



The Distribution System Security and Planning Standards

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Distribution System Operator

ESB Networks Ltd.

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1 Introduction

ESB Networks Ltd; licensed by the Commission for Energy Regulation under S.I. 280 of 2008 as the Distribution System Operator (hereinafter “ESBN”, “ESB Networks”, “DSO”); is required to:

‘operate and ensure the maintenance of and develop, as necessary, a safe, secure, reliable, economical and efficient electricity distribution system...’

To this end, condition 11 calls for DSO to prepare this document: “The Distribution System Security and Planning Standards”. The Security and Planning Standards are prepared in adherence to the Distribution Code, which specifies the relationship between the Grid and Distribution Codes.

This document outlines the DSO’s approach to the development of network. The document gives details of how we assess the connection of new loads and embedded generators to the Distribution System. It is intended as a guide to Users of the Distribution System and is referred to in the Distribution Code (Item 13).

In developing the distribution system ESBN will engage as required with EirGrid – as Transmission System Operator – to ensure that the overall electricity system (both distribution and Transmission) is developed in a co-ordinated manner. Furthermore – and as also set out in condition 11 of the DSO licence – ESBN have engaged with EirGrid in this most recent revision.

1.1 Definitions

The definition and interpretation of terms used in this document are to be taken as defined in the Distribution Code and General Conditions for Connection to the Distribution System (hereinafter “General Conditions”), both available on ESBN’s website¹. For guidance purposes some terms are included in this document in Section 8 of this document

1.2 Aim of Planning

The aim of planning is to ensure that the Distribution System is developed in an orderly and cost effective manner in order to deliver a safe, secure and reliable distribution system having due regard to the environment. It is necessary to ensure that there is capacity available to meet new connections; whether demand or generation; as they arise; and to meet ongoing growth requirements. It is also necessary to ensure that new connections are made:

- in an economic fashion
- with a view to the possible future needs of the customer and the network
- in a way that is technically acceptable.

In terms of general system development, the MV and HV three phase backbone networks are planned to a single contingency standard. This means that the system is designed to withstand an outage of a single item of plant, and any outages experienced for this single contingency are only for such time as is required to transfer customers from faulted plant. In summary,

¹ www.esb.ie/esbnetworks

ESBN will provide customer connections, which will deliver the required capacity to an acceptable standard as detailed in the Distribution Code and will comply with the Grid Code at all points of connection to the Transmission System. A higher standard of installation or a higher security of connection arrangement can be provided at the customer's request, however, the full additional costs will be attributed to the customer.

2 Distribution System

The standard configuration of the Distribution System is illustrated schematically in Figure 1 below².

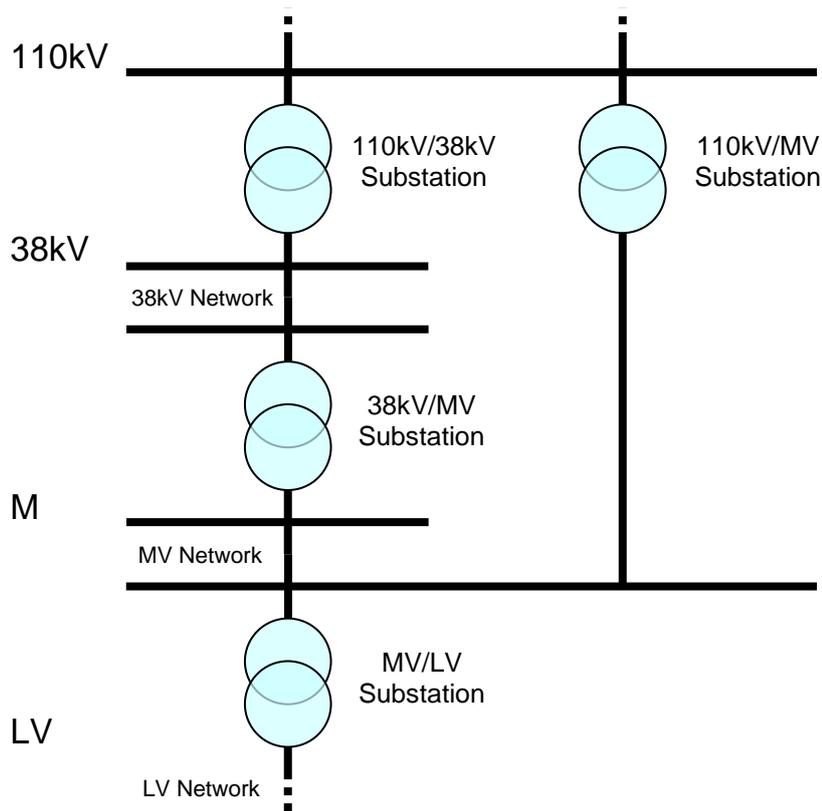


Figure 1. Representation of the Distribution System

² The 110kV system is primarily a Transmission voltage and connections at this voltage level are normally dealt with by the Transmission System Operator (TSO), however exceptions exist. Tailed 110kV substations used to connect lower voltage demand customers are deemed to be DSO operated installations. It is likely that in time such substations will be looped and typically become part of the Transmission network. Where this is the case, network will be developed in consultation with the TSO in accordance with Transmission Standards, or developed in such a way as to allow these standards to be easily met in the future.

2.1 Voltage Levels

There are a number of standard voltages in use on the Distribution System and customers will be connected at one of these levels. Voltage Levels at which a connection can be provided are as follows:

Voltage Level	Nominal Voltage
Low Voltage (LV)	230V (single phase)
	400V (3 phase)
Medium Voltage (MV)	10kV ³
	20kV
High Voltage (HV)	38kV
	110kV

Table 1

Generally the voltage level at which customer connection will be made is dependent on the capacity range of the application (import or export). The typical voltage level for various import and export capacity ranges is shown in Table 2 below.

Voltage	Typical Capacity Range	
	Demand	Generation
LV	0 – 500kVA	
MV	500kVA – 10MVA	
38kV	>5MVA	5MVA – 40MVA
110kV	>5MVA ⁴	>5MVA ⁵

Table 2

LV Demand connections: For existing LV demand connections seeking an MIC increase, it may be possible to provide under certain conditions capacities over 500kVA at LV, however in most cases connections above 500kVA are connected at MV

MV Demand connections: At MV the capacity available from an existing 38/MV substation will generally be limited by the 38kV circuit capacity on standby and by capacity available following outage of one transformer in the substation, allowing for planned requirements, so that at best no more than 5MVA would typically be available. In 110/MV substations capacity available

³ Urban MV Networks are largely operated at 10kV, while rural MV networks are operated at either 10kV or 20kV.

⁴ Depending on network configuration, or where lower voltage networks are not available, a demand connection of >5MVA may require a connection at 110kV.

⁵ 110kV generation connections would normally be expected for generation capacities >40 MVA, unless the Least Cost Technically Acceptable [LCTA] method of connection for a Generator or Group of Generators dictates otherwise, in which case generation capacities >5MVA may also be connected at that voltage (110kV).

is again determined by 110kV circuit capacity, by capacity available following a transformer outage and by planned capacity requirements.

Feeding higher demand loads, up to 10MVA, at MV assumes a 110/MV substation nearby, typically in a business park or adjacent to the load. No single MV demand customer should exceed 10MVA. Individual customer loads not in the vicinity of a 110/MV substation would be fed at 38kV or 110kV

2.2 Effects of Disturbing Loads

Certain types of equipment such as motors and welders may cause fluctuations in the supply voltage, which cause disturbances to the connection of other customers. Where customers intend to install any equipment likely to cause supply disturbances, this equipment must be evaluated to assess the likely impact. The limits imposed on disturbing loads are specified in the Distribution Code. It may be necessary, depending on the characteristics of the equipment, for a customer connection to be made using a different network configuration via a higher voltage, a dedicated substation or other method.

3 Assessment of New Connections

The assessment of the connection requires details of the load or generation to be connected. The details should be provided by completing an application form which can be obtained from ESNB website.

3.1 Information Required from Customers

Details of the information required from demand customers and generators seeking connections or extensions to the Distribution System are provided in the Distribution Code. Application forms for connection are available on the ESNB website. Specifically the following information may be requested, depending on the nature of the development.

3.1.1 Geographical location

Site location maps and site layout plans in order to determine the location of the proposed development in relation to the existing network.

3.1.2 Maximum Import and/or Export Capacity (MIC, MEC)

Maximum Import Capacity (MIC) required, the size and nature of the load, diversity of the load and proposed phasing of the development i.e. the pace at which the load is expected to ramp up to full demand. In the case of generators; the Maximum Export Capacity (MEC), the size and nature of the export required and the proposed phasing of the development etc.

3.1.3 Disturbing Loads

Details of any disturbing elements⁶ of the load for demand applications⁶ are required such as:

⁶ Disturbing loads are not typically a feature of generator connections

- Large motors - details of starting arrangements for all large motor.
- Disturbing Loads i.e. electric welding, and details of the nature and usage pattern of the disturbing load.
- Harmonics - details of any non-linear equipment likely to produce harmonics on our system and any filtering arrangements which the customer may have already in place. The customer should also provide details of compensation or balancing equipment connected.
- Unbalanced Loads – Where a customer has a three phase supply, load should be balanced as evenly as possible over the three phases.

The above is an example of the information which may be requested. Depending of the size and complexity of the load, additional information may also be requested.

- Power Factor – The power factor of the customers load as seen by the network is assumed to be between 0.95 and unity.

Examples of disturbing loads are given in Section 6.

3.1.4 Multi-Unit/Multi-Connection development versus Single Unit/Connection

Whether the application is for infrastructure to facilitate load connections to multiple end customers within a development or is for connection of a single load customer.

3.1.5 Specific Requirements

Details of any specific customer requirements for connection.

3.1.6 Demand Diversity

Customers should note when assessing the capacity requirements they should consider that not all of the equipment will be operating at full load at the same time. The customer should apply a diversity factor to each component of the load, as well as to the overall load in order to assess the capacity required. Diversity factors will vary depending on the nature of the load. For domestic customers the diversity will be applied by DSO

3.1.7 Domestic Customers

The standard domestic connection offered by DSO is 12kVA. Domestic customers can be part of a housing scheme, or can be non-scheme. A housing scheme is defined in 'Basis of Charges for the Connection to the Distribution System' which is available from the ESNB website

3.1.8 Generation Customers

Generation applications will need to provide details and characteristics of the plant proposed for connection and data to facilitate modelling the impact of

this plant on the wider electricity system. For full information see application form NC5, available from the ESN website.

3.2 Requirements for a Terminal Substation

A Customer or Developer should check directly with ESN at the earliest stage of project design regarding a requirement for the provision of a Terminal Substation / Site for the development. However the following sections set out guidelines on this requirement.

3.2.1 Requirement for a HV Terminal Substation and Site (Demand).

Where the connection voltage is determined to be at 38kV or 110kV then a HV Terminal Substation and site, to comply with the appropriate specification for 38kV or 110kV connection, is required in all cases. The terminal substation may be either indoor or outdoor based on the least cost technically acceptable solution. Typically substations being developed in urban areas and town centres will be indoor, whereas those in more rural locations will be outdoor (subject to a suitability study).

3.2.2 Requirements for a HV/MV Transformer Substation and Site (Demand)

In some cases where a customer is connected at MV, but this load cannot be met by the existing MV network, a HV/MV terminal substation and site may be required. The general guidelines and site requirements for a Terminal Substation and site under these circumstances are shown in Table 3 below. Please note that these requirements are in addition to those outlined in 3.2.3 below.

Maximum Import Capacity (MIC)	Customer requirement for the provision of a Substation Building and Site
≥ 5MVA	HV/MV Terminal Substation will be required in most cases for loads greater than this level
<5MVA	<p>A HV/MV Transformer Substation may be required where this is the least cost technically acceptable solution based on :</p> <ul style="list-style-type: none"> • The MIC (MVA) of the proposed load. • Disturbing elements of customer load • The distance from the existing substations to the proposed load. • Any spare capacity above planned requirements available on existing substations and on the local MV network. • The Customer's future expansion plans

Table 3

3.2.3 Requirements for a MV Terminal Substation and Site (Demand).

MV connected customers are required to provide an MV Terminal Substation Building and site to comply with the standard ESB NETWORKS MV

Substation Building Specification in all cases⁷. A customer MV Switchroom housing the customer owned main incoming circuit breaker will be required to be located immediately adjacent to and adjoining the ESB substation building.

3.2.4 Requirements for a MV/LV Transformer Substation (Demand).

The general guidelines for the provision of an MV/LV Transformer Substation Building and site to ESB Networks, by a customer connected at LV are shown on the attached table.

Maximum Import Capacity (MIC)	Customer requirement for the provision of a Transformer Substation Building
≥ (Greater than or equal to) 200kVA	Customer / Developer to provide a Transformer Substation Building. See “Basis of Charges for Connection to the Distribution System” which can be obtained from ESNB’s website
Urban Areas <200kVA	In certain cases for loads less than 200kVA in Urban Areas a Transformer Substation building is required where this is the least cost technically acceptable solution based on: <ul style="list-style-type: none"> • The MIC (kVA) of the proposed load. • The distance from existing substations to the proposed load. • Any spare capacity above planned requirements available on existing substations and on the local LV networks. • The Customer’s future expansion plans. • Nature of development; - In a mixed development where there are both commercial and residential loads being connected.
Rural Areas <200kVA	Connection to a pole mounted transformer (up to 200kVA) is the norm. Where future expansion is envisaged that would raise the proposed MIC above 200kVA. A Transformer Substation building will be required.
Environmental Considerations	In locations where the electrical equipment would be contaminated by dust or other hazardous substances which would lead to a breakdown of the electrical insulation

Table 4

Where an ESB MV/LV transformer substation is required, a customer LV Switchroom housing the customer owned switchgear will be required to be located immediately adjacent to and adjoining the ESB substation building.

A unit substation and site may be suitable for low density distributed load developments, i.e. residential developments only, and will generally not be considered for mixed or commercial/industrial high load density type developments.

3.2.5 Requirement for Generators.

The requirement for a terminal substation and site or transformer substation and site for Generation connections is broadly similar to Demand

⁷ Available from ESNB’s website www.esb.ie/esbnetworks

connections, i.e. depending on proposed generation capacity and connection voltage. Given the additional complexity of group processing, potential interaction between generation connections and other criteria, the specific substation and site requirements for a generator will be advised as a matter of course during the application process.

4 Determining the Least cost Technically Acceptable Solution.

4.1 General

In the context of demand connections, the Least Cost Technically Acceptable Solution is defined as the most economic and technically acceptable connection option solution taking into account an estimate of the standard costs incurred at the customer end of the connection, the future development requirements in the area and the cost of network losses that are expected to arise. Any costs incurred by DSO in providing a connection or installing infrastructure which are deemed by DSO to be over and above the Least Cost Technically Acceptable solution, and which are at the request of the customer are borne in full by the customer or developer.

In the context of generation, and in particular the Group Processing Approach, the LCTA solution will take account of the sub-group as a whole. As the charging methodology is different for generators, while the criteria for technical acceptability are similar, the least cost aspect refers to the cost to be charged to the generator or sub-group as a whole.

The following factors are taken into account when determining the method of connection and the Least Cost Technically Acceptable solution in the context of the development of the area.

4.1.1 Adverse Interactions

The customer's connection and its interaction with the wider electricity distribution system must not have an adverse effect on another connection or part of the distribution system such that it causes the quality of supply to fall outside the standards as set out in the Distribution Code.

4.1.2 Location of Substation site

Selection of a suitable site for the substation to be developed by DSO will depend on the location of the project to be connected, the location of the Transmission and Distribution network to be connected to the substation, and other geographical factors.

The following items might typically be considered when assessing a site:

1. The substation should be accessible for potential future connections
2. Where possible, the substation should be located such that road/water crossings are avoided
3. Substations located at site boundaries are generally more suitable

4. Typically site locations close to a public road, which limit the need for excessive intrusion on customer or third party land, would be best
5. Substations should be at ground level with good access for equipment and personnel, should have suitable routes in the ground for cable entries and should not be liable to flooding. Access for communications cables should also to be catered for.
6. Finally the structural finish required on the substation must take account of the area in which the substation is being built. For examples, a higher standard would typically be required in a residential/commercial area rather than an industrial estate.
7. ESNB will acquire the freehold interest in the land within the curtilage of the substation. ESNB will obtain and maintain a right of way to the substation.

The above give some guidelines which may be used in selecting the best site for a substation. However each situation must be assessed individually before choosing the best site location.

The specific criteria, which are used to determine the Least Cost Technically Acceptable Solution in the context of a Business Park or Town Centre, are outlined in Section 7.

4.1.3 Location of Customer

The position of the project to be connected relative to a **suitable** network will be a significant factor in determining the connection method. The project may be close to the network but this does not necessarily mean that a connection can be made at this point. Connections can only be made from that part of the network which has adequate capacity, taking into account the impact of existing and other proposed projects.

In general the least cost technically acceptable method of connection is to the adjoining network but there are several factors which may necessitate an alternative connection e.g.

- The adjoining network may not be at the appropriate voltage level or it may not have the necessary capacity.
- System requirements for the adjoining network may mean there is not sufficient spare capacity to allow the new connection.
- The capacity of the networks at the same voltage may vary considerably from one location to another. In urban areas, for example, it may be possible to connect a project at a lower voltage than would be the case in rural areas.

4.1.4 Short Circuit Capacity

The design short circuit ratings for various connection voltages are provided in section DCC6.5.1 of the Distribution Code.

The short circuit rating of Customers' equipment should not be less than the design capacities given in section DCC6.5.1 of the Distribution Code. It should be noted however, that the actual short circuit level at the connection point may differ from the design level.

Generation connections can increase the fault level on the system, which can drive the requirement for reinforcement work.

4.1.5 Protection Information

Protection systems and devices are provided for the ESB system and plant. Typically they cause plant to be switched out to protect the ESB system, staff and customers in the event of a fault on the system. How they operate will depend on their location on the system and the plant they are installed to protect. ESB Networks plan for network development including protection in order to minimise the extent and duration of any fault-related outage, damage to plant and duration of voltage dips to a reasonable level.

In general the provision of primary and back-up protection for both phase and earth faults is considered mandatory. However in relation to the fault types listed below primary protection is mandatory, with back-up protection provided where practicable:

- LV Faults
- 10kV earth faults fed from interface transformers
- MV phase faults at the extremities of networks or close to high capacity sources.

Some protection schemes used are as follows:

4.1.5.1 Impedance (distance) Protection

This operates by determining the impedance of a fault back to source, and tripping the faulted feeder to clear a fault. Impedance protection is generally installed on 110kV feeders, 38kV feeders ex 110kV substations, on 38kV feeders in loops or meshes and on some feeders on open radial networks.

4.1.5.2 Differential Protection

This operates by determining the difference in current between the two ends of a feeder. It is installed on 110kV busbars, power transformers and on HV feeders when the impedance of the feeder is too low for impedance protection to be effective. The latter includes cable networks and very short overhead lines

4.1.5.3 Earth Fault Protection

This is provided in many variations depending on the way the system neutral is treated. This form of protection can be watt metric or transient (38kV), directional comparison (110kV), residual overcurrent (110kV, MV) or directional residual overcurrent (MV).

4.1.5.4 Protection on MV Networks

Phase overcurrent protection is provided on 38kV/MV station MV feeders to protect against phase faults. This can be by relays and circuit breakers, reclosers or expulsion/current limiting fuses

Reclosing is provided on long MV feeders. This ensures that – where a fault is transient (e.g. a falling branch) – supply interruption will be very short. Customer processes in such locations should be designed to tolerate recloser operation e.g. self-priming pumps, use of UPS, ride through facility etc.

A number of additional schemes are in use across the ESNB system. These include permissive intertrip schemes, rudimentary busbar protection schemes, circuit breaker fail schemes and parameter changeover logic.

4.1.5.5 LV Protection

This is comprehensively covered in ESB’s National Code of Practice for Customer Interface.

The above are some of the protection schemes in use by ESB. The protection required on the network in any given location is assessed and designed to suit the particular circumstance while complying with ESB policy and practice.

4.2 Demand Connection Considerations

4.2.1 Voltage Drop

One of the factors limiting the connection of new load to a network is the level of voltage drop incurred in carrying the current from the substation to the customer’s premises. This is particularly true of rural networks where the length of network involved is often large. Section DPC4.2.2 of the Distribution Code outlines ESNB’s responsibilities in relation to voltage ranges and the international standard EN50160.

The voltage ranges at the ESB Substation busbars using these design standards will be as follows:

Voltage at Busbar.					
	LV	10kV	20kV	38kV	110kV ⁸
Normal Feed	207V to 246V single phase; 360V to 424V Three phase.	≤10.70kV	≤21.40kV	≤41.6kV	≤120kV

Table 5

The above voltages are part of the criteria to which the network is planned. Operational conditions may mean that the voltage varies from these values.

If the voltage drop is outside standard then:

- an alternative method of connection will be required; or

⁸ 110kV mentioned excludes 110kV network under TSO control.

- a voltage injection from a new substation should be considered

4.2.2 Network Examination Pertinent to Load Connections

On deciding on the method of connection it must first be established that the existing network has adequate capacity. If this is not the case then it will be necessary to upgrade the network or construct additional network to facilitate the new connection

Networks are assessed to determine:

- Voltage levels
- Line/cable loading under normal feeding and standby feeding conditions.
- Substation loading under normal and standby feeding conditions
- Short circuit capacities on the networks in question

Expected circuit loading is calculated for both Winter and Summer loading conditions. The network capacity limits are specified for two conditions of ambient temperature⁹ to correspond to Winter and Summer conditions. In addition, any new load in excess of a given threshold¹⁰ must be assessed by the TSO to determine the impact on the Transmission System.

The planning and design of the network does not allow any plant or network to be loaded beyond its normal rating, as specified by the manufacturer, except in emergency situations designated by the DSO.

4.2.3 Substation Capacity

Having established that the capacity of the network is sufficient the capacity of the substation feeding this network must be considered. Where the substation capacity is not adequate to take the additional load either it must be upgraded, an alternative substation must be used or a new one constructed.

4.2.4 Other Reinforcements

The addition of a new or increased load at one voltage may result in reinforcement being carried out at the voltage level above. This could occur, for example, where a line or substation is nearing its capacity and the addition of the new load requires this to be increased. In some cases the reinforcement may not be required immediately but may have to be done sooner than previously planned as a result on the new load being connected.

For larger loads Transmission reinforcements may also be required and this would be specified by the TSO.

⁹ Weather conditions are: ambient temperature 5° or 25°, 2MPH cross wind, full sun radiation.

¹⁰ The threshold at present is 4MVA unless otherwise requested by the TSO for specific locations.

4.2.5 Network Configuration (how the load is connected)

Major¹¹ loads are connected to the system through ESB substations on the customers' premises.

- The connection may be looped in which case two connecting lines/cables (normal and standby) are provided at the same voltage from a main circuit which can be fed from either end. The main circuit is operated normally open at a suitable point on the circuit or in the case of some 38kV network the loop may be operated normally closed.
- Dual Radial connections at MV may be used if appropriate to the local network configuration. The standard implementation will utilise service connections from shared network

Except in exceptional circumstances, point loads greater than 1MVA will be looped and the main circuit designed to provide full standby.

There is no standby connection for tail fed arrangements should the outage or fault occur on the tail. Such connections may be used in cases where it is uneconomic to provide a looped connection, and by agreement with the customer, having due regard to the continuity implications of such a connection.

4.2.6 Treatment of Electrical Losses for Demand Connections.

Electrical losses on the network impose a significant cost – both financial and environmental - and must be managed. Therefore losses are taken into account in determining the optimum connection method. For MV and HV circuits losses are calculated for three phase only as single phase losses are small in comparison. Losses are proportional to

$$I^2 R$$

where 'I' is the peak load in amps on the section of line concerned and 'R' is the DC resistance at 20°C of the conductor or equivalent conductor on that section in ohms per km per conductor.

It can be seen that if the line is heavily loaded then a small load increase will dramatically increase the cost of losses.

The setting of overall design parameters for the network takes account of the economic loading of conductors so that the long-term effect of losses is minimised.

4.2.7 Economic Analysis for Establishing a Load Connection.

A number of options may be available to provide new or increased capacity to a customer. In evaluating the cost/savings involved in each option, the time at which these will be incurred is relevant. Therefore, to compare different options economically all cash flows are evaluated in terms of the current value of money. All future cash flows are converted to present value by discounting. The time span of the analysis should extend to the point when options have attained equivalent stages of development. This does not

¹¹ Larger capacities, typically 4MVA and above at MV or any capacity connected at 38kV, 110kV

always happen and depending on the project a time span of up to 20 years may be considered.

The main costs to be included in the analysis are:

- Gross cost of networks and substations and reinforcements;
- Losses.
- Continuity (e.g. value on Customer Minutes Lost, and how the project might affect continuity)
- Relevant transmission costs – to be advised by the TSO.

In assessing the various options the detailed planning criteria must be considered. Thus factors such as network configuration, operation and protection policy on looped and radial circuits and limitations on substation types (looped, tail, or teed) are addressed.

The Least Cost Technically Acceptable Connection Method to provide the capacity required will be the most economic solution based on the above calculations.

The principles of the charges for connection are contained in the “Basis of Charges for Connection to the Distribution System”.

4.3 Generation Connection Considerations

4.3.1 Volt Rise

When Generators feed power into an existing distribution system, the voltage on the system usually rises. Limits need to be imposed on any such voltage rise in order to ensure that there is no detrimental effect to existing customers.

At LV, the volt-rise limits are dictated by EN 50160

For generator connections at MV or higher, it must be ensured that at any Point of Common Coupling with customers supplied via standard ESNB transformer the maximum voltage imposed by the presence of the generator [V1 below], will not exceed the tapping range of such transformers connected at the Point of Common Coupling. Otherwise, all customers downstream could be provided with voltage outside standard.

For lines/cables to which only generators are connected, some additional latitude on voltage rise limits is given to planners, subject to global considerations that relate to the partial sterilisation of such lines/cables for subsequent connection of demand connections [V2 of Figure 2 below]. The Distribution Code indicates the absolute maximum voltages at the connection point to be expected at generator sites. Customer design at such sites should take these into account, particularly, if applicable, in relation to tapping ranges of On Line Tap Changers on the customer’s step-up transformers.

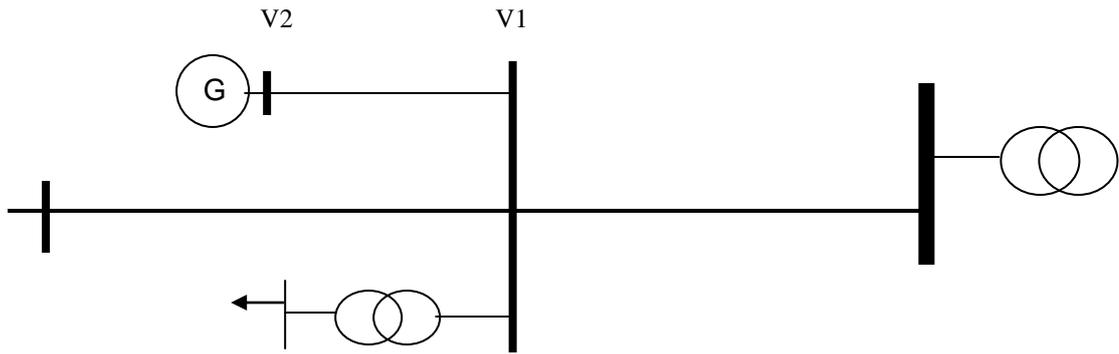


Figure 2

The table below shows the maximum voltage at the connection point for generators:

Nominal Voltage	Highest Voltage at PCC ¹² with demand supplied via ESN standard transformers	Highest Voltage at connection Point
230V	253V	253V
400V	440V	440V
10kV	11.1kV	11.3kV
20kV	22.1kV	22.5kV
38kV	43kV	43.8kV
110kV	120kV	120kV

Table 6

4.3.2 Network Examination

On deciding on the method of connection it must first be established if the existing network has adequate capacity to cater for both the real and reactive power ranges of the generation. If this is not the case then it may be necessary to upgrade the network or construct additional network to facilitate the new connection

Connections for wind farms greater than 0.5MW are typically studied by group processing the resultant outcome being the least cost technically acceptable connection method for the group

Networks are assessed to determine:

- Voltage levels

¹² Point of Common Coupling; the point at which the connection interacts electrically with other customer connections

- Line/cable loading under normal and standby feeding conditions.
- Line/cable loading for reactive power ranges of the generation based on normal and standby conditions

Substation loading under normal and standby conditions In general, the most onerous scenarios are studied for the particular parameters being assessed. In the majority of cases, in assessing the impact of a generator connection, this is under minimum load conditions. Where a maximum load condition is more onerous, this will also be studied.

The planning and design of the network does not allow any plant or network to be loaded beyond its normal rating, as specified by the manufacturer, except in emergency situations designated by the DSO.

4.3.3 Demand Customers Applying to Install Export Capacity

Existing demand customers should note that their MIC does not necessarily equate to an inherent symmetrical MEC. Studies will need to be carried out to determine the voltage rise, impact on customers sharing point of common coupling and upstream (higher voltage) systems.

e.g. DSO cannot guarantee that an existing demand customer with an MIC of 3MVA can export (have an MEC of) 3MVA on the same connection without any further reinforcement requirements.

4.3.4 Reinforcements

The addition of a new or increased capacity or connected generation at one voltage may result in reinforcement being carried out at the voltage level above. This could occur, e.g. where an MV generation connection feeds through the 38kV/MV substation and resultant power flow on the 38kV network exceeds the conductor capacity. In some cases planned reinforcement, not required at present may have to be done sooner than previously planned as a result of the new/additional generation.

Transmission reinforcements may also be required and this would be specified by the TSO.

4.3.5 Transformer Capacity for Generation in Existing Substations

In assessing a proposed connection of a generator or generators to a busbar of an existing station, the ability of the existing transformer or transformers to accommodate the flow of power due to the presence of the generators must be assessed. The following principles and guidelines are used in such assessments.

4.3.5.1 Use of Minimum Load

In assessing transformer capacity, the minimum load or Summer Night Valley (SNV) load is taken into account

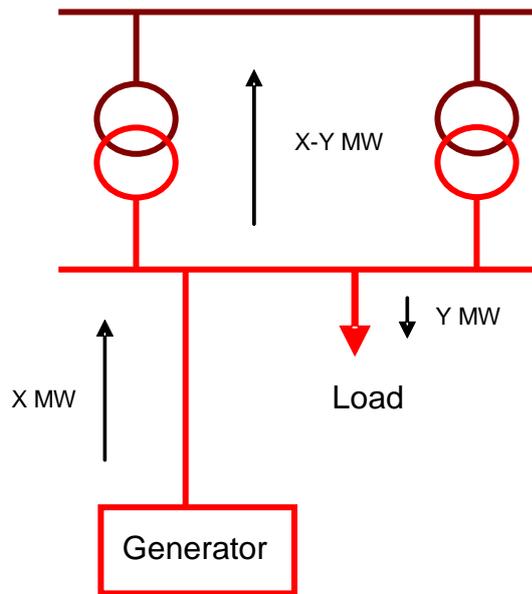


Figure 3

The reason for this is illustrated the example shown above, there are X MW being generated. There is Y MW of load on the station. Therefore, the power flowing through the transformers is then $X - Y$ MW. Therefore, for a given amount of generation, the power flowing through the transformers from the generation will be at maximum when the load is at the station is a minimum. .

4.3.5.2 Consideration of VArS

Each transformer has a rated capacity which is expressed in apparent power (MVA or kVA). In order to reflect this, it is necessary therefore to consider MVArS as well as MWs. Load generally tends to import VArS. Generation may, depending on a number of factors, operate importing or exporting VArS. For the former case, the MVArS for load and generation would add as opposed to netting off as with MWs. Available capacity will be determined by considering the combined impact of MWs and MVArS.

4.3.5.3 Transformer Overload Allowance for Wind Generation

Before allowing a new generator to connect it has to be determined whether the additional generated power causes the transformer's rated capacity to be exceeded. For wind generation an allowance of 10% is permitted recognising that the ambient temperature at times when the wind is blowing will generally be lower than the value assumed when designing a transformer for a given rating.

4.3.5.4 Two Transformer Stations

Where in an existing demand station, there are two transformers normally operating in parallel in a station, the capacity available for the connection of generation takes account of only one of the transformers. This allows one of transformers to be taken out of service if required, without causing an outage for the generator(s).

4.3.6 Existing or Committed Generation Connections

Any generators already connected or committed to connect must also be considered when determining available system capacity.

4.3.7 Loss of Feeder and Voltage Change

In the event that a generator to which it is proposed to connect to a Point of Common Coupling with existing demand customers, trips for any reason; a resulting step change in voltage will be experienced by the existing customers. In order to minimise the effect on other customers, the step change in voltage is limited to 10%.

4.3.8 Losses

As set out in Section 4.2.6, losses on the distribution system have a financial rather than a purely technical impact on the system. As a consequence and acknowledging that Distribution Loss Adjustment Factors (DLAF) are applied to generation connections, losses are not a technical constraint for networks used for dedicated generation connections. Based on the DLAF, it will be for the applicant to assess the energy sales implications of the connection method offered. In the event that the applicant, having assessed such implications, determine that their interests would be better served by an alternative connection method involving less losses but most likely a higher capital cost, then they are within their rights to request a modification to their connection in the normal way.

For networks which will be shared by two or more generators, ESNB will, subject to all other technical criteria being satisfied, offer a conductor size which will in ESNB's view yield the most efficient use of that asset over the lifetime. However should all parties sharing the network request a modification to a higher conductor size then – subject to the connection method being technically acceptable – a revised connection method may be offered.

4.3.9 38kV Connected Tees

A maximum of one 38kV tee'd connection to an existing 38kV overhead line is, in principle, allowed between 38kV cubicles fitted with standard 38kV protection. However this may be over-ruled on a case by case basis if protection studies indicate unacceptable breaches of protection performance.

Where such a tee is part of a least cost technically acceptable connection method fed by overhead lines, it ESNB policy to install a minimum of two 38kV Load Break Fault Make Switches (LBFM) at the tee points. If operational requirements dictate, three switches may be required.

In the event that the method of connection changes, for any reason, from overhead line to all UG cable; a teed connection will no longer be technically acceptable and alternative approaches will be looked at.

4.3.10 Use of Normal and Standby Circuits

Where the method of connection for a given generator is to an existing 38kV demand station which is looped, it must be possible to accommodate the full MEC on both normal and standby 38kV circuits.

This would also extend to consideration of the capacity of 110/38kV transformers in the 110/38kV station on the standby circuit, under intact and n-1 system conditions.

4.3.11 Impact on short circuit levels

In assessing a generator connection, due regard should be had, to the impact of the proposed generator[s] on the short circuit levels prevailing on the Distribution network.

Where an impact is identified such that there are safety implications, for example where the generator would cause the prevailing short circuit level at the location of DSO operated circuit breakers to exceed their interrupting capabilities, the generator will not be allowed to connect until the issue has been resolved.

4.3.12 Impact on Distribution System stability

Where the DSO form the view that a large generator could pose a localised threat to the stability of the Distribution System, for example rotor angle stability, DSO reserve the right to carry out or otherwise initiate, specific stability studies to quantify such impacts.

Where the outcomes of such studies identify necessary changes to, for example, protection operating times or drive specific remedies, these must be in place before the generator in question is connected.

4.3.13 Harmonics

Some generators produce harmonics which can distort the connection voltage waveform to such an extent that electrical equipment may not operate correctly.

Generators are assessed to determine the likelihood of this and in certain cases an alternative connection method may be required, or may have specific harmonic distortion limits applied. These limits may be different to those specified in the Distribution Code.

5 Security Issues

Some more general issues which are considered as part of planning for the whole system are as follows:

5.1 Security of Connection

Security of Connection is an important consideration in the planning of the Distribution System. ESB Networks are planned on the basis of maintaining a

level of supply reliability which meets the needs of the majority of customers. However ESB Networks, in common with other power utilities, do not guarantee standby supply being available in all circumstances. Accordingly customers with critical loads should ensure that alternative supplies (e.g. generators, UPS systems) are available if their process is critical.

For generation connections, see 5.2 for examples illustrating security implications for a given connection arrangement.

It should be noted that the Security of Connection is not only dependent on the Distribution connection methodology but also on the Transmission System Security and Planning Standards.

In certain situations where a looped connection is particularly difficult; loads somewhat in excess of 1MVA may be tolerated without standby provision. However these situations should be avoided as far as possible and should be remedied at the earliest opportunity.

5.2 Security Implications for Generator Connections

5.2.1 Connection to the Generator via Single Item of Plant

Depending upon the nature and topology of the connection method offered for a generator connection, one or more generators may be connected via a single item of plant, hereinafter referred to as “the single item of plant”. An example would be where one or more generators are connected via a new dedicated transformer.

Any fault outage which causes the single item of plant to be unavailable will result in an outage of the Generator.

In the event of a planned outage which causes the single item of plant to be unavailable, this will also result in an outage of the Generator. In such an event, the Generator will be notified as per the Distribution Code DPC 4.4.3.

Examples of these occurrences for various topologies are given in the following Sections

5.2.1.1 Tail Fed and Single Transformer Stations

Connection to the Generator is Made Through a New Generation Only Tail Fed Transformer Station

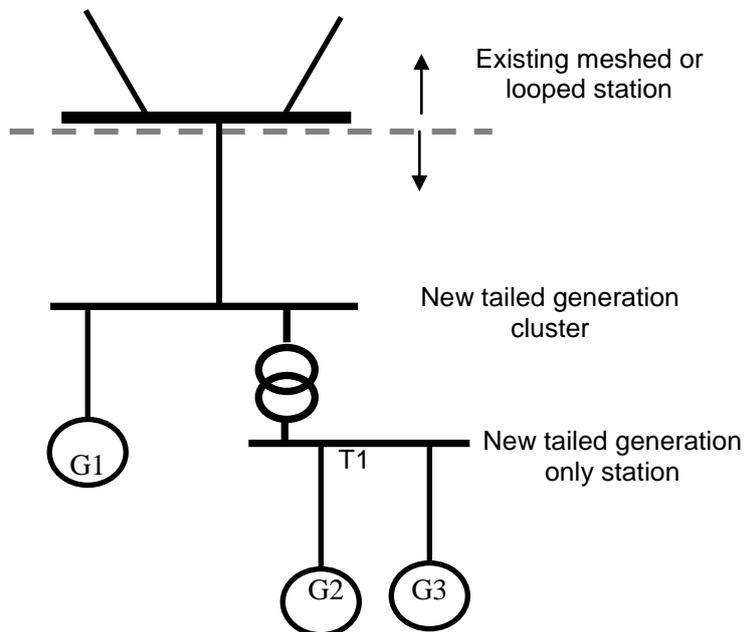


Figure 4

- As depicted in Fig 4 above, any outage to the higher voltage line/cable feeding the tailed station or tailed station busbar will cause an interruption to G1, G2 and G3. A connection will not be restored to the generators in question until such time as the line/cable in question is restored to service
- As depicted in Fig 4 above, any outage to the transformer T1 will cause an interruption to G2 and G3. A connection will not be restored to the generators in question until such time as T1 is restored to service
- In the event of planned outage, the Generator will be notified as per The Distribution Code (DPC 4.4.3).

Connection to the Generator is Made Via an Existing/Proposed Tail Fed or Single Transformer Station, Supplying Demand

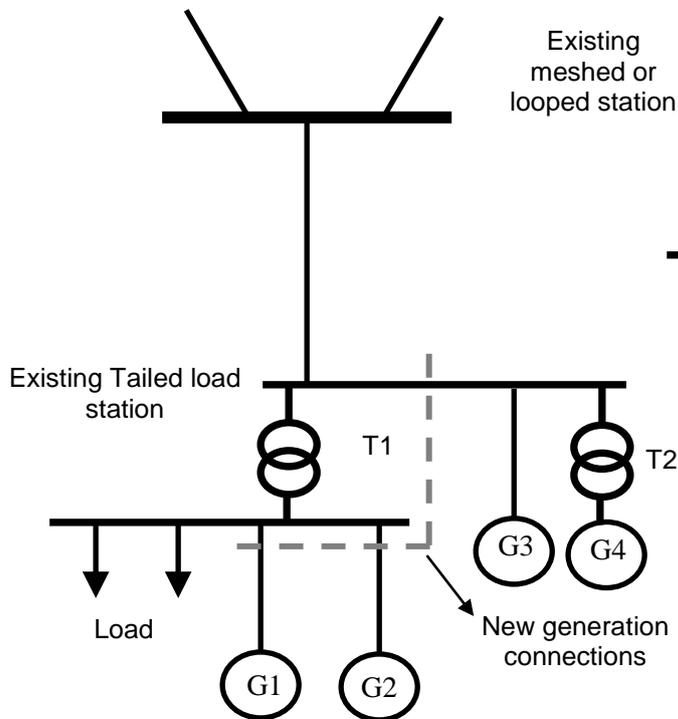


Figure 5

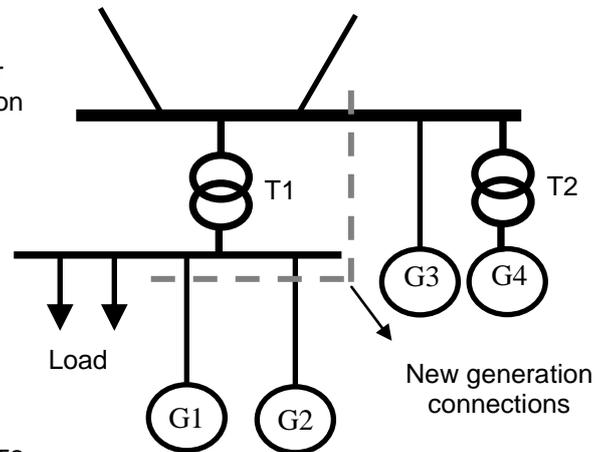


Figure 6

- As depicted in Fig 5 above, any outage to the higher voltage line/cable feeding the tailed station or tailed station busbar will cause an interruption to G1, G2, G3 and G4.
- As depicted in Fig 5 and 6 above, any outage to the transformer T1 will cause an interruption to G1 and G2.
- As depicted in Fig 6 above, if the looped station is single busbar, an outage of the half busbar at the looped station to which G3 and G4 is connected, will cause an interruption to G3 and G4.
- In the event of planned outage, the Generator will be notified as per the Distribution Code.

5.2.2 Connection to Lower Voltage Busbar of New-Build Station for Generation

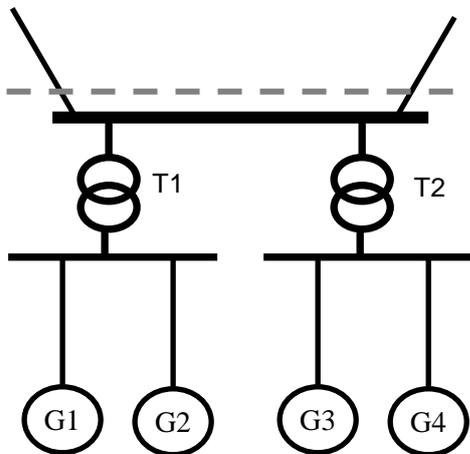


Figure 7

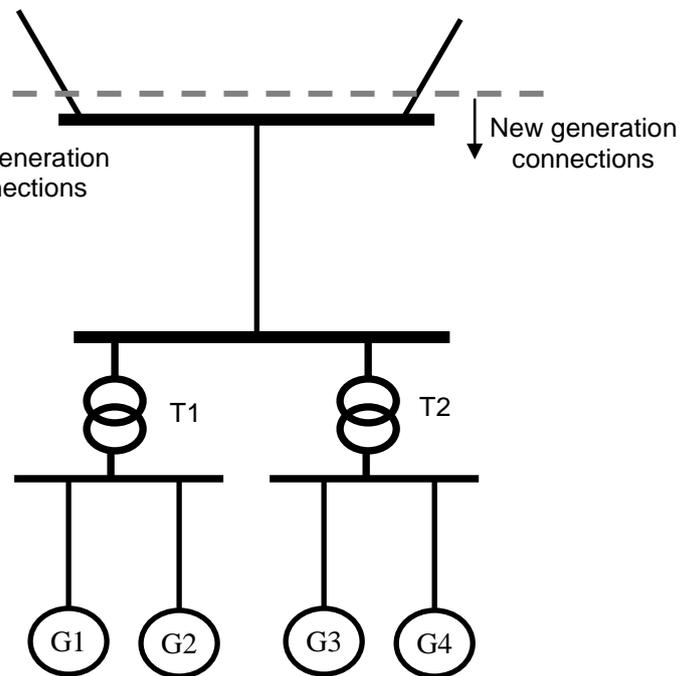


Figure 8

- Unless otherwise agreed, redundancy of the transformers is not a consideration in the design of the station. i.e. effectively the transformers in question each operate similar to tail fed single transformer stations and do not provide standby to the other
- As depicted in Fig 7 and 8 above, any outage to the transformer T1 will cause an interruption to G1 and G2. A connection will not be restored to the generators in question until such time as T1 is restored to service
- As depicted in Fig 7 and 8 above, any outage to the transformer T2 will cause an interruption to G3 and G4. A connection will not be restored to the generators in question until such time as T1 is restored to service
- As depicted in Fig 8 above, any outage to the higher voltage line/cable feeding the tailed station or tailed station busbar will cause an interruption to G1, G2, G3 and G4. A connection will not be restored to the generators until such time as the high voltage line/cable is restored to service
- In the event of a planned outage, the Generator will be notified as per the Distribution Code.

Where there are multiple lower voltage busbar sections, separated by open busbar sectionalising Circuit Breakers, in the event of loss of a transformer due to a fault, adjacent bus sectionalising Circuit Breaker(s) will not be closed through Operator intervention

5.2.3 Connection to Lower Voltage Busbar of a Conventional Transformer Station for Demand with Two Equally Sized Transformers

This section sets out the operational implications of the proposed feeding arrangement. Section 4.3.5. sets out how the planners establish the capacity available.

Where the Lower Voltage Busbar is Operated Solid

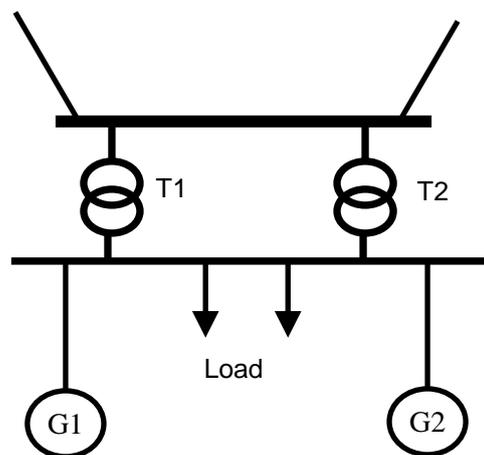


Figure 9

- Any individual planned outage of T1 or T2 will not in general result in an outage of G1 or G2.
- A fault on T1 or T2 could result in an outage for G1 and G2
- Any fault on the lower voltage busbar will result in an outage of the G1 and G2.

Where the Lower Voltage Busbar is Operated with a Normally Open Busbar Sectionalising Circuit Breaker

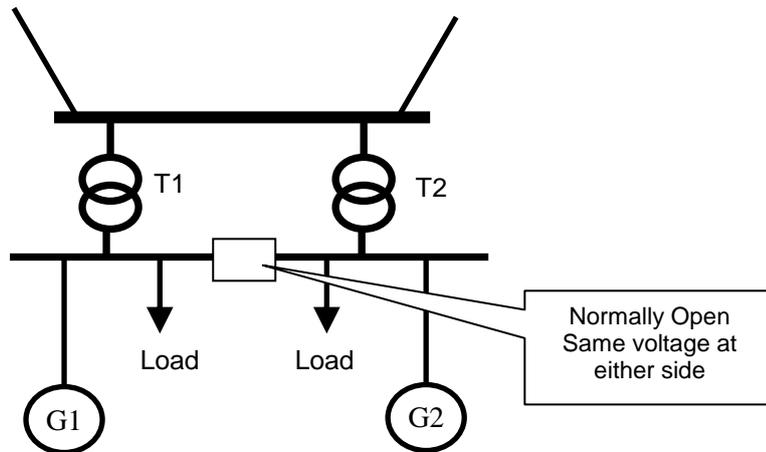


Figure 10

- Any planned outage of the transformer or half busbar which normally feeds the Generator will not result in an outage of the Generator.
- Any fault outage of the transformer which normally feeds the Generator will result in a temporary outage to that Generator until the lower voltage sectionalising Circuit Breaker is closed through Operator intervention.

Where the Lower Voltage Half-Busbars are Operated at Different Voltages and are Coupled by an Inter-Tie Transformer via a Normally Open CB

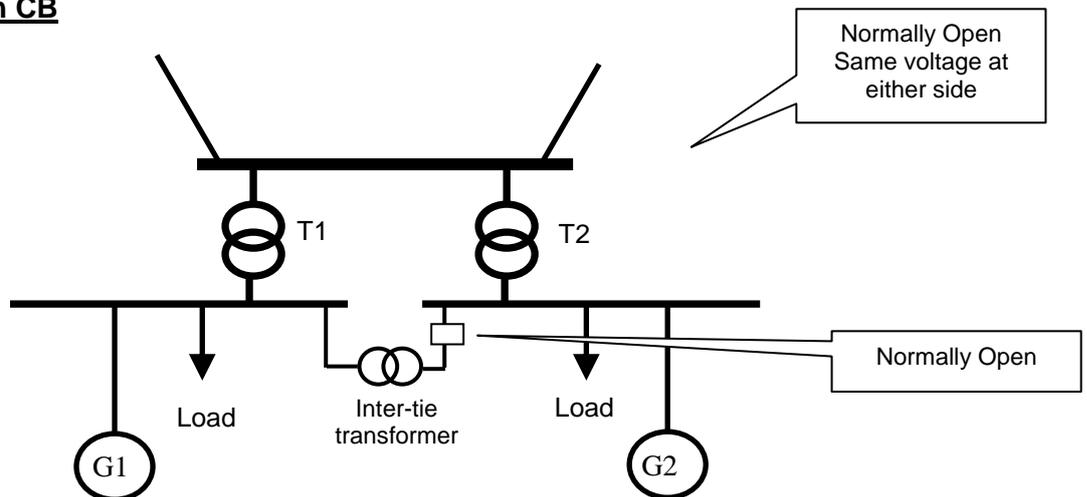


Figure 11

- Any fault outage of the transformer which normally feeds the Generator will result in an outage of the Generator.
- A planned outage of T1 or T2 may result in an interruption G1 or G2 depending upon the size of the generation relative to that of the inter-tie transformer.

5.2.4 Planned Outages

Whilst every effort will be made to minimise necessary planned outage time, any works carried out during a planned outage which affects the Generator, shall unless otherwise agreed, be done during normal working hours. In the event that the Generator seeks to reduce the time of the outage through the working of additional hours and or weekend work, this will only be done with the prior agreement of ESNB and at the Generator's costs.

6 Examples of Disturbing Loads

No.	Load Type	Impact	Factors	Mitigation
1.	Welders	Flicker	Number and Rating	Restriction on Operation Reinforced Network Connection
			Usage Pattern	
			Welder Type	
2.	Large Motor or Generator	Flicker	Rating (kVA)	Restriction on starts per day Reinforced Network Connection
			Machine characteristics	
			Starting arrangements	
3.	Rectifiers & Inverters	Harmonics	Control method (e.g. 6 or 12 pulse)	Harmonic Filter Reinforced Network Connection
			Filtering Arrangements	

7 Least Cost Technically Acceptable Solution in the context of a Business Park/Town Centre

When a new HV substation is required to provide connections to customers in a Business Park, Town Centre or other large Residential/ Commercial Development (a “Business Park”), the Least Cost Technically Acceptable connection method for the development will be determined by considering the following questions in conjunction with the various criteria outlined in section 4.0 of this document:

Site Cost

ESB will seek to purchase a suitable site from the developer of the Business Park and will make a payment to the developer in return for the transfer of the freehold interest in the substation site with suitable right of way access and a suitable access roadway to a public road.

The amount to be paid will relate to the value of the substation site at the time of the earliest (definitive) grant of full planning permission for the development. The amount will be finally negotiated to the agreement of both parties on receipt of full planning permission for the substation. It is intended that the payment will equate to the typical value of such land in or near the location of the development and would be arrived at using best industry practice.

Where the ESB is required to pay the developer a price for the site which is in excess of the value as determined in the above manner, or where the ESB is required to buy a site outside of the development at a price in excess of the value as determined in the above manner, then the ESB will recoup these additional costs in full from the developer. See also answer to question on site location below.

HV Substation Type

There are three alternative HV substation types:

- Outdoor substation with AIS switchgear.
- Indoor single-storey substation with GIS switchgear.
- Indoor multi-storey substation with GIS switchgear.

In general indoor GIS substations can be built on smaller sites than outdoor AIS substations. ESB defines the Least Cost Technically Acceptable substation type in any particular situation by estimating the overall development costs including the site cost. Where the substation type which is being built is other than the Least Cost Technically Solution substation type as identified by this process, then ESB will determine the additional cost which it will incur and will recoup these costs in full from the developer.

Site Condition

ESB defines the Least Cost Technically Acceptable site conditions as good level open ground with unimpeded access. Where the site conditions are other than these then ESB will determine the additional cost which it will incur in developing a substation at the site and will recoup these additional costs in full from the developer.

Site Location

ESB defines the Least Cost Technically Acceptable site location as being near the centre of the development within easy reach of all of the new customers in order to minimise the cable runs required to provide connections, and which facilitates the long term development of the networks in the area. Where the site location is other than this then ESB will determine the additional cost which it will incur in developing a substation at the site and will recoup these additional costs in full from the developer. These will include the additional costs which ESB will incur in extending its networks to other customers outside the confines of the Business Park from this sub-optimally located substation.

Special Requests

Where the developer makes any special requests of ESB which ESB agrees to accede to then ESB will determine the cost of these special requests and will recoup these costs in full from the developer.

Other Factors

Where an issue arises during either the design or construction of the substation which has not been explicitly detailed above and which requires ESB to pursue a course of action involving expenditure which is demonstrably over and above the Least Cost Technically Acceptable, then ESB will recoup these costs in full from the developer.

8 Definitions

Defined terms used in this document shall have the meanings given to these terms in the Distribution Code and/or General Conditions as appropriate.

Term	Definition
Cable	Underground electrical circuit comprising insulated conductors which are contained within an outer sleeve to form a single Unit
Connection Asset	The network erected to connect the connection point to the existing Distribution System. The connection asset forms part of the Distribution System and, for Demand connections is typically not shared by other users. In generation connections – typically those processed under the Group Processing Approach – some connection assets maybe shared.
Continuity or Continuity of Supply	This describes the quality of a supply as it relates to outages, whether caused by faults or planned work. A set of measures are required to describe continuity but, in general, the lower the incidence of outages and the shorter their duration, the higher the continuity.
Distribution System	The electric lines, plant and switch-gear used to convey electricity to final customers (excluding customers connected directly to the transmission system (grid)).
Disturbing Load	An electrical load that of its nature may affect the quality of electricity supply of other customers. Examples are welders, large electric motors etc. (See Section 6)
Diversity	The ratio of actual peak loading in a customer's premises to the sum of all the individual load ratings connected within the premises.
Dual Radial Supply	Two independent service connections with a N.O. point on the customer busbar. The customer busbar is usually equipped with a 2 out of 3 way circuit breaker interlocking scheme to permit only momentary paralleling of supplies.
Flicker	Voltage fluctuations, caused by a disturbing load (or rapid variations in generator output), the major effect of which is flickering of standard (incandescent) light bulbs.
Full Standby	Full standby is the standard of supply such that – for an outage of the normal Circuit to a customer – the full load can be fed from an alternative source at the same voltage. It does not take into account the level of standby available at higher voltage levels.
Line	Overhead electrical circuit comprising electrical conductors supported by poles and or pylons
Load Break Fault Make Switch	Load Break Fault Make (LBFM) switches are electrical switches which can break load current and connect fault current
Looped Connection	<p>A looped connection is one where there are two connections to the feeding ESB Networks substation from a main circuit such that the substation can be fed from either connection. In the case of an MV connection the final connection to the customer is extended by means of a single circuit from a ring main unit to which the two main incoming circuits are terminated. For HV supplies the connection will be provided by means of either a single or double connection from a busbar in an adjacent ESB Networks substation</p> <p>In the event of a fault on either connection the customer should only be without supply for the switching time necessary to restore supply. A looped connection may be from a main circuit which has either full or partial standby.</p> <p>In a non-looped supply a fault on the customer connection would result</p>

Term	Definition
	in loss of supply until the connection was repaired.
Losses	Electrical losses account for the difference between the power entering the distribution system and that delivered to customers. Losses can be regarded as the energy lost in the network due to the heating effect of the electricity passing through it.
Maximum Import Capacity	The maximum permissible amount of electricity to be imported from the Distribution System at the Connection Point expressed in kVA and referred to as being the “Maximum Import Capacity” in Schedule 1 to the Connection Agreement
Maximum Export Capacity	The maximum permissible amount of electricity to be exported onto the Distribution System at the Connection Point expressed in kVA and referred to as being the “Maximum Export Capacity” in Schedule 1 to the Connection Agreement
Normal Feeding	The network configuration under normal conditions and when all distribution plant is in service. The normal feeding arrangement is typically designed to provide best voltage performance, to minimise network losses and to make optimum use of the capacity of feeding substations is also a factor
Partial Standby	Partial standby is where standby may be available under certain fault conditions, but will not be available for all faults.
Point of Common Coupling (PCC)	The point at which a customer connection interacts electrically with other customer connections
Ring Main Unit	Ring Main Unit (RMU) is an MV switch unit that facilitates the looping of an MV circuit into a Substation. A third circuit may be extended from this switch to connect electrical load. The circuit switches on the RMU are load break fault make switches.
Security of Connection	The expectation that the connection point will remain energised.
Short Circuit Level	The short circuit level is a measure of the ‘strength’ of the network i.e. the ability to limit the impact of disturbing loads and to maintain voltage stability. The size of the customer switched load relative to the short circuit level determines whether the voltage quality will be maintained within standard.
Short Circuit Rating	This refers to the Short Circuit Rating of the item of plant concerned.
Standby Feeding	The feeding arrangement when one or more items of network plant is out of service. The exact feeding arrangement will depends on which items are out of service. As standby feeding is a temporary arrangement, different standards of voltage apply.
Terminal Substation	A standard structure owned and operated by the DSO containing the distribution equipment necessary to connect a customer to the distribution system. Terminal substations are operated at the connection voltage of the customer i.e. transformation is not required.
Transformer Substation	A standard structure owned and operated by the DSO containing one or more transformers, to convert electricity at one standard distribution voltage to a lower standard voltage.
ESB Networks Website	www.esb.ie/esbnetworks