upper limit of supply to property (following current industry practice this can be 80 – 100A per phase).

Consultants

One consultant highlighted that amending G83 to allow for connection beyond 16A / phase may affect the simplicity of the current document as the more onerous requirements of the EMC compatibility standards for >16A would need to be taken into account.

Other

One respondent felt that whilst 16A was generally appropriate for single-phase connection, 25A was more appropriate for three phase connections.

2.1.5 Have connections made under G83 been queried when the DNO is notified?

DNOs

Broadly the consensus was no, however sometimes there is a follow up if the initial information supplied is inadequate. One respondent also raised the issue of "type-approval" to reduce the need for DNO verification and to reduce the risk of issues being raised post connection.

2.1.6 Is the DNO always notified of G83 connections?

The consensus amongst all respondents was that there probably are connections where the DNO is not being notified. One respondent raised the possibility of including G83 application forms and DNO contact details with the devices themselves, making the customer more aware of their obligations under the ESQCR.

2.1.7 Should the G83 notification processes align more closely with that required under the Electricity, Safety, Quality and Continuity Regulations (ESQCR)?

DNOs

The DNOs felt that rather than adopting the notification requirements of the ESQCR, it is the ESQCR notification requirements that should be amended to align with G83, where the requirement to notify the DNO is within 30 days of commissioning (rather than prior to commissioning).

2.1.8 Have any network problems been experienced with connecting DG under G83?

Only one respondent registered a case of spurious tripping of a PV generator due to system issues. Eleven other respondents had encountered no issues.

2.1.9 Were any of the following difficulties experienced when connecting DG under G59?

2.1.9.1 Specification of protection

Five respondents had experienced protection specification difficulties although all reported that these were normally resolvable. One respondent reported that National Grid had queried the settings on a particular DG and its consequent ability to ride through low voltage events.

2.1.9.2 Appropriateness of protection for new technologies (e.g. wind)

Four respondents reported difficulties here, although again these were resolved. One Developer respondent reported that European turbine suppliers fit the protection they think necessary and then adapt it to the recommendations / connection agreement specifications, rather than design to the recommendations at the outset.

2.1.9.3 Testing & Commissioning of parameters

Seven respondents had experienced difficulties here, particularly with setting Loss of Mains protection to avoid nuisance tripping. One respondent also noted that the test witnessing requirements were vague in G59 and ETR113. Another noted that the commissioning requirements seemed to differ between each DNO.

The testing of Loss of Mains protection (either df/dt or Vector Shift types) presents specific challenges. The manner in which the protective device measures the waveform parameters can be very susceptible to the particular test equipment being used, and can result in inaccurate/ inappropriate results.

2.1.9.4 Points of Isolation

Four respondents reported difficulties with one reporting that it had not been possible to agree on a suitable point of isolation prior to or during the G59 witness test. Another respondent called for a standardized approach to agreeing suitable point(s) of isolation.

2.1.9.5 Operational & Safety Aspects

Only three respondents reported difficulties here, with one highlighting that the European HV safety procedures were not as stringent as those in the UK. Another outlined an operational difficulty where a generator is embedded within a client's site, with some DNOs insisting on disconnection of the entire site when power is exported from that site onto the network, rather than just to disconnect the embedded generator thus leaving the on-site demand energised. It is known that in similar instances, the disconnection of the site is only initiated if the DG zone continues to export.

2.1.9.6 Earthing & Neutral Voltage Displacement (NVD)

Six respondents reported issues with earthing & NVD. From the DNO side it was felt that the requirements for earthing and NVD identified in G59 and ETR113 are often overlooked by installers. Another respondent felt that the requirement for NVD protection was not consistent amongst DNOs, while one of the equipment manufacturers felt that the specification of NVD protection was excessive, and could make their generation technology commercially non-viable.

2.1.9.7 Application of Special Network Protection and Voltage monitoring distant from Point of Connection

Five respondents reported difficulty here, with one example cited of unnecessary duplication of protection, and another respondent questioning the need for a certain DNO's blanket insistence on a specific special network protection. One respondent highlighted the need for the recommendations to make allowance for new and accepted principles of monitoring and protection, as long as safety was not compromised. Caution is required in the specification of voltage monitoring schemes to ensure any hysterisis is set at an appropriate level consistent with the marginal over voltages usually involved.

2.1.9.8 Power Quality & Voltage Levels

Six respondents recorded issues here, although most reported that these were resolved by negotiation or through incurring added expense. One respondent raised the possibility of the recommendations allowing for transient excursions outside the permitted ranges.

2.1.9.9 General Comments

Generally it was felt that the difficulties experienced in applying G59 were often caused by lack of communication and/or lack of understanding of the requirements between the DNOs and the DG applicants.

2.1.10 Is G59 being applied to schemes greater than 5MW at voltages greater than 20kV without consideration of G75 clauses?

Note: G75 references G59 as a source of technical guidance but does not state that G59 is applicable to generators within the scope of G75.

DNOs

The DNOs point out that as G59 and G75 are recommendations, their boundaries are flexible and that this is to the benefit of the customer, and that G75 would be applied as appropriate.

Developers

The developer respondents experience is that G59 is applied well beyond its nominal boundaries and that the DNOs are sporadic in their application of G75.

Consultants

The consultants also have experienced confusion over the boundary between G59 and G75, and acknowledge that the requirements of G59 have been applied inappropriately in their opinion, even on occasion to connections at 132kV.

Other

Another respondent acknowledged that in their experience many <10MW schemes have been connected at 33kV with little reference to G75.

2.1.11 Is the current definition of the boundaries of the recommendations by generation capacity and voltage the correct method? And if so are they set at the correct levels?

DNOs

One respondent acknowledged that there was confusion in the application of G59 with its effective remit of DG from 16A per phase up to 5MW / 20kV and beyond as modified by G75 and Grid Code requirements. Another thought that G59 and G75 should be merged to give one protection standard up to 50MW with the provisions of the Grid Code applying from there on. Another respondent highlighted that the connection requirements were determined by the nature/ characteristics of the local network to which the generator is being connected, as well as the operational regime of that generator. The other DNO respondents thought that the current boundaries with their inherent flexibility had been proven to work well for both DNOs and customers, and the point was made that with any boundary, there are always winners and losers, and the key question should address the materiality of any changes.

Developers

One developer respondent proposed that G59 be extended to cover all 33kV connections with G75 reserved solely for 132kV connections in England & Wales (Grid Code for 132kV in Scotland). Another respondent proposed that requirements at specific voltage levels could be standardised while other requirements, related to generator capacity, could be more site specific.

Consultants

One respondent notes that the current arrangement is too confusing because the requirements are poorly defined.

Other

One respondent thought that movement away from the existing bands would only create confusion and increase differences in interpretation. While another thought that while the definition of applicability of G83 was probably correct, there should be significant alteration to both the capacity/ voltage level categories of connections covered by G59 and G75, and the method of defining those categories, (Fault Level being mentioned as an alternative). Another respondent noted that G59 should be modified to clarify the boundary between it and G75.

2.2 Multiple Distributed Generator Installations

2.2.1 What are the key interaction issues when connecting multiple DG to a network?

DNOs

- Network Stability
- Managing Voltage Levels in real time
- Assessment of grouped output / management of power flows /constraints
- Voltage regulation and power flows in rural networks
- Fault levels in urban networks
- Appraisal of additional protection that may need to be considered to offset increased risk of islanding

Developers

- As DNOs
- Protection co-ordination
- Increased risk of islanding / frequency control when islanded

Equipment Manufacturers

- As DNOs / Developers
- Reverse Power Capability of DNO network transformers etc

Consultants

- As DNOs / Developers

2.2.2 Should G59/75/83 be amended to allow for interaction of multiple DG?

DNOs

One respondent highlighted that G59 presumes no active network management, and that the recommended methods for compliance could be modified for installations that were connecting to such networks. Another DNO respondent requested that additional guidance be provided within G59 on the protection requirements for multiple DG installations and particularly on the provision of retrospective additional protection requirements. Other DNO respondents thought that the current recommendations were sufficient to cover multiple DG installations.

Developers

One respondent felt that multiple DG issues could be incorporated in G59/G75, but only if it improved access and reduced the cost of connecting to the DNO network. Other developer respondents thought that allowance for the interaction of multiple DG would overly complicate the recommendations and that instead these issues should be incorporated into other engineering recommendations which could be cross referenced to G59/75/83 to form a suite of documents.

Consultants

One respondent noted that G75 should be the document which should define the technical requirements for the larger / more complex / multiple schemes.

Other

One respondent agreed that references to multiple generator connections could be included in G59/G75 and increased network capacity for generators should result. There was a need to establish a common specification for parallel generator power factor and voltage control.

Another respondent expected that any successor to G59/75 would need to cover interaction in some manner, although this was not considered necessary for G83.

2.2.3 Is there a methodology for managing such interactions

DNOs

The consensus view was that no such methodology is required as interactions are already currently accommodated on the network, and that the issues are more commercial than technical, (i.e. they revolve around how the cost of any network reinforcement required is shared between the new and existing users, indeed these same commercial issues could arise from the connection of a single DG with existing demand customers).

Developers

One Developer respondent also thought that it is a commercial issue, although did raise the potential for active network management. Another respondent mooted the idea of an independent arbiter of design to ensure a pro-active approach across all DNOs.

Consultants

One consultant respondent though that the issue of interaction generally meant asking who would pay for the DNO studies and noted that historically the last to connect normally pays.

Other

Some consideration of how those generators that are controlled under the Grid Code are managed in respect of voltage and frequency control might be useful.

2.2.4 Does the connection of any specific generation types under these recommendations raise more issues than others?

The consensus response was that fuel source / generator type was much less a consideration than the capacity and connection point onto the network. Problems were highlighted where the cost of meeting the requirements tended to be a relatively high proportion of the overall project costs.

2.2.5 Is there a capacity threshold where the installation of multiple DG would not require prior notification to the DNO?

The consensus response was No on the basis that the DNO is best placed to monitor the capability of the network to accommodate multiple small generators. While, in many cases DNOs will have no trouble in waiving through many multiple applications, there will be some cases where this accommodation will be marginal because of local network conditions and may need further study. Hence it is not possible to generalize.

2.3 Fault Ride Through (FRT)

2.3.1 Is the ability to ride through network faults and the requirements of G59 mutually exclusive?

DNOs

There was a mixed response from the DNOs respondents on this issue. One thought that the under voltage relay requirement under G59 would trip the generation in a voltage dip scenario, effectively preventing fault ride through. Two respondents thought that it was the design of the protection rather than the drafting of G59 that prevented fault ride through under certain out-of-zone fault conditions and that "A quality LoM (Loss of Mains protection) should allow fault ride through and detect true loss of mains". Two respondents also made reference to the fact that, as G59 is a recommendation, the protection settings can reflect network conditions and should be a balance between facilitating fault ride through and avoiding islanding.

Developers

One developer respondent again highlights their experience that NGETL (National Grid Electricity Transmission Ltd) are not yet comfortable with the compatibility of G59 protection with the Fault Ride through requirements under the Grid Code, and that by asking the generators to demonstrate this there is a "massive duplication of effort". Instead they would like to see further clarification on this by asking NGETL to do some baseline studies. They also considered that G59 protection operate times could be set outside FRT time requirements.

Consultants

The consultant respondent makes the point that while in theory the ability to ride through faults and to meet the requirements of G59 should not be mutually exclusive, in practice it is. They suggest that if a different type of loss of mains protection (e.g. intertripping) were used this problem would be resolved.

Other

One respondent also highlighted the susceptibility of the under voltage relay to tripping under the extended fault conditions identified in the Grid Code. Another echoed other respondents by indicating that in their opinion the problem lay with the type/design of the loss of mains protection, and that "a reliable and secure LoM is required."

2.3.2 Is there a future need for both fault ride through of aggregated DG and the intent of G59 to prevent unplanned islanding?

The majority of respondents agreed that there would be a need for both fault ride through capability and protection against unplanned islanding.

DNOs

One respondent who agreed mentioned that while G59 allows for flexibility in the settings for protection that would facilitate fault ride through, it is often difficult to predict how local networks will behave under fault conditions due to the limitations of dynamic modelling capabilities. Another acknowledged that FRT was becoming increasingly important to prevent system instability, while a third thought that more explicit beneficial guidance could be developed as experience is built up.

One DNO respondent who disagreed thought that FRT for generators under 50MW was impractical, and that G59 under voltage protection was essential to prevent some DG going unstable.

Developers

One Developer respondent thought that FRT would have to be implemented from a low level of DG penetration in order to prevent this penetration being limited in the future. Another acknowledged that careful consideration was required between FRT requirements and under voltage protection, and that this may be a particular problem with multiple generators connected at the same voltage levels in the same vicinity.

2.4 Banding

2.4.1 Does the banding of connections by voltage and capacity work given that the connection interface issues are system (local network topology) based?

Overall there was an almost even split between those respondents who agreed that the current method worked (7) and those that thought it needed to be modified in some way (6)

DNOs

Of those DNO respondents who agreed, most thought that the banding worked because it simplified the connection interface with the customer and appropriately manage the level of network risks. Also, the flexibility in the recommendations allowed DNO engineers to apply them with common sense. There was some acknowledgment that there may be generic

criteria, other than pure generator capacity or voltage level, which could be applied to resolve some of the issues.

One respondent pointed out some potential misunderstandings of the term "banding". The "banding" concept was developed by the TSG to be a division of GB DG at the highest level to understand the big picture (ie a separate application to that of G59/75/83). "It is not helpful or useful to try to apply these concepts for detailed local network topology planning purposes. On this point the Distribution Code Review Panel expressed the view – "*In particular it is recognized that the benefit of banding is to help classify generation for aggregate planning purposes, and inclusion in the Distribution Code could lead to confusion and inappropriate application of banding to individual projects.*""

One respondent who thought that the current system could be improved highlighted the difficulty in banding generation for particular network scenarios due to the complex technical considerations.

Developers

One respondent points out that the criteria for any bands or boundaries need to be clear and objective, and that banding works best where there are a large number of connection applications to be considered. Another developer respondent also agrees that banding does help to define complexity but acknowledges that some projects will always fall between bands.

Another developer points out that requirements cannot be considered on generator capacity in isolation, but also must take account of the system the generator is connected to (the effect of a 20MW connection at 11kV compared to 132kV for example), and proposes that there may be a need to recognise the differences due to generator type such as asynchronous (some wind farms), synchronous (hydro) and inverter connections (PV).

Consultants

While acknowledging that banding provides the opportunity to simplify connection requirements the respondent felt that the banding of G59 was confusing due to poor definition

Equipment Manufacturers

This respondent explained that, in their experience, permission to generate (connect) was based upon local network fault capacity, and therefore they were less likely to be refused an application to connect a small (<2MW CHP) generator, however would still be subject to the same criteria as large generators.

Other

One respondent felt that banding would not affect interface issues and hence that it may be more appropriate for other, more commercial, applications such as charging.

Another respondent raised the possibility of using examples to determine the criteria for each band/ boundary.

2.4.2 Do we need "system" banding (e.g. Voltage / radial / ring network) as well or as an alternative to generator capacity banding?

Overall most respondents felt that this was not required

DNOs

One respondent re-iterated that banding on generator size is inadequate and that there are other generic criteria that need to be factored into any banding approach.

Another DNO respondent thought that there were insufficient generalities between systems to make this possible, and that the installation of multiple DG onto the same network could only exacerbate this. Two other DNO respondents felt that additional system banding would only complicate matters further.

Developers

All three developer respondents felt that some type of banding that dealt with the network to which connection is proposed would be advantageous.

Consultant

This respondent felt that the current system should be improved rather than a new system introduced.

Other

One respondent felt that there was a need for system banding as generator connection arrangement was dependent on both the network voltage and network design philosophy.

2.4.3 Advantages and disadvantages of "system" banding

2.4.3.1 Advantages

DNO's

- Development of standard approach to each Scenario

Others

- More consistent interconnection across UK

2.4.3.2 Disadvantages

DNO's

- Would require additional information exchange at an early stage of the interface design as the developer would need to understand the attributes of the system rather than just the size of the generator
- One size fits all banding is often inappropriate

Developers

- One size fits all banding is often inappropriate
- Perverse incentive for generator to attempt connection at an inappropriate connection point in order to avoid potentially more onerous requirements of another band

Others

- There would be a wider range of connections to be incorporated in G59 and G83 and that therefore this may be more appropriate for G75 only

2.4.4 Is the present guidance on implementation included in ETR113 adequate for most generators within the scope of G59?

DNOs

- Two respondents thought that while generally satisfactory, ETR113 could be usefully updated to reflect experience with connecting new technologies (e.g. Doubly Fed Induction Generators on Wind farms).
- One respondent though that experience with active networks could be a future amendment.
- A third DNO respondent also thought ETR113 needed updating to keep up with current regulations and technologies.
- A fourth DNO respondent recognised that there may be advantages in making the document more prescriptive without losing the flexibility to make judgements depending on the individual connection circumstances.

Developers

The respondent thought that ETR113 would benefit from a revision that includes more recent generator technologies rather than just synchronous machines.

Consultants

The consultant respondent also agreed that a revision was required citing an example of the inappropriate protection recommendations for LoM protection when considering high levels of DG penetration into the network.

Other

Other respondents also sought a review of ETR 113, recommending that guidance with respect to islanding be substantially reviewed, and that there was now a need to recognise that DG could be contributing to general supply security.

2.4.5 In your experience what is the highest voltage and size of facility where Loss of Mains (LoM) protection has been requested?

DNOs

There was some confusion in the responses in that some DNOs considered inter-tripping as a form of LoM protection, whilst others considered LoM to only include rate of change of frequency (df/dt) and vector shift. The DNO respondents generally felt that df/dt (or vector shift) protection should generally be limited to generators below 50MW. df/dt relays have been applied to generators up to 240MW as protection against islanding.

Developers

The developers experience is that df/dt vector shift protection has been applied at up to and including 132kV connections. There appears to be an increased use of intertripping being applied to larger generators.

Consultants

The consultant respondent believes that LoM protection should be required at all voltages below 132kV, but mentions that the use of df/dt relays has led to unreliable LoM protection.

Other

One of the other respondents believes that LoM protection should be extended beyond the lower limit in G59 to all generators. This would align G59 and G83 in this respect and would improve overall ability to disconnect for Loss of Mains across different types and sizes of generator.

2.4.6 Is the <200kVA exclusion in ETR113 from the need to provide Neutral Voltage Displacement (NVD) protection in rural networks still adequate?

DNO's

Most DNO respondents noted that the exclusion was not mandatory and that they would reserve the right to specify NVD protection if the particular connection arrangement required it (e.g. if the minimum load is less than twice the DG installed capacity).

Consultants

One consultant respondent felt that the need for NVD protection has always been contentious and that clear rules should be given in a revised G59. However, should the decision be made that NVD may be dispensed with, there should be a balancing condition that the G59 functions be executed using devices compliant to IEC EN 60255.

2.4.7 Is the <150kVA exclusion in ETR113 from the need to provide LoM protection still appropriate?

DNOs

Generally the DNO respondents felt that this clause was no longer appropriate as the need to provide LoM is network dependent, and also that the cost of LoM protection is now relatively small and that most G59 relays may include this function anyway (note: this refers to df/dt and vector shift).

Developers / Consultants

Both the developer and consultant respondents felt that the level of "exclusion" was more an economic judgement rather than a technical one.

Other

Both respondents felt that LoM should be applied to all generators, especially when considering the possible aggregation of such small generators, and that the guidance in ETR113 should be revisited in light of G83 to ensure consistency.

2.4.8 Should the Engineering Recommendations also include information about the appropriateness of different types of connection (e.g. loop-in or tee)?

The overall response to this question was no

DNOs

The DNOs generally felt that this was a commercial consideration rather than a technical one, and related more to overall planning / system design than the interface issues which are the current remit of G59/75/83.

Developer

One developer felt G59/75/83 recommendations could not predetermine the appropriateness of different types of connection in all circumstances and that engineering judgement is required. They also reiterated the point that the ENA Engineering Recommendations are all too often treated as absolute standards. Another developer felt that variations in connection design could be covered in site-specific requirements.

Consultant

The consultant felt that this did need clarification, but acknowledged it was a cost versus performance issue rather than a purely technical consideration.

Other

One respondent argued that a decision making framework for the type of connection is necessary to ensure consistency and transparency, although acknowledged that the Engineering Recommendations may not be the most appropriate location for this guidance. Another concurred with the Consultant position, whilst noting that ring connections can offer reduced voltage rise issues.

2.4.9 Would a unified recommendation, which covered all capacities and connection voltages, be more effective than the current suite of recommendations?

Those respondents for this suggestion (5) were outnumbered by those against (9).

DNOs

One DNO respondent was in favour and proposed one recommendation containing general information and specialised sections for:

(a) generators less than 16A per phase, and

(b) large generators over 50MW.

There was general DNO accord that G83 should remain essentially as it is currently.

Most DNO respondents were against the idea in principle citing the possibility of overloading small DG developers with inappropriate information, or that the current suite works well, as the reason. One DNO respondent qualified this by stating "this was far less important than the clear application of requirements across the size range with no ambiguity", and that "there is a case for reviewing this". Another respondent raised the potential of consolidating G59/G75/ETR113 and the data requirements of the Distribution Code into one document.

Developer

One respondent in favour thought that the format of G83 should be used for a unified document with clear indication of those areas where engineering judgement should be applied.

Another respondent who disagreed thought that there would be a greater risk of sections being misapplied in a unified document.

Equipment Manufacturers

Both respondents were in favour, one thought it should be modelled on G5/4 with separate stages for various technical parameters, while another voiced concern that this should not result in requirements for large generators being imposed on small generators.

Other

One respondent thought that G83 should be kept separate, but that integration of G59 and G75 was probably appropriate. Another respondent proposed three standards: -

- Generators not deemed to contribute to national or local supply security
- Generators that are deemed to contribute to local supply security
- Generators that are deemed to contribute to national and local supply security.

2.4.10 What changes to G59/75/83 would you like to see?

G83

- Increase limit from 16A / phase (see section 2.1.4)
- Recommendations for the necessary type testing of diverse types of parallel generators

G59

- Update references to superseded legislation and terms
- Some scope to move certain aspects into the Distribution Code
- Modify to fit with G75 / G83
- Clear definition of capacities (aggregate or individual)
- Take account of active network management (and the additional communications functions that will result, which may allow intertripping to be substituted for the LoM protection function at little cost increase)
- Clarify requirements for wind farms and where they apply (at the point of common coupling or at each individual turbine).
- Updating for the latest protection available
- Allowance for generators that contribute to supply security
- Guidance on control of voltage for parallel generators
- Appropriate LoM protection for all generators
- Recommendations for connection security
- Amended to make LoM protection applicable to all three phase generators > 16A/phase
- The document made less restrictive by identifying three categories of generator: -

  (1) Generators not connected securely and carry high risks from islanding. Full G59 protection is appropriate.

(2) Generators not connected securely but have a protection interface with LOM not based on rate of change of frequency or any other device that may be sensitive to tripping at a time of national frequency disturbances.

(3) Generators of category (2) which are connected securely with interconnection or alternate connections. In addition the generator should be capable of riding through the effects of credible network faults.

Category (1) generators are connected with minimal costs and low security and low dependability.

Category (2) generators without fault ride through assist national supply security.

Category (3) generators with fault ride through can also assist local network.

Additional costs of category (2) and (3) generators should be recoverable by generator either as additional unit charge, reduced connection charges or both. If borne by DNO costs of enhanced connections should also be recoverable.

Generators using intertripping equipment to ensure disconnection if islanded should be treated as category (2).

G75

- Modified so that it is a stand alone document (at present it refers to G59 for a lot of the detailed requirements
- Proper application by the DNOs to all generation schemes above 5MW
- Generator Banding and a scale of recommendations for connection security

2.5 Protection required at respective voltage levels

Details of the protection thought to be required at various connection points are contained in Appendix 2 Section 5. Of the general comments, those made by one of the consultant respondents are listed in full below.

"There are basic functions for protection to meet the statutory requirements of the ESQCR:

- To disconnect as rapidly as possible all sources of energy to a faulty part of the network for both earth faults and phase faults
- That all parts of an energised network need to have a neutral earth

In addition the ESQCR requires that voltage quality meets certain requirements:

- Frequency within limits
- EMC low voltage disturbances – flicker, harmonics, voltage fluctuations, dips etc within limits
- Maximise continuity of supplies

Also Ofgem requires that continuity of supply to customers be maintained at a high level, so the introduction of DG should maintain or enhance the existing reliability

The design and operation of DG connections should be governed by these requirements. It is appropriate that the degree of sophistication of the protection and control systems reflects the importance and consequences of mal operation at any particular voltage level and network location

The protection and other control equipment need to perform the necessary monitoring and operate suitable circuit breakers to ensure that all these aspects of the ESQCR are met.

For various reasons one particular protection technique may not operate at a particular location and so a different technique may need to be chosen e.g. changing Earth Fault to Directional Earth Fault.

To simplify the application of the above functional requirements, simplified rules are appropriate for certain size bands. To conform to EU standards break points at 16A, and 75A are appropriate at LV, and say around 5MW at 11kV – a full analysis is always appropriate for >5MW and >11kV"

2.6 Maximum Generator Sizes at respective voltage levels

Again for the detailed responses see Appendix 2 Section 6.

General Comments: -

DNOs

The maximum generation that can be connected at each point is dependent upon voltage, fault level and power flow constraints: -

- Fault levels are network dependant
- Voltage is network dependant
- Power flow - (busbar connected) relates to transformer capacity
- Power flow - (circuit connected) relates to circuit capacity

Consultants

In low voltage networks generators must reasonably match local loads in profile and maximum values otherwise voltage cannot be maintained within statutory limits. This is important to generators accommodated out in the network. Larger generating capacity can be located at 11kV/LV transforming points but load profile may reduce permitted sizes.

When connected to 11kV overhead lines, maximum generator sizes follow a general rule of 4 MVA.km, where distance is the distance from the nearest primary substation. Local variations occur because of pockets of load and heavier line constructions but this is unlikely to exceed 150%. Lower limits apply to multiple generators. The limits primarily are because of low load voltage rise and lack of 11kV/LV transformer voltage control.

Higher voltage 33kV and 132kV networks have a greater capacity because of downstream transformer on load tap changing. Lower limits are fixed by economics. Higher limits are fixed by network voltage and plant ratings, operating constraints and the method of connection.

Control of source voltage, particularly 11kV, automatically by local or remote means, can increase the size of generator that can be connected to a network away from the source.

Network configurations such as closed ring or parallel feeder increase security of connections and reduce network impedance. Generally a larger generator rating may be accommodated without voltage issues.

2.7 Further Comments

DNOs

- Existing documents work well although not perfect (and circumstances are so variable that it is not clear that significant overall benefits can be achieved by re-writing)
- Recommendations need updating to reflect modern applications
- Provide good structure for DNOs and customers

Equipment Manufacturers

- Require international connection standard for inverter connection to allow best practice to be applied across countries without unnecessary barriers.

Consultants

- DNOs need to be able to justify technical decisions on connection of DG to applicant, Health & Safety executive and DTI
- Not much wrong technically with existing recommendations

Other

- The network support role of embedded generators and contribution towards satisfying P2/6 requirements should be recognised within the recommendations.

3 Conclusions

3.1 Overall conclusions

In conclusion most respondents agreed that it was necessary to have some flexibility in the way these recommendations or any subsequent replacement should be applied and that the current suite of documents works well in this regard. However a number of respondents also felt that there should be more transparency and consistency in the decision making process. This would enable a greater understanding for all the parties concerned of why the requirements are not applied in the same way for all project types and locations.

3.2 G83 specific conclusions

- Generally it was felt that the application of G83 was about right, and that the 16A / phase level was adequate as long as the current flexibility remained to apply G83 requirements beyond this level where the DNO deemed it appropriate.
- A further example of flexibility would be the type approval of interface equipment to G83 requirements beyond the current 16A / phase levels[3] where appropriate, to simplify the commissioning tests (and avoid the hire of expensive specialist test equipment).
- It was recognised that the DNO's need to be notified about the connection and disconnection of SSEG on their networks for reasons of managing network safety and planning. The following issues about the DNO notification process were identified:
    - That it was generally considered that the notification details format incorporated in G83 was adequate
    - That there were suspicions that a number of SSEG systems were connected to UK DNO networks without notification.
    - That the notification requirement of 30 days subsequent to commissioning the SSEG, identified in G83, was considered to be preferable to the requirements stated in ESQCR of "…. before, or at the time of, commissioning the source."

[3] It is noted that the limit of 16A / phase is also contained in ESQCR (Part VI, Para 22. (2). (a)).

3.3 G59 / G75 / ETR113 specific conclusions

- Some respondents felt that by placing the G59 recommendations into generator connection offers, compliance with these 'recommendations' became mandatory. Consequently some respondents' felt that they were unable to negotiate with DNOs on the application of these recommendations and that the documents were therefore "owned" by the DNOs rather than the industry as a whole.
- There appears therefore to be a need for improvements in communication between DNOs and DG developers (including improved participation by the developers). Whilst it is understood that each DNO must take account of the specific network topography in specifying the requirements for a particular connection, there is a need to demonstrate transparency and consistency across DNOs. It is considered that some restructuring of key documents will be beneficial (e.g., incorporating an overview of functional requirements within the Distribution Code).
- The commissioning test issues identified (where for example a particular type of LoM relay may only operate satisfactorily with a limited number of test sets) may require the protection manufacturer to specify a procedure or which particular test sets are compatible with his devices.
- It was also generally recognised that there is an "anomaly" in the recommendations between G83 and G59. For example in the provision of LoM protection, where G83 requires LoM protection for its entire range, while G59 requires LoM protection for its entire range except for DG <150kVA.
- Difficulty was experienced in many cases in determining effective LoM (vector shift and df/dt) protection setting levels that are not susceptible to false tripping but that will operate reliably to prevent unwanted or dangerous islanding.
- A need was identified for a review of probable issues arising from multiple DG installations with a view to establishing principles of guidance.
- Most respondents recognised that there would be an increasing interaction between protection specified under G59 and the need to ride through faults, but that currently this level of interaction and the technical conflicts necessary to satisfy both sets of issues was poorly understood.
- One respondent also raised the point that the connection requirements are driven by the need to meet the statutory requirements of the ESQCR and to ensure continuity of supply, and that it "is appropriate that the degree of sophistication of the protection and control systems reflects the importance and consequences of mal operation at any particular voltage level and network location".
- As indicated earlier, while broadly happy with the DG size ranges within G59/ G75/ G83, a number of respondents felt that G59 was being applied sometimes inappropriately beyond its nominal 5MW, 20kV limit, and that as a consequence the division between G59 and G75 was blurred and inconsistent.
- It was generally felt that there was scope for updating ETR113 to accommodate more modern technologies in Generation and to remove inappropriate protection technologies.

4 Recommendations

4.1 Overall Recommendations

- To objectively review what protection requirements are needed for connection across all distributed generation capacities to meet system security and safety needs.
- To review current document structure, and in particular the interaction between the Distribution Code, G59, G75 and ETR113 to ensure that the principles behind these requirements, the requirements themselves and the guidance on how to apply them are clearly explained, can be applied consistently across all parts of the distribution network, and are consistent with the wider system requirements of the GB System Operator. (See Section 4.6 for a proposed structure).
- To ensure that the revised document structure retains the flexibility of the current recommendations suite.
- To advocate within the recommendations the need for LoM protection devices which are resilient to spurious tripping. For example, the work presently being done on the development of improved LoM relay dependability and discrimination by Strathclyde University and the ENA is welcomed, and should be encouraged to ensure an adequate solution is available at the earliest opportunity."
- To undertake detailed analysis on the effects of system disturbances on DG to establish the extent of the problem of spurious tripping and provide guidance to both DNOs and generators on the optimum settings for currently available LoM protection devices.
- That the connection requirements for all DG outside G83 are reassessed and boundaries established dependent on system need as defined in the over-arching "principles" (See Section 4.6) rather than nominal capacity and voltage levels. One such principle set could be system supply security with the DG boundaries assessed against: -
    - DG who do not contribute to local or national supply security
    - DG who contribute to local supply security
    - DG who contribute to local and national supply security

  In this way the appropriate protection type and devices could be better specified according to the need. It would also help to bring the recommendations into line with the Grid Code. For example FRT would be specified on a 5MW DG in northern Scotland while only at 50MW in England & Wales, both generators coming under the third group outlined above, even though their capacity and connection voltage may currently place them under G59 and G75 respectively.

4.2 G83 specific recommendations

- The inclusion of Commissioning Notification forms with each SSEG device sold in the UK (to prompt householders and contractors to notify the DNO as per G83 and ESQCR)[4].
- The notification process could be further encouraged if DNO confirmation of notification were required to be included in a "house passport" (a collection of documents to be presented by the vendor at any subsequent house sale to confirm compliance with the Building & ESQC Regulations).
- The DTI be requested to change the requirement in ESQCR to notify the connection of single unit "G83" generation pre-installation to notification within 30 days of commissioning (to remove the current conflict in accordance with the majority industry view ascertained from the questionnaire).

4.3 G59 specific recommendations

- An alternative approach to specifying approved test equipment could be for the use of type-approved protective devices that are pre-tested and certified before being shipped by the manufacturer, and incorporate a self-test capability for confirmation of integrity on installation.
- Any review of G59 should consider the most cost-effective and practical means of providing protection against unintentional islanding. It will be appropriate for this review to consider the likely impacts of active network management, particularly with regard to enhanced communication systems likely to be in place between the DG facility and the network "source" substation.
- The development of an effective LoM protective device be promoted to improve the non-spurious detection of true LoM events and trip the generation only in the event of islanded operation whilst also meeting Grid Code resilience requirements for FRT.
- The exclusion of generation rated <150kVA from requiring LoM protection should be withdrawn. (This will remove the anomaly/ conflict with G83).
- However, LoM protection may be omitted where local network topology means that voltage/frequency protection trip settings would be sufficient to disconnect the generator in the event of a loss of mains type fault, for example where minimum local load significantly exceeds local generation.

4.4 G75 specific recommendations

- To better define the boundary between G59 and G75 and to ensure consistency of application, a minimum change solution could be to make G75 a fully stand-alone document covering those generators that may need to support national network security, to reflect the requirements of the revised GB Grid Code, for example on the provision of FRT capability.

[4] It is expected that, since the implementation of the "Part P" element in the Building Regulations early in 2005, most SSEG installations will be installed by an electrical contractor (who are typically more used to submitting paperwork, eg Completion Certificates, to the DNOs for installation work).

4.5 ETR113 specific recommendations

- ETR113 should be reviewed and updated to accommodate modern generation technologies and protection techniques
- If the recommendation structure were to be reviewed (See Section 4.6) ETR113 could potentially be combined with G59 and G75 to provide suitable guidance on how the connection "requirements" may be met.

4.6 Proposed Structure

To promote consistency and clarity one proposal would be to look objectively at what is required for connection across all distributed generation, and then to present these requirements clearly as part of a revised structure as laid out below: -

- **Principles** which set out the over-arching technical need for certain requirements, such as provision of FRT for example
- **Requirements,** which lay out the minimum mandatory requirements with which each generator or group of generators must comply. Ideally this would form part of the Distribution Code and possibly mirror in format the Connection Conditions of the Grid Code. It would be these Distribution Code Requirements that would then be referenced in Generator connection agreements against which compliance would be sought, rather than making the recommendations in G59 mandatory by including them in the connection agreement. These requirements would need to be carefully structured to ensure some limited flexibility was retained in their application in the interest of all parties concerned. Note that NGETL currently have an ongoing consultation paper (D / 05 - Grid Code Changes associated with Licence Exempt Embedded Medium Power Stations) out on how elements of the Grid Code may be applied to Medium capacity embedded power stations. One proposal is to impose these requirements on the DNOs who would then include them in their Distribution Code.
- **Guidance** which demonstrates examples of how the recommendations may be applied in practice (essentially combining the guidance part of G59 with ETR113)

An example of how such a framework may work is given below, in this case for Loss of Mains (LoM) protection: -

Principle:

Generators connecting to the distribution network that are not able to sustain an islanded section of that network that meets the required characteristics for public distribution systems must be automatically disconnected to avoid endangering personnel or equipment.

Requirement:

All embedded generators shall include protection that, so far as is reasonable practical, disconnects the generation from the distribution system on loss of one or more phases of the DNO supply. The protection must achieve the following minimum requirements:

1. Disconnect the generator within "x" seconds of the loss of mains event.
2. Be immune to normal distribution system operating conditions (see "section Y")
3. Be immune from the distributed voltage and frequency disturbances arising from transmission system faults (see "section Z"), or loss of significant generator (e.g. 600MW+), or loss of major interconnector (e.g. France/ England; Scotland/ England).

Guidance (possible extract):
It is recognised that no loss of mains protection device can achieve full discrimination between significant disturbances at transmission level and the prevention of DG supplying an unplanned island. The objective is to select a device(s) that reduce the risk of islanding to an acceptable level. The risk of islanding is a product of the probability and consequence of its occurrence. In cases where the dependency on available LoM protection is considered inadequate, the residual risk of islanding can be mitigated to an acceptable level by neutral voltage displacement……..etc etc

Within this framework it is envisaged that the "principles" and "requirements" are located in the Distribution Code and that the "guidance" is part of a separate document aimed at DNOs and Generators. A golden rule being that no "requirements" are introduced into the guidance document. Therefore, the guidance document would be referred to only as information relating to the connection.

5 Appendices

5.1 Appendix 1 – List of Consultees for Connection Standards Banding for Distributed Generation Questionnaire

Consultee Group	Consultee
Transmission Network Operators (TSOs), Distribution Network Operators (DNOs) & Regulators	National Grid Transco
	CE – NEDL/ YEDL
	Central Networks
	EDF Energy – Eastern/ London/ South East
	Northern Ireland Electricity
	Scottish Power – Distribution/ Manweb
	Scottish & Southern Energy Distribution
	United Utilities
	Western Power Distribution
	Ofgem
Trade Associations	Association of Electricity Producers
	Biogas Association
	British Hydropower association
	British Wind Energy Association
	Building Services Research & Information Association
	Combined Heat & Power Association
	Energy Networks Association
	Micropower Council
	PV – UK
	Renewable Power Association
	Scottish Renewables Forum

Developers	Amec Wind
	E.ON
	NPower Renewables
	RES
Equipment Manufacturers	BP Solar
	Clarke Energy
	Dulas
	Element Engineering
	Enercon
	GE Wind
	Gilbert Gilkes & Gordon
	Intelligent Power
	MK Engineering
	Natural Power
	Nordex
	Proven Energy
	Renewable Power Devices
	Siemens-Bonus
	SMA
	Solar Century
	Vestas Wind Systems
Consultants	ERA Technology
	Garrad Hassan
	Halcrow
	Mott McDonald
	PB Power
	SKM

Protection Manufacturers	ABB T&D
	Areva T&D
	Siemens T&D
	VA Tech
Others	Causebrook, A
	CREST – Loughborough University
	Queens University, Belfast, Department of Electrical Engineering
	Rogers, WJS
	University of Manchester, Department of Engineering