DISTRIBUTED GENERATION CO-ORDINATING GROUP

TECHNICAL STEERING GROUP

TECHNICAL GUIDE TO THE CONNEXION OF GENERATION TO THE DISTRIBUTION NETWORK

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Prepared under the DTI New & Renewable Energy Programme

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TECHNICAL GUIDE TO THE CONNECTION OF GENERATION TO THE DISTRIBUTION NETWORK

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1 INTRODUCTION

1.1 Who is this Guide for?

1.1.1 This Technical Guide is intended to help developers of any form of distributed generation, ie electricity generation schemes that are connected to the UK's local electricity distribution networks. It does not apply to large generation schemes of the type that are typically directly connected to the transmission network at voltages of 275kV and above. The types of generation that most frequently connect to the distribution networks include:

- renewable energy schemes (including wind generators and solar photovoltaic schemes);
- waste to energy schemes;
- on-site generation and combined heat & power (CHP) schemes; and
- peak lopping schemes using back-up generators.

1.1.2 Throughout this Guide, the person or organisation planning to develop an electricity generation scheme is referred to as the "developer".

1.1.3 Getting a generation scheme connected to the local distribution network involves considerable interaction between the developer and the network operator who is responsible for the operation and maintenance of the distribution system. Throughout this guide, these network operators are referred to as Distribution Network Operators (DNOs). This term refers to the twelve distribution companies in England and Wales, and ScottishPower and Scottish and Southern Energy in Scotland. All of these companies are holders of Electricity Distribution Licences.

1.1.4 Where necessary, this guide distinguishes between the arrangements that apply in Scotland in respect of the regulatory framework and other issues and those which apply in England and Wales.

1.1.5 The content of this Guide reflects the electricity industry structure, statutory framework and DNO practices in force at the time of writing. The Guide will be updated from time to time, particularly to reflect the results of significant industry developments (eg the fourth Distribution Price Control Review, which is expected to be implemented in April 2005).

1.2 What is the aim of the Guide?

1.2.1 The main aim of the Guide is to provide a 'route-map' of the processes of getting a generation scheme connected to the network. These are addressed at a high level initially, in order to orientate and give guidance to those developers who maybe unfamiliar with some of the processes for getting generation connected in the UK. In particular, there are a number of options open to developers in the way that connections are constructed; it is helpful for all parties to have a clear understanding of these, before embarking on the details of each stage in the connection process.

1.2.2 The connection process involves discussions and agreements between the developer and the local DNO. This process is more likely to be successful if the parties can communicate effectively and understand each other's concerns. So, in addition to its main aim of providing a route-map of the process, the Guide has a number of subsidiary aims:

- to provide background information about the electricity industry, in terms of its structure and the regulatory framework that underpins the connection process;
- to highlight some of the technical issues that commonly arise during connection negotiations, and their implications for DNOs and developers;
- to describe the main factors affecting connection costs and timescales for achieving connections; and
- to identify the different contracts that relate to the connection.

1.2.3 Every distributed generation scheme has a unique set of technical and commercial characteristics, so it is not really possible to provide specific guidelines and solutions for the design of connection arrangements. Instead, the Guide is intended to give the reader a general understanding of the connection process and the issues which affect the design and cost of connections for distributed generation.

1.3 What is not covered in the Guide?

1.3.1 In addition to arranging a network connection, the developer of an electricity generation scheme has to address many other issues in order to get the scheme up and running. Some of these are listed here:

- Designing, installing and operating the generator installation
- Buying and selling electricity
- Planning the project
- Financing the project
- Resolving local planning issues

These issues are outside the scope of this Guide.

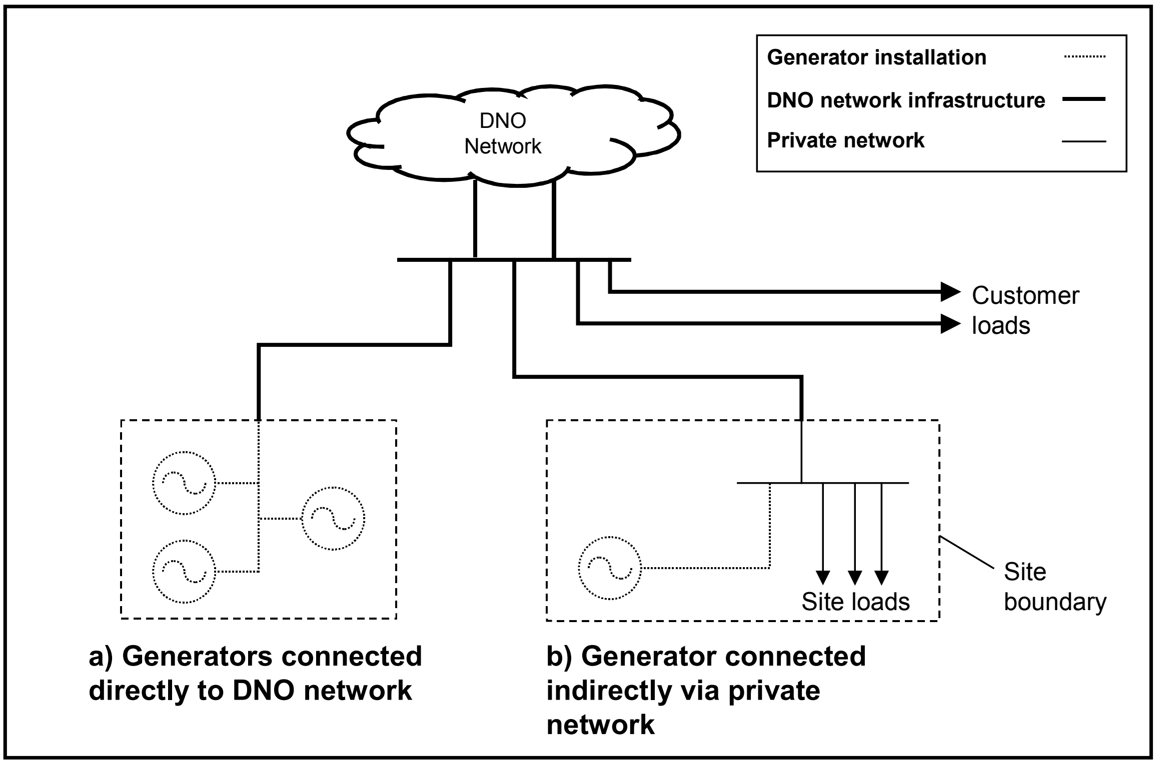
1.4 Clarification of key terms

What is distributed generation?

1.4.1 An electricity generation scheme is classed as distributed generation if it is intended to operate while electrically connected to a DNO's distribution network. Such schemes may also be referred to as "embedded" generators. This mode of operation is sometimes described as "mains paralleling", since it involves operation of the generator in parallel with the mains electricity supply.

1.4.2 The generator may be directly connected to the DNO's network, as shown in Figure 1.1(a), or indirectly connected via a privately-owned network, as shown in Figure 1.1(b). The generator may export power into the DNO's network, or it may simply be used to offset some of the consumption associated with electricity demand on the same site.

Figure 1.1: Distributed generation connections



What is a DNO?

1.4.3 A DNO (Distribution Network Operator) is a company which is responsible for the operation and maintenance of a public electricity distribution network. ScottishPower, Scottish and Southern Energy and the twelve electricity distribution businesses in England and Wales all hold Distribution Network Operator Licences, and are therefore termed DNOs. These companies typically form part of a group that undertakes other areas of business as well; for the purposes of getting a plant physically connected to a distribution network, however, it is the network operator business with which the developer will interface. The developer may discuss and enter into an agreement with any electricity supply business for the sale of energy and/or purchase of top-up and standby supplies. Such negotiations will, however, be completely separate from discussions with the DNO business regarding the physical connection.

1.4.4 Some companies have separate connection businesses, which can act as contractors for the installation of new connection infrastructure, in addition to having DNO businesses. However it is the DNO businesses that are responsible for providing connections under contractual arrangements with the generation developers. Where the DNO has set up a separate connections business, it may utilise its services for the purposes of carrying out the procurement and physical installation of connection assets. If the developer wishes to contract with a third party connection provider for the development of the contestable component of the connection work, it may wish to approach the DNO's connection business as one of a number of competitive tenderers (see the section of this Guide that deals with Competition in Connections, Section 4).

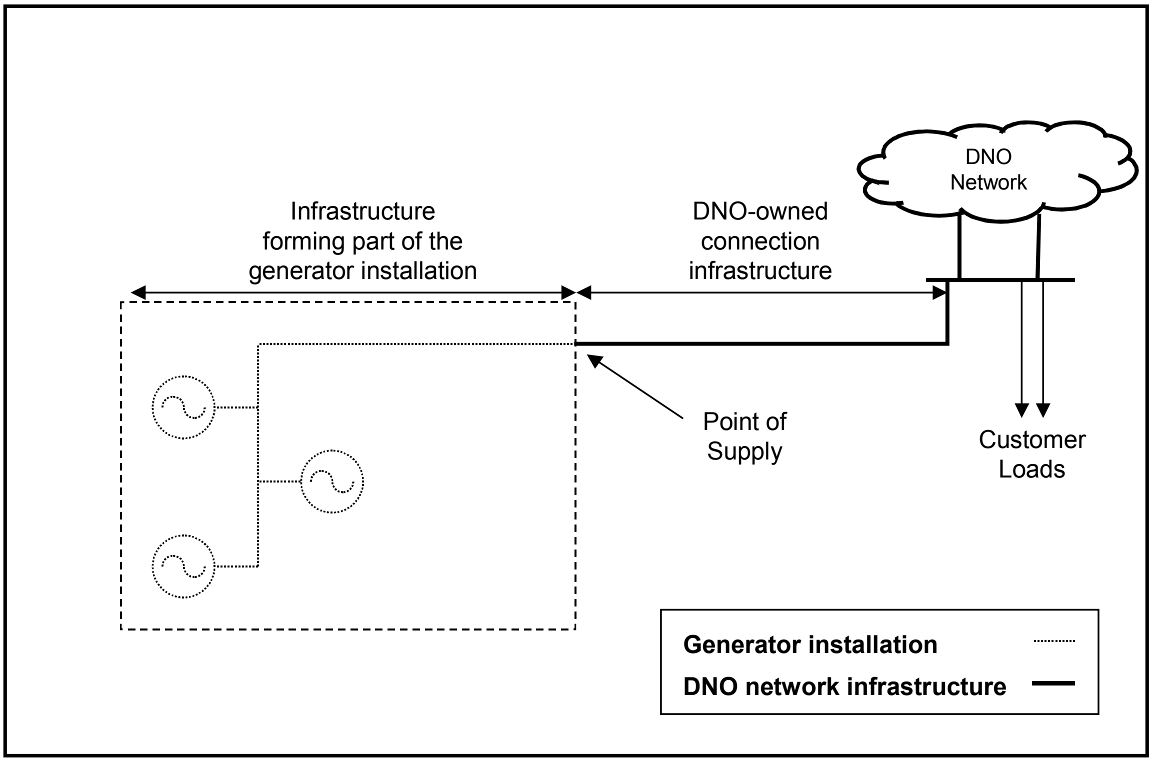
1.4.5 To discuss the connection of a planned distributed generation scheme, the developer should therefore establish and maintain clear lines of communication with the appropriate personnel in the DNO. It is this business which is responsible for planning the development of the network and for engineering new connections. Furthermore, the DNO is subject to regulations requiring it to provide technical information about the distribution network, and to offer terms for providing a connection. This Guide therefore focuses on the dialogue required between the developer and the DNO in getting generation connected to the distribution network.

<u>What is a connection?</u>

1.4.6 Various physical and contractual arrangements must be in place before a generation scheme can be connected to a DNO's network for mains parallel operation. The physical arrangements consist of electrical infrastructure such as cables, switchgear, civil works etc which constitute the electrical connection itself. The contractual arrangements consist of agreements between the developer and others. These agreements cover many issues, including connection arrangements, power purchase arrangements etc. DNOs and developers are also required to comply with the Distribution Code in developing and operating connections.

1.4.7 The physical infrastructure which connects a distributed generator to a DNO network can be divided into two sections: that owned by the developer, and that owned by the DNO (see Figure 1.2). The interface between these two parts is known as the Ownership Boundary, or Point of Supply. This is typically defined at a busbar within the connection site. The developer has sole responsibility for the design, installation and operation of the equipment on its own side of this interface, although the DNO will want to assure itself that this equipment does not pose a hazard to their distribution network. The DNO will assume responsibility for operation and maintenance of all infrastructure on their side of the interface, but the design and installation of any new DNO-owned infrastructure is a matter for dialogue and agreement between the developer and the DNO. In this Guide, references to 'the connection', 'connection schemes', 'connection costs' etc relate specifically to this DNO-owned infrastructure.

Figure 1.2: Typical connection configuration



2 GETTING CONNECTED

2.1 Introduction

2.1.1 This section of the Technical Guide presents all of the key stages that a generation developer and the DNO are likely to go through in connecting a generator to the distribution network. This is a process that requires a high degree of interaction between the developer and the DNO, and the Technical Guide therefore focuses on the information exchanges that typically need to take place and the essential steps that must be taken by each party to ensure the efficient completion of the connection.

2.1.2 The detailed tasks that must be undertaken in getting connected vary with the size of the generation plant that is being developed. In general, the bigger the plant, the more complex the connection requirements. Later in this Guide, the detailed requirements for connecting plants of different sizes are explained. In particular, developers of small-scale distributed generators (ie generating units rated up to and including 16A per phase at LV – 400/230V) are not required to enter into detailed connection discussions with the DNO prior to commissioning their plants, although they must notify the DNO upon commissioning.

2.1.3 For larger generators, the connection process comprises a number of key stages. These are shown conceptually in Figure 2.1, and consist of:

- a **Project Planning Phase**, during which the developer formulates its plans for the generation scheme and consults published information, such as DNOs' Long Term Development Statements (LTDSs), to identify the opportunities for the connection of generation to a DNO's network;

- an **Information Phase**, during which the developer submits information about the proposed generating plant to the DNO. The DNO in turn explains the configuration of the distribution network in the vicinity of the proposed connection site and the potential design issues and costs involved in connecting generation at that point;

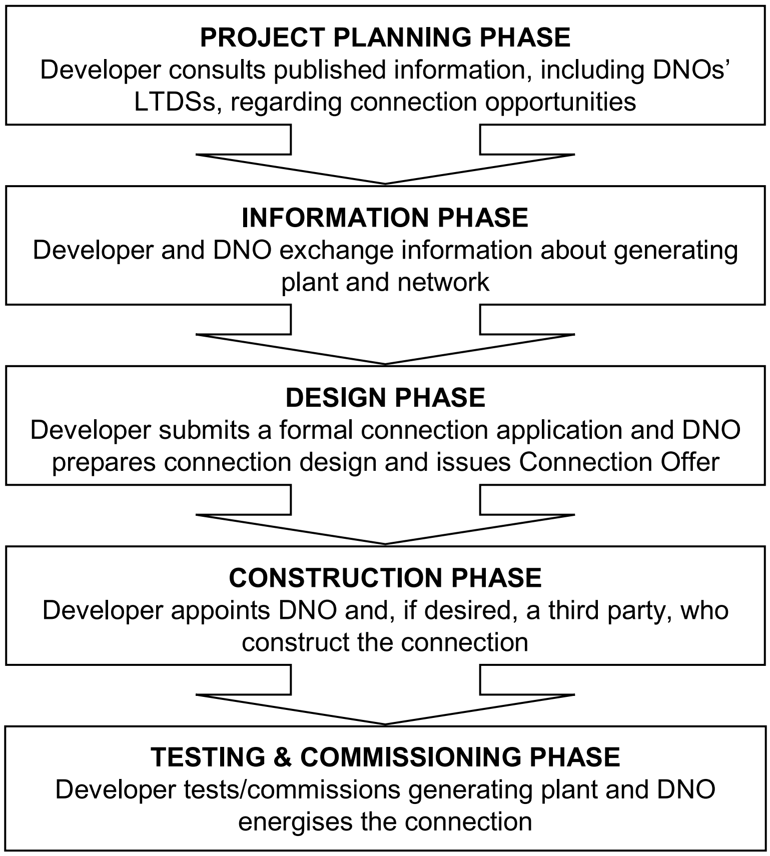
- a **Design Phase**, in which the developer submits a formal Connection Application to the DNO. The DNO produces detailed connection designs and costings and identifies how much of the connection construction work could be undertaken by a third party (the Contestable Work) and how much the DNO must undertake itself;

- a **Construction Phase**, in which the developer enters into contracts with the DNO and, if so desired, a third party contractor for the construction of the connection and these parties carry out the necessary physical works; and

- a **Testing & Commissioning Phase**, where the DNO and the developer complete the necessary Connection and Use of System

Agreements, the developer tests and commissions the generating plant (noting that DNO may wish to witness these tests) and the DNO carries out the necessary tests on the connection and energises it, thereby connecting the developer's plant to the distribution network.

Figure 2.1: High level overview of the connection process

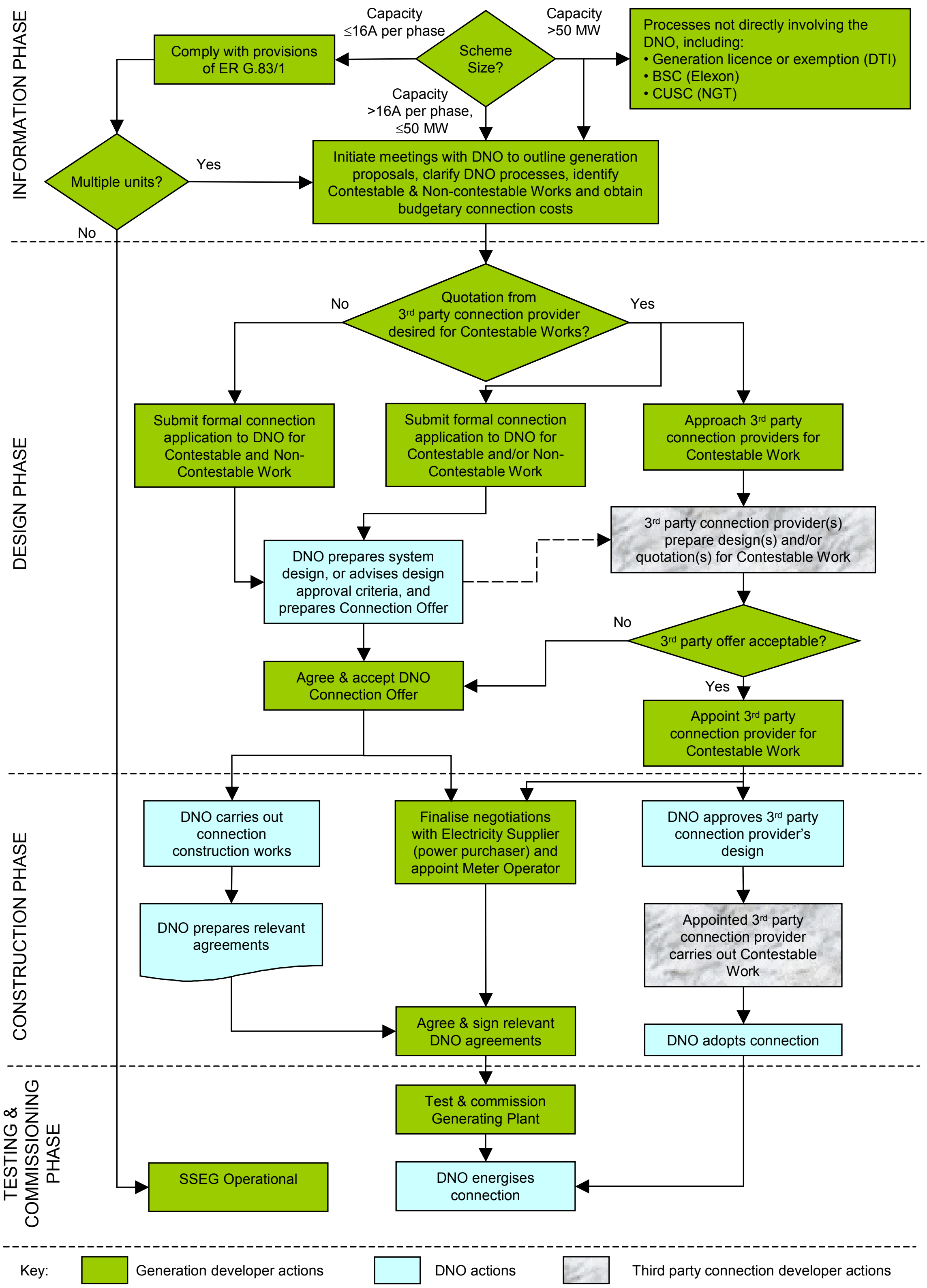


2.1.4 Throughout the above process, the developer will need to provide increasing amounts of data about the generation scheme to the DNO. This data remains confidential to the DNO until such a time as a Connection Offer is accepted by the developer.

2.2 The Connection Process – Main Tasks

2.2.1 The high level steps described above can be broken down into a number of more detailed stages. These are shown in Figure 2.2. This section of the Guide highlights each of these stages in turn, and explains the tasks that the developer, the DNO or a third party connection provider will typically undertake. As noted in Section 2.1.2, the route that the developer needs to follow in order to get a power plant connected varies with the plant size; the alternatives are explained below.

Figure 2.2: Main Tasks in the Connection Process



Small Scale Embedded Generation (≤16A per phase) (SSEG)

2.2.2 The requirements for developers looking to connect Small Scale Embedded Generation (SSEG) rated at up to and including 16A per phase are defined in Engineering Recommendation G83/1. This defines two stages of connection:

- a Stage 1 Connection, comprising the installation of a single SSEG unit – in this case, the developer is required to ensure that the local DNO is made aware of the SSEG installation. In addition the developer must provide the DNO with information on the installation, within 30 days of the SSEG unit being commissioned[1]. There is no requirement for the developer to make a formal Connection Application in respect of a plant of this size, however;

- a Stage 2 Connection, where the developer plans to install multiple SSEG units in a close geographic region. Here the developer is required to obtain the prior approval of the DNO, using a process that is similar to that described below for plants in the range from over 16A per phase up to 50MW.

Generation >16A/phase, ≤50MW

Project Planning Phase

2.2.3 In order to develop its plans for the generation project, the developer should make use of publicly available documentation regarding the DNO's network to assess the potential for connection in the vicinity of the proposed site for the project. Suitable sources of data include the DNO's LTDS. Additional information may be obtained from early contact with the DNO to discuss the proximity of suitable connection points to the proposed generation site, information about any other planned distributed generation in the area or any other information that is readily available regarding "spare" capacity on the network.

2.2.4 Work at this stage could include the execution of a feasibility study to assess possible connection layouts and indicative costs. This can be carried out by the DNO or by an external contractor. Such a study should include consideration of the standard of security that is required in the connection between the generating plant and the DNO's network. The levels of security that are accommodated in the design of the DNO's network for demand connections are defined in Engineering Recommendation P2/5.

Information Phase

2.2.5 It is important that developers discuss their plans with the DNO at an early stage, and maintain close liaison with the DNO throughout the planning and construction of their plant. This will help to ensure that the connection design

[1] See Engineering Recommendation G83/1 Section 5.1.1

is developed in a way that fully reflects the operating characteristics of the generator.

2.2.6 The developer should seek initial meetings with the DNO early in the development programme for the generation project, in order to:

(a) give an outline of the proposed generation scheme to the DNO;

(b) discuss the process that the DNO will wish to follow through the various phases of the connection development;

(c) initiate a request to the DNO to prepare an indicative connection design and a budgetary cost estimate (after undertaking any necessary studies) and to prepare a statement of the likely split between:

– the Contestable Work associated with the connection, for the execution of which the developer could appoint a third party contractor in the role of a connection provider; and

– the Non-contestable Work which the DNO needs to be able to carry out itself (which typically comprises planning and design work, the construction of reinforcements to the existing distribution network, obtaining planning consents and wayleaves involving the exercise of the DNO's statutory powers, operation/repair/maintenance of the connection assets and the inspection and testing of the connection works).

2.2.7 A key decision affecting the way in which the connection process proceeds is whether or not the developer wishes to appoint a third party to carry out the Contestable Work associated with the connection. If a third party connection provider is to be contracted, this process will generally need to be initiated in parallel with appointing the DNO to carry out the Non-contestable Work.

Design Phase

2.2.8 A formal Connection Application must be submitted to the DNO, in accordance with the DNO's specific procedures. This needs to be accompanied by all of the technical details of the plant that are required by the DNO to develop a detailed design for the connection and any associated system reinforcement that may be required. The DNO will advise the developer as to the type of information that needs to be provided with the application, in order to enable the DNO to prepare a detailed design for the connection scheme. The DNO is required under the terms of its Licence to provide a quotation for connection within 3 months of receiving a complete application (ie an application that includes the necessary supporting information).

2.2.9 A firm quotation for carrying out the Non-contestable Work will then be prepared by the DNO. The DNO will also prepare a quotation for the Contestable Work, if asked to do so.

2.2.10 The preparation of detailed designs for the connection infrastructure may be a contestable activity, depending on the policy of individual DNOs. If a DNO specifies that design of the connection is non-contestable, it will be necessary for the developer to obtain a design from the DNO as the basis for inviting tenders from third party connection providers. In the event that connection design is deemed a contestable activity by the DNO, the DNO will nevertheless wish to approve the design prior to the commencement of connection construction works.

2.2.11 The developer will receive a Connection Offer from the DNO presenting the technical and commercial basis on which it would carry out the Non-contestable Work and, if applicable, the Contestable Work. The developer should review this carefully (possibly with the aid of an independent consultant), and discuss and agree the details of the offer with the DNO. The developer and the DNO will then enter into a formal agreement setting down the terms on which the Connection Offer is accepted. If the parties cannot reach agreement, the matter may ultimately by referred to Ofgem for determination.

2.2.12 In parallel with this process, the developer may, as noted earlier, invite quotations from other contractors for carrying out the Contestable Work. The developer will then need to adjudicate these and decide whether to appoint the DNO or another to undertake this work. The developer will need to enter into a formal agreement with whichever party is to undertake the Contestable Work.

Construction Phase

2.2.13 Once the DNO and, if applicable, a third party connection provider have been appointed to construct the connection, they will generally liaise to ensure that the works are carried out in accordance with the required standards and to manage the interfaces between each party's construction works. Liaison will also be required between the developer and the DNO in relation to any reinforcements that the DNO needs to carry out remotely from the generating plant, to ensure that a coordinated programme for completion of these reinforcements and the commissioning of the generating plant is agreed.

2.2.14 Whilst the construction of the connection is ongoing, the developer will need to focus on a number of other activities specifically associated with the generating plant itself. These include tasks such as:

- completing the construction of the plant;

- ensuring that appropriate provisions for wayleaves are incorporated in any lease option that is required for the generating site – if the location of the generating site is owned by a landowner other than the developer, provision should be made in the lease option for the appropriate wayleaves to be signed to enable DNO cables to come onto the generating site;

- appointing a Meter Operator to undertake the provision of metering equipment and to make arrangements for meter reading and data collection by the appropriate parties (noting that if the generator is exempt from the requirement to hold a Licence and does not propose to trade through the Balancing and Settlement Code (BSC), the supplier who will be purchasing the power plant output is required to register the metering equipment under the relevant BSC Code of Practice and may therefore arrange for the provision of the relevant equipment by a Meter Operator); and

- finalising negotiations with the supplier who is to purchase the energy produced by the plant and the supplier who is to provide top-up and standby supplies.

2.2.15 Before the physical operation of the generating plant can commence, the DNO and the developer will need to enter into a number of agreements, including:

- a Connection Agreement and, in Scotland only, a Use of System Agreement - these cover the conditions under which the generating plant is entitled to be physically connected to the DNO network and to remain connected and energised during the normal operation of the network. These agreements are likely to take the form of standard documents with scheme-specific annexes, which will probably be prepared in first draft by the DNO for discussion, agreement and signature;

- an Adoption Agreement, detailing the terms under which the DNO will take the relevant connection assets into its control and ownership as part of the distribution network, where these have been constructed by a third party connection provider. This will normally be sent out with the formal connection offer at the Design Phase, where a developer is considering utilising a third party connection provider to undertake the Contestable Work. The agreement includes details of the responsibilities of all three parties (the DNO, the developer and the third party connection provider) regarding the construction of the Contestable Work; and

- an agreement covering the arrangements for operation of the connection interface between the distribution network and the generating plant by the DNO's and developer's staff. Suitable provisions may be contained in a Schedule to the Connection Agreement, or in a separate agreement, such as a Joint Operating Agreement.

Testing and Commissioning Phase

2.2.16 The steps outlined above indicate the key actions required to get to the point where there is a physical connection in place between the generating plant and the DNO network. At this stage, the connection needs to be tested and commissioned by the DNO to confirm its integrity and safety and to enable energisation of the connection to take place.

2.2.17 The connection commissioning process requires careful liaison between the DNO and the developer, in relation to the programme for commissioning the rest of the generating plant. In particular, the DNO will wish to be assured of the state of readiness of the developer's plant on the developer's side of the DNO/generator boundary. It may, of course, be necessary for the connection to be available before final commissioning of the generating plant can take place, to ensure, for example, that plant auxiliary supplies are available via the connection itself. All of these issues require detailed coordination between the DNO and the developer in the final testing and commissioning stages.

2.2.18 Following signature of the appropriate Connection and, where applicable, Use of System Agreements, the developer is required to submit to the DNO the final, confirmed parameters of the generation scheme (the Registered Project Planning Data) in accordance with the terms of the Distribution Code[2].

2.2.19 It will be the developer's responsibility to ensure that the electricity supplier who is purchasing the energy output from the plant is informed of the proposed commissioning programme, including the date on which power imports and exports across the connection are proposed to commence. The electricity supplier can advise on the necessity to liaise with the relevant electricity market authorities. Commercial arrangements will need to be in place for the purchase of commissioning supplies by the generator and, conversely, for the sale of energy produced during the commissioning process. These commercial arrangements will include the need to ensure that the correct metering is installed and functional, prior to the commencement of energy import and export from the site.

Generation ≥50 MW

2.2.20 The process for connecting large generation projects (ie those above 50MW in size) to the distribution network is the same as that described from paragraph 2.2.5 onwards, in terms of the interactions required between the developer and the DNO. For projects of this size, however, the developer is likely to be involved in a number of other processes, reflecting the increased complexity of its involvement in the electricity market.

2.2.21 The main issues with which the developer of this size of plant will be concerned over and above its relationship with the DNO include:

- the possible need for a **Generation Licence**. At the time of writing, generation licences are not required for generation of less than 50MW capacity. Generators in the range 50-100MW may apply to the Department of Trade & Industry for exemption from the necessity to

[2] See Distribution Data Registration Code DDRC4 in the Distribution Code

hold a licence. Generators of capacity greater than 100MW are required to apply for a Licence from Ofgem;

- **Balancing and Settlement Code** (BSC) participation. Generators above 100MW in export capacity are required to become a party to the BSC. Below this level of output, however, the need for BSC participation is determined primarily by the mechanism by which the developer wishes to trade electricity. The developer needs to consider this carefully, in relation to any wish to trade energy through power exchanges and/or the balancing mechanism under the New Electricity Trading Arrangements (NETA), in which case it will be necessary for the developer to become a signatory to the BSC;

- the need to become a party to the **Connection and Use of System Code (CUSC)**, if by virtue of its selected trading arrangements the generator is deemed to be using the National Grid transmission network. This is considered to be the case for any distributed generation that is trading in such a way that it is required to sign the BSC.

2.3 Where to find more detailed information

2.3.1 A number of reference documents within the electricity industry contain detailed provisions with which developers of distributed generation projects are required to comply in different circumstances. Developers should ensure prior to, and throughout, their discussions with DNOs that they are familiar with the contents of the following key documents, as applicable to their specific generating schemes:

- the Grid Codes of England & Wales and Scotland;

- the Distribution Code of Great Britain;

- Engineering Recommendation G75/1, relating to the connection of Generating Plant to public distribution systems above 20kV or with outputs over 5MW;

- Engineering Recommendation G59/1, and the associated Technical Report TR113, relating to the connection of Generating Plant with outputs not exceeding 5 MW connected to systems with voltages at or below 20kV; and

- Engineering Recommendation G83/1, relating to the connection of Small-Scale Embedded Generators (up to 16A per phase) in parallel with public LV distribution networks.

2.3.2 In addition to the above, a number of the principles contained in Engineering Recommendation G81 are appropriate for consideration in the context of distributed generation connections. This Engineering Recommendation relates primarily to design and planning, materials specification, installation and records for Greenfield LV housing estate underground network installations and associated, new, HV/LV distribution substations, many of the principles of which are applicable to new generation connections.

2.3.3 Details of the above Engineering Recommendations and other reference documents are contained in Appendix G to this Technical Guide.

2.3.4 The remainder of this Technical Guide provides more detailed information about the technical and commercial issues involved in connecting generation to the distribution system. This includes:

- in Section 3, further information about the **Connection Application process** and the associated **costs and charges**;
- in Section 4, details of the status of **competition** in relation to the provision of connections by third parties and the issues that are important to the developer in dealing with third party connection providers;
- in Section 5, a **glossary** of the key terms used in this documents; and
- at the end, a **subject index** to the document as a whole.

2.3.5 A series of appendices to the main document contains specific information about some of the predominantly technical factors that have to be taken into account when connecting generating plants to the distribution system. In many instances these cross-refer to a range of industry standard codes and standards. Details of how to obtain copies of these documents are contained in Appendix G.

2.3.6 The coverage of the appendices in this Technical Guide is as follows:

- Appendix A presents a guide to the **structure of the UK electricity industry**, which provides useful background information regarding the organisations that are responsible for running the electricity market and operating the physical assets that make up the integrated networks;
- Appendix B addresses the **statutory legal framework** that defines the operation of the electricity sector;
- Appendix C is a key **technical** Appendix, which focuses on the effects that distributed generation has the distribution networks and the operational and planning issues that result for DNOs;
- Appendix D focuses on a specific subset of the technical matters associated with the connection of distributed generation, concerned with **protection, earthing and safety** provisions;

- Appendix E details the type and sources of **data regarding DNOs' networks** that are available, in particular the information that DNOs publish in their "Licence Condition 25" statements of future plans for the distribution networks, which can be helpful to developers seeking to refine their own plant designs;

- Appendix F presents **checklists** for developers to assist in navigating through the various processes involved in getting plant connected to the distribution network;

- Appendix G details the **standards and other documents** to which developers and DNOs will typically need to refer in the planning and construction of distributed generation connections; and

- Appendix H lists the **contact details** for DNOs with which developers are likely to interface in the process of developing, commissioning and operating distributed generating plants. It also contains details for Transmission Operators and for trade associations that may be of assistance to developers.

3 CONNECTION APPLICATIONS, COSTS AND CHARGES

3.1 Introduction

3.1.1 When a developer makes a Connection Application, the DNO is obliged to offer terms for providing a suitable connection for the proposed generation scheme. These terms will include charges to the developer, to cover the DNO's costs in providing the connection. The aim of this chapter is to describe the stages in the application process, the main components of the costs of connection, and the basis on which these costs are charged to the developer. The chapter also outlines some of the other charges which the developer may have to pay. Finally, there is a section concerning the allocation of connection costs in situations where two or more Connection Applications are received by the DNO.

3.2 Connection application process and timescales

3.2.1 The developer should at an early stage in the planning of the generation project obtain details from the DNO of the distribution network in the vicinity of the proposed plant. General information about the long term development plans for the distribution network is available in the Long Term Development Statement which is produced by each DNO in accordance with Condition 25 of its Licence, and which is available from the DNO. In order to obtain more specific information, however, the developer may make a request to the DNO for an estimate of the present and future circuit capacity, forecast power flows and loadings on the relevant parts of the distribution network. The DNO is permitted to charge for the provision of this information under the terms of its Licence, and is allowed up to 10 days from receipt of the request for information to advise the developer of its estimated reasonable costs in preparing the statement.

3.2.2 The DNO is required under the terms of its Licence to produce this information as soon as practicable, and no later than 28 days from the time when the developer agrees to pay the costs (if any) of providing the necessary information[3]. The DNO may make representations to Ofgem to be allowed a longer time period for the provision of information in circumstances where the complexity of the developer's proposals makes this necessary.

3.2.3 The information that the DNO will provide should be sufficient to enable the developer to identify and evaluate the opportunities for connecting to and using the relevant parts of the DNO's network. It may also, at the request of the developer, include a commentary on the DNO's views regarding the suitability of the relevant part of the distribution network to accommodate new connections and the export of power from the proposed generating plant.

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[3] See Electricity Distribution Licence Condition 4

3.2.4 Developers may also wish to request the DNO or a third party (eg an engineering consultant) to carry out feasibility studies to identify budgetary connection costs for their proposed schemes. The reliability of these estimates will be significantly influenced by the quality of the information that can be made available by the developer at this time to enable a reasonable assessment of the likely connection configuration and capacity to be carried out. The developer should expect to be invoiced for the costs of such studies, which are likely to increase if multiple options for the generation scheme are to be considered.

3.2.5 It is generally desirable for the developer to have a discussion with the DNO prior to submitting a formal Connection Application. This will enable key issues to be addressed in relation to the details of the proposed scheme and the associated network implications. The types of issue that may need to be considered include:

- limits on the capacity of the existing network for accommodating power exports from the proposed generator, without network upgrading – see further information on the relevant issues in Appendix C;

- the potential for any proposed future work on the relevant area of the distribution network to affect the upgrading work that may be needed to support the proposed generation scheme;

- the likely requirements of the DNO regarding the performance of the generating plant, which need to be taken into account by the developer in the detailed design stage of the project; and

- the potential impact on the reinforcements required to accommodate the developer's plant of any other generation projects that are known to be seeking connection in the same area of the network (see Section 3.6 below).

3.2.6 Once the developer has decided to proceed with an application for connection to the DNO, it should lodge a request using the appropriate pro-formas issued by the DNO. The DNO may require certain items of Standard Planning Data and Detailed Planning Data to be provided with the application, in accordance with the Distribution Code[4]. The DNO will treat information submitted by the developer which relates to the proposed generation project as confidential until such time as a Connection Offer has been accepted by the developer.

3.2.7 The DNO is required as an obligation of its Licence[5] to offer terms under which it would enter into an agreement for the connection of the proposed

[4] See the Distribution Code of Licensed Distribution Network Operators of Great Britain, DPC7

[5] See Electricity Distribution Licence Condition 4B

generation plant and/or the use of the DNO network for exporting power from the plant ("Use of System"). In the case of applications for Use of System only (which could for generation only arise in Scotland), this offer must be made within 28 days of the receipt by the DNO of a complete application. For applications requiring terms for connection (or modification of an existing connection) as well as Use of System, the corresponding time limit is 3 months.

3.2.8 The Connection Offer prepared by the DNO will contain the technical and commercial terms under which it is prepared to carry out the necessary connection works and provide Use of System services to the developer. The offer will include differentiation between Contestable Work (ie that for which the developer may, if it wishes, seek quotations from third party connection providers) and Non-contestable Work (that which must be carried out by the DNO itself), where this breakdown has been requested by the developer. It will also contain details of the costs associated with connection provision. Further information about the way in which these costs are derived is given below.

3.2.9 A key issue affecting both the timescales and costs of achieving a connection relates to the process of obtaining Wayleaves for the necessary connection assets. In order to minimise the uncertainty surrounding wayleaving for a new connection, it is recommended that:

- the developer explores in early discussions with the DNO whether there is reason to believe that obtaining the necessary wayleaves could prove contentious, and consider asking the DNO to explore this issue further as part of any feasibility studies that the developer may commission from the DNO;

- the developer asks the DNO to indicate as part of the Connection Offer any circumstances in which connection costs may vary significantly due to uncertainties surrounding wayleaving and/or planning consent issues, and to itemise the costs included in the quotation for these components;

- the developer asks the DNO to consider alternative routings at an early stage, where these could result in more straightforward planning and wayleaving processes, and indicates the different connection costs that may be associated with these – for example, the installation of cabling along a public highway, whilst being potentially more expensive than the installation of an overhead line, may incur fewer wayleaving complications than the overhead line option ; and

- the DNO is asked to indicate those wayleaves that will not require the execution of its own statutory powers, and which could therefore in principle be negotiated by a third party connection developer under the provisions of Competition in Connections (see Section 4).

3.3 Costs of connection infrastructure

3.3.1 The connection cost for a generation scheme depends on the nature and extent of the works which have to be carried out to provide the connection. Table 3.1 provides indicative costs for some of the main elements of this work, although the statements produced by DNOs in accordance with Condition 4 of their Licences should include a schedule listing the works and equipment of significant cost that are likely to be required for the purposes of connection. The unit costs for works such as trenching and cabling depend on the length of circuit to be installed. The lower unit costs apply to cases where several kilometres of circuit are needed.

3.3.2 To obtain a more accurate picture of the connection costs, the developer can ask the DNO to provide a budget estimate for the project in question or obtain estimates of connection costs from specialist electrical engineering consultants, as noted in Section 3.2.4.

3.3.3 Developers should exercise care in interpreting budget estimates of connection costs. Normally, these estimates relate only to the cost of the infrastructure on the DNO side of the point of supply. It is important to note, however, that whilst DNOs will use reasonable endeavours to identify all of the remote reinforcement costs associated with the proposed connection at the budgetary costing stage, it is possible that not all of the reinforcement costs will have been included at this time.

3.3.4 There can also be significant costs associated with electrical infrastructure on the developer's side of the point of supply.

3.3.5 These two areas of cost must be considered in total when evaluating projects, and also when considering alternative connection options. As an example, the DNO may indicate that the connection costs would be lower if they were to provide a supply at 33kV instead of 11kV. This option might require the developer to install and operate a 33kV/11kV transformer, in which case the cost of this transformer would have to be weighed against the lower DNO costs.

Table 3.1: Indicative costs of Connection Works

Works	Approx. cost
Cable trenching and reinstatement	
in public highway (tarmac)	£50-100 per metre
in fields or rough ground	£20-40 per metre
11kV equipment* (up to 5MW capacity)	
underground cable	£20-50 per metre
overhead line	£10-45 per metre
switching substation (no transformer)	£15,000-50,000
33kV equipment* (up to 20MW capacity)	
underground cable	£20-100 per metre
overhead line	£20-55 per metre
switching substation (no transformer)	£100,000-250,000
*costs include supply, installation, testing and commissioning, but exclude O&M 132kV costs vary widely and indicative costs cannot be presented.	

3.3.6 Finally, connection schemes proposed by the DNO or by others may involve requirements or assumptions regarding the provision of equipment on the developer's side of the point of supply. These assumptions are not always obvious to the developer, and this can lead to misunderstandings and under-budgeting. Technical assistance can help developers to avoid these situations; DNOs are, however, under no obligation to provide such assistance.

3.4 Basis of DNO connection charges

Initial costs and O&M costs

3.4.1 In cases where work has to be done to modify an existing connection or to provide an entirely new one, some or all of this work will have to be done by the DNO. Thus, some initial costs will be incurred. These costs are likely to be charged to the developer up-front, as part of the connection charge, however the developer may wish to explore the option of deferred payment terms with the DNO.

3.4.2 The DNO will also incur costs associated with the operation, maintenance repair and replacement of the new or modified connection infrastructure. These operation and maintenance (O&M) costs must be considered in addition to the initial costs. O&M costs are often capitalised and charged to the developer up-front as part of the connection charge. Alternatively, it may be possible for the developer to pay an annual service charge to cover these costs. These principles are subject to possible revision under the terms of the fourth

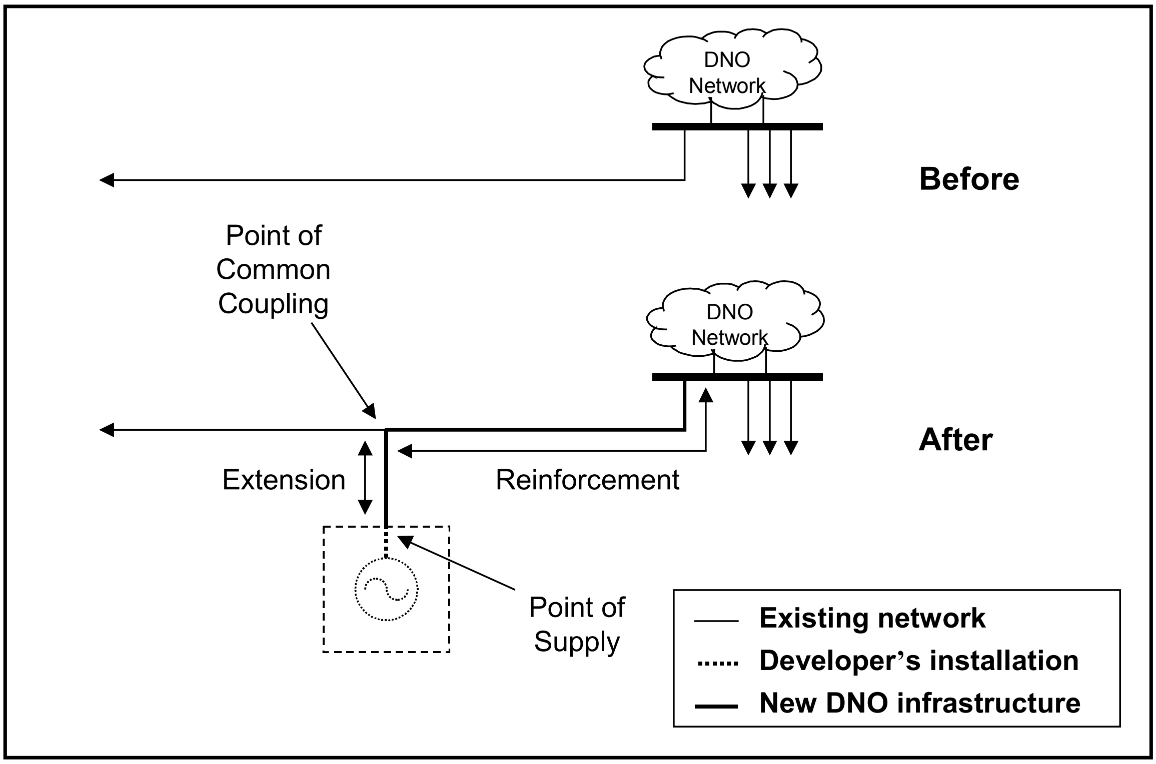
Distribution Price Control Review. This is being undertaken by Ofgem and will become effective on 1 April 2005.

3.4.3 O&M charges are normally capitalised at between 10% and 30% of the value of the assets, depending on the DNO and the assets involved. Where connection costs involve reinforcement and engineering costs it may be that a proportion of, or no, O&M charges will be applied to some of these items. The approach adopted by each DNO is explained in its Licence Condition 4 statement.

<u>Extension costs and reinforcement costs</u>

3.4.4 In effect, the connection provides an electrical path into the network, starting at the ownership boundary between the generator installation and the DNO's network. The work required to provide this path can be broken down into two categories. Firstly, **new infrastructure** must be installed in order to provide an extension of the existing network, from the point of common coupling on the existing network up to the new point of supply (which is typically defined as a busbar within the connection site). Secondly, some **reinforcement** of the existing network infrastructure may be necessary in order to accommodate the planned generation capacity. These components of the connection work are illustrated in Figure 3.1.

Figure 3.1: Extension and reinforcement works



3.4.5 Reinforcement work is usually required to increase the electrical capacity of those parts of the network which form part of the electrical path from the generator into the network. However, some network reinforcements do not fit this pattern. For example, it may be necessary to upgrade the switchgear at a substation some distance from the proposed generation scheme, due to the increase in fault level caused by the connection of the generator. Alternatively, equipment such as reactors, static var compensators etc, may be needed in order to cater for situations in which voltage rise may occur on the distribution system, eg during times of light demand when the generator is nevertheless exporting power.

Return on investment

3.4.6 According to Condition 4B of the DNO Licence, connection charges should be set at a level which enables the DNO to recover 'the appropriate proportion' of both their initial costs and their O&M costs associated with the provision of the connection. This includes initial and O&M costs for reinforcement of existing network infrastructure, as well as for extension of the network. In addition, the connection charges should provide the DNO with a reasonable rate of return on any capital expenditure. A pre-tax return of around 6.5% per annum was indicated by Ofgem in their 1999 proposals for distribution price control.

Allocation of costs

3.4.7 In most cases, it will be appropriate for the DNO to charge all the costs of the connection works to the developer. However, there are cases in which the works carried out to provide a connection can provide benefits to the DNO or to other users of the network. Network reinforcement is often beneficial from the DNO's viewpoint, and new network infrastructure installed to provide a connection for one generation scheme may be used subsequently to provide connections for other generators or electricity users. Under the provisions of the Electricity (Connection Charges) Regulations 2002 and the associated amendment, for connections after 1 June 2003, DNOs are required to reimburse to any party (including generators) an appropriate proportion of the amount they have paid for their connection, in the event that the connection infrastructure is utilised within a period of five years to connect another party to the distribution network.

3.4.8 Condition 4B of the DNO Licence specifies that any benefit obtained by the DNO or by third parties, including possible future benefits, should be taken into account when determining the appropriate proportion of the connection costs to be charged to the developer. It should be noted that the reference in this Licence Condition to reinforcement costs being waived on circuits where the increased load requirement is less than 25% of the existing network capacity applies to demand and not to generation.

3.4.9 The provisions of Licence Condition 4B are designed to ensure that the developer is only charged for the costs of network reinforcement works which clearly arise from the need to provide the connection.

3.5 Other charges

3.5.1 In addition to the DNO connection charge itself, there are a number of other charges which developers of distributed generation schemes should be aware of. These charges include:

- distribution use-of-system charges;
- top-up and stand-by charges;
- metering and data management charges; and
- charges for use of the NGT transmission system.

Use of System charges

3.5.2 Although electricity demand customers pay both connection and use-of-system charges, distributed generators are exempt from the need to pay distribution use-of-system charges in England and Wales. This is because all the DNO's costs associated with generator connections are recovered through the connection charge together with any ongoing service charges. Developers should note that the structure of charges is an area of focus for the fourth Distribution Price Control Review being undertaken by Ofgem, the results of which will become effective in April 2005.

Top-up and stand-by charges

3.5.3 Top-up and stand-by electricity supplies are often required to supplement the output from distributed generators. Top-up supplies cover any routine shortfall between the output of the generator and the on-site demand, or the demands of directly supplied customers. Stand-by supplies cover these demands in exceptional circumstances such as generator outages. Stand-by supplies are usually required, even by generators with no on-site demand or customers, to cover the generator's own auxiliary load during start-up.

3.5.4 Top-up and stand-by supplies can be purchased from any electricity supplier, other distributed generation, or directly through NETA market mechanisms such as the UK Power Exchange or the Balancing Mechanism.

Metering and data management charges

3.5.5 Distributed generation is bound by certain metering and data management requirements. These requirements, and the associated charges, relate to the activities of meter installation, meter operation, meter reading, data collection and data aggregation. The developer should consider obtaining quotations from a number of Meter Operators for the provision of the required services. The supplier who will be purchasing the output from the developer's generating plant should be the first point of contact when looking to appoint a Meter Operator.

Charges for use of the NGT transmission system

3.5.6 At present, NGT must be notified by the DNO of the proposed connection of any distributed generation scheme, although in practice DNOs and NGT operate sensible de minimis limits around 30MW, depending on the effect that the distributed generation will have on the transmission system. Any generator can, in theory, apply to trade energy directly in the wholesale market and to be bound by the Balancing and Settlement Code (BSC). In this case the generator would become liable for NGT Use of System charges. Any generator of capacity greater than 100MW is bound by its licence to comply with the BSC (and the Connection and Use of System Code – CUSC) and pay NGT Use of System charges.

3.5.7 Any generator >50MW should notify NGT about its intention to connect to the DNO's network. This will allow NGT to study the impact of the generator on the operation of the transmission system. Depending on the results of these studies, NGT might require the generator to enter into a bilateral agreement with NGT to cover certain technical requirements. If the study indicates a need to carry out work on the NGT system in order to accommodate the generating plant, connection may be delayed until the NGT work has been carried out. NGT will generally charge their connected customer - the DNO - for the work it carries out. The DNO is likely to pass this cost on to the developer.

3.5.8 Discussions are ongoing as to a possible reduction in the threshold above which NGT must be notified about future distributed generation schemes to 30MW Connection Entry Capacity. Following the decision by the Gas and Electricity Markets Authority not to direct this change to the CUSC, in July 2003, this matter is under review. Developers are likely to be advised by the DNO on any data submission requirements that such an obligation may impose.

3.6 Interactive Applications

3.6.1 It is not uncommon for two or more generation schemes to be in development in the same geographical area. In such cases, the limited availability of spare network capacity can lead to disputes between the developers and the DNO over the allocation of network reinforcement costs. Historically, different approaches to dealing with this situation have been adopted by different DNOs, with reinforcement costs typically being allocated on a "first come, first served" basis. A standard approach has now been agreed by the DNOs, the key features of which are summarised below and are likely to be included in future Licence Condition 4 Statements produced by DNOs.

3.6.2 The principles that have been agreed are normally applicable to the connection of generators in excess of 1MVA capacity, connected at 11kV and above. DNOs will, however, apply the principles in other cases where it is appropriate to do so.

3.6.3 Connection Applications are defined as "interactive" in circumstances where offers of connection to two or more applicants are made which:

- make use of the same part of the Existing Network or the Committed Network; or

- would otherwise have an operational effect on that network; and

- result in a material impact on the terms and conditions for each connection if it is assumed that one or more of the other Connection Offers had been accepted.

3.6.4 If between the date on which a completed Connection Application is received by the DNO and that on which a Connection Offer is made, the DNO receives one or more Connection Application(s) that are deemed "interactive", the DNO will inform all parties in writing that the applications are interactive with each other. The terms for connection will in each case specify that the Connection Offers are interactive with other applications.

3.6.5 The date and time that each Connection Application was made will be used to sequence Connection Offers such that the first offer is made to the first applicant, etc.

3.6.6 Applicants will have up to 90 days in which to accept a Connection Offer, during which time, if the DNO receives one or more connection applications that are deemed "interactive", the applicant will be notified accordingly. The first applicant will during this period have priority over subsequent applicants who may receive offers during this time, and this will be explained in the Connection Offer to the first applicant. Offers to subsequent applicants will indicate that for some of the validity period of the offer it is subject to the decision of the prior applicant(s) on whether to proceed with their connection(s). Connection Offers will also specify the date on which they become unconditional (ie due to the previous Connection Offer(s) lapsing).

3.6.7 In making any Connection Offer the DNO takes account of the Existing Network and the Committed Network at the time of the application. Any assets specified in an offer are not, however, treated as part of the Committed Network until that offer has actually been accepted.

Sharing costs between generation schemes

3.6.8 In allocating the cost of connection work between itself and the developer, the DNO is obliged to consider the possible future benefits arising from this connection work, either to itself or to third parties. Thus, if connection work carried out for one generation scheme is of direct benefit to a second scheme, the DNO should allocate the cost of this work appropriately between the two projects.

3.6.9 This obligation also applies to cases where the second project is developed some time after the connection work has been carried out. If the developer of the first project met all the cost of the connection work, the developer may be able to obtain a refund or rebate from the DNO, corresponding to an appropriate fraction of these costs. The DNO, in turn, will charge this cost to the developer of the second project.

3.6.10 If it appears likely that connection infrastructure will be of benefit to future projects, the developer should ensure that provisions for refunds are written into the DNO's connection quotation. If some of the connection work is to be carried out by a third party, it may be necessary to include clauses for refunds in the adoption agreement.

3.6.11 There have been cases of cost sharing when Connection Applications for generation schemes have coincided with applications for new or increased demand from nearby load customers. These cost sharing arrangements have been to the benefit of all the parties concerned.

3.6.12 Another possible mechanism for sharing connection costs between generation projects is for the developers to make a joint application for connection works. At the time of writing, no connections have been constructed under this type of arrangement. However, this type of 'consortium connection' may become increasingly attractive, particularly in areas where there is a combination of high potential for distributed generation on the one hand, and insufficient distribution infrastructure on the other.

4 COMPETITION IN CONNECTIONS

4.1 Introduction

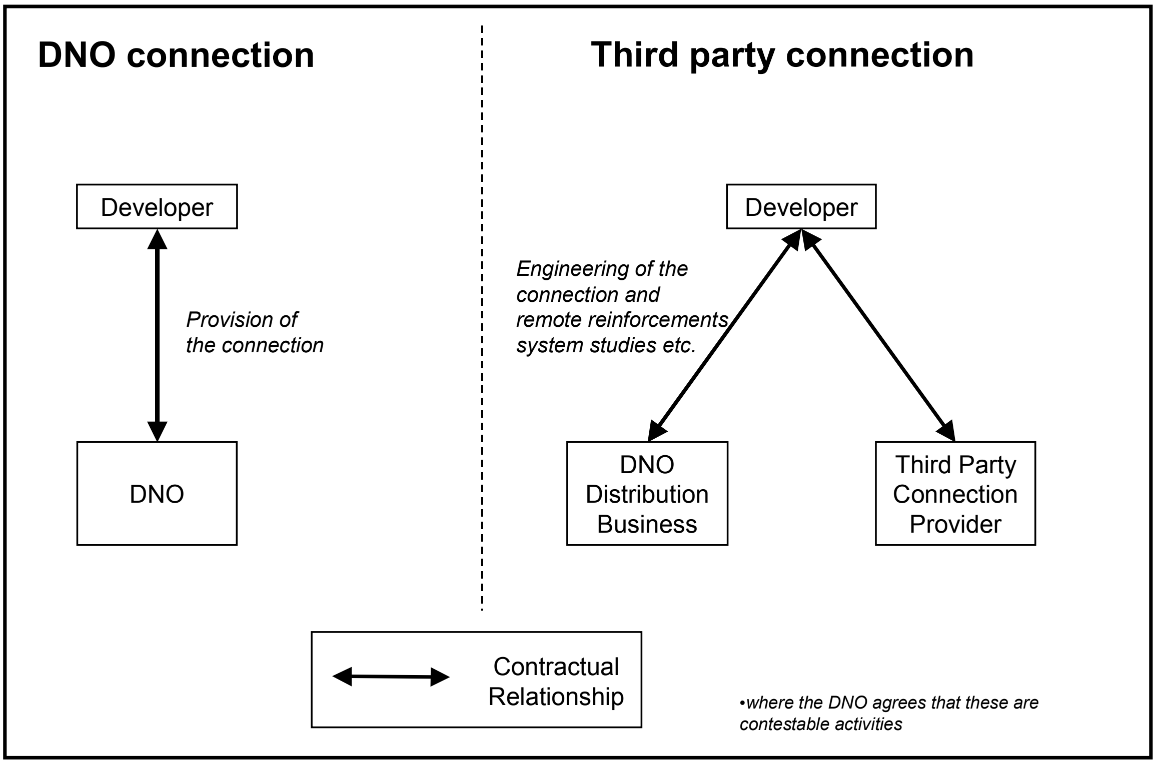
4.1.1 In getting a connection built, a developer has two options:

- to ask the DNO to undertake all the necessary works to provide the connection, and to pay the corresponding charges; or

- to contract with a third party to provide and install the connection infrastructure, and to obtain the DNO's agreement to adopt this infrastructure.

4.1.2 These two options both involve a contractual relationship between the developer and the DNO, as shown in Figure 4.1.

Figure 4.1: Contractual relationships in the connection process



4.1.3 The third party connection option involves the developer in an additional relationship, with the third party connection provider. By choosing the third party connection option, however, the developer gains access to a wider range of potential contractors. This can result in lower costs and may give the developer greater control over construction timescales. (Where connections are provided by third parties, however, DNOs may nevertheless impose operation and maintenance charges in respect of the assets that they adopt.) Developers will wish to weigh the potential benefits against the time and effort involved in managing this additional relationship.

4.1.4 As part of the contractual relationship between the various parties, it is important that there is clarity relating to the ownership of equipment being offered for adoption.

4.2 DNO connections

4.2.1 If the developer wishes, the DNO will arrange for all the necessary connection works to be undertaken. The cost of these works will be charged to the developer, on the basis set out in the DNO Licence.

4.2.2 In practice, the DNO distribution business will undertake the design and specification of the connection infrastructure, but the installation work will often be undertaken by another organisation under contract to the distribution business. This organisation may be the DNO's own connection business, or it may be an external contractor.

4.3 Third Party Connections

4.3.1 Instead of getting the DNO to undertake the connection works, the developer can opt to contract with a third party to carry out some of the work. This option to contract with third parties to do connection work is known as competition in connection. Developers can make use of competition in connection to ensure that they get connection work done at competitive prices and to timescales within their own influence.

4.3.2 Competition in connection was introduced in early 1995, and since then developers have often taken up this option. DNO personnel are now familiar with these DNO-specific arrangements.

4.3.3 As the DNOs usually take over the ownership, operation and maintenance of connection infrastructure installed by third parties, they are keen to ensure that work is carried out to an acceptable standard. For this reason, connection work done by third parties is subject to inspection and approval by the DNO.

4.4 Contestable Work and Non-Contestable Work

4.4.1 So that they can maintain co-ordination and control of their networks, the DNOs require that they undertake some of the tasks relating to the provision of a new connection. This part of the connection work is referred to as Non-contestable Work as it is not open to competition. Conversely, the part of the work that is open to competition is referred to as Contestable Work.

4.4.2 The costs incurred by the DNO in carrying out the Non-contestable Work are charged to the developer. These charges are governed by the conditions of the DNO Licence, as in the case of an all-in DNO connection. Thus, the developer must pay some charges to the DNO, in addition to paying the third party contractor for carrying out the Contestable Work.

4.4.3 Each DNO provides its own definition of contestable and non-contestable works in its Licence Condition 4 statement. The various DNOs' definitions are broadly similar. Table 4.1 shows which activities are typically non-contestable and which are contestable. Note that all activities to do with the existing network are non-contestable.

Table 4.1: Typical outline of non-contestable and contestable activities

	Non-contestable activities	Contestable activities
Activities to do with the existing network	• Assessing the effects of the new connection on the existing network. • All work to do with reinforcing the existing distribution infrastructure. • Deciding on the point of connection to the existing network. • Connecting the new installation to the network, and energising the connection. • Removing or moving existing connection infrastructure.	
Activities to do with new assets	• Design and specification of the contestable work. • Obtaining any necessary consents and wayleaves involving exercising statutory powers. • Operation, repair and maintenance of extension assets. • Inspection, monitoring and testing of contestable work.	• Subject to agreement with the DNO and as defined in the DNO's Licence Condition 4 statement, preparing the connection design and obtaining wayleaves that do not require the DNO to exercise its statutory powers. • Procuring and providing materials for the extension. • Trenching and other preparation of the site. • Construction of the extension. • Recording of work and cable routes and equipment on site and the provision of this information to the DNO. • Reinstatement of the site, including the circuit route. • Making provision for the installation of metering equipment.

4.5 Contractor Approval

4.5.1 Third party contractors must be approved by the DNO before they can carry out Contestable Work under competition in connection. If the developer wants to obtain third party bids for Contestable Work, they should contact the local DNO to obtain contact details of approved contractors.

4.5.2 Some DNOs subscribe to a contractor evaluation scheme which is run by Lloyds Register. Under this scheme, Lloyds Register evaluates contractors on behalf of individual DNOs. However, it is the DNO that decides whether or not to grant approval. If approval is granted, the contractor is issued with a certificate jointly by Lloyds Register and the DNO in question. Developers should note that a contractor with a Lloyds Register certificate may not be approved by all the DNOs who subscribe to the scheme.

4.6 Adoption Agreements

4.6.1 If the developer contracts with a third party for the provision of Contestable Work, they will also be required to enter into an Adoption Agreement with the DNO.

4.6.2 Adoption Agreements cover arrangements for the DNO to take over responsibility for the infrastructure installed by the third party, including arrangements to ensure that the work meets the DNO's requirements. The general scope of adoption agreements is specified in the DNO's Licence

Condition 4 statement, although the exact wording of a particular adoption agreement depends on the details of the project in question.

4.7 Practicalities of third party connections

4.7.1 If the developer wishes to get third party quotations for connection work, it must first establish:

- the scope of the work that is contestable;
- the relevant standards for the specification of work, materials and equipment; and
- details of approved contractors.

4.7.2 It is up to the DNO to define the scope of the Contestable Work, although they may be open to negotiation on some points. Formal notification of the scope of the Contestable Work is normally provided in the DNO's connection quotation. The DNO will also have preferred design standards, and preferred specifications for materials and equipment. However developers should be aware that the statutory requirements for connection works are set out in the Distribution Code. These requirements are based on national and international standards, and DNOs are obliged to consider specifications that comply with these standards. DNOs are also entitled to seek clear confirmation and proof that these standards are met, and also may charge for the additional operating costs imposed by equipment that is otherwise unique on their systems.

4.7.3 On making the request for a connection quotation, the developer should inform the DNO of their interest in obtaining third party bids for Contestable Work, and ask for the quotation to show charges for Contestable Work and Non-contestable Work separately. The developer can also take this opportunity to ask the DNO for details of approved contractors, and for their preferred design standards and equipment specifications.

4.7.4 The DNO is obliged to provide the quotation within three months of receiving a Connection Application that is complete and includes the data required by the DNO in accordance with the Distribution Code.[6] The quotation should specify the contestable activities and scope of supply. If the developer wishes to accept the quotation, this will normally need to be done within a time period that is specified in the quotation by the DNO. This time period will typically be between 30 and 90 days[7].

4.7.5 If the developer decides to contract with a third party for Contestable Work, it is the developer's responsibility to ensure that the contractor's work is

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[6] See the Distribution Code of Licensed Distribution Network Operators of Great Britain, DPC7

[7] It should be noted, however, that the approach agreed between DNOs for handling interactive connection applications (see Section 3.6) assumes a 30 day period for offer acceptance.

acceptable to the DNO under the terms of the Adoption Agreement. So, before contracting with a third party, the developer should ensure that the contractor's bid covers all the necessary items of work, and provides for materials and equipment which comply with the requirements of the Adoption Agreement. The developer should keep the DNO fully informed of the source and specification of equipment to be procured and installed as part of the third party contract. It may be prudent to set up a design review to enable the DNO to formally review and approve the contractor's proposed scope of supply.

5 GLOSSARY

active power – the multiple of the components of alternating current and voltage that equate to true power. Normally measured in kilowatts (kW) or megawatts (MW).

adoption agreement – an agreement between a developer and a DNO, concerning the transfer into DNO ownership of infrastructure supplied and installed by a third party.

approved contractor – a contractor which has been approved by the DNO for carrying out third party connection work.

Balancing and Settlement Code (BSC) – the code which determines the rules governing the Balancing Mechanism and the settlement process for electricity trading in England and Wales as from time to time amended.

capacity factor – a factor, generally applied to renewable energy schemes, which relates the maximum continuous power output of the generator to the expected long run average power output.

committed network – future network configuration for which financial approval has been given.

condition 4 statement – document published by a DNO outlining the basis of charges for connection to the DNO's distribution system.

connection agreement – an agreement setting out terms relating to a connection with the DNO Distribution System (excluding any bilateral agreement with the transmission licensee).

Connection and Use of System Code (CUSC) – contractual framework for connection to and use of the NGT transmission system.

connection voltage – voltage level at which a site is connected to the transmission or distribution system.

contestable – that part of the connection works which is open to competition.

CDM Regulations – the Construction (Design and Management) Regulations 1994. Regulations specifying the duties of designers to minimise health and safety hazards involved in the construction of buildings and other installations.

CD&M Regulations – see CDM Regulations.

Declared Net Capacity (DNC) – declared net capacity: the maximum power available for export on a continuous basis minus any power imported by the station from the network to run its own plant.

determination (of disputes) – any dispute arising under certain sections of the Electricity Act 1989 between a DNO and a person requiring a supply of electricity, can be referred to Ofgem for determination. These determinations are then published as a matter of public record, and then form 'case law' on the subject.

distributed generator – a generator which is connected to a DNO's distribution network rather than to the transmission grid. Distributed generation is generally a lot smaller than plant connected to the transmission grid as the maximum operating voltage of the distribution network is 132kV (and 33kV in Scotland).

Distribution Network Operator (DNO) – a holder of a Distribution Licence.

electronic inverter system – an electronic device placed between a generator and the network it is connected to for the conversion of power at one frequency to another (including dc/ac). The output voltage and frequency may be determined by the control equipment associated with the inverter or by the voltage and frequency of the network it is connected to.

embedded generator – now generally termed distributed generator (see above), although this term is still used in the Distribution Code of Great Britain and the Grid Codes.

extension – It is sometimes necessary to extend the DNO's distribution network in order to provide a connection for a new user or generator of electricity. Network extensions are often required for generation schemes in remote locations.

fault contribution – the contribution of an electrical source, such as a distributed generator, to the total fault levels in a distribution network.

high voltage (HV) – any voltage exceeding Low Voltage (ie exceeding 1000volts between phase conductors or exceeding 600volts between phase conductors and earth).

induction generator – a type of rotating electrical generator which operates at a speed not directly related to system frequency. The machine is generally excited by reactive power drawn from the network to which it is connected and the output voltage and frequency are determined by those of the network to which it is connected.

islanding – islands of supply are discrete parts of a distribution system which are capable of generating and maintaining a stable supply of electricity to the customers within those discrete parts without any connections to the rest of the system.

line drop compensation – a voltage control scheme (used for the control of voltage levels in distribution networks) which compensates for the change in voltage drop in a long line as the current in the line changes.

loss of mains – the loss of an electrical connection between a section of a distribution network and the main grid supply, often due to the operation of circuit breakers.

low voltage (LV) – in relation to alternating current, a voltage exceeding 50 volts measured between phase conductors (or between phase conductors and earth), but not exceeding 1000volts measured between phase conductors (or 600volts if measured between phase conductors and earth).

Long Term Development Statement (LTDS) – (sometimes referred to as the LC25 statement). Statement prepared annually by each DNO as required by Standard Condition 25 of the Electricity Distribution Licence.

mains paralleling – the operation of an electrical generator while connected in parallel with the main grid supply.

negative reactance compounding – a voltage control scheme (used for the control of voltage levels in distribution networks) which allows the voltage–regulated system to be fed from two or more transformers in parallel.

Ofgem – the Office of Electricity & Gas Markets (under the Gas and Electricity Markets Authority, established by the Utilities Act 2000).

point of common coupling – the point in the distribution network where the lines or cables which are used solely to provide the supply to one customer (eg a generation scheme) are connected to infrastructure which is also used to provide supplies to other customers.

primary – generic term used by a DNO to indicate the source of the main 11kV or 6.6kV HV distribution network; eg primary substation – 33/11kV or 66/11kV transformation substation infeed to the 11kV network; 11kV primary busbar – source 11kV busbar for an 11kV network.

protection system – the provisions for detecting abnormal conditions in a system and initiating fault clearance or actuating signals or indications.

reactive power – the product of voltage and current and the sine of the phase angle between them which is normally measured in kilovar (kVAr) or megavar (MVAr).

reactor – wound network component generally used to limit reactive power flows and hence fault levels.

reinforcement – Reinforcement work is usually required to increase the electrical capacity of those parts of the network which are affected by the introduction of new generation or demand. Other work might include upgrading the switchgear at a substation some distance from the proposed generation scheme, due to the increase in fault level caused by the connection of the generator.

Small Scale Embedded Generator (SSEG) – a source of electrical energy and all associated interface equipment, rated up to and including 16A per phase, single or multi phase 230/400V ac and designed to operate in parallel with a public low voltage distribution network.

Static Var Compensator (SVC) – equipment for injecting or absorbing reactive power (Vars) at the point of connection to assist in control of system voltage.

supplier – a person or company providing a supply of electricity. This could be the local DNO, a second tier supplier or an exempt supplier.

synchronous generator – a type of rotating electrical generator which operates without slip and at a speed that is directly related to system frequency.

thermal rating – the current-carrying capacity of a cable, an overhead line or any other item of electrical infrastructure, which is determined by the heating effect arising from electrical losses.

third party connection – connection provided by a contractor other than the local DNO.

Use of System (UoS) – the use of a transmission or distribution network by a generator, a supplier, a customer or an interconnected party for the purposes of transporting electricity.

A Appendix A: Overview of the UK Electricity Industry

A.1 Introduction

A.1.1 The aim of this appendix is to provide some background information about the Electricity Industry in England and Wales and in Scotland.

A.1.2 The chapter is divided into two main sections. The first section contains information relating to commercial relationships and industry regulation. The second section contains information about the technical operation of the electricity system.

A.2 Commercial and regulatory issues

The commercial structure of the industry

A.2.1 The commercial structure of the electricity industry in England and Wales provides a competitive market in electricity retailing, thus enabling industrial, commercial and domestic electricity users to contract with any one of a number of competing electricity suppliers.

A.2.2 There is also a wholesale electricity market, in which suppliers buy electricity in bulk from competing electricity generators. At present, the central feature of this wholesale market is the New Energy Trading Arrangements (NETA) (see below).

A.2.3 The transmission and distribution systems are owned and operated by regulated monopoly businesses: National Grid Transco owns the transmission system in England and Wales; twelve Distribution Network Operators (DNOs) own the distribution networks. These wires businesses recover the costs of operating and maintaining these systems by levying use of system charges on all electricity traded using these networks.

A.2.4 In Scotland the commercial structure of the electricity industry is different from that in England and Wales. The Scottish electricity market is split into two mutually exclusive trading areas of two electricity companies, ScottishPower and Scottish and Southern Energy. These companies are responsible for the operation of the transmission and distribution networks in their areas. They are also active in electricity generation, trading and supply. The Scottish electricity market is also open to other suppliers, traders and independent generators. There is currently no equivalent of NETA in Scotland.

A.2.5 At the time of writing, the construction of a GB-wide wholesale trading arrangement is under development, under the auspices of the British Electricity Trading and Transmission Arrangements (BETTA) project.

The current commercial arrangements and their associated regulatory structures are discussed below.

Wholesale Trading

A.2.6 In England and Wales the wholesale electricity market is dominated by bilateral trading ahead of time between suppliers and large generators, which can self-dispatch, under the NETA arrangements.

A.2.7 Electricity cannot be stored and has to be kept in balance on a second by second basis by the National Grid Transco (NGT). NGT operates a balancing mechanism to ensure system security. About 2 per cent of electricity is bought and sold by NGT through this mechanism. Electricity is also traded on forward and futures markets and through power exchanges. NETA went live in March 2001, replacing the Electricity Pool.

A.2.8 Generators are out of balance if they cannot provide all the electricity they have been contracted to provide, or they have generated too much. Suppliers are out of balance if their contracted customers have consumed more electricity than they have contracted for, or they have consumed too little. This will mean that NGT will face additional costs because it may have to buy or sell electricity at short notice to keep the system in balance. The charges (prices) participants face for being out of balance are based on these additional costs. The Balancing and Settlement Code (BSC) governs the operation of the balancing mechanism, and is run by the BSC Company (ELEXON).

A.2.9 More than 90 per cent of energy generated by smaller (renewable and CHP) generators is in effect consolidated, ie sold direct to suppliers who sell it as part of their energy portfolio. This means that smaller generators do not have to participate directly in the market and generally have limited impact on their suppliers' overall imbalance risk.

A.2.10 Because of their size, some smaller generators are exempt from transmission charges, losses charges and other system operation costs. These are known as embedded benefits. This exemption applies to generating plants with a Declared Net Capacity (DNC) of less than 50MW. Between 50MW and 100MW the decision on licensing is that of the DTI, and those plants that are deemed to be exempt from the requirement to hold a Generation Licence are then exempt from transmission charges and losses charges (see section A.2.25).

The Connection and Use of System Code

A.2.11 The NGT transmission system is vital to the operation of the wholesale electricity market in England and Wales. The transmission system provides the physical means by which electricity can be traded between generators and suppliers operating in different regions.

A.2.12 The Connection and Use of System Code (CUSC) is the legal document that forms the basis of the contractual framework for connection to, and use of, National Grid's HV transmission system. It is a multi-party document creating contractual obligations among and between all users of the transmission system, parties connected to the transmission system, and NGT.

Persons wishing to use the NGT transmission system or to connect to it will normally be required to sign the CUSC.

A.2.13 Many distributed generators connected to distribution systems will not need to become involved with CUSC issues because of the very limited influence of their plant on the planning and operation of the England and Wales transmission system. DNOs however monitor the significance of the level of distributed generation with respect to NGT activities, and will notify NGT of larger single or aggregations of such generation.

A.2.14 If distributed generation in an area is above about 30MW capacity, NGT may then approach some generators to enter into a Bilateral Agreement relating to connection and/or use of the National Grid Transmission System by "embedded generation" in distribution systems, and by Small Power Station Trading Parties, (all as provided for in the CUSC).

A.2.15 Similar arrangements apply in Scotland, although notification of distributed generation above 50MW tends to be the norm.

Bill Before Parliament for Whole GB Competitive Market

A.2.16 At the time of writing, a Bill is under consideration that is intended to provide a legal framework through which a single competitive wholesale electricity market can be achieved for the whole of England, Scotland and Wales. Specifically it allows for the implementation of British Electricity Trading and Transmission Arrangements (BETTA).

A.2.17 In order to deliver BETTA, arrangements are being proposed that are designed to promote the creation of a GB-wide wholesale electricity market, to create a single set of arrangements for access to and use of the transmission system and to create a single GB-wide transmission system operator. BETTA will also bring about the introduction of a GB-wide Balancing and Settlement Code (BSC), a GB Connections and Use of System Code (CUSC) and a GB Grid Code, which will mean a fully integrated and consistent set of rules in relation to connection to and use of the transmission system, and balancing and settlement, for the whole of GB. BETTA will also result in the introduction of a new code governing the interface between the Scottish and England and Wales transmission networks.

A.2.18 It is expected that the licence conditions relating to the BSC, the CUSC, the Grid Code, the SO-TO (System Operator-Transmission Owner) Code, the Settlement Agreement for Scotland and the Trading Code (among others) will need to be modified pursuant to this power and the power set out in clause 5 as these documents will be replaced or amended or made redundant as a result of BETTA.

The Electricity Act and the Utilities Act

A.2.19 The primary legislation governing the electricity supply industry in Great Britain is the Electricity Act 1989 and the Utilities Act 2000. The 2000 Act abolished the Office of the Director General of Electricity Supply (created by the 1989 Act) and established the Gas and Electricity Markets Authority - the office of which is known as Ofgem. The principal duties of the Authority are to:

- protect the interests of consumers by, wherever possible, promoting effective competition in generation, transmission, distribution or supply;
- secure reasonable demand for electricity is met;
- secure that licence holders are able to finance their licensed activities;
- secure a diverse and long term energy supply;
- promote efficiency and economy by those transmitting, distributing and supplying electricity;
- protect the public from the dangers arising from the generation, transmission, distribution or supply of electricity;
- take account of the affect on the environment of electricity generation, transmission, distribution and supply; and
- have regard to the interests of the disabled and sick, the elderly, those on low incomes and those in rural areas.

A.2.20 The 1989 Electricity Act provides for the granting of licences for transmission, generation, distribution and supply by the Gas and Electricity Markets Authority.

A.2.21 The Electricity Act and the Utilities Act are forms of enabling legislation that provide a framework that can be amended through the use of secondary legislation. The secondary legislation that applies to these Acts is encompassed within Statutory Instruments issued by the Secretary of State.

Regulation and licensing

A.2.22 Ofgem is responsible for regulating prices and performance in the monopoly elements of the electricity supply industry, and also for making determinations to resolve disputes between different parties in the electricity supply industry. Ofgem's role in the 'competitive' areas of the electricity supply industry such as generation and supply should diminish as competitive markets become established.

A.2.23 Ofgem also has regulatory jurisdiction over Scotland, although its statutory duties with respect to the Scottish electricity supply industry are shared with the Secretary of State for Scotland.

A.2.24 The Secretary of State has the power, after consultation with Ofgem, to grant licences for the generation, transmission or supply of electricity and to authorise exemptions from the requirement to hold a generation or supply licence. Licences granted under the Electricity Act have a number of regulatory functions:

- to regulate, where appropriate, the economic behaviour of licence holders
- to set up a framework for competition in generation and the progressive introduction of competition in supply
- to underpin the arrangements relating to security of supply
- to protect the technical integrity of power systems
- to make provision for certain types of customer services

A.2.25 As a rule, companies involved in the generation, transmission, distribution or supply of electricity are required to hold licences. There are some exemptions to this requirement.

<u>Generation</u>

- Owners of large electricity generating plants are required to hold generation licences. This requirement applies to large distributed generators, as well as to major power stations. Owners of smaller generation schemes are exempted from the requirement to hold generation licences. This exemption covers most distributed generators.
- The criteria for exemption are normally based on the declared net capacity (DNC) of the scheme. If the DNC of the scheme is above 100MW a licence is required: for a DNC of less than 50MW the plant is fully licensed by "exemption" (Class A exemption), and between 50MW and 100MW the decision on licensing is that of the DTI on a case by case basis.

<u>Transmission</u>

- NGT is the only holder of a transmission licence in England and Wales. This details the regulatory provisions governing the company's duties to maintain an efficient, co-ordinated and economical electricity transmission system, not to discriminate between users or classes of users and to facilitate competition in the generation and supply of electricity. NGT's transmission licence prohibits it from purchasing or otherwise acquiring electricity on its own account for the purpose of sale to third parties.

Distribution

- The twelve DNOs of England and Wales hold distribution licences. Under the terms of these licenses, each DNO is allowed to distribute electricity within its own geographical area. To facilitate competition in supply, each DNO is required under the terms of its licence to allow any licensed supplier to use its distribution network for the purpose of transferring electricity from the transmission system (and from distributed generators) to customers.

Supply

- Unless covered by an exemption, any person who supplies electricity to any premises is required to hold a supply licence. A company can be exempted from the need to hold a Supply Licence if it fulfils one of the criteria for exemption specified in The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001 – Statutory Instrument No. 3270. These include exemption for small suppliers who do not supply any electricity other than that which they generate themselves, and who do not supply more than 5MW at any time, of which not more than 2.5MW is supplied to domestic consumers. (This is a complex area, however, in which specific legal advice should be sought as to any requirement for a Supply Licence in a particular situation.)

- Holders of supply licences are required to be signatories to the CUSC.

Scottish Licences

- Scottish DNOs and transmission system operators now hold separate distribution and transmission licences which are materially identical in their content to those in England and Wales.

Others

- In addition to the main electricity supply industry activities of generation, transmission, distribution and supply, there are also a range of other activities for which a form of licensing is required. These other activities concern the management of data relating to transfers of electricity. They include the provision of electricity meters, meter operation, data collection and data aggregation.

A.3 Technical Description

A.3.1 The aim of this section is to provide a brief technical overview of the UK's electricity system, particularly as it relates to the connection of distributed generators.

Generation, transmission and distribution

A.3.2 The UK benefits from having a highly developed electricity system, the backbone of which is the super-grid, an HV transmission system.

A.3.3 Most of the electricity consumed in the UK is still generated in large power stations running on coal, natural gas and nuclear power. These large power stations are connected directly to the transmission system. In general, the coal-fired stations are located on the coalfields of Scotland and northern England. The gas-fired stations are less geographically concentrated, but many are located close to the major North Sea gas terminals on the east coast of England. The nuclear stations are sited around the coastline of England, Wales and Scotland.

A.3.4 Whereas the UK's electricity generation capacity is located mainly in the north, consumption is weighted towards the population centres of south-east England and the midlands. Each region of the country is served by an electricity distribution network, which is connected to the transmission system at one or more grid supply points. Power passes through the distribution network, from the grid supply point to the final users.

A.3.5 In addition to these main generators, numerous small electricity generators are connected throughout the local distribution networks rather than to the transmission system. The operation of "distributed" generators results in a reduction in the amount of power that has to be imported from the transmission system via the grid supply point. These distributed generators are supplied by landfill gas, municipal waste, wind, natural gas and other fuel sources. It is the government's target for the year 2010 to have 10% of all electricity provided by renewable resources, some of which will be from distributed generation, and the remainder from more major sources (eg wind farms and combined heat and power plants) connected at transmission voltages.

Control of System Frequency

A.3.6 In the UK, the electricity system operates at a frequency of 50Hz and all electricity users - and generators - rely on the fact that the system frequency is kept very close to this level. This is achieved by scheduling generation to match demand, and by means of deliberate control actions on the part of some generators.

A.3.7 In the main, distributed generators are not called upon to contribute to these frequency control processes.

Interconnected electricity networks

Physical infrastructure of electricity networks

A.3.8 Electricity transmission and distribution networks are made up of several interconnected 'layers'. Each layer consists of a network of wires (ie overhead lines and underground cables) operating at a particular nominal voltage.

Transformers act as the connections between layers, allowing power to be transferred between different nominal voltage levels. In general, power flows down through the layers, from higher voltage systems to lower voltage systems.

A.3.9 Most electricity users are connected to LV systems operating at 400/230V, although some larger users are connected at higher voltages.

Standard nominal voltages

A.3.10 The transmission system consists of systems operating at nominal voltages of 400kV, 275kV and, in Scotland, 132kV. Distribution networks include systems operating at 132kV and 66kV (in England & Wales only), together with all of the networks operating at 33kV, 22kV, 20kV, 11kV, 6.6kV and 400V. Engineers use the nominal voltage to refer to a particular layer of the network. Thus, people talk about 'the 11kV system' or 'the 33kV system'.

A.3.11 European Standard EN 50160 (BS EN 50160) defines standard or nominal voltages for public electricity supply. EN 50160 cites HD 472 which allows for national variations from 230/400V +/-10% at LV. For the UK a standard of 230/400V +10% and –6% is adopted. HD 472 calls for full harmonisation across the EU on +/-10% from 1 January 2008.

A.3.12 The terms HV (high voltage) and LV (low voltage) are often used, but they can mean different things to different people. The Electricity Safety, Quality and Continuity Regulations define HV to mean anything above 1000V measured between phase conductors (or 600V measured between phase conductors and earth), with LV covering voltages exceeding 50V measured between phase conductors (or between phase conductors and earth), but not exceeding 1000V measured between phase conductors (or 600V measured between phase conductors and earth). BS EN 50160 uses the same definition for LV, but defines voltages from 1000V to 35kV as MV (medium voltage).

Control of System Voltage

A.3.13 The control of voltage levels in distribution networks is an important issue, due to the need to maintain consistent supplies to electricity users. Although DNOs try to keep system voltages close to their nominal levels, the actual voltage varies from point to point around the system, and also with time as the load on the system changes. Voltages tend to fall when people are using a lot of electricity and they are often lower at the ends of long distribution lines.

A.3.14 Conversely, power in-feeds from distributed generators tend to increase local voltage levels.

A.3.15 DNO distribution networks are designed to provide electricity to users at reasonably constant voltage levels.

A.3.16 Systems operating at higher voltages (such as 66kV) are used to transport larger amounts of electricity over long distances, and, in consequence, are subject to relatively large voltage variations. Such variations would result in unacceptable variations in voltages to most customers unless this was corrected for.

A.3.17 To achieve this, the transformers that transfer power from the higher-to the lower-voltage systems are fitted with automatic controls that compensate for voltage changes on the HV side. Additionally some schemes also compensate for voltage changes in the lower-voltage system (line drop compensation), and some allow the use of two or more transformers in parallel (negative reactance compounding).

A.3.18 The presence of distributed generation can assist in improved voltage profiles, but often makes the process of voltage control more complex.

A.3.19 New Grid Code regulations are under consideration which for renewable/ distributed generation are likely to require that voltage control equipment is installed on all windfarms of greater than 5MW and that plants should be capable of operating within a power factor range of around 0.95 leading to 0.9 lagging (ie exporting Vars). These modifications are under consideration by Ofgem at the time of writing.

Protection in distribution networks

Faults and fault currents

A.3.20 Although distribution networks are very reliable systems, electrical faults do occur. These faults may be caused by events such as an overhead line breaking, or the accidental excavation of an underground cable. When these things happen, very high currents can occur at the fault and in the parts of the network that feed current into the fault. If they are not quickly detected and stopped, these fault currents are a risk to life and can cause extensive damage to cables, transformers and other equipment, as well as affecting the supply of electricity to consumers.

Protection systems

A.3.21 To protect people and to guard the distribution infrastructure from the effects of faults, fuses and circuit breakers are fitted at strategic points in the network, together with other systems which trip the circuit breakers on detection of unusually high currents or other abnormal conditions. These circuit breakers and tripping devices are known as protection systems.

A.3.22 The operation of protection systems following a fault often results in some electricity users being disconnected from the supply. Most distribution networks are designed to ensure that faults can be isolated with minimum disruption to users. However, networks in isolated rural areas are often less robust, with ‘radial’ lines supplying users along the length of valleys, roads and so on. If a fault occurs on a radial line, it can only be isolated by disconnecting all the users beyond the fault.

A.3.23 The presence of distributed generation means that back-feed of energy to faulted infrastructure can occur: this can be dangerous unless suitable protection is also installed at the interface of the generator and its distribution system, so careful attention has to be given to the methods of operation of such plant.

Auto-Reclosers

A.3.24 Distribution networks in rural areas are prone to transient faults, usually caused by branches, birds and other objects touching against overhead lines. When these faults occur on radial lines, they can result in the disconnection of many users from the supply. To minimise the inconvenience caused by such faults, circuit breakers in radial lines are usually fitted with automatic re-closing devices. These devices re-close the circuit breaker a few seconds after it is tripped. If the fault has not cleared (for example, a tree branch fallen away) by this stage, the protection will be activated and the circuit breaker will trip again. However, if the fault has cleared, the line will then remain reconnected to the supply.

A.3.25 Automatic re-closers are usually set to operate up to three or four times after a fault. If the fault does not clear after this number of operations, the circuit breaker remains tripped and must be re-set manually. The dead time between each successive reclosure is important information for distributed generators in order that generator protection can be designed to avoid the auto-recloser closing with the generator and the grid out of synchronism.

Fault levels and switchgear ratings

A.3.26 At a given moment, every point in a distribution network has a particular fault level. The fault level is a measure of the current which would occur in the event of a solid three-phase short circuit at that point. Fault levels are expressed in units of apparent power (kVA or MVA).

A.3.27 The fault levels in a distribution network can change over time, due to changes in the configuration of the network to allow routine maintenance or to isolate faults. Thus, it is not very useful to give a single value for the fault level at a point in the network - whatever the fault level is today; it may be different next week. Instead, maximum and minimum values are usually specified for the fault level at a particular point. The actual fault level will vary within the range specified by these values.

A.3.28 Changes to the network, such as the connection of new generators or loads, can result in increases in fault levels. However, the rating of existing circuit breakers places an upper limit on the range of fault levels that can be permitted in a particular part of the network. This upper limit is sometimes referred to as the design fault level in that part of the network. Design fault levels in distribution networks can sometimes be a limiting factor in the connection of new generators or loads.

A.3.29 Generally generators would not be permitted to push maximum fault levels beyond the design fault levels. In some cases they may be required to contribute to the cost of new switchgear to accommodate the increase in fault level. Fault levels are discussed more fully in Appendix C of this document.

A.3.30 Many DNOs use common standards for the specification of circuit breakers to be fitted in their networks. As a result, similar values are often specified for design fault levels in DNO networks. Table A.1 below shows typical design fault levels at some common UK distribution voltages.

Table A.1: Typical design fault levels for common UK distribution voltages

System voltage (kV)	11	33	132
Design fault level (MVA)	250	750	3,500

Distribution network planning

A.3.31 Electricity distribution networks are extended, reinforced and modified in response to changing patterns of demand for electricity.

A.3.32 New housing developments, industrial sites and electricity generation schemes all require extensions to distribution networks. Existing network infrastructure sometimes has to be upgraded so that it can support growing demand for electricity. Old equipment has to be replaced, and parts of networks that are no longer in use have to be de-commissioned at some time.

A.3.33 All of these changes have to be co-ordinated to maintain standards of safety, reliability, operability etc.

A.3.34 DNOs have statutory obligations for planning and developing their networks, and for achieving standards of safety and reliability as well as maintaining the system's technical efficiency. For these reasons, they must be involved in the process of designing and specifying connection arrangements for new electricity users and generation schemes.

Control and operation of the distribution network

A.3.35 Most distribution networks can be operated in a variety of configurations. This is a useful feature, which can reduce the disruptions caused by network faults and routine maintenance work. In the event of a fault, for example, the network operator can re-configure the network, selecting the configuration that maintains supplies to the greatest number of customers while the fault is being rectified.

A.3.36 This type of operational flexibility is of growing importance, due to the increasing emphasis placed on maintaining supplies to customers. It is also being aided by the introduction of computer-based systems that enable the control and operation of distribution networks to be automated. These systems carry out switching and re-configuration operations using real-time data combined with ‘knowledge’ about the network.

A.3.37 Re-configuration of the distribution network can result in changes to the electrical characteristics of the network from the point of view of a distributed generator. For example, the fault level at the connection can be reduced significantly, and the generator can be subject to greater voltage fluctuations. The effect of alternative network configurations should be considered when designing a connection arrangement.

B Appendix B: Statutory Framework for Connection of Distributed Generation

B.1 Introduction

B.1.1 The statutory framework for the connection of distributed generators is set out in various clauses of DNOs' Licences, the Distribution Code and the Grid Codes.

B.1.2 At the time of writing,

- in England and Wales, the relevant documents are the Electricity Act 1989 (as amended) the DNO Licences, the Distribution Code, and the Grid Code published by National Grid Transco ;
- in Scotland the statutory provisions are similar to those for England and Wales, but there is a different Grid Code.

B.1.3 However, also at the time of writing, the development of harmonised documentation for all of Great Britain is nearing completion driven by BETTA.

B.2 The DNO Licences – with regard to connections

B.2.1 DNOs have a number of obligations relating to the connection of new customers (including generators) to their networks. These obligations are specified in the DNO Licences. The conditions of the licences include provisions relating to:

- transparency of connection charges and provision of network information;
- non-discrimination in the provision of connections;
- the requirement to offer terms for connection; and
- resolution of disputes.

In the DNO Licences these provisions are contained in conditions 4, 4A and 4B.

Transparency of connection charges and provision of network information

Condition 4 statements

B.2.2 Each DNO is obliged to publish information about the charges they make for connection to their distribution systems. The DNO provides this information in the form of a statement of basis of charges for connection to the distribution system, also known as a Condition 4 statement. The form of this document must be approved by Ofgem, and should enable people applying for connection to make a reasonable estimate of the connection charges. DNOs provide copies of their connection charge statements on request, at a nominal price.

B.2.3 The Condition 4 statement includes four schedules:

- The first outlines the basis of the charges made, and the principal terms and conditions for connection to the network.
- The second lists items of significant cost required for connection to the network, together with indicative charges for each item.
- The third provides an illustrative list of abnormal services that may be reflected in the connection charge.
- The fourth outlines the principles for the calculation of tariff support allowances.

B.2.4 The statement also includes a section covering the operation of competition in connection.

Statement of system capacity and loading

B.2.5 If asked to do so by a developer or any other person, a DNO is obliged to provide a statement containing specific information about the network circuits and nodes specified in the request.

B.2.6 In addition to present and future circuit capacity, forecast power flows and loading, and fault levels, this statement must contain 'such further information as shall be reasonably necessary to enable [the developer] to identify and evaluate the opportunities available when connecting to and making use of the part or parts of [the DNO's] distribution system specified in the request.' If specifically requested, the DNO is also obliged to include, in the statement, their comments about the suitability of that part of the system for new connections. The document also outlines the information that should be provided in such a statement.

B.2.7 The DNO can charge the developer for 'reasonable costs' incurred in the preparation of the statement. An estimate of these costs must be provided to the developer within ten days of receiving the original request. If the developer undertakes to meet these costs, the DNO must provide the statement itself within a further 28 days. If the request involves a lot of work, Ofgem may allow the DNO a longer period to prepare the statement.

Non-discrimination in the provision of connections

B.2.8 In carrying out connection works, DNOs are not permitted to give preferential treatment to particular applicants, types of applicants, or to their own subsidiary businesses.

B.2.9 Applicants who feel that they have been discriminated against can raise the matter with Ofgem.

Requirement to offer terms for connection

B.2.10 If a developer makes an application for connection to the system, the DNO is obliged to offer to enter into a Connection Agreement. This agreement should set out the terms and conditions under which the DNO will provide a connection to their system. More specifically, it should specify the rights and obligations of each party with respect to the installation, use and operation of the connection, and detail the connection charges to be paid by the developer.

B.2.11 The DNO can refuse to offer terms for connection if the developer fails to provide the necessary information with their application, or if the developer refuses to be bound by the terms of the appropriate Distribution Code or Grid Code, as applicable. The DNO can also refuse if providing the connection would be likely to breach any of their duties and obligations under their licence, the Electricity Act, the Electricity Safety, Quality and Continuity Regulations, the Grid Code or the Distribution Code. In practice, this means that the DNO can refuse to provide a connection if they are not satisfied that the applicant is competent to manage the planned generator installation.

B.2.12 DNOs are obliged to offer connection terms 'as soon as practicable', but within three months of receiving an application with all the necessary information. This time limit can be extended with the permission of Ofgem.

Resolution of disputes

B.2.13 In the event of a dispute between a DNO and a developer, either party can ask Ofgem to issue a determination to settle the dispute. A determination issued by Ofgem is binding on both parties. Ofgem will intervene in a dispute if they consider that the DNO has failed to meet any of its obligations with regard to disclosing information and offered terms, or that the connection terms offered by the DNO are unreasonable.

B.3 The Distribution Codes

B.3.1 There is a single Distribution Code for Great Britain. The Distribution Code specifies standards for the design and operation of DNO-owned distribution networks. To meet these standards, DNOs need to be forewarned about the connection of large loads and generator installations to their networks. The Distribution Code therefore requires users of distribution networks, such as electricity consumers and generators, to provide certain information about new loads and generator installations. It also specifies arrangements for the design of connections to DNO networks, and certain requirements for the control and protection of distributed generators.

B.3.2 These requirements are contained in sections DPC5, DPC6 and DPC7 of the Code.

Provision of generator information

B.3.3 To allow the DNO to assess the effect of the planned generation scheme on the distribution network, the developer must provide the DNO with certain information. The amount of information to be provided depends on the size of the generator installation and the required connection voltage. The following basic data must be provided for all generator installations.

(a) Location and timescale

- the point of connection to the DNO's system
- the date from which the connection is required

(b) Generator

- generator type (synchronous, asynchronous, etc.)
- terminal voltage (kV)
- rated kVA
- rated kW
- maximum active power sent out (kW)
- reactive power requirements (kVAr)

(c) Other plant details

- type of prime mover
- anticipated operating regime (continuous, intermittent, peak lopping)
- fault level contribution
- method of voltage control
- generator transformer details
- requirements for top-up and stand-by supplies
- interface arrangements
- earthing arrangements
- switching arrangements

B.3.4 The following additional data must be provided if the capacity of the generator installation is greater than 5MW, or if the connection voltage is higher than 20kV. It should be noted that most of the specified data is only applicable to synchronous generators.

(a) Generator

- MW/MVAr capability chart
- type of excitation system
- inertia constant (MWs/MVA) for the whole machine
- stator resistance
- direct axis reactances (sub-transient, transient and synchronous)
- quadrature axis reactances (sub-transient and synchronous)
- direct axis time constants (sub-transient and transient)
- quadrature axis time constant (sub-transient)
- zero sequence resistance and reactance
- negative sequence resistance and reactance

(b) Generator transformer

- resistance and reactance
- MVA rating
- tap arrangement
- vector group
- earthing arrangement

(c) Automatic voltage regulator

- block diagram of the AVR system
- gains, time constants and voltage control limits

(d) Speed governor and prime mover

- block diagram of the governor system
- gains, time constants
- prime mover rating and maximum power

(e) Capacity and stand-by requirements

- registered capacity and minimum generation of each generating unit (MW)
- auxiliary power requirements (active and reactive) at maximum generation (MW and MVAr)
- auxiliary power requirements (active and reactive) at minimum generation (MW and MVAr)

B.3.5 If the capacity of the generator installation is greater than 50MW in England or Wales, or 30MW in Scotland, additional data specified in the Grid Code must also be provided direct to the Transmission System Operator (TSO).

Requirements for the design of the generator installation

B.3.6 To ensure that the operation of generator installations does not contribute to problems on the network, developers must ensure that their installations meet certain technical requirements.

Generating plant performance

B.3.7 The generator installation should be capable of supplying its full declared output regardless of variations in system frequency over the range 49.5 to 50.5Hz. The power output of the installation should not be affected by permitted voltage variations on the network.

Control arrangements

B.3.8 For certain types of generator installations, the DNO may specify that a continuously acting fast response automatic excitation control system is required to provide suitable control of voltage over the operating range of the installation.

Protection co-ordination

B.3.9 The protection systems installed with the generator installation must co-ordinate properly with the protection systems on the DNO's network. To ensure that this is achieved, the generator protection must satisfy the following requirements:

(a) It must meet target clearance times specified by the DNO.

(b) Its settings must be agreed between the developer and the DNO.

(c) It must co-ordinate with any auto-reclose policy specified by the DNO.

Islanding

B.3.10 The DNO should specify whether they want the distributed generator to remain connected in the event that the section of the DNO network to which it is connected becomes isolated from the rest of the network. If so, arrangements must be put in place to ensure that the generator is disconnected before the islanded section of network is reconnected to the rest of the network.

Black start capability

B.3.11 The developer must notify the DNO if their generator installation is capable of starting without connection to an external power supply.

Commissioning tests

B.3.12 If the developer needs to connect the generator installation to the DNO's network before the commissioning date, to carry out tests, this must be done in accordance with the requirements of the connection agreement. In particular, the developer must provide the DNO with a commissioning programme and normally obtain the DNO's approval for this programme.

B.4 The Grid Codes

B.4.1 The Grid Codes specify standards for the design and operation of transmission systems.

B.4.2 Although distributed generators are not directly connected to transmission systems, their operation can have a significant effect on the operation of these systems. For this reason, transmission system operators need to be informed about the connection of large distributed generation plants to DNO networks, which are in turn connected to their transmission systems. The Grid Codes specify requirements for the provision of information regarding such generator installations, as well as certain requirements for the performance, control and protection of these generators.

B.4.3 The Grid Code for systems in England and Wales is published by National Grid Transco: the requirements for the connection of distributed generators are contained in PC.A.3, PC.A.5 and CC.6.3.

B.4.4 ScottishPower and Scottish and Southern Energy each control separate parts of the Scottish grid system. There is a single Grid Code for both areas, although some differences exist in relation to data management practices. In both cases the requirements for the connection of distributed generators are contained in the Planning Code's appendix B, section B.3, and in the connection conditions, sections 4.2 and 4.3.

The Grid Code in England and Wales

B.4.5 At present NGT must be notified by the DNO of the proposed connection of any distributed generation scheme, although in practice DNOs and NGT operate sensible de minimis limits around 30MW, depending on the effect that the DG will have on the transmission system. Any generator can, in theory, apply to trade energy directly in the wholesale market and to be bound by the Balancing and Settlement Code. In this case the generator would become liable for NGT Use of System (UoS) charges. Any generator of capacity greater than 100MW is required by law to be licensed and is bound by its licence to comply with the BSC (and CUSC) and to pay UoS charges.

Provision of generator information

B.4.6 The Grid Code requirements for provision of information do not apply to most distributed generation schemes. However in England and Wales any power station over 50MW needs to provide information direct to NGT. Unusually the DNO and NGT might agree that some information about a power station smaller than 50MW is legitimately required by NGT, in which case the process for data exchange will be agreed between the parties.

B.4.7 Where the Grid Code requirements apply, the developer must provide technical details of the generation scheme to NGT. These details must include all the information required under the Distribution Code, plus some additional information. Developers who are required to comply with this requirement should consult the Grid Code itself.

Requirements for the design of the generator installation

B.4.8 The Grid Code requirements for technical and design criteria do not apply to generation schemes with registered capacities of less than 50MW. They also do not apply to 'hydro units and renewable energy plant not designed for frequency and voltage control'. Thus, these requirements do not apply to most distributed generation schemes.

B.4.9 Where the Grid Code requirements do apply, they cover a number of aspects of the performance and control of the generating plant. Again, some of the requirements mirror those in the Distribution Code, but the Grid Code includes some additional requirements. Developers who are required to comply with these requirements should consult the Grid Code itself.

The Grid Codes in Scotland

B.4.10 The Scottish Grid Codes contain similar requirements to the NGT Grid Code with respect to the connection of generators. However, it is not clear whether any of these requirements apply to distributed generators, of any description. Given this situation, the best strategy for developers is to discuss with the local DNO (which is also the local transmission system operator) whether they need to meet any requirements over and above those specified in the Distribution Code.

B.4.11 In Scotland, local distribution networks include fewer HV circuits than those in England and Wales, and there is less scope for the connection of large distributed generation schemes.

B.4.12 As a result, some generation schemes which would be ‘embedded’ in the distribution network if they were located in England and Wales may have to be connected to the transmission system in Scotland. Developers of such schemes must comply with all the Scottish Grid Code requirements for the connection of generators.

C Appendix C: Distributed Generation and its effects on the Distribution System

C.1 Introduction

C.1.1 Since the 1950s, the design and operation of most electricity distribution networks in the UK has been based on a key assumption - that power always flows from HV systems to lower voltage systems to the customer, who may be a major industrial user connected at 11kV or higher or a small scale domestic user connected at LV. The introduction of Distributed Generation within the Electricity Distribution Network at all voltage levels is radically altering the way in which electricity distribution networks perform and therefore the future design and operation of such networks.

C.1.2 To help third parties "…contemplating entering into distribution arrangements with the licensee…" each DNO is required to publish annually a Long Term Development Statement, often referred to as the LC25 statement. This statement, as well as outlining the topology of each network, current and future developments and opportunity for development (load and generation), includes information on design philosophy and network characteristics for each distribution voltage level (Appendix E).

C.1.3 This Appendix C describes some of the key technical characteristics of electricity generating plant, the effects distributed generators have on electricity distribution networks and the concerns of DNOs.

C.2 Characteristics of Generating Plant

C.2.1 The electrical characteristics of the generator are an important factor in the design of the connection scheme. In determining both the direct connection and capability of the distribution network, the electrical capacity of the scheme, whether the scheme exports power into the network, and the characteristics of the particular generation technology should be taken into account. Some of the key factors are considered below.

Size and rating

C.2.2 The 'size' of a generation scheme is normally expressed in terms of its rated electrical power output in kilowatts (kW) or megawatts (MW). The Rated Power Output normally refers to the maximum continuous output which can be sustained by the generation scheme. Some generators operate at or near their rated output for most of the time, but others - notably wind, wave and solar installations - generate considerably less than their rated output most of the time.

C.2.3 The Declared Net Capacity (DNC) of a generation scheme is a measure of the expected average power output of a generation scheme. It is calculated by multiplying the rated power output less the power consumed by the plant by a specified 'capacity factor'. The value of this capacity factor is 0.33 for wave energy schemes, 0.43 for wind energy schemes, and 1.00 for other types of generation schemes, as defined in The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001 – Statutory Instrument No. 3270.

C.2.4 The DNC of a generation scheme was a key parameter in the process for awarding contracts under the Non-Fossil Fuel Obligation.

C.2.5 As well as generating real electrical power, generation schemes often generate or consume reactive power (see C.3.18, C.3.19). This must be taken into account in the design of the connection scheme, as transfers of reactive power will contribute to the total current in the connection.

Export level

C.2.6 Many generation schemes supply some on-site demand (including that consumed by the plant itself), with the result that the maximum power exported into the network is less than the rated power output of the generating plant. In such cases, it is the maximum export level rather than the rated output which determines the required connection capacity.

C.2.7 In some cases the normal on-site demand is greater than the rated output of the generation scheme, so no power is exported. Even if this is the case, operation of the generation scheme can have consequences for safe operation of the network under fault conditions. Fault levels in the network will be increased, and there is potential for islanded operation (see C.3.47). For this reason, the statutory requirements apply to all distributed generators, regardless of whether they export power or not.

Characteristics of Generation Technologies

C.2.8 Various technologies are used for generating electricity from other forms of energy. These generator technologies can be grouped as follows:

- rotating machines coupled to synchronous AC generators
  - steam turbines
  - gas turbines
  - diesel engines
  - spark ignition engines
  - large water turbines

- rotating machines coupled to induction generators
  - small water turbines
  - fixed speed wind turbines
  - variable speed wind turbines (doubly fed induction generators)

- AC Current sources coupled via electronic inverter systems
  - variable speed wind turbines
  - wave and tidal devices

- DC current sources coupled to electronic inverter systems
  - fuel cells

– photo-voltaics
– some wind turbines

C.2.9 The electrical characteristics of synchronous generators, induction generators and electronic inverters are quite different, particularly with respect to fault level contribution (see section C.3.25) and harmonics (see section C.3.37).

C.2.10 Table C.1 indicates the relative effect of these devices.

	Synchronous generators	**Induction Generators**	**Electronic Inverters**
Fault Contribution	high	low	low
Harmonic Contribution	very low	very low	significant

Table C.1: Network effects of generation technologies

C.3 Effects of Generators on Distribution Networks

C.3.1 Connecting a generation scheme to an electricity distribution network will affect the operation and performance of the network. The DNO will be concerned to maintain network safety, and to ensure that operation of the scheme does not cause problems for nearby electricity users. In particular the DNO will wish to establish that:

- voltage levels are kept within statutory limits;
- thermal ratings of equipment are not exceeded;
- fault ratings of switchgear and cables are not exceeded; and
- voltage disturbance effects in terms of step changes, flicker and harmonics are kept to a minimum and within nationally accepted limits.

C.3.2 Through careful design of the connection arrangement, the developer and the DNO can ensure that the scheme does not cause problems. In some cases, distributed generators can enhance the performance of the network.

System or Network Studies

C.3.3 The DNO will need to study the effect of a proposed generation scheme on the network. Due to the complexities of the networks and the amount of data involved these system studies, for both load flow and fault level, are generally carried out using specialist computer software packages. There are a number such packages commercially available but those typically used by DNOs are:

- PSS/E from Power Technologies Ltd;
- ERACS from ERA Technology;
- DINIS from Fujitsu; and
- IPSA from IPSA Power, a spin-off company from UMIST.

C.3.4 These packages also provide the facility for undertaking both steady state and transient stability assessment of the proposed generation and its effect on the stability of other rotating plant installations.

C.3.5 Using one of these packages, a user can create a 'model' of the network in question. This may be drawn from LC25 published data or from the detailed network database of network connectivity and electrical parameters maintained by a DNO. The user can then specify the loading on the network and any fault conditions or transient events. Once all this data has been entered, the user can invoke a part of the software package which carries out the analysis and stores the results in one or more output files.

C.3.6 The results will typically show for each network condition specified:

- Load Flows
  - current flows in each branch of the network
  - sending and receiving end real and reactive power flows for each branch
  - voltage conditions at each node
  - voltage boost (+/-) at each voltage controlled node
  - losses

- Fault Level – for each faulted node
  - total fault current at the faulted node
  - angle of fault current relative to the node reference voltage
  - fault current distribution

C.3.7 The connection of a distributed generator to a distribution network will inevitably result in some local changes to the characteristics of the network. To evaluate the possible consequences of these changes, the DNO will usually carry out network studies with the distributed generator included in the network model. In carrying out these studies, the DNO engineers will be particularly interested in whether the proposed generator connection results in any of the following:

- Thermal ratings of equipment being exceeded (see section C.3.11)
- Unacceptable voltage rises (see section C.3.15)
- Fault level limits of existing switchgear being exceeded (see section C.3.25)
- Transformers operating with reverse power flows (see section C.3.32)

If the existing network configuration is unable to accommodate the proposed generation connection because of one or more of the above effects further studies may be undertaken, in consultation with the developer, to look at alternative connection points or network modifications to establish an acceptable connection.

C.3.8 Information derived from the studies may also be used to consider:

- the effects of the proposed generation on existing protection schemes, assessing whether discrimination can be achieved and whether changes will be needed; and
- potential voltage step change, flicker and harmonic effects.

C.3.9 Where considered necessary the DNO may also wish to undertake stability studies for the proposed generation installation to ensure that there are no other potential disturbance effects arising from the installation (section C.3.43).

C.3.10 The DNO engineers may carry out the system studies themselves, or they may contract the work out to a third party. Either way, the cost of the studies will be charged to the developer. The developer is therefore the 'customer' in this situation, and should be provided with a full set of results from the studies. If the DNO offers terms for providing the connection that the developer considers unreasonable, the developer may be able to use the study results to challenge the basis of the offer.

Thermal Ratings

C.3.11 Each element of the distribution infrastructure - lines, cables, transformers etc - has a limited current-carrying capacity. If it is loaded above this limit for an extended period of time, it will overheat. For this reason, the current-carrying capacity of the device is referred to as its thermal rating. Loading a device beyond its thermal rating may lead to permanent damage, or even to a dangerous event such as a fire or explosion.

C.3.12 The thermal rating of an item of equipment will depend upon a number of factors including:

- load shape, peak current, load duration and repetition;
- ambient temperature and seasonal effects; and
- equipment location.

Different thermal ratings may be quoted by a DNO eg continuous, cyclic, seasonal.

C.3.13 Connecting a generator to a distribution system has the effect of changing the current flows in the system and changing the shape of the load cycle seen by each element of the network. It is important therefore to check what rating is being quoted, continuous – 100% rated current for 100% time, cyclic – based on a specific load shape, load-duration, seasonal variation, etc.

C.3.14 With a suitable choice of site and connection scheme, connecting a generator may have a beneficial effect, with no increases in current levels and some significant reductions. Although this is clearly a desirable outcome, it is not always possible or cost-effective. In many cases, the most 'convenient' connection design results in higher current levels in parts of the system. These new current levels may exceed the thermal ratings of existing cables or lines. If so, the developer may opt to pay for these existing assets to be reinforced or up-rated. However, if the cost of this reinforcement is very high, it may be worth considering an alternative connection arrangement, possibly at a higher voltage level. The connection of generation to HV systems is less likely to be constrained by thermal ratings than connection to lower voltage systems.

Voltage Control Issues

Steady State Voltage Rise

C.3.15 Past design of power systems has been driven by the assumption that power flows from a higher voltage system to a lower voltage system, from source to end customer, and the voltage drop across the network is controlled so that the DNO meets its statutory duty to maintain voltage at the customer terminals within a determined range about a declared value.

C.3.16 The typical distribution network configuration from 132kV source busbar (33kV source busbar in the case of Scotland) achieves this by using transformers equipped with onload automatic tap changers feeding 33kV(or 66kV and 22kV) and 11kV (or 6.6kV) busbars to maintain the lower voltage busbar constant within a narrow bandwidth, typically +/-1.75%, about a target voltage. This ensures a substantially constant low voltage for variations in the higher voltage system and voltage drop within the feeding transformer.

C.3.17 11kV to LV transformers have a limited range of off-load selectable fixed taps, the operating fixed tap position is chosen in conjunction with the calculated appropriate volt drop in the 11kV and LV feeder to satisfy two basic criteria:

- at minimum 11kV source voltage and maximum feeder demand the voltage at a remote end consumer is no less than the statutory minimum; and
- at maximum 11kV source voltage and minimum feeder demand the voltage at the transformer LV bus bar or first LV customer does not exceed the statutory maximum.

C.3.18 The addition of generation at any voltage level will modify the current flows in the network and tend to push up voltages within that network. The criteria remain that customers should be supplied within the declared range of the appropriate statutory voltage.

C.3.19 The rise in voltage level will depend upon a number of factors, including:

- the level of generation compared to the level of minimum demand;
- location of the generator in relation to the system source and major demands. Dependent upon the location of the generator and the relative export from a distributed generator compared with the network demand so the generator will reduce the current flowing in the network between it and the source thus reducing the voltage drop between source and generator connection point. However once the generator starts to export power to the source the voltage at the point of

connection will start to rise in order to overcome the impedance of the network;

- reactive power export or import levels. The apparent power (expressed as MVA or kVA) at any point in a network is the product of the voltage and current at that point. Apparent power has two elements: real power (MW or kW) and reactive power (MVAr or kVAr). The quantities are related via the term power factor which is the ratio of real power to apparent power. Real and Reactive power may be imported or exported and the direction of flow is not interdependent. Thus a generator may export real power but either export reactive power (typical of a synchronous generator) or import reactive power (typical of an induction generator). It is general practice for a DNO to ask a distributed generator to operate at or near to unity power factor, that is with minimum reactive power import or export, in order to maximise the real power capability of the network, however, there may be cases, given the network capacity, where it is desirable for the generator to import or export reactive power in order to assist network voltage regulation.

Step voltage change

C.3.20 The process of starting a distributed generator can sometimes cause step changes in voltage levels in the distribution network. These step changes are caused by inrush currents, which may occur when transformers or induction generators are energised from the network. Synchronous generators do not give rise to inrush currents themselves, but their generator transformers may do so if they are energised from the network.

C.3.21 Step voltage changes will also occur whenever a loaded generator is suddenly disconnected from the network due to faults or other occurrences. Where there are multiple generators connected within an installation, for example a wind farm, it will be necessary to consider the voltage step change occurring from both the sudden disconnection of the total site and the sudden disconnection of an individual generator.

C.3.22 The magnitude of a step voltage change depends on the method of voltage control, types of load connected and the presence of other local generation. Typical limits for step voltage changes caused by the connection and disconnection of generating plants at the distribution level, as defined in Engineering Recommendation G75/1, should be ±3% for infrequent planned switching events or outages (in accordance with Engineering Recommendation P28) and ±6% for unplanned outages such as faults.

C.3.23 Where induction generators are used, such as in fixed speed wind turbines, they are normally fitted with 'soft starters'. These devices limit inrush currents to roughly the same level as the normal rated current. This reduces the magnitude of the step voltage changes which occur on starting.

C.3.24 Likewise a characteristic of inverter coupling of a power source is an inherent limitation of inrush currents on synchronising.

Fault level contribution

C.3.25 All components of an electrical network have a fault rating which define for the component:

- an ability to withstand the mechanical forces due to the peak fault current;
- a short time thermal limitation; and
- for circuit breakers the ability to extinguish the arc drawn when switch contacts part under fault conditions.

C.3.26 Typically distribution switchgear will quote:

- rated continuous load current (amps);
- rated symmetrical rms breaking current (kA); and
- rated peak making current (kA).

C.3.27 In addition some switchgear, particularly that for use at 132kV will quote:

- rated asymmetrical breaking current (kA).

C.3.28 The DNO will normally assess symmetrical (ie balanced 3 phase) and asymmetrical (ie single phase-earth) fault currents, for both the breaking and peak making conditions, at all switchgear nodes on the network taking into account assessed infeeds from all rotating plant. Generally, with resistance or reactance neutral point earthing, distribution network asymmetrical fault currents are limited, not excessive and therefore not a problem. However the 132kV network uses multiple direct neutral point earthing and in this case asymmetrical fault currents can exceed symmetrical currents.

C.3.29 Calculation of fault currents for three phase symmetrical and single phase to earth asymmetrical fault conditions are undertaken using the software noted above and follow the methodology in Engineering Recommendation G74. The software employed also allows the calculation of other fault conditions which may be of use in looking at protection settings and discrimination.

C.3.30 Connecting a generator to a distribution network has the effect of increasing the fault levels in the network close to the point of connection. The additional fault level at the point of connection due to the presence of the generator is referred to as the fault contribution of the generator. If the local fault level is already close to the design fault level of the system, the fault contribution of the generator may take the fault level over the limit.

C.3.31 This problem may be tackled in a number of ways. It may be possible to use a different type of electrical source with an inherently lower fault contribution. If the connection scheme includes step-up transformers, it may be possible to specify high impedance transformers. Alternatively, a reactor can be included in the connection scheme. If the problem cannot be overcome in these ways it may be necessary to consider a connection at a different voltage level with a higher design fault level.

Reverse power flows

C.3.32 The assumption that power always flows from HV systems to lower voltage systems is being undermined by increased connection of distributed generating plant to the distribution network. In some cases, the connection schemes for these distributed generators result in reverse power flows in distribution transformers. In these cases, the generator exports more than enough power to supply all the loads on the system to which it is connected. The surplus power is transferred back through the distribution transformer, and is fed into a higher voltage system.

C.3.33 The possibility of reverse power flows in transformers can sometimes present a problem with the choice of tapping for fixed tap transformers or the operation of automatically controlled on load tap changers which are fitted to transformers to provide voltage regulation on the LV side of the transformer:

- the design of some on load tap changers is such that reverse power may not be possible or may be limited to significantly less than the rating of the transformer;
- in some extended rural 33kV networks the transformer tapping and nominal ratio have been chosen to provide maximum boost to the lower voltage thus under reverse power conditions it is possible that the tapping range is inadequate to keep the lower voltage within specified limits;
- whilst most voltage control schemes used to operate tap changers perform quite satisfactorily under reverse power conditions there are those which may not operate as intended and this is an issue which needs to be addressed with the DNO.

Voltage Flicker

C.3.34 Voltage flicker refers to rapid fluctuations in the voltage level on a distribution system. These fluctuations can be very annoying for local electricity users, as they cause light bulbs to ‘flicker’ instead of producing a steady light. Fluctuations at frequencies close to 8Hz cause the most annoyance.

C.3.35 The potential to cause voltage flicker is peculiar to fixed-speed wind turbines, particularly where these are connected to a weak rural network with a low fault level and is due to the electrical characteristics of induction generators. The power output of the wind turbines varies rapidly due to wind turbulence and this may be reflected back into the distribution network, although a wind farm with several turbines is less likely to cause flicker as the variations in power output of the different turbines tend to cancel out. Variable-speed wind turbines are less likely to cause flicker. Gensets and other types of generators operating at constant power output do not cause flicker.

C.3.36 Engineering Recommendation P28 specifies recommended limits on flicker in distribution networks.

Harmonics

C.3.37 Ideally, the voltage at any point in a distribution system should have a perfectly sinusoidal, 50Hz waveform. However, this is rarely achieved in practice. Any non-linear device drawing current from or injecting current into the power system will introduce harmonic components which will show as distortion of the voltage waveform. Typical equipment includes rectified power supplies, compact fluorescent lights, variable speed motor drives and other switched loads including inverter-coupled generation schemes.

C.3.38 Limits on the level of harmonic currents that generators and loads are permitted to inject into distribution networks are specified in Engineering Recommendation G5/4. Engineering Recommendation G5/4 also specifies the planning limits on the level of harmonic voltage distortion at any point in a distribution network and the methodology for assessing the connection of new load.

C.3.39 G5/4 uses a three-stage approach to the assessment of non-linear load and generation plant for connection to a network:

- Stage 1: connection of equipment of limited size to LV networks without individual assessment (G83/1 equipment falls within this group);
- Stage 2: connections of equipment and load of a size greater than the maximum in Stage 1 to all systems less than 33kV; measurements of existing network harmonic distortion may be necessary; predicted levels to be less than specified levels;
- Stage 3: connection of non-linear loads connected at 33kV and above or loads which are not found to be acceptable under Stage 2; measurements of existing network harmonic distortion will be necessary.

Voltage and Current Unbalance

C.3.40 The connection of unbalanced loads and generation to the distribution network can result in unbalanced currents and voltages. However, the vast majority of distributed generation schemes use 3-phase generators or inverters which inject balanced currents into the distribution network. Such generation schemes do not increase levels of voltage unbalance in the network. In fact, distributed generators which use 3-phase induction generators can actually reduce voltage unbalance.

C.3.41 Issues associated with the connection of single phase small scale generation are fully discussed in Engineering Recommendation G83/1.

C.3.42 Limits on the level of voltage unbalance in public distribution networks are specified in Engineering Recommendation P29.

Stability

C.3.43 For a full assessment of the overall performance of the distribution network and of the proposed generating plant a DNO may wish to undertake steady state and transient stability investigations:

- to predict the ability of the generator to recover and remain connected to the network following a fault within the network;
- to assess the interaction of generators and other rotating plant connected to the network immediately following a fault;
- to ensure there is little possibility of voltage disturbances due to the failure of the generator to remain in synchronism.

C.3.44 The generation installation will be 'steady state stable' if following a small disturbance, such as load or circuit switching, it returns to a steady state operating condition. Likewise the generator will be 'transiently stable' following a large system disturbance if it remains in synchronism and returns to a new steady state operating position following the removal of the disturbance.

C.3.45 The oscillations in the generator system occurring as a result of the disturbance are generally damped out but undamped oscillations with consequent voltage and power swings may affect other generating units and will lead to loss of synchronism.

C.3.46 For a full discussion of stability issues refer to Engineering Recommendation G75/1 section 9.

Islanded Operation

C.3.47 A DNO will not normally accept islanded operation of part of its distribution network by a distributed generator connected to that part of the network. However, if a generator supplies load on the customers' side of the connection point, then for loss of the connection to the distribution network it is possible for the generator to maintain that load. This "islanded" arrangement will dictate the generator G59/1 protection arrangements, neutral earthing and synchronising arrangements. This is discussed in more detail in Engineering Recommendation G59/1.

D Appendix D: Protection, Earthing and Safety

D.1 Introduction

D.1.1 The aim of this appendix is to describe the normal arrangements for protection and earthing of distributed generators and the connected distribution system, focusing particularly on the division of responsibilities regarding switchgear and other assets at the point of supply. Other issues relating to site safety are also discussed.

D.2 Agreement of earthing and protection design

D.2.1 The DNO has a responsibility to ensure that the generator installation will not adversely affect the distribution network and other customers, before they allow it to be connected to the distribution network. For this reason, they have a legitimate interest in the design of the protection and earthing systems for the installation, and in other safety issues such as the provision of the emergency trip button. It is therefore essential for the developer or their engineers to obtain agreement with the DNO on these arrangements, before placing contracts for the supply and installation of equipment.

D.2.2 The best way to obtain this agreement is through discussion with the DNO. The provision, by the developer, of a single line diagram describing their proposed design provides a useful focus for discussion, enabling the DNO to understand the developer's proposals and, if required, to make suggestions for changes. Scope of supply issues should also be clarified. Written confirmation of the agreed design and scopes of supply should be obtained before committing to any supply or installation works.

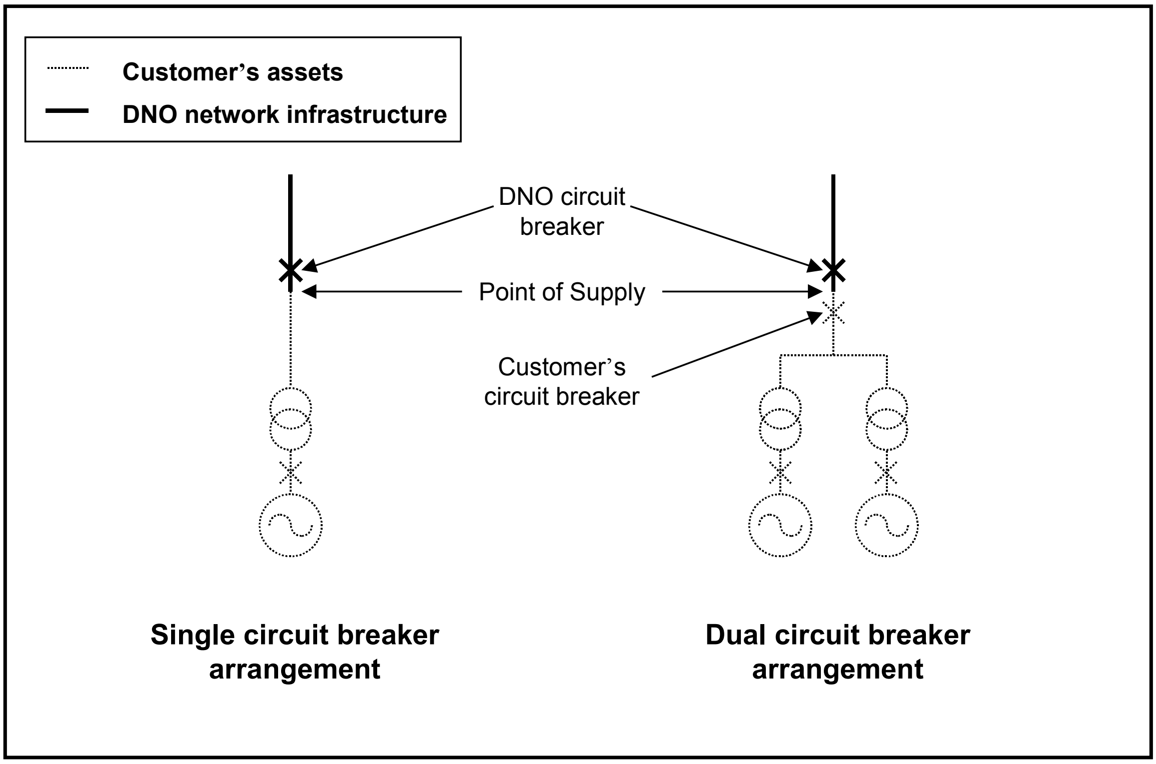
D.3 Protection

Switchgear

D.3.1 A circuit breaker must be installed at the point of supply to the generator installation to allow isolation of the generator from the DNO's distribution network. For the majority of projects the DNO will accept a single circuit breaker at the interface, under their ownership and control, and arranged to trip from the generator's protection, although the DNO will not allow synchronising on this interface circuit breaker. The circuit breaker allows the DNO to disconnect the generation plant from the distribution system if necessary, however DNO engineers have to be called out to provide isolation and earthing for the generator installation, and the DNO will charge for this service.

D.3.2 The single circuit breaker arrangement is subject to the need for the DNO to undertake a risk assessment should it feel that the duty on the circuit breaker or the protection system is likely to be unusually onerous. There may therefore be cases where it is considered advisable for a second circuit breaker to be installed on the developer's side of the point of supply (see Figure D.1). This second circuit breaker is tripped by the generator's protection and also allows the developer to provide their own isolation and earthing for maintenance of the generator installation.

Figure D.1: Circuit breakers at the Point of Supply



D.3.3 The generator installation may include additional circuit breakers, isolators or other switchgear, to allow isolation of individual machines or transformers.

Protection of developer assets by DNO circuit breaker and protection

D.3.4 Under all circumstances the DNO's circuit breaker will protect some developer assets, even if this is just a short section of busbar between the DNO's circuit breaker and the developer's circuit breaker. If there is no developer's circuit breaker, the DNO's circuit breaker may protect transformer cables (tails) and transformer windings. These arrangements must be agreed with the DNO. Furthermore, it is the developer's responsibility to ensure that their assets are adequately protected, and that they satisfy the Electricity Safety, Quality and Continuity Regulations.

Short circuit protection

D.3.5 The developer must install protection systems to detect and isolate faults in the generator installation. As a minimum, these systems should protect the generators, transformers and cables against the following conditions:

- over-current; and
- earth fault.

D.3.6 Additional protection may be required, depending on the design of the installation. Guidance on the protection of generator installations is provided by Engineering Technical Report 113.

G59/1 Protection

D.3.7 Every distributed generator connection arrangement must include a suite of protection systems which is commonly referred to as G59/1 protection. This name is derived from the name of the document which specifies these protection requirements - Engineering Recommendation G59/1. This document strictly applies only to generation under 5MW and connected at 20kV or below. However, the same protection is usually fitted for all distributed generator connections.

D.3.8 G59/1 protection includes systems for the detection of the following conditions at the generator installation:

- over-voltage
- under-voltage
- over-frequency
- under-frequency
- loss of mains

and possibly:

- neutral voltage displacement (NVD)
- reverse power

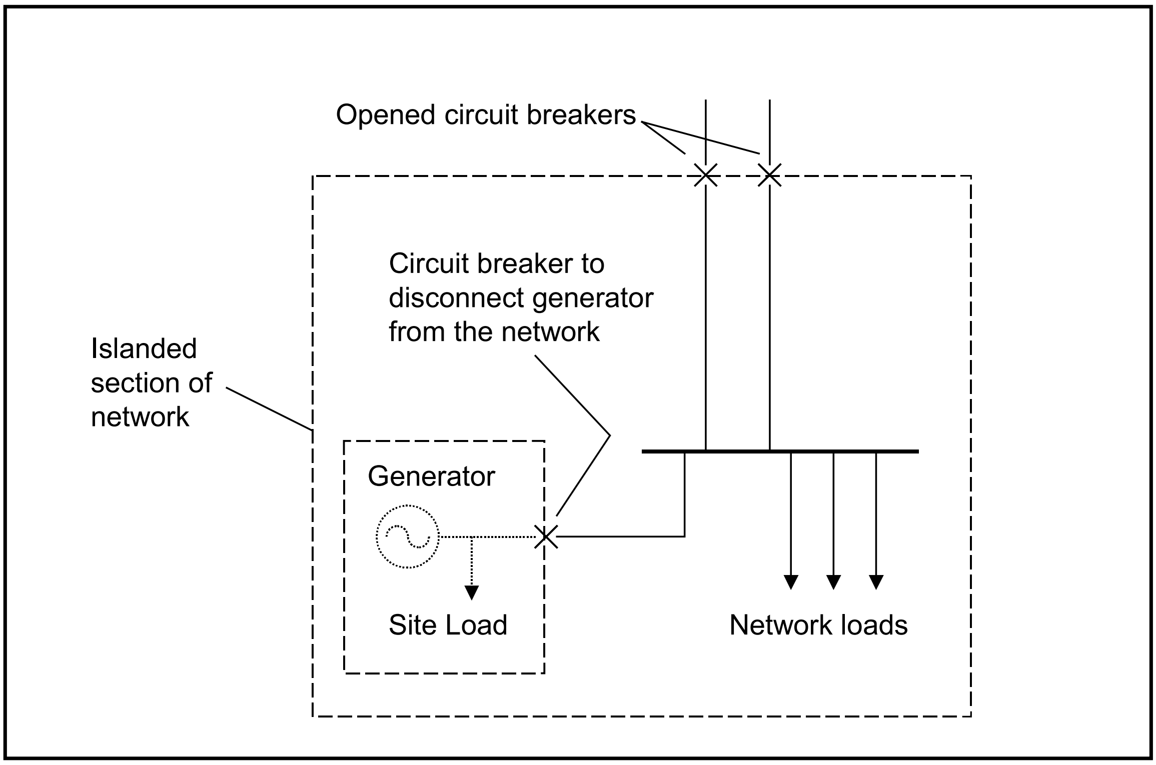
D.3.9 A set of relays must be installed at the point of supply to detect these conditions. Indicative settings for these relays are specified in Engineering Recommendation G59/1. However, the document is a recommendation rather than a standard, and it may be appropriate to apply different settings to suit the specific circumstances.

D.3.10 The relays which form the G59/1 protection are normally within the developer's scope of supply, and are used to trip the interface circuit breaker or the generator circuit breakers.

Loss of Mains Protection

D.3.11 In the event of an electrical fault in a distribution network, circuit breakers in the network are tripped in order to isolate the fault from the supply. The operation of these circuit breakers results in a part of the network being disconnected from the main grid supply. If one or more distributed generators are connected to this part of the network, it is possible that these generators could continue to operate, supplying power to loads which are connected to the same section of the network. This scenario, illustrated in Figure D.2, is referred to as islanding.

Figure D.2: Islanded operation of a section of network



D.3.12 Unplanned islanded operation of distributed generators is generally regarded as unsafe and undesirable. To prevent unplanned islanding, all distributed generators must be fitted with loss of mains protection, which aims to detect when the generator is islanded and to disconnect it from the network.

D.3.13 Although there are various types of relay that can be used to detect loss of mains the most commonly used form of LoM protection is the rate of change of frequency relay, usually referred to as a RoCoF relay (pronounced 'rock-off'). Alternatively, vector shift or other types of relay can be used to detect loss of mains.

D.3.14 Although loss of mains protection systems will detect islanding in most cases, there is no system which can guarantee to detect it in all cases. Problems can arise when the islanded part of the network includes loads which closely match the output of the distributed generator. It is extremely difficult for loss of mains protection systems to detect islanding in this situation. The only way to guarantee loss of mains protection is to provide inter-tripping with the DNO's circuit breaker at the primary sub-station. This arrangement means that the generator is automatically disconnected from the DNO's network if the local network becomes disconnected from the grid. Whilst inter-tripping of the generator, and its interlocking to prevent reconnection prior to the network connection being restored, is readily achievable where the generator is close to the DNO primary substation this may not be the case for a remote generator. The cost of inter-tripping has, therefore, to be weighed against the provision of loss of mains protection together with a risk assessment of the potential failure to detect the islanding situation.

G75/1 Protection

D.3.15 Engineering Recommendation G75/1 specifies certain protection requirements for larger distributed generating plants, specifically those with outputs of over 5MW or connected above 20kV. G75/1 does not give specific recommendations for relay settings, but gives guidelines as to operational requirements.

D.3.16 It should be noted that some of the recommendations in G75/1 may not be applicable to distributed generation projects in Scotland.

Batteries and Auxiliary Supplies

D.3.17 Protection relays are normally powered by batteries. The DNO will always provide their own battery to operate the DNO protection relays and provide tripping supplies for the interface circuit breaker. The DNO may be prepared to provide the generator with a fused supply from the battery and its charger provided that supplies are not extended outside the site boundary, that the drain imposed on the battery by the generators equipment is fixed and specifically agreed and that the battery charger is fitted with an alarm connected to the DNO's telecontrol system. However, the DNO will expect to be able to recover any costs associated with a failure of the battery charger as a result of any failure on the generators system.

D.3.18 For this reason it is considered preferable for the generator to provide his own battery system which is continuously topped up by a charger connected to an AC supply. The battery bank should be sized to provide enough standby time to cover supply failures or prolonged outages.

D.3.19 The top-up supply may be provided in various ways:

- from a separate LV supply provided by the DNO;
- from an auxiliary transformer connected to the developer's HV system; or
- from the developer's LV system.

D.3.20 This decision has implications for metering in the case of renewable generation schemes selling their output under the NFFO or Scottish Renewables Order (SRO) orders. If a separate DNO supply is used to provide power to the site for battery top-up or any other purpose, this power may have to be 'netted off' the power exported from the site for the purpose of calculating payments to the generator under the renewable order scheme.

Telecontrol

D.3.21 A DNO's telecontrol installation policy will be outlined in its LC25 statement. Typically a DNO has telecontrol equipment installed at all primary and higher voltage substations for monitoring and control of all automatic circuit breakers, transformers and auxiliary equipment. Where a generator connection is made to an 11kV primary busbar or a higher voltage system then full telecontrol of that connection will be required. For remote connections to the 11kV system the requirement for monitoring is considered on a case by case basis.

D.4 Site Earthing

Site Earth Electrode

D.4.1 The developer is normally required to provide a site earth electrode and main earthing terminal which will be used for earth bonding of the DNO-owned assets on the site. This earthing system is normally used to earth some of the developer's assets as well. In general, the resistance of this earth electrode should be less than 10 ohms. The earthing system must be designed to ensure that the installation is safe under earth fault conditions, especially with regard to step and touch potentials.

D.4.2 The DNO may supply an earth electrode connection through a cable sheath. However, the continuity of a single sheath cannot be assumed, so the requirement to install a site earth electrode still applies. The cable sheath should be bonded to this electrode.

D.4.3 The reader should refer to the Electricity Safety, Quality and Continuity Regulations and BS 7671 for guidance on earthing systems and terminology.

DNO Neutral to Earth Connection

D.4.4 The design of the system to which the generation scheme is connected (ie the DNO's 11kV or higher voltage system) has an impact on the earth fault protection of the generator installation. This system will normally have one point of connection from neutral to earth at the DNO's source substation. The method used to make this connection is a key determinant of the earth fault currents which might occur.

- Solidly earthed - The neutral point is solidly bonded to earth. This can result in high earth fault currents.

- Resistance earthed - The neutral point is bonded to earth through a resistance to limit earth fault currents. Most DNO networks are earthed using this method.

- Arc suppression coil earthed - The neutral point is connected to earth through inductive coils which are tuned to match the network capacitance. This limits the fault current that flows in the event of an earth fault. These systems are designed to operate for extensive periods with an earth fault in place. This form of neutral point earthing results in the displacement of the neutral point and places a higher stress on any components (especially cables and transformers) connected to it. The design of any such components on the developer's system should be checked against this scenario. Alternatively developers may wish to fit their own neutral voltage displacement protection and alarm or trip in such circumstances.

D.4.5 The developer should be aware that for the 132kV distribution network (England and Wales) multiple solidly earthed neutral point earthing is used which results in high levels of earth fault current, in many cases exceeding the level of three phase earth fault current.

Developer's Neutral to Earth Connections

D.4.6 The developer is responsible for providing neutral to earth connections for any LV systems at the site, where these systems are not connected directly to a DNO LV system. This generally applies wherever an HV/LV transformer is provided by the developer.

D.4.7 Neutral earthing arrangements of LV systems vary depending on the type of generators which are used in the generation scheme. With induction machines, the neutral to earth connection is normally made at the generator transformer. This arrangement can also be used with synchronous generators, although some generator contractors insist on making the connection at the generator. Where multiple neutral to earth links are used, care must be taken regarding circulating currents.

Separation or Bonding of HV and LV Earths

D.4.8 For sites with both HV and LV systems, there are two options for the provision of earth electrodes for the two systems

- Provide two separate earth electrodes for the HV and LV systems.
- Provide a common earth electrode (or bond HV and LV electrodes together)

D.4.9 In generation projects with individual generation units of less than 2MW, it may be cost-effective to use a common earthing system for the developer's LV and HV systems. It is generally accepted that the overall resistance of a common earth electrode must be no greater than 1 ohm, although the Electricity Safety, Quality and Continuity Regulations 2002 now state that "a generator or distributor shall, in respect of any high voltage network which he own or operates…ensure that the earth electrodes are designed, installed and used in such a manner so as to prevent danger occurring in any low voltage network as a result of any fault in the high voltage network".

D.4.10 For further guidance on the requirements and design of earthing systems, and to ensure that the requirements of the ESQCR Regulations are met, reference should be made to BS7671, Engineering Recommendation S34 and Technical Specification 41-24.

Equipotential Bonding

D.4.11 The developer is responsible for all equipotential bonding and protective conductors to comply with the IEE Wiring Regulations (BS7671).

D.5 Safety Issues

Emergency Trip Button

D.5.1 The Electricity at Work Regulations require that an emergency trip button is provided at the point of supply, to enable the developer to trip the DNO-owned circuit breaker in the event of an emergency. If the DNO installs the connection assets, they may include the emergency stop button in their scope of supply. However, some DNOs do not provide the emergency stop button, in which case the developer must provide it. In some DNO areas, the developer is required to provide a relay and battery as part of the emergency stop function.

D.5.2 The emergency stop button is normally located in the substation where the DNO's circuit breaker is installed. The button must be located in an area of the substation which can be accessed by the developer's personnel. Sometimes it is appropriate to relay duplicates of this stop button function to other parts of the generation site such as the generator control rooms or cubicles.

Isolation and Earthing

D.5.3 If the developer wishes to undertake maintenance work on electrical equipment in the generator installation, this equipment must be isolated and earthed. Isolation and earthing of some parts of the generator installation will involve opening a circuit breaker at the point of supply (see section D.3.1). In the case of the single DNO owned interface circuit breaker the generator's assets can only be isolated by opening the DNO's circuit breaker. The DNO will charge the developer for the cost of sending out an engineer to provide isolation and earthing, and may not be able to provide this service on demand. If, however, the developer has their own circuit breaker in addition to the DNO's circuit breaker, isolation and earthing becomes a straightforward process under the control of the developer.

Islanded Operation

D.5.4 As noted in appendix C paragraph C3.48, a DNO will not normally accept islanded operation of part of its distribution network by a distributed generator connected to that part of the network. Where a generator supplies load on the developer's side of the connection point, then for loss of the connection to the distribution network it is possible for the generator to maintain that load. This "islanded" arrangement has implications for:-

- the generator G59/1 protection arrangements, circuit breaker tripping and interlocking to prevent reclosure until the DNO connection is restored;

- neutral earthing where the islanded installation includes an HV developer owned distribution network; arrangements for maintaining an HV neutral earth, by the developer, under these conditions and its interlocking with the DNO connection will have to be discussed and agreed with the DNO;

- synchronising arrangements; arrangements for re-synchronising the generation installation and the developer owned islanded network, to prevent out of phase reclosure, will have to be agreed with the DNO.

D.5.5 These issues are discussed in more detail in Engineering Recommendation G59/1 and its accompanying technical report ETR113.

E Appendix E: DNO Network Information

E.1 Introduction

E.1.1 This appendix describes the network information which is available within the public domain or which can be made available on request to a DNO and the type of information which should be provided by a DNO in a more comprehensive statement of system capacity and loading. The content and presentation of network data and the system capacity statement will vary between DNOs and the example shown here is typical.

E.1.2 Each DNO maintains a data base (or series of data bases) of distribution network data from 132kV (33kV in the case of Scotland) through to the LV system which will include electrical connectivity, electrical and physical parameters of all elements of the network. Load data is recorded for all monitored circuits and demand nodes and analysed to give maximum demand, load duration and load curve information. These data bases are the prime source of information for a DNO's ongoing functions from long term planning through to day to day network operation.

E.1.3 Some of this data is available in the public domain through the annual Long Term Development Statement (see Section E.2 below) published by each DNO covering network data for the 132kV (33kV in the case of Scotland) and HV networks together with 11kV source busbars. 11kV and LV network data may be provided on request by a DNO. The distribution network is dynamic, particularly so at the 11kV and LV level, therefore any provision of data (including the LC25 statement) by a DNO to a third party will be a snapshot in time and have a limited life.

E.2 Long Term Development Statement

E.2.1 Standard Condition 25 of the Electricity Distribution Licence requires that each Distribution Network Operator has in place and maintains, at the direction of Ofgem, a Long Term Development Statement (often referred to as the LTDS or LC25 statement) of such form as may be specified by Ofgem, covering each of the five succeeding years beginning with 1st April of the specified year.

E.2.2 The purposes of Standard Condition 25 are :

- to secure the provision by the licensee of information which will assist any person who contemplates entering into distribution arrangements with the licensee to identify and evaluate the opportunities for doing so; and
- to ensure the general availability of such information in the public domain.

E.2.3 The general format is for a 4-part statement comprising:

1 – Introductory section: stand-alone section outlining the purpose, content, cost and contact details for the main statement but containing sufficient high level information relating to the design and operation of all voltage levels of the distribution network together with an outline of the detailed information within the main statement. This should enable the developer to determine if the full statement will be of assistance.

2 – Summary Information: discussion of overall design philosophy and practices and a high level summary of the design policies applied, at minimum, to the lower voltage networks (20kV and below). Also included is a description of general network characteristics and policies over the full range of network and related issues.

3 – Detailed Information: details of the 132kV networks (33kV in Scotland) to the lower voltage busbars of primary substations, including any interconnectors at lower voltages that are needed to assess the capability of the higher voltage network. The detailed information will include schematic diagrams, connectivity and electrical parameters for circuits and transformers together with fault level information and load forecasts for the period of the statement.

4 – Network Development: indication of areas of the network that are expected to reach or exceed their capability during the period covered by the statement; development proposals on the network where finance has been secured and can therefore be viewed as firm; a high level summary of interest in demand and generation connections together with a high level discussion of opportunity.

E.2.4 The stand-alone introductory section is intended to be available at no cost to any interested third party and is available on most DNO web sites together with information regarding the availability and cost of the full statement.

E.2.5 The statement is of value to a potential developer in that it provides a significant level of background information on the particular DNO network configuration and design practices, at minimum for voltage levels of 20kV and below (more usually from 132kV). If a developer is contemplating a proposal which is of a size likely to require connection directly to a primary substation lower voltage busbar or to a higher voltage network then the statement has the information available at the time of publication to enable the developer to make an initial assessment of network capability and identify potential problems before entering into detailed discussions with the DNO. It should, however, be borne in mind that during the currency of the statement there may be further commitments to network capacity which were not firm at the time of publication. Similarly lower voltage network data can be made available on request for the developer to make his own initial assessments.

E.3 Statement of System Capacity and Loading

E.3.1 If asked to do so by a developer or any other person, a DNO is obliged to provide a more extensive statement containing information about the network circuits and nodes specified in the request. In addition to electrical parameters, present and future circuit capacity, forecast power flows and loading, and fault levels, this statement must contain 'such further information as shall be reasonably necessary to enable [the developer] to identify and evaluate the opportunities available when connecting to and making use of the part or parts of [the DNO's] distribution system specified in the request'. If specifically requested, the DNO is also obliged to include, in the statement, their comments about the suitability of that part of the system for new connections.

E.3.2 The DNO can charge the developer for 'reasonable costs' incurred in the preparation of the statement. An estimate of these costs must be provided to the developer within 10 days of receiving the original request. If the developer undertakes to meet these costs, the DNO must provide the statement itself within a further 28 days. If the request involves a lot of work, OFGEM may allow the DNO a longer period to prepare the statement.

Scope of Statement

E.3.3 It is usual for the developer, or those acting on their behalf, to ask the DNO for information relating to a particular system within the local network, such as a 33kV system or an 11kV system. Obviously, information would normally be requested for the system to which the proposed generation scheme is likely to be connected.

E.3.4 Thus, the DNO's statement would normally contain information relating solely to the system in question. Incoming and outgoing feeds to other systems and MVA ratings of transformers at the interface might be indicated in diagrams, but it is not normal for more detailed information about these feeds to be provided, other than that sufficient for the developer to make an assessment of network capability.

Content of Statement

E.3.5 A well-prepared statement might include the following elements:

- Operational schematic diagrams of the system - These diagrams provide information about the configuration of the system, and the location of grid infeeds, loads, transformers and circuit breakers. An example is shown in Figure E.1.

- Physical map - This map shows the geographical location of the assets in the schematic diagram.

- Tables of circuit data - These tables specify connection nodes and the key parameters of each circuit in the system. The parameters include resistance and reactance (quoted in ohms or per unit/percentage values on a specific MVA base – usually 100MVA) and may include:

  - for lines and cables: route length, conductor type, construction specification and ratings (possibly differentiated into normal, summer and winter ratings);

- for transformers: vector group, tap range, LV busbar target voltage and ratings (again possibly differentiated into continuous, emergency and cyclic rating).

This data may be provided in the form of output from the DNO's load flow software system, as shown in Figure E.2. It may be accompanied by a schematic diagram generated by the same software, such as the one shown in Figure E.3, and a table relating node names to geographic locations. This can be useful to help identify the nodes and circuits described in the tables.

- Table of loads - This table specifies the location and magnitude of the loads on the system. It should specify the active and reactive loads at conditions of maximum demand and should also enable some estimate to be made of the minimum demand levels. Care needs to be taken to establish an understanding of the demands tabulated – the figures given may be the maximum demand at each individual location, alternatively the figures may be the demand seen at each individual location at the time of the maximum demand of the network (or other system) under consideration.

- Short circuit data - This should include, as a minimum, the three phase fault level, together with the X/R ratio, at the infeed to the system and should be such as to allow the developer to assess both peak and steady state fault levels within the network under consideration.

Figure E.1: Operational schematic of part of a network

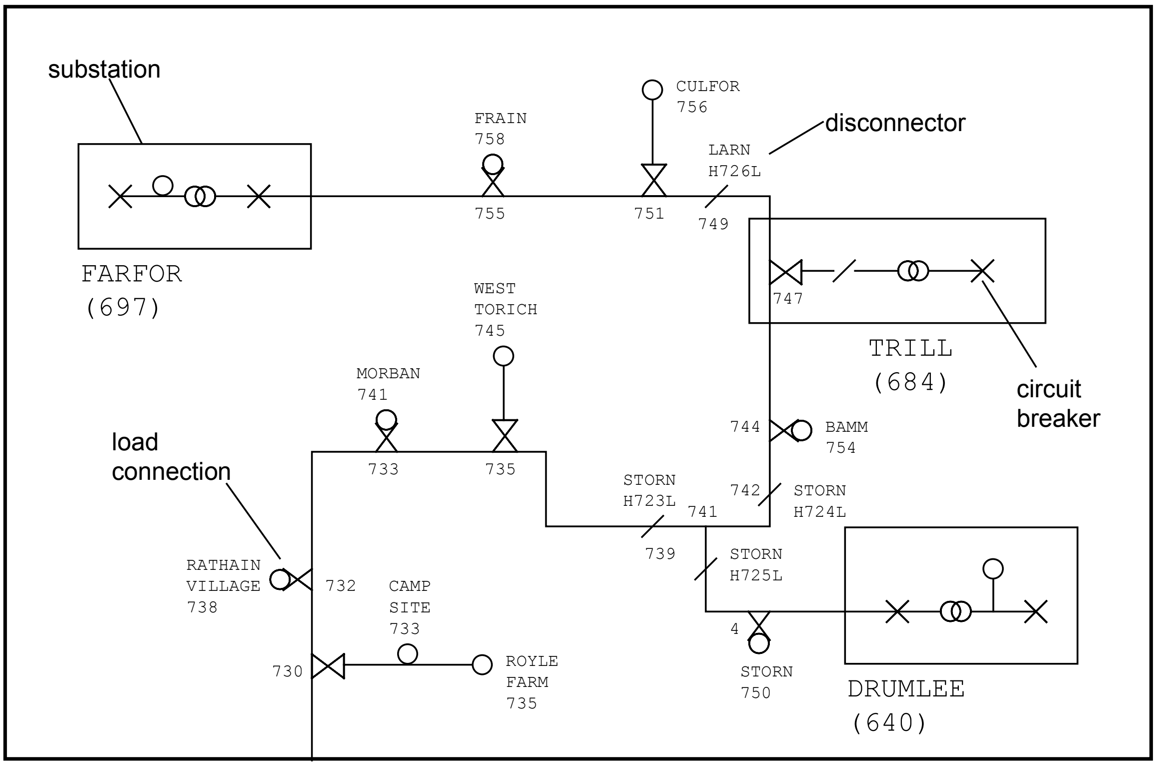


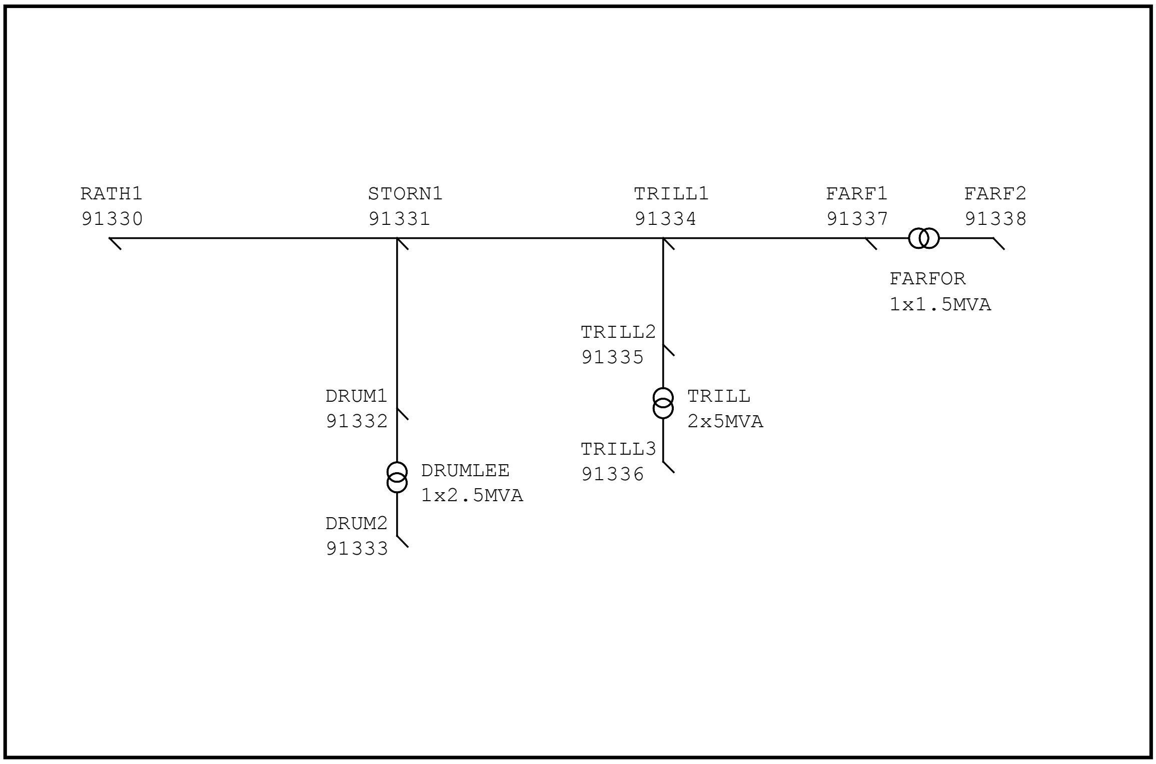
Figure E.2: Table of circuit data

FROM NAME	NUMBER	TO NAME	NUMBER	KM	R	X	RATE1	RATE2	RATE3
RATH1	91330	STORN1	91331	10.7	0.3531	0.4216	18.10	16.45	14.81
STORN1	91331	DRUM1	91332	2.9	0.0957	0.1143	4.14	3.76	3.38
STORN1	91331	TRILL1	91334	4.2	0.1386	0.1655	18.10	16.45	14.81
TRILL1	91334	TRILL2	91335	0.3	0.0099	0.0118	13.61	12.37	11.13
TRILL1	91334	FARF1	91337	7.4	0.2442	0.2916	4.95	4.50	4.05

circuit identification (FROM NAME, NUMBER, TO NAME, NUMBER)
circuit length (km) (KM)
circuit resistance (ohms) (R)
circuit reactance (ohms) (X)
winter rating (MVA) (RATE1)
normal rating (MVA) (RATE2)
summer rating (MVA) (RATE3)

Note: table format may not be as shown

Figure E.3: Network schematic with node numbering



F Appendix F: Checklists

F.1 Introduction

This appendix contains checklists for the various phases of the connection process, as outlined in the main document. These checklists are intended as a memory-jogger for the developer, rather than as something to be followed slavishly. Some of the actions may not be relevant or appropriate to some projects, and the order in which they are carried out may vary from one project to another.

F.2 Information Phase

	Done	Date
Data gathering		
Maps obtained		
Site visited / surveyed		
Informal contacts with the DNO		
Initial phone call		
Meeting held		
Request for network data		
Formal request made		
Data received		
Provide data on generation scheme		
Data to be provided agreed with DNO		
Data sent		

F.3 Design phase

	Done	Date
Agree connection scheme and budget		
Route and connection voltage agreed		
Formal request for budget made		
Budget received		
Make connection application to DNO		
Formal application made		
Application acknowledged by DNO		
Up-front payment made		
Connection quotation received		
Connection quotation accepted/rejected		
Make connection application to other provider		
Application for quotation made		
Connection quotation received		
Connection quotation accepted/rejected		
Agree single line diagram		
Proposed SLD issued to DNO		
Comments received / meeting held		

	Done	Date
Amended SLD issued and agreed		
Detail design		
Developer system		
DNO system		
Earthing System		
Protection Studies		

Planning and wayleaving activities

	Done	Date
Division of responsibilities		
Responsibilities agreed with the DNO		
Planning		
Local planning authority notified of plans		
Formal planning application submitted		
Planning permission granted / withheld		
Application made for section 36 consent		
Section 36 consent granted / withheld		
Wayleaving		
Initial approach to landowners made		
Negotiations started		
Negotiations concluded		
Application made for section 37 consent		
Section 37 consent granted / withheld		

F.4 Construction Phase

	Done	Date
Construction Design & Management Regulations		
Health and Safety Plan completed		
Principal Contractor appointed		
Planning Supervisor appointed		
First site meeting held		
Health and Safety File(s) completed		
Place orders		
Civil works		
Miscellaneous site work (fencing, roads etc)		
Generation plant and equipment		
Third party connection work		
Metering equipment and services		
Earth electrode(s)		
Telecommunications connection		

Documentation

	Done	Date
Issues to be agreed with the DNO		
Nomenclature agreed		
Responsibility schedule agreed		
Protection settings agreed		
Connection agreement signed		
Technical & operating agreement signed		
Information to be posted at point of supply		
Contact details posted		
Responsibility schedule posted		
Protection settings posted		
Single line diagram posted		
Site safety rules posted		
Completion and hand-over documentation		
Hand-over certificates received		
Health and safety file received		

F.5 Testing and Commissioning Phase

	Done	Date
Planning		
Test programme agreed with DNO		
Provision of test results agreed with DNO		
Safety measures as appropriate, eg:		
Operational safety rules completed		
Authorised persons appointed		
Clearance certificates signed		
Equipment locked off		
Permit to work system initiated		
Test execution and energisation		
Pre-commissioning tests executed		
G59/1 tests completed & witnessed		
Connection energised		
First synchronisation witnessed		
Meters commissioned		

G Appendix G: Standards and Other Documents

Electricity Safety, Quality and Continuity Regulations (ESQCR)
The Electricity Safety, Quality and Continuity Regulations 2002 - Statutory Instrument Number 2665 -HMSO ISBN 0-11-042920-6 abbreviated to ESQCR in this document.

[Available FoC on DTI web site: www.dti.gov.uk]

BS EN 50160
Voltage characteristics of electricity supplied by public distribution systems

BS 7671: 2001 Requirements for Electrical Installations
IEE Wiring Regulations Sixteenth Edition.

Distribution Codes

a) The Distribution Code of the DNOs of Great Britain

[Available FoC on Distribution Code website www.dcode.org.uk]

b) The Distribution Code for Northern Ireland

Grid Codes

a) The Grid Code for England and Wales

b) The Grid Code for Scotland

c) The Grid Code for Northern Ireland

Engineering Recommendation G5/4 (2001)
Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution networks in the United Kingdom.

Engineering Recommendation G.59/1, Amendment 1 (1995)
Recommendations for the Connection of Embedded Generating Plant to the Regional Electricity Companies' Distribution Systems.

Engineering Recommendation G74
Procedures to meet the requirements of IEC 909 for the calculation of short-circuit currents in three phase AC power systems

Engineering Recommendation G.75/1, (2002)
Recommendations for the connection embedded generation plant to public distribution networks above 20kV or with outputs over 5MW.

Engineering Recommendation G.83/1, (2003)
Recommendations for the connection of small-scale embedded generators (up to 16A per phase) in parallel with public low-voltage distribution networks.

Engineering Recommendation P2/5
Security of Supply

Engineering Recommendation P28 (1989)
Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom.

Engineering Recommendation P29 (1990)
Planning limits for voltage unbalance in the UK for 132 kV and below.

Electricity Association Engineering Recommendation S34 (1986)
A guide for assessing the rise of earth potential at substation sites, 1986.

Electricity Association Technical Specification (EA TS) 41-24 (Issue 1, 1992)
Guidelines for the design, installation, testing and maintenance of main earthing systems in substations,.

Engineering Technical Report No. 113, Revision 1 (1995)
Notes of Guidance for the Protection of Embedded Generating Plant up to 5 MW for Operation in Parallel with Public Electricity Suppliers' distribution systems.

All Engineering Recommendations are available from:

Energy Networks Association
18 Stanhope Place
Marble Arch
London
W2 2HH

Tel: 0207 706 5100
Fax: 0207 706 5101

www.energynetworks.org.uk

H Appendix H: Contact Details for Organisations

Note – an up-to-date version of this data is kept on the ENA's website at http://www.energynetworks.org/dg02.asp

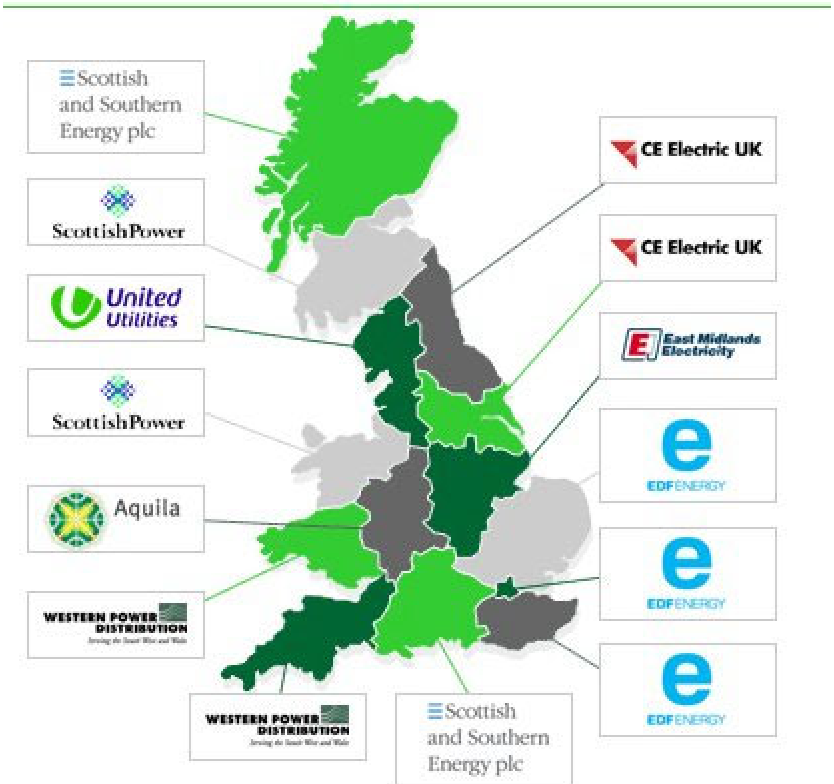
Company	Address	Contact Details	Area Served
Aquila Networks	Network Connections Section Aquila Networks Toll End Road Tipton West Mids DY4 0HH	Dave Harrison Tel: 08457 353637 ext 05/2477 or direct dial 0121 522 5018 or Wayne Oxborough Tel: 08457 353637 ext 05/2703 www.aquila-networks.co.uk	West Midlands
EDF Energy EPN / LPN / SPN Areas	Projects Gateway EDF Energy Metropolitan House Darkes Lane Potters Bar Herts EN6 1AG	Tel: 08701 964599 Fax: 0845 6500248 www.edfenergy.com	London, Eastern and South East
EME	Domestic Utility Connections Manager New Business East Midlands Electricity Herald Way Pegasus Business Park East Midlands Airport Castle Donnington DE 74 2TU	Kevin Sankar Tel: 01332 393452 www.eme.co.uk	East Midlands
CE Networks YEDL NEDL	Connections Commercial Manager Manor House Station Road New Penshaw Houghton Le Spring DH4 7LA	Connections Centre Tel: 08450 702 703 www.ce-electricuk.com	North East Yorkshire
NIE	Distributed Generation Connections Manager Power Networks Northern Ireland Electricity Danesfort 120 Malone Road Belfast BT9 5HT	Stephen Thompson Tel: 02890 661100 ext 32706 Fax: 02890 689265 stephen.thompson@nie.co.uk www.nie.co.uk	
ScottishPower (Manweb Area)	Network Investment SP PowerSystems Ltd ScottishPower 3 Prenton Way Prenton Merseyside CH43 3ET	Dave McCann Tel: 0151 609 2288 Fax: 0151 609 2309 www.scottishpower.co.uk	Merseyside and North Wales

Company	Address	Contact Details	Area Served
ScottishPower (Central and Southern Scotland)	Network Investment SP Power Systems Ltd New Alderston House Dove Wynd Strathclyde Business Park Bellshill ML4 3FF	Mr Paul McGimpsey Tel: 01698 413000 Fax: 01698 413321 www.scottishpower.co.uk	South of Scotland
SSE	Contracts Manager S+S 1st Floor North Inveralmond House 200 Dunkeld Road Perth PH1 3AQ	C B Neill Tel: 01738 456463 Fax: 01738 456555 www.scottish-southern.co.uk	North Scotland and Central Southern England
United Utilities	Terms & Conditions Manager United Utilities Service Delivery Hartington Road Preston PR1 8LE;	Tel:01772 848344 Fax:01772 848431 connections.liaison@uuplc.co.uk www.uuplc.co.uk/	North West
WPD	Business Support, Western Power Distribution, Phoenix Way Llansamlet Swansea SA7 9HW	Tel: 0845 601 3341 Fax: 01792 784510 wpdnewsupplieswales@westernpower.co.uk www.westernpower.co.uk	South Wales
WPD	Western Power Distribution Records Team Lostwithiel Road Bodmin Cornwall PL31 1DE	Tel: 0845 601 2989 Fax: 01209 616892 wpdnewsupplies@westernpower.co.uk www.westernpower.co.uk	South West
National Grid Transco	The National Grid Company plc National Grid House Kirby Corner Road Coventry CV4 8JY	National Grid Helpdesk Tel: 0800 777770 ISCustomerServiceSupport@uk.ngrid.com www.nationalgrid.com/uk	

Other organisations that could provide useful information for the connection of Distributed Generation are listed below:

Organization	Web-site
Combined Heat and Power Association (CHPA)	www.chpa.org.uk
Office of Gas and Electricity Markets (Ofgem)	www.ofgem.gov.uk
Department of Trade and Industry (DTI)	www.dti.gov.uk
British Wind Energy Association (BWEA)	www.bwea.org.uk

Organization	Web-site
Elexon	www.elexon.co.uk
Distributed Generating Co-ordinating Group	www.distributed-generation.gov.uk
Association of Electricity Producers	www.aepuk.com
Energy Networks Association	www.energynetworks.org.uk
Renewable Power Association	www.r-p-a.org.uk/
British Hydropower Association	www.british-hydro.org/
The Distribution Code of Great Britain	www.dcode.org.uk/



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