Northern Ireland

Transmission System Security and Planning Standards

Security and Quality of Supply Standard (NI)

02 June 2023

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1 Introduction

Role and Scope

1.1 Pursuant to the relevant conditions of the Transmission Licences in Northern Ireland, this document sets out the main standard that transmission licensee shall use in the planning of the Northern Ireland Transmission System. For the avoidance of doubt the Northern Ireland Transmission System is made up of both the *onshore transmission system* and any *offshore* transmission systems that are subject to transmission licences in Northern Ireland.

1.2 The planning criteria set out the requirements for the *transmission capacity* for the transmission system.

1.3 Additional criteria, for example covering more detailed and other aspects of quality of supply, are contained in the SONI Grid Code which should be read in conjunction with this document.

1.4 The consideration of *secured events* as defined in this Standard may lead to the identification of inadequate capability of equipment or systems not owned or operated by the *transmission licensee* (for example, the overloading of lower voltage connections between bulk supply points). In such cases the *transmission licensee* will notify the *distribution licensee* affected. Reinforcement or alternative operation of the transmission system to alleviate inadequacies of equipment or systems not owned or operated by the transmission licensee would be undertaken where it is agreed by the *network operator* affected and the relevant transmission licensee.

1.5 The criteria presented in this Standard represent the minimum requirements for the planning of the transmission system. While it is a requirement for *transmission capacity* to meet the planning criteria, it does not follow that the *transmission capacity* should be reduced so that it only meets the minimum requirement of those criteria. For example, it may not be beneficial to reduce the ratings of lines to reflect lower loading levels which have arisen due to changes in the generation or demand patterns.

Document Structure

1.6 This Standard contains technical terms and phrases specific to transmission systems and the Electricity Supply Industry. The meanings of some terms or phrases in this Standard may also differ from those commonly used. For this reason a 'Terms and Definitions' has been included as Section 10 to this document. All defined terms have been identified in the text by the use of italics.

1.7 The criteria and methodologies applicable to the *onshore transmission system* differ in certain respects from those applicable to the *offshore transmission systems*. In view of this, the two sets of criteria and methodologies are presented separately for clarity. The criteria and methodologies applicable to the *onshore transmission system* are presented in Sections 2 to 6 and the criteria and methodologies applicable to *offshore* transmission systems are presented in Sections 7 to 9.

Onshore Criteria and Methodologies

1.8 For ease of use, the criteria and methodologies relating to the planning of the *onshore transmission system* have been presented according to the functional parts of the *onshore transmission system* to which they primarily apply. These parts are the generation points of connection at which *power stations* feed into the *Main Interconnected Transmission System* (MITS) through the remainder of the MITS to the *Grid Supply Points* (GSP) and on to *Bulk Supply Points (BSP)*. It should be noted that demand is considered to exist at both BSPs and GSPs.

These parts are illustrated schematically in Figure 1.1.

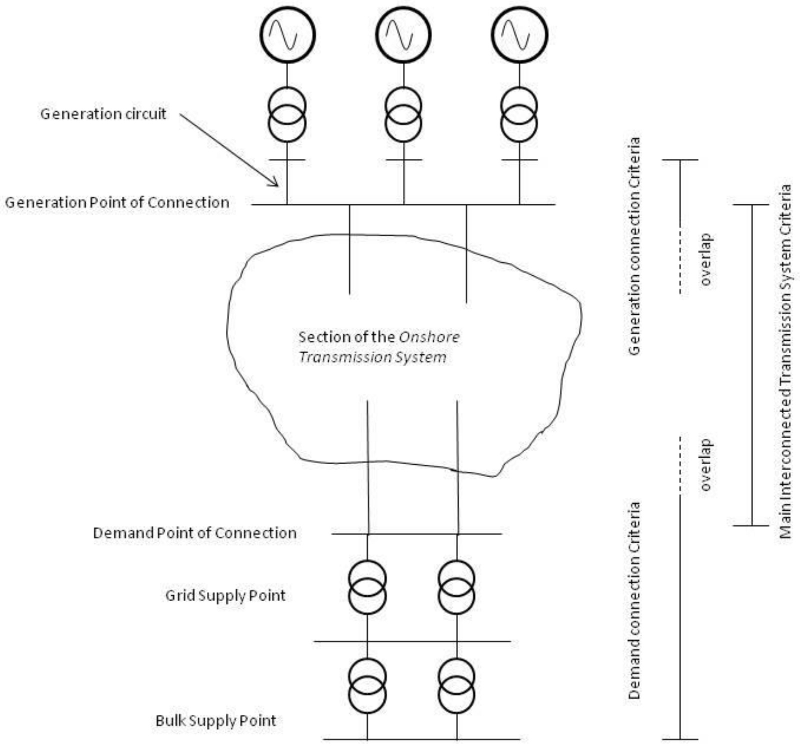

Figure 1.1 The *onshore transmission system* with a directly connected *power station*

1.9 The generation connection criteria applicable to the *onshore transmission system* are set out in Section 2 and cover the connections which extend from the generation points of connection and reach into the MITS. The criteria also cover the risks affecting the transmission system arising from the *generation circuits*.

1.10 The demand connection criteria applicable to the *onshore transmission system* are given in Section 3 and cover the connections which extend from the lower voltage side of the BSP transformers and again reach into the MITS.

1.11 Section 4 sets out the criteria for minimum *transmission capacity* on the MITS, which extends from the generation points of connection through to the demand points of connection on the high voltage side of the GSP transformers.

1.12 Planning assumptions regarding operational mitigation measures of the *onshore transmission system* are presented in Section 5.

Offshore Criteria and Methodologies

1.13 For ease of use, the criteria and methodologies relating to the planning of the *offshore transmission systems* have also been presented according to the functional parts of an *offshore transmission system* to which they primarily apply. An *offshore transmission system* extends from the *offshore grid entry point*/s (GEP) at which *offshore power station*s feed into the *offshore transmission system* through the remainder of the *offshore transmission system* to the point of connection of the *offshore transmission system* at the *first onshore substation, i.e. up to the secondary side of the transmission transformer*. In the first instance, this point of connection at the *first onshore substation* is the *interface point* (IP).

1.14 The functional parts of an offshore transmission system include:

The *offshore* connection facilities on the *offshore platform*/s, which may include:

1.14.1 The *offshore grid entry point*/s (GEP) at which *offshore power station*s feed into an *offshore transmission system*,

1.14.2 Any *offshore supply point*/s (OSP) where *offshore power station* demand is supplied from an *offshore transmission system*

1.14.3 AC or DC *offshore transmission circuits*

The cable circuit/s, which may include:

1.14.4 AC or DC cable *offshore transmission circuits* connecting an *offshore platform* either directly to an onshore overhead line forming part of the *offshore transmission syste*m or to onshore connection facilities forming part of the *offshore transmission system*.

An overhead line section, which may include:

1.14.5 AC or DC overhead line *offshore transmission circuit*s connecting the cable *offshore transmission circuit*s either directly to the *first onshore substation* or to onshore AC transformation or AC/DC conversion facilities not forming part of the *first onshore substation*.

Onshore connection facilities, which may include:

1.14.6 AC/DC conversion facilities connecting DC overhead line or DC cable *offshore transmission circuit*s to the *interface point*. Such facilities may constitute the *first onshore substation*

1.14.7 AC transformation facilities connecting AC overhead line or AC cable *offshore transmission circuit*s to the *interface point*. Such facilities may constitute the *first onshore substation*.

1.15 The above functional parts of an *offshore transmission system* are illustrated schematically in Figure 1.2. There are many variations to the form of an *offshore transmission system*. Figure 1.2 illustrates one example. The offshore *generator* has the option to connect to an *offshore transmission system* (i.e. at the secondary side of the transmission transformer) at a voltage level (in that system) of his choosing. Accordingly, the *offshore GEP* can be at a voltage level of the *generator*'s choosing and the extent of the offshore generation connection criteria would vary accordingly. However, under the default arrangements, the offshore *generator*'s circuits cannot be wholly or mainly at a voltage level of 110kV or above since such a combination of circuits would then constitute part of an *offshore transmission system*. Please note that, while Figure 1.2, have been drawn such that they represent the functional parts of an AC *offshore transmission system*, they are equally representative of the functional parts of a DC *offshore transmission system*. The *first onshore substation* forms part of the *onshore transmission system*.

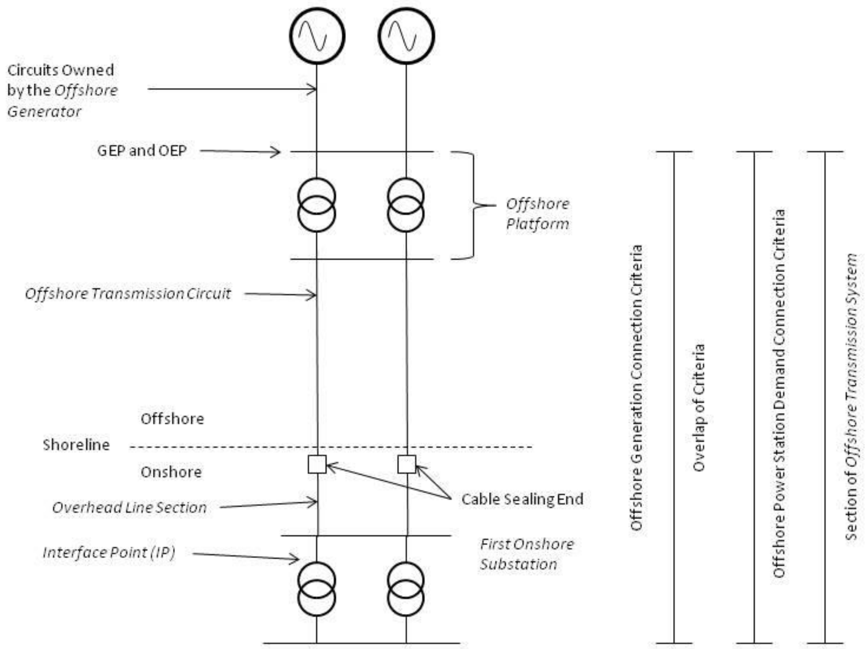

Figure 1.2 The offshore transmission system with a directly connected power station and *first onshore substation*

1.16 The generation connection criteria applicable to an *offshore transmission system* are set out in Section 7 and cover the connections which extend from the offshore *grid entry points* (GEP), through the *offshore transmission system*, to the *interface point* (IP).

1.17 The demand connection criteria applicable to an *offshore transmission system* are given in Section 8 and cover the connection of station demand at the *offshore platform*. These criteria extend from the *offshore supply point* (OSP) on the *offshore platform* through the *offshore transmission system* to the onshore *interface point* (IP).Voltage limits for use in planning and operating an *offshore transmission system* are presented in Section 9.

Overlap of Criteria

1.18 As described above, and illustrated in Figures 1.1 and 1.2, there will be parts of the Northern Ireland *transmission system* where more than one set of criteria apply. In such places the requirements of all relevant criteria must be met.

1.19 In particular, should an *offshore transmission system* be connected to the onshore MITS by two or more AC *offshore transmission circuit*s routed to different onshore substations or to separate *busbar* sections at the same onshore substation, those AC *offshore transmission circuit*s would parallel the MITS. In such cases the onshore criteria would also apply to the relevant sections of the *offshore transmission system*.

2 Generation Connection Criteria Applicable to the *Onshore Transmission System*

2.1 This section presents the planning criteria applicable to the connection of one or more *power stations* to the *onshore transmission system*. The criteria in this section will also apply to the connections to a BSP in respect of *distribution embedded generation*.

2.2 In those parts of the *onshore transmission system* where the criteria of Section 3 and/or Section 4 also apply, those criteria must also be met.

2.3 In planning generation connections, this Standard is met if the connection design either:

2.3.1 Satisfies the deterministic criteria detailed in paragraphs 2.5 to 2.12; or

2.3.2 varies from the design necessary to meet paragraph 2.3.1 above in a manner which satisfies the conditions detailed in paragraphs 2.14 to 2.18.

2.4 It is permissible to design to standards higher than those set out in paragraphs 2.5 to 2.12 provided the higher standards can be justified economically. Guidance on economic justification is given in Appendix E.

Limits to *Loss of Power Infeed* Risks

2.5 For the purpose of applying the criteria of paragraph 2.6, the *loss of power infeed* resulting from a *secured event* on the *onshore transmission system* shall be calculated as follows:

2.5.1 the sum of the registered capacities of the *generating units* disconnected from the system by a *secured event*, plus

2.5.2 the planned import from any external systems disconnected from the system by the same event, less

2.5.3 the *forecast minimum demand* disconnected from the system by the same event but excluding (from the deduction) any demand forming part of the *forecast minimum demand* which may be automatically tripped for system frequency control purposes and excluding (from the deduction) the demand of the largest single end customer.

2.6 Generation connections shall be planned such that, starting with an *intact system*, the consequences of *secured events* on the *onshore transmission system* shall be as follows:-

2.6.1 following a *fault outage* of any single *main interconnected transmission circuit*, no *loss of power infeed* shall occur;

2.6.2 following the *planned outage* of any single section of *busbar* or mesh corner, no *loss of power infeed* shall occur;

2.6.3 following a *fault outage* of any single *generation circuit* or single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed the *largest single infeed*;

2.6.4 following the concurrent *fault outage* of any two *transmission circuits*, or any two *generation circuits* on the same *double circuit overhead line*, or the *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

2.6.5 following the *fault outage* of any single *transmission circuit*, single section of *busbar* or mesh corner, during the *planned outage* of any other single *transmission circuit* or single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

2.6.6 following the *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, during the *planned outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

Generation Connection Capacity Requirements

<u>Background conditions</u>

2.7 The connection of a particular *power* station or section of *distribution system* with *embedded generation* shall meet the criteria set out in paragraphs 2.8 to 2.12 under the following background conditions:

2.7.1 the active power output of the *power station* shall be set equal to its *registered capacity*;

2.7.2 for connections to the *transmission system*, the reactive power output of the *power station* shall be set to the full leading or lagging output that corresponds to an active power output equal to *registered capacity*;

2.7.3 for the connection to the *onshore transmission system* of a part of the *distribution system* which has embedded generation, the reactive power output of that generation shall be set according to the requirements of the Distribution Code and the electrical characteristics of the local distribution system;

2.7.4 for connections to an *offshore transmission system*, the reactive power output of the *offshore power station*/s shall normally, and unless otherwise agreed, be optimised depending on the capabilities of the generation and the charging of the connecting cables; and,

2.7.5 conditions on the *transmission system* shall be set to those which are reasonably to be expected to arise in the course of a year of operation. Such conditions shall include forecast demand cycles, typical *power station* and distribution embedded generation operating regimes and typical *planned outage* patterns modified where appropriate by the provisions of paragraph 2.10.

Pre-fault criteria

2.8 The *transmission capacity* for the connection of a *power station* or section of *distribution system* with *embedded generation* shall be planned such that, for the background conditions described in paragraph 2.7, prior to any fault there shall not be any of the following:

2.8.1 equipment loadings exceeding the *pre-fault rating*;

2.8.2 voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*;

2.8.3 *system instability or*

2.8.4 unacceptable power quality.

Post-fault criteria – background condition of no *local system outage*

2.9 The *transmission capacity* for the connection of a *power station* shall also be planned such that for the background conditions described in paragraph 2.7 with no *local system outage* and for the *secured event* of a *fault outage* on the *onshore transmission system* of any of the following:

2.9.1 a single *transmission circuit*, a reactive compensator or other reactive power provider;

2.9.2 a *double circuit overhead line* on the 275kV network;

2.9.3 a single *transmission circuit* with the prior outage of another *transmission circuit*;

2.9.4 a section of *busbar* or mesh corner; or

2.9.5 a single *transmission circuit* with the prior outage of a generating unit, a reactive compensator or other reactive power provider;

there shall not be any of the following:

2.9.6 a *loss of supply capacity* except as permitted by the demand connection criteria detailed in Section 3;

2.9.7 *unacceptable overloading* of any *primary transmission equipment*;

2.9.8 *unacceptable voltage conditions* or *insufficient voltage performance margins*; or

2.9.9 *system instability* or

2.9.10 unacceptable power quality

2.10 Under *planned outage* conditions it shall be assumed that the prior circuit outage specified in paragraphs 2.9.3 and 2.9.5 reasonably forms part of the typical outage pattern referred to in paragraph 2.7.5 rather than in addition to that typical outage pattern.

Post-fault criteria – background condition with a *local system outage*

2.11 The *transmission capacity* of the *onshore transmission circuits* for the connection of one or more *onshore power stations* to an *onshore transmission system* shall also be planned such that, for the background conditions described in paragraph 2.7 with a *local system outage*, there shall not be any of the following:

2.11.1 a *loss of supply capacity* except as permitted by the demand connection criteria detailed in Section 8;

2.11.2 *unacceptable overloading* of any *primary transmission equipment*;

2.11.3 *unacceptable voltage conditions* or *insufficient voltage performance margins*

2.11.4 *system instability*or

2.11.5 unacceptable power quality.

2.12 Where necessary to satisfy the criteria set out in paragraph 2.11, investment should be made in *transmission capacity* except where operational measures suffice to meet the criteria in paragraph 2.11 provided that maintenance access for each *transmission circuit* can be achieved and provided that such measures are economically justified. The operational measures to be considered include rearrangement of transmission outages and appropriate re-dispatch of *generating units* including *distribution embedded generation* from those expected to be available. Guidance on economic justification is given in Appendix E.

Switching Arrangements

2.13 Guidance on substation configurations and switching arrangements are described in Appendix A. These guidelines provide an acceptable way towards meeting the criteria of paragraph 2.6. However, other configurations and switching arrangements which meet those criteria are also acceptable.

Variations to Connection Designs

2.14 Variations, arising from a generation customer's or *distribution licensee*'s request, to the generation connection design necessary to meet the requirements of paragraphs 2.5 to 2.11 shall also satisfy the requirements of this Standard provided that the varied design satisfies the conditions set out in paragraphs 2.15.1 to 2.15.2. For example, such a generation connection design variation may be used to take account of the particular characteristics of a *power station* or *distribution embedded generator*.

2.15 Any generation connection design variation must not, other than in respect of the generation customer or *distribution licensee* requesting the variation, either immediately or in the foreseeable future:

2.15.1 reduce the security of the MITS to below the minimum planning criteria specified in Section 4; or

2.15.2 compromise any *transmission licensee's* ability to meet other statutory obligations or licence obligations.

2.16 *Operational intertripping* of *distribution embedded generation* may be used to avoid overload of a radial *transmission circuit*, specifically a second transformer or radial circuit, following the *fault outage* of the first transformer or radial circuit. Each scheme will be assessed on a case by case basis, considering complexity, operational issues and provided that the *distribution licensee* confirms that power quality remains within Distribution System Security and Planning Standards.

2.17 Should system conditions subsequently change, for example due to the proposed connection of a new customer, such that either immediately or in the foreseeable future, the conditions set out in paragraphs 2.15.1 to 2.15.2 are no longer satisfied, then alternative arrangements and/or agreements must be put in place such that this Standard continues to be satisfied.

2.18 The additional operational costs and/or any potential reliability implications shall be calculated by simulating the expected operation of the transmission system. Guidance on economic justification is given in Appendix E.

3 Demand Connection Criteria Applicable to the *Onshore Transmission System*

3.1 This section presents the planning criteria for the connection of *demand groups* to the *onshore transmission system*.

3.2 In those parts of the *onshore transmission system* where the criteria of Section 2 and/or Section 4 also apply, those criteria must also be met.

3.3 In planning demand connections, this Standard is met if the connection design either:

3.3.1 satisfies the deterministic criteria detailed in paragraphs 3.5 to 3.10; or

3.3.2 varies from the design necessary to meet paragraph 3.3.1 above in a manner which satisfies the conditions detailed in paragraphs 3.12 to 3.15.

3.4 It is permissible to design to standards higher than those set out in paragraphs 3.5 to 3.10 provided the higher standards can be economically justified. Guidance on economic justification is given in Appendix E.

Demand Connection Capacity Requirements

3.5 The connection of a particular *demand group* shall meet the criteria set out in paragraphs 3.6 to 3.10 under the following background conditions:

3.5.1 when there are no *planned outages*, the demand of the *demand group* shall be set equal to *group demand*;

3.5.2 when there is a *planned outage* local to the *demand group*, the demand of the *demand group* shall be set equal to *maintenance period demand*;

3.5.3 the contribution of generation facilities embedded within the distribution network shall be consistent with those assumed by the Distribution System Security and Planning Standards as applied by the *distribution licensee*;

3.5.4 any *transfer capacity* (i.e. the ability to transfer demand from one *demand group* to another) declared by the *distribution licensee* shall be represented taking account of any restrictions on the timescales in which the *transfer capacity* applies. Any *transfer capacity* declared by the *distribution licensee* for use in planning timescales must be available for use in operational timescales; and

3.5.5 demand and generation outside the *demand group* shall be set in accordance with the economic dispatch using the appropriate method described in Appendix D.

3.6 The *transmission capacity* for the connection of a *demand group* shall be planned such that, for the background conditions described in paragraph 3.5, under *intact system* conditions there shall not be any of the following:

3.6.1 equipment loadings exceeding the *pre-fault rating*;

3.6.2 voltages outside the *pre-fault planning voltage limits* or insufficient voltage performance margins;

3.6.3 *system instability* or

3.6.4 *unacceptable power quality*.

3.7 The *transmission capacity* for the connection of a *demand group* shall also be planned such that for the background conditions described in paragraph 3.5 and for the *planned outage* of a single *transmission circuit* or a single section of *busbar* or mesh corner, there shall not be any of the following:

3.7.1 a *loss of supply capacity* for a *group demand* of greater than 1 MW;

3.7.2 *unacceptable overloading* of any *primary transmission equipment*;

3.7.3 voltages outside the *pre-fault planning voltage limits* or insufficient voltage performance margins;

3.7.4 *system instability* or

3.7.5 *unacceptable power quality*.

3.8 The *transmission capacity* for the connection of a *demand group* shall also be planned such that for the background conditions described in paragraph 3.5 and the initial conditions of:

3.8.1 an *intact system* condition; or

3.8.2 the single *planned outage* of another *transmission circuit*, *generating unit*, a reactive compensator or other reactive power provider,

3.8.3 for the *secured event* of a *fault outage* or

3.8.4 a single *transmission circuit*,

there shall not be any of the following:

3.8.5 a *loss of supply capacity* such that the provisions set out in Table 3.1 are not met;

3.8.6 *unacceptable overloading* of any *primary transmission equipment*;

3.8.7 *unacceptable voltage conditions* or *insufficient voltage performance margins*;

3.8.8 *system instability* or

3.8.9 *unacceptable power quality*.

3.9 In addition to the requirements of paragraphs 3.6 to 3.8, for the background conditions described in paragraph 3.5, the system shall also be planned such that operational switching does not cause *unacceptable voltage conditions*.

3.10 For a *secured event* on connections to more than one *demand group*, the permitted *loss of supply capacity* for that *secured event* is the maximum of the permitted loss of supply capacities set out in Table 3.1 for each of these *demand groups*.

Table 3.1 Minimum planning supply capacity following *secured events*

Group Demand	Initial system conditions	
	Intact system	With *single planned outage* ***Note 1***
Over 300 MW	**Immediately** *Group Demand*	**Immediately** *Maintenance Period Demand* **Within time to restore *planned outage*** *Group Demand*
Over 60 MW to 300 MW	Immediately *Group Demand* minus 20 MW **Within 3 hours** *Group Demand*	**Within 3 hours** Smaller of (*Group Demand* minus 100 MW) and one-third of *Group Demand*. **Within time to restore *planned outage*** *Group Demand*
Over 24 MW to 60 MW	**Within 15 minutes** Two thirds of *Group Demand* **Within 3 hours** *Group Demand*	**Within time to restore *planned outage*** *Group Demand*
Over 8 MW to 24MW	**Within 15 minutes** *Group Demand* minus 8 MW **Within 3 hours** *Group Demand*	Nil
Over 1 MW to 8 MW	**Within 3 hours** *Group Demand minus 1 MW* **In repair time** *Group Demand*	Nil
Up to 1 MW	**In repair time** *Group Demand*	Nil

Notes

1. The *planned outage* may be of a *transmission circuit*, *generating unit*, reactive compensator or other reactive power provider.

Switching Arrangements

3.11 Guidance on substation configurations and switching arrangements are described in Appendix A. These guidelines provide an acceptable way towards meeting the criteria of this chapter. However, other configurations and switching arrangements which meet the criteria are also acceptable.

Variations to Connection Designs

3.12 Variations, arising from a demand customer's request, to the demand connection design necessary to meet the requirements of paragraphs 3.5 to 3.10 shall also satisfy the requirements of this Standard provided that the varied design satisfies the conditions set out in paragraphs 3.13.1 to 3.13.2. For example, such a demand connection design variation may be used to reflect the nature of connection of embedded generation or particular load cycles.

3.13 Any demand connection design variation must not, other than in respect of the demand customer requesting the variation, either immediately or in the foreseeable future:

3.13.1 reduce the security of the MITS to below the minimum planning criteria specified in Section 4; or

3.13.2 compromise any *transmission licensee's* ability to meet other statutory obligations or licence obligations.

3.14 Should system conditions change, for example due to the proposed connection of a new customer, such that either immediately or in the foreseeable future, the conditions set out in paragraphs 3.13.1 to 3.13.2 are no longer satisfied, then alternative arrangements and/or agreements must be put in place such that this Standard continues to be satisfied.

3.15 The additional operational costs and/or any potential reliability implications shall be calculated by simulating the expected operation of the *transmission system*. Guidance on economic justification is given in Appendix E.

4 Design of the *Main Interconnected Transmission System*

4.1 This section presents the planning criteria for the *Main Interconnected Transmission System* (MITS).

4.2 In those parts of the *onshore transmission system* where the criteria of Section 2 and/or Section 3 also apply, those criteria must also be met. In those parts of the *offshore transmission system* where the criteria of Section 7 and/or Section 8 also apply, those criteria must also be met.

4.3 In planning the MITS, this Standard is met if the design satisfies the minimum deterministic criteria detailed in paragraphs 4.4 to 4.13. It is permissible to design to standards higher than those set out in paragraphs 4.4 to 4.13 provided the higher standards can be economically justified. Guidance on economic justification is given in Appendix E.

Minimum Transmission capacity Requirements

<u>At *ACS peak demand* with an *intact system*</u>

4.4 The MITS shall meet the criteria set out in paragraphs 4.5 to 4.6 under both the Stressed Case and Economic Dispatch background conditions below:

<u>Stressed Case Dispatches</u>

4.4.1 there shall be several stressed case dispatches to be considered:

4.4.1.1 in merit *generating units* will be dispatched at maximum output with no *operating reserve* with all *interconnectors* intact;

4.4.1.2 dispatching of out of merit generation may also be considered depending on plant margins;

4.4.1.3 full variable generation cases should be considered respecting the level of diversity;

4.4.1.4 the case with a single interconnector circuit is out on long term outage should be considered, with generation economically dispatched ;

4.4.1.5 further details are provided in Appendix C.

<u>Economic Dispatch</u>

4.4.2 *generating units*' outputs shall be set as described in Appendix D;

Reactive Power Capability

4.4.3 The expected availability of generation reactive capability shall be set to that which ought reasonably to be expected to arise. This shall take into account the variation of reactive capability with the active power output (for example, as defined in the machine performance chart). In the absence of better data the expected available capability shall not exceed 90% of the Grid Code specified capability, (unless modified by a direction of the Utility Regulator) or 90% of the contracted capability for the active power output level, whichever is relevant.

4.5 The minimum *transmission capacity* of the MITS shall be planned such that, for the background conditions described in paragraph 4.4, prior to any fault there shall not be:

4.5.1 equipment loadings exceeding the rating;

4.5.2 voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*;

4.5.3 *system instability or*

4.5.4 unacceptable power quality..

4.6 The minimum *transmission capacity* of the MITS shall also be planned such that for the conditions described in paragraph 4.4 and for the *secured event* of a *fault outage* of any of the following:

4.6.1 a single *transmission circuit*, a reactive compensator or other reactive power provider;

4.6.2 a *double circuit overhead line* on the 275kV network;

4.6.3 a section of *busbar* or mesh corner; or

4.6.4 any single *transmission circuit* with the prior *planned outage* of another *transmission circuit*, or a *generating unit*, reactive compensator or other reactive power provider together with any economic re-dispatch of generation during the planned outage,

there shall not be any of the following:

4.6.5 *loss of supply capacity* (except as permitted by the demand connection criteria detailed in Section 3 and Section 3.8);

4.6.6 *unacceptable overloading* of any *primary transmission equipment*;

4.6.7 *unacceptable voltage conditions* or *insufficient voltage performance margins*;

4.6.8 *system instability or*

4.6.9 unacceptable power quality.

Under conditions in the course of a year of operation

4.7 The MITS shall meet the criteria set out in paragraphs 4.8 to 0 under the following background conditions:

4.7.1 conditions on the Northern Ireland *transmission system* shall be set to those which ought reasonably to be foreseen to arise in the course of a year of operation. Such conditions shall include forecast demand cycles, typical *power station* operating regimes and typical *planned outage* patterns; and

4.7.2 the expected availability of generation reactive capability shall be set to that which ought reasonably to be expected to arise. This shall take into account the variation of reactive capability with the active power output (for example, as defined in the machine performance chart). In the absence of better data the expected available capability shall not exceed 90% of the Grid Code specified capability, (unless modified by a direction of the Utility Regulator) or 90% of the contracted capability for the active power output level, whichever is relevant.

4.8 The minimum *transmission capacity* of the MITS shall be planned such that, for the background conditions described in paragraph 4.7, prior to any fault there shall not be:

4.8.1 equipment loadings exceeding the rating;

4.8.2 voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*;

4.8.3 *system instability or*

4.8.4 unacceptable power quality.

4.9 The minimum *transmission capacity* of the MITS shall also be planned such that for the conditions described in paragraph 4.7 and for the *secured event* of a *fault outage* of any of the following:

4.9.1 a single *transmission circuit*, a reactive compensator or other reactive power provider;

4.9.2 a *double circuit overhead line* on the 275kV network;

4.9.3 a section of *busbar* or mesh corner; or

4.9.4 any single *transmission circuit* with the prior *planned outage* of another *transmission circuit*, or a *generating unit*, reactive compensator or other reactive power provider together with any economic re-dispatch of generation during the planned outage,

there shall not be any of the following:

4.9.5 *loss of supply capacity* (except as permitted by the demand connection criteria detailed in Section 3 and Section 3.8);

4.9.6 *unacceptable overloading* of any *primary transmission equipment*;

4.9.7 *unacceptable voltage conditions* or *insufficient voltage performance margins*; or

4.9.8 *system instability*.

4.10 Where necessary to satisfy the criteria set out in paragraphs 4.8, investment should be made in *transmission capacity* except where operational measures, including *operational intertripping* suffice to meet the criteria in paragraphs 4.8 provided that maintenance access for each *transmission circuit* can be achieved and provided that such measures are economically justified. The operational measures to be considered include rearrangement of transmission outages and appropriate reselection of *generating units* from those expected to be available, for example through balancing services. Guidance on economic justification is given in Appendix E.

General criteria

4.11 In addition to the requirements set out in paragraphs 4.4 to 0, the system shall also be planned such that operational switching does not cause *unacceptable voltage conditions*.

4.12 *Transmission circuits* comprising the *supergrid* part of the MITS shall not exceed the circuit complexity limit defined in paragraphs B.3 to B.7 of Appendix B.

4.13 Guidance on complexity of *transmission circuits* on the MITS operated at a nominal voltage of 110kV is given in paragraphs B.8 to B.13 of Appendix B. Relaxation of the restrictions cited in paragraphs B.8 to B.13 may be justified in certain circumstances following consideration by the *transmission licensee* responsible for the design of the circuits and their operation.

Switching Arrangements

4.14 Guidance on substation configurations and switching arrangements are described in Appendix A. These guidelines provide an acceptable way towards meeting the criteria of this section. However, other configurations and switching arrangements which meet the criteria are also acceptable.

5 Allowable mitigation measures in the operational timeframe

Normal operation

5.1 For planning purposes it can be assumed thatvariable for economic operation there should be no *constraint* of in economic generation.

Planned system and generation outages

5.2 During an outage of one or more in economic generators, it is acceptable to re-dispatch generation such as to mitigate any *unacceptable overloads*, *unacceptable voltage conditions* or *system instability* that may be caused by further single and double circuit outages, where economically viable (N-G-1).

During an outage of a transmission circuit, it is acceptable to re-dispatch generation such as to mitigate any *unacceptable overloads*, *unacceptable voltage conditions, insufficient voltage* or *system instability* that may be caused by further *transmission circuit* outage, where economically viable (N-1-1).

Post Fault Mitigation Measures

5.3 The following mitigation measures may be used in the time domain of the post fault period:

- Power flow controller adjustment;
- Transformer tapping;
- Automatic switching of fixed reactive compensation;
- *Operational intertripping*

In the event of the TO providing pre-fault and post fault ratings the following mitigation measures may also apply:

- Constraining *generation*;
- Circuit reconfiguration.

6 Voltage Limits in Planning the *Onshore Transmission System*

Voltage Limits in Planning Timescales

6.1 The *pre-fault planning voltage limits* on the *onshore transmission system* are as shown in Table 6.1.

Table 6.1 Assumed *Pre-fault planning voltage limits*

Nominal Voltage	Minimum	Maximum
400 kV	370kV	410kV **Note 1**
275 kV	261kV	289kV
110 kV	105kV	120kV

Notes

1. 420kV (+5%) is permissible for no longer than 15 minutes.

6.2 A voltage condition on the *onshore transmission system* is unacceptable in planning timescales if, after either

6.2.1 a *secured event*, or

6.2.2 operational switching,

and the affected site remains directly connected to the *onshore transmission system* in the *steady state* after the relevant event above, either of the following conditions applies:

6.2.3 the voltage step change at an interface between the *onshore transmission system* and a customer exceeds that specified in Table 6.2, or

6.2.4 there is any inability following such an event to achieve a *steady state* voltage as specified in Table 6.3 at *onshore transmission system* substations or GSPs using manual and/or automatic facilities available, including the switching in or out of relevant equipment.

6.3 The *steady state* voltages are to be achieved without widespread post-fault generation transformer re-tapping or post-fault adjustment of SVC set points to increase the reactive power output or to avoid exceeding the available reactive capability of generation or SVCs.

6.4 The *voltage step change* limits must be applied with load response taken into account.

Table 6.2 The *voltage step change* limits in planning timescales

Transmission secured fault or switching event	Voltage fall	Voltage rise
Following loss of single circuit	-6%	+6%
Following loss of *double circuit overhead line*	-10%	+6%
All operational switching set out in ER P28/2	In accordance with ER P28/2	

Table 6.3 The *steady state* post fault voltage limits in planning timescales

Nominal Voltage	Minimum	Maximum
400 kV	380kV (95%) **Note 1**	410 kV (102.5%) **Note 2**
275 kV	248kV (90%)	289 kV (105%)
110 kV	**Note 3**	115 kV (105%)
<110kV	**Note 3**	105%

Notes

1. It is permissible to relax this to 360kV (-10%) if:
   - the affected substations are on the same radially fed spur post-fault;
   - there is no lower voltage *interconnection* from these substations to other *supergrid* substations; and
   - no auxiliaries of large *power station*s are derived from them.
2. It is permissible to relax this to 420kV (+5%) if lasting for no longer than 15 minutes.
3. It shall be possible to operate the lower voltage *busbar* of a BSP at 100% of nominal voltage after tap changing.

7 Generation Connection Criteria Applicable to an *Offshore Transmission System*

7.1 This section presents the planning criteria applicable to the connection of one or more *offshore power station*s to an *offshore transmission system*. The criteria in this section apply from the offshore *grid entry point*/s (GEP) at which each *offshore power station* connects to an *offshore transmission system*, though the remainder of the *offshore transmission system* to the point of connection at the *first onshore substation*, which is the *interface point* (IP) in the case of a direct connection to the *onshore transmission system*.

7.2 The generation connection criteria, applicable to an *offshore transmission system*, presented in this section, are based on a series of cost benefit analyses carried out. The scope of those analyses have been assessed and bounded for application within Northern Ireland. Accordingly, the generation connection criteria presented in this section should only be applied up to the following limits.

7.2.1 the capacity for offshore wind farm *power station* is limited to a maximum of 500MW, consistent with the *largest single infeed* in Northern Ireland.

7.2.2 the type of variable power source powering the *offshore power station* was limited to wind and tidal.

7.2.3 the distance from an offshore *grid entry point* on an *offshore platform* to the *interface point* at the *first onshore substation* is limited to a maximum of 100km;

7.2.4 the length of any overhead line section of an *offshore transmission system* was limited to a maximum of 50km; and

7.2.5 Radial offshore network configurations only have been considered. Until reviewed, section 4 shall apply in respect of interconnected offshore networks.

The above limits will be subject to periodic review in the light of technological developments and experience. The limits should not be exceeded without justification provided by further review.

7.3 Planning criteria are defined for all elements of an *offshore transmission system* including: the *offshore transmission circuits* and equipment on the *offshore platform* (whether AC or DC); the *offshore transmission circuits* the *offshore platform* to the *interface point* including undersea cables and any overhead lines (whether AC or DC); and any onshore AC voltage transformation facilities or *DC converter* facilities.

7.4 In those parts of the *transmission system* where the criteria of Section 8 and/or Section 4 also apply, those criteria must also be met.

7.5 In planning offshore generation connections, this Standard is met if the connection design either:

7.5.1 satisfies the deterministic criteria detailed in paragraphs 7.7 to 7.19; or

7.5.2 varies from the design necessary to meet paragraph 7.5.1 above in a manner which satisfies the conditions detailed in paragraphs 7.21 to 7.24.

7.6 It is permissible to design to standards higher than those set out in paragraphs 7.7 to 7.19 provided the higher standards can be economically justified. Guidance on cost benefit analysis is given in Appendix E.

Limits to *Loss of Power Infeed*

7.7 For the purpose of applying the criteria of paragraphs 7.8 to 7.13, the *loss of power infeed* resulting from a *secured event* shall be calculated as follows:

7.7.1 the sum of the registered capacities of the *offshore power stations* disconnected from the system by a *secured event*, less

7.7.2 the *forecast minimum demand* disconnected from the system by the same event but excluding (from the deduction) any demand forming part of the *forecast minimum demand* which may be automatically tripped for system frequency control purposes and excluding (from the deduction) the demand of the largest single end customer.

<u>*Offshore Platforms* (AC and DC)</u>

7.8 Offshore generation connections on *offshore platforms* shall be planned such that, starting with an *intact system*, the consequences of *secured events* on the *offshore transmission system* shall be as follows;

7.8.1 <u>Transformer on an *offshore platform*</u>

7.8.1.1 In the case of offshore wind farm *power station* only connections, and where the *offshore grid entry point capacity* is 90MW or more, following a *planned outage* or a *fault outage* of a single AC offshore transformer circuit on the *offshore platform*, the *loss of power infeed* shall not exceed the smaller of either:

50% of the *offshore grid entry point capacity*; or the *largest single infeed*.

7.8.1.2 Following a *fault outage* of a single AC *offshore transmission circuit* on the *offshore platform*, during a *planned outage* of another AC *offshore transmission circuit* on the *offshore platform*, the further *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

7.8.2 <u>DC Converters on an *offshore platform*</u>

7.8.2.1 Following a *planned outage* or a *fault outage* of a single *DC converter* on the *offshore platform*, the *loss of power infeed* shall not exceed the *largest single infeed*;

7.8.2.2 Following a *fault outage* of a single *DC converter* on the *offshore platform*, during a *planned outage* of another *DC converter* on the *offshore platform*, the further *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

7.8.3 <u>Busbars and Switchgear on an *offshore platform*</u>

7.8.3.1 Following a *planned outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed the *largest single infeed*;

7.8.3.2 Following a *fault outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

7.8.3.3 Following a *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

7.8.3.4 Following a *fault outage* of any single section of *busbar* or mesh corner, during a *planned outage* of any other single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

7.8.3.5 Following a *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, during a *planned outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 2.0 times the largest single infeed.

<u>Offshore Cable Circuits (AC and DC)</u>

7.9 The transmission connections between one *offshore platform* and another *offshore platform* or from an *offshore platform* to the *interface point* at the *first onshore substation* shall be planned such that, starting with an *intact system* and for the full *offshore grid entry point capacity* at the offshore *grid entry point*, the consequences of *secured events* shall be as follows:

7.9.1 Following a *planned outage* or a *fault outage* of a single cable *offshore transmission circuit*, the *loss of power infeed* shall not exceed the single largest infeed; and

7.9.2 Following a *fault outage* of a single cable *offshore transmission circuit* during a *planned outage* of another cable *offshore transmission circuit* the further *loss of power infeed* shall not exceed 1.3 times the single largest infeed.

<u>Overhead Line Sections (AC and DC)</u>

7.10 In the case of AC overhead line connections of 110kV, between the incoming AC cable *offshore transmission circuits* and the *first onshore substation* or the onshore AC transformation facilities (as the case may be), a single circuit is sufficient. The justification for additional circuits however may be determined by economic analysis. In this analysis the maximum capacity of an 110kV overhead line, the reactive power losses and the distance should be taken into account.

7.11 In the case of AC overhead line connections of 220kV or above, between the incoming AC cable *offshore transmission circuits* and the *first onshore substation* or the onshore AC transformation facilities (as the case may be), a single circuit is justified as a minimum for *offshore grid entry point capacities* of 500MW or less and a minimum of two circuits are justified as a minimum for *offshore grid entry point capacities* greater than 500MW. In addition the wind farm must not have a common mode of failure that would result in greater than the 500 MW being tripped. The justification for additional circuits however may be determined by economic analysis.

7.12 Overhead line (AC or DC) connections between the cable (AC or DC) *offshore transmission circuits* and the *first onshore substation* or the onshore AC transformation facilities or DC conversion facilities, as the case may be, shall be planned such that, starting with an *intact system* and for the full *offshore grid entry point capacity* at the offshore *grid entry point*, the consequences of a *secured event* on the *offshore transmission system* shall be as follows:

7.12.1 Following a *planned outage* or a *fault outage* of a single overhead line circuit, the *loss of power infeed* shall not exceed the *largest single infeed*;

7.12.2 Following a *fault outage* of a single overhead line circuit during a *planned outage* of another overhead line circuit, the further *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

Connection Facilities at *First Onshore Substation* (AC and DC)

7.13 The transmission connections at the onshore AC transformation or DC conversion facilities shall be planned such that, starting with an *intact system*, the consequences of *secured events* on the *offshore transmission system* shall be as follows;

7.13.1 Transformers at *first onshore substation*

7.13.1.1 In the case of *offshore power station* only connections, and where the *offshore grid entry point capacity* is 120MW or more, following a *planned outage* or a *fault outage* of a single AC offshore transformer circuit at the onshore AC transformation facilities, the *loss of power infeed* shall not exceed the smaller of either:

50% of the offshore grid entry point capacity; or the *largest single infeed*.

7.13.1.2 Following a *fault outage* of a single AC *offshore transmission circuit* at the onshore AC transformation facilities, during a *planned outage* of another AC *offshore transmission circuit* at the onshore AC transformation facilities, the further *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

7.13.2 DC Converters

7.13.2.1 Following a *planned outage* or a *fault outage* of a single *DC converter* at the onshore DC conversion facilities, the *loss of power infeed* shall not exceed the *largest single infeed*;

7.13.2.2 Following a *fault outage* of a single *DC converter* at the onshore DC conversion facilities, during a *planned outage* of another *DC converter* at the onshore DC conversion facilities, the further *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*.

7.13.3 Busbars and Switchgear

7.13.3.1 In the case of *offshore power station* connections, following a *planned outage* of any single section of *busbar* or mesh corner, no *loss of power infeed* shall occur;

7.13.3.2 Following a *fault outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed the 1.3 times the *largest single infeed*;

7.13.3.3 Following a *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, the *loss of power infeed* shall not exceed 1.3 times the *largest single infeed*;

7.13.3.4 Following a *fault outage* of any single section of *busbar* or mesh corner, during a *planned outage* of any other single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed the 2.0 times the *largest single infeed*;

7.13.3.5 Following a *fault outage* of any single *busbar* coupler circuit breaker or *busbar* section circuit breaker or mesh circuit breaker, during a *planned outage* of any single section of *busbar* or mesh corner, the *loss of power infeed* shall not exceed 2.0 times the *largest single infeed*.

Generation Connection Capacity Requirements

Background conditions

7.14 The connection of a particular *offshore power station* shall meet the criteria set out in paragraphs 7.15 to 7.24 under the following background conditions:

7.14.1 the active power output of the *offshore power station* shall be set to deliver active power at the offshore *grid entry point* equal to its *registered capacity*;

7.14.2 the reactive power output of the *offshore power station* shall normally, and unless otherwise agreed, be set to deliver zero reactive power at the offshore *grid entry point* with active power output equal to *registered capacity*; and the reactive power delivered at the *interface point* shall be set in accordance with the reactive requirements placed on the *offshore transmission system* and

7.14.3 conditions on the Northern Ireland *transmission system* shall be set to those which ought reasonably to be expected to arise in the course of a year of operation. Such conditions shall include forecast demand cycles, typical *power station* operating regimes and typical *planned outage* patterns modified where appropriate by the provisions of paragraph 7.17.

Pre-Fault Criteria – background conditions of no *local system outage*

7.15 The *transmission capacity* of the *offshore transmission circuits* for the connection of one or more *offshore power station*s shall be planned such that, for the background conditions described in paragraph 7.14, with no *local system outage* and prior to any fault there shall not be any of the following:

7.15.1 Equipment loadings exceeding the *pre-fault rating*;

7.15.2 Voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*; or

7.15.3 *System instability*.

Post-Fault Criteria – background conditions of no *local system outage*

7.16 The *transmission capacity* of the *offshore transmission circuits* for the connection of one or more *offshore power station*s shall also be planned such that for the background conditions described in paragraph 7.14 with no *local system outage* and for the *secured event* on the *offshore transmission system* of any of the following:

7.16.1 In the case of an *offshore power station* connection with an *OffGEP capacity* of 90MW or more, with the *OffGEP capacity* reduced by 50%, a *fault outage* or *planned outage* of a single AC *offshore transmission circuit* on the *offshore platform*;

7.16.2 In the case of an *offshore power station* connection with an *OffGEP capacity* of 120MW or more, with the *OffGEP capacity* reduced to 50%, a *fault outage* or a *planned outage* of a single AC *offshore transmission circuit* at the onshore transformation facilities

And in all cases other than specified in 7.16.1 and 7.16.2 above:

7.16.3 a *fault outage* or a *planned outage* of a single *offshore transmission circuit*;

And in all cases:

7.16.4 a *fault outage* or a *planned outage* of a single reactive compensator or other reactive provider;

7.16.5 a *fault outage* of a *single offshore transmission* circuit during a *planned outage* of another *offshore transmission circuit*;

7.16.6 a *fault outage* or a *planned outage* of a single section of *busbar* or mesh corner;

There shall not be any of the following:

7.16.7 a *loss of supply capacity* except as permitted by the demand connection criteria detailed in Section 8;

7.16.8 *unacceptable overloading* of any *primary transmission equipment*;

7.16.9 *unacceptable voltage conditions* or *insufficient voltage performance margins*;

7.16.10 *system instability* or

7.16.11 *unacceptable power quality*.

7.17 Under *planned outage* conditions it shall be assumed that the *planned outage* specified in paragraphs 7.16.5 reasonably forms part of the typical outage pattern referred to in paragraph 7.14 rather than in addition to the typical outage pattern.

Post-fault criteria – background conditions with a *local system outage*

7.18 The transmission capacity of the *offshore transmission circuits* for the connection of one or more *offshore power stations* to an *offshore transmission system* shall also be planned such that, for the background conditions described in paragraph 7.14 with a *local system outage*, there shall not be any of the following:

7.18.1 a *loss of supply capacity* except as permitted by the demand connection criteria detailed in Section 8;

7.18.2 *unacceptable overloading* of any *primary transmission equipment*;

7.18.3 *unacceptable voltage conditions* or *insufficient voltage performance margins*;

7.18.4 *system instability or*

7.18.5 unacceptable power quality.

7.19 Where necessary to satisfy the criteria set out in paragraph 7.18, investment should be made in *transmission capacity* except where operational measures suffice to meet the criteria in paragraph 7.18 provided that maintenance access for each *offshore transmission circuit* can be achieved and provided that such measures are economically justified. The operational measures to be considered include rearrangement of transmission outages and appropriate reselection of *generating units* from those expected to be available, for example through balancing services. Guidance on economic justification is given in Appendix E.

Switching Arrangements

7.20 Guidance on offshore substation configurations and switching arrangements are described in Appendix A. These guidelines provide an acceptable way towards meeting the criteria of paragraphs 7.8 to 7.13. However, other configurations and switching arrangements which meet those criteria are also acceptable.

Variations to Connection Designs

7.21 Variations, arising from a generation customer's request, to the generation connection design necessary to meet the requirements of paragraphs 7.7 to 7.19 shall also satisfy the requirements of this Standard provided that the varied design satisfies the conditions set out in paragraphs 7.22.1 to 7.22.3. For example, such a generation connection design variation may be used to take account of the particular characteristics of an *offshore power station*.

7.22 Any generation connection design variation must not, other than in respect of the generation customer requesting the variation, either immediately or in the foreseeable future:

7.22.1 reduce the security of the MITS to below the minimum planning criteria specified in Section 4; or

7.22.2 result in additional investment or operational costs to any particular customer or overall, or a reduction in the security and quality of supply of the affected customers' connections to below the planning criteria in this section or Section 8, unless specific agreements are reached with affected customers; or

7.22.3 compromise any *transmission licensee's* ability to meet other statutory obligations or licence obligations.

7.23 Should system conditions subsequently change, for example due to the proposed connection of a new customer, such that either immediately or in the foreseeable future, the conditions set out in paragraphs 7.22.1 to 7.22.3 are no longer satisfied, then alternative arrangements and/or agreements must be put in place such that this Standard continues to be satisfied.

7.24 The additional operational costs referred to in paragraph 7.22.2 and/or any potential reliability implications shall be calculated by simulating the expected operation of the Northern Ireland *transmission system*. Guidance on economic justification is given in Appendix E.

8 Demand Connection Criteria Applicable to an *Offshore Transmission System*

8.1 This section presents the planning criteria applicable to the connection of *offshore power station demand groups* to the remainder of the Northern Ireland *transmission system*.

8.2 In those parts of an *offshore transmission system* where the criteria of Section 7 also apply, those criteria must also be met.

8.3 In planning demand connections, this Standard is met if the connection design either:

8.3.1 satisfies the deterministic criteria detailed in paragraphs 8.5 to 8.10; or

8.3.2 varies from the design necessary to meet paragraph 8.3.1 above in a manner which satisfies the conditions detailed in paragraphs 8.12 to 8.15.

8.4 It is permissible to design to standards higher than those set out in paragraphs 8.5 to 8.10 provided the higher standards can be economically justified. Guidance on economic justification is given in Appendix E.

Offshore Power Station Demand Connection Capacity Requirements

8.5 The connection of a particular *offshore power station demand group* shall meet the criteria set out in paragraphs 8.6 to 8.10 under the following background conditions:

8.5.1 when the power output of the *offshore power station* is set to zero and there are no *planned outages*, the demand of the *offshore power station demand group* shall be set equal to *group demand*; and

8.5.2 demand and generation outside the *offshore power station demand group* shall be set in accordance with an economic dispatchusing the appropriate method described in Appendix D.

8.6 The *transmission capacity* for the connection of an *offshore power station demand group* shall be planned such that, for the background conditions described in paragraph 8.5, under *intact system* conditions there shall not be any of the following:

8.6.1 equipment loadings exceeding the *pre-fault rating*;

8.6.2 voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*;

8.6.3 *system instability* or

8.6.4 *unacceptable power quality*.

8.7 The *transmission capacity* for the connection of an *offshore power station demand group* shall also be planned such that for the background conditions described in paragraph 8.5 and for the *planned outage* of a single transmission circuit or a single section of *busbar* or mesh corner, there shall not be any of the following:

8.7.1 a *loss of supply capacity* for a *group demand* of greater than 1 MW;

8.7.2 *unacceptable overloading* of any *primary transmission equipment*;

8.7.3 voltages outside the *pre-fault planning voltage limits* or *insufficient voltage performance margins*;

8.7.4 *system instability* or

8.7.5 unacceptable power quality.

8.8 The *transmission capacity* for the connection of an *offshore power station demand group* shall also be planned such that for the background conditions described in paragraph 8.5 and the initial conditions of:

8.8.1 an *intact system* condition; or

8.8.2 the single *planned outage* of another *transmission circuit* or a *generating unit*, a reactive compensator or other reactive power provider,

for the *secured event* of a *fault outage* of:

8.8.3 a single *transmission circuit*,

there shall not be any of the following:

8.8.4 a *loss of supply capacity* such that the provisions set out in Table 8.1 are not met;

8.8.5 *unacceptable overloading* of any *primary transmission equipment*;

8.8.6 *unacceptable voltage conditions* or *insufficient voltage performance margins*; or

8.8.7 *system instability* or

8.8.8 *unacceptable power quality*.

8.9 In addition to the requirements of paragraphs 8.6 to 8.8, for the background conditions described in paragraph 8.5, the system shall also be planned such that operational switching does not cause *unacceptable voltage conditions*.

8.10 For a *secured event* on connections to more than one *offshore power station demand group* , the permitted *loss of supply capacity* for that *secured event* is the maximum of the permitted loss of supply capacities set out in Table 8.1 for each of these *offshore power station demand groups*.

Group Demand	Initial system conditions	
	Intact system	With single *planned outage* Note 1
Over 1MW to 12MW	**Within 3 hours** Group Demand minus 1 MW In repair time Group Demand	Nil
Up to 1MW	**In repair time** *Group Demand*	Nil

Table 8.1 Minimum planning supply capacity following *secured events*

Notes

1. The *planned outage* may be of a *transmission circuit*, *generating unit*, reactive compensator or other reactive power provider.

Switching Arrangements

8.11 Guidance on substation configurations and switching arrangements are described in Appendix A. These guidelines provide an acceptable way towards meeting the criteria of this chapter. However, other configurations and switching arrangements which meet the criteria are also acceptable.

Variations to Connection Designs

8.12 Variations, arising from a *generator*'s request, to the demand connection design necessary to meet the requirements of paragraphs 8.5 to 8.10 shall also satisfy the requirements of this Standard provided that the varied design satisfies the conditions set out in paragraphs 8.13.1 to 8.13.3. For example, such a demand connection design variation may be used to limit overall costs.

8.13 Any demand connection design variation must not, other than in respect of the *generator* requesting the variation, either immediately or in the foreseeable future:

8.13.1 reduce the security of the MITS to below the minimum planning criteria specified in Section 4; or

8.13.2 result in additional investment or operational costs to any particular customer or overall, or a reduction in the security and quality of supply of the affected customers' connections to below the planning criteria in this section or Section 7, unless specific agreements are reached with affected customers; or

8.13.3 compromise any *transmission licensee's* ability to meet other statutory obligations or licence obligations.

8.14 Should system conditions change, for example due to the proposed connection of a new customer, such that either immediately or in the foreseeable future, the conditions set out in paragraphs 8.13.1 to 8.13.3 are no longer satisfied, then alternative arrangements and/or agreements must be put in place such that this Standard continues to be satisfied.

8.15 The additional operational costs referred to in paragraph 8.13.3 and/or any potential reliability implications shall be calculated by simulating the expected operation of the Northern Ireland transmission system. Guidance on economic justification is given in Appendix E.

9 Voltage Limits in Planning an *Offshore Transmission System*

Voltage Limits

9.1 The *pre-fault planning voltage limits* and *steady state* voltage limits on an *offshore transmission system* are as shown in Table 9.1.

Table 9.1 *Pre-fault planning voltage limits* and *steady state* voltage limits in both planning and operational timescales

Nominal Voltage	Minimum	Maximum
400kV **Note 1**	-10%	+5%
Less than 400kV down to 110kV inclusive	-10%	+10%
Less than 110kV	-6%	+6%

Note 1: For 400kV, the maximum limit is aligned with the equivalent onshore limit pending review in the light of technological developments.

9.2 A voltage condition on an *offshore transmission system* is unacceptable in both planning and operational timescales if, after either

9.2.1 a *secured event*, or

9.2.2 operational switching, and

9.2.3 the affected site remains directly connected to the *Northern Ireland transmission system in the steady state after the relevant event above, the following condition applies*:

9.2.4 there is any inability following such an event to achieve a *steady state* voltage as specified in Table 9.1 at the *offshore transmission system* substations or OSPs using manual and/or automatic facilities available, including the switching in or out of relevant equipment.

9.3 In planning timescales, the *steady state* voltages are to be achieved without widespread post-fault generation transformer re-tapping or post-fault adjustment of SVC set points to increase the reactive power output or to avoid exceeding the available reactive capability of generation or SVCs.

10 Terms and Definitions

ACS Peak Demand	The estimated unrestricted winter peak demand (MW and MVAr) on the Northern Ireland transmission system for the *average cold spell* (ACS) condition. This represents the demand to be met by *power station*s and *generating units* directly connected to the Northern Ireland transmission system or embedded in the Distribution System) and by electricity imported into the *onshore transmission system* from external systems across external *interconnections* (and which is not adjusted to take into account demand management or other techniques that could modify demand).
Annual Load Factor	The ratio of the actual energy output of a generating unit, CCGT module or *power station* (as the case may be) to the maximum possible energy output of that generating unit, CCGT module or power station (as the case may be) over a year. It is often expressed in percentage terms.
Authority	This means the Utility Regulator established by the Energy (Northern Ireland) Order 2003.
Average Cold Spell (ACS)	A particular combination of weather elements which give rise to a level of peak demand within a financial year (1 April to 31 March) which has a 50% chance of being exceeded as a result of weather variation alone.
Bulk Supply Point (BSP)	A point at which the onshore *transmission system* connects to the *distribution system*. For the avoidance of doubt this point will generally be at a 110/33kV substation and the interface will be the 33kV transformer terminals.
Busbar	The common connection point of two or more transmission circuits.
Corrective Action	Manual and automatic action taken after an outage or switching action to assist recovery of satisfactory system conditions; for example, tap changing or switching of plant.
Credible demand sensitivities	Such variations in demands above those forecast as are appropriate to the locations and the forecast error for the number of years ahead for which the forecast has been produced, e.g. that which corresponds to an 80% demand forecast confidence level.
DC Converter	Any apparatus used as part of the Northern Ireland Transmission System to convert alternating current electricity to direct current electricity, or vice-versa. A *DC Converter* is a standalone operative configuration at a single site comprising one or more converter bridges, together with one or more converter transformers, converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion. In a bipolar arrangement, a *DC Converter* represents the bipolar configuration.

Demand group	A site or group of sites which collectively take power from the remainder of the *onshore transmission system*.
Distribution embedded generator	A generator connected to the *distribution system*.
Distribution Licensee	Means the holder of a Distribution Licence in respect of an onshore distribution system granted under Electricity (Northern Ireland) Order 1992.
Distribution System	Means the system comprising of electric lines owned and operated by the distribution licensee within the Authorised Area (excepting lines forming part of the transmission system or any Interconnector), and any other electric lines which the Authority may specify as forming part of the Distribution System. For the avoidance of doubt the interface between the *Transmission System* and the *Distribution System* is the low voltage terminals on a 110/33kV transformer.
Double Circuit Overhead Line	In the case of the onshore and offshore transmission system, this is a transmission line which consists of two circuits sharing the same towers for at least one span
Interconnection	Apparatus for the transmission of electricity to or from the *onshore transmission system* into or out of an *interconnected system*.
Interconnected System	A transmission or distribution system located outside the Northern Ireland transmission system operator area, which is electrically connected to the *onshore transmission system* by an external *interconnection*
Fault outage	An outage of one or more items of primary transmission apparatus and/or generation plant initiated by automatic action unplanned at that time, which may or may not involve the passage of fault current. First Onshore Substation The *first onshore substation* defines the onshore limit of an offshore transmission system. An offshore transmission system cannot extend beyond the *first onshore substation*. Accordingly, the security criteria relating to an offshore transmission system extend from the offshore GEP up to the *interface point*, which is located at the *first onshore substation*. The security criteria relating to the *onshore transmission system* extend from the *interface point* located at the *first onshore substation* and extend across the remainder of the *onshore transmission system*. The *first onshore substation* will comprise, inter alia, facilities for the connection between, or isolation of, transmission circuits and/or distribution circuits. These facilities will include at least one *busbar* to which the offshore transmission system connects and one or more circuit

	breakers and disconnectors. For the avoidance of doubt, if the substation does not include these elements, then it does not constitute the *first onshore substation*. The *first onshore substation* will be owned by the relevant transmission licensee.
Forecast Minimum Demand	This is the minimum demand level expected at a GSP or OSP or a group of GSPs or group of OSPs. Unless more specific data are available, this is the expected demand at the time of the annual minimum demand on the Northern Ireland transmission system as provided under the Grid Code. In the case of a group of GSPs or group of OSPs, the demand diversity within the group should be taken into account.
Generating Plant Type	A type of generating unit classified by the type of prime move, e.g. thermal hydro.
Generating Units	An onshore generating unit or an offshore generating unit.
Generation Circuit	The sole electrical connection between one or more onshore generating units or one or more *Bulk Supply Points* supplying *Distribution Connected Generators* and the *Main Interconnected Transmission System* i.e. a radial circuit which if removed would disconnect the associated generation.
Generation Point of Connection	For the purpose of defining the boundaries between the MITS and *generation circuits*, the *generation point of connection* is taken to be the *busbar* clamp in the case of an air insulated substation, gas zone separator in the case of a gas insulated substation, or other equivalent point as may be determined by the relevant *transmission licensee* for new types of substation
Generator	A person who generates electricity under licence granted by the Northern Ireland *Authority* for Utility Regulation under Article 10 of the Electricity (Northern Ireland) Order 1992.
Grid Entry Point (GEP)	A point at which a generating unit, which is directly connected to the Northern Ireland transmission system, connects to the Northern Ireland transmission system. The default point of connection is taken to be the *busbar* clamp in the case of an air insulated substation, gas zone separator in the case of a gas insulated substation, or equivalent point as may be determined by the relevant *transmission licensee* for new types of substation.
Grid Supply Point (GSP)	A substation on the *onshore transmission system* which the voltage is transformed from 275kV to 110kV.
Group Demand	For a single BSP or OSP: The forecast maximum demand for the BSP or OSP provided in accordance with the requirements of the Grid Code by the *network operators* or non-embedded customers taking demand from the Northern

	Ireland transmission system. For multiple BSPs, OSPs or when assessing a GSP: The sum of the forecast maximum demands for the BSPs or OSPs as provided by the *network operators* or non-embedded customers taking demand from the Northern Ireland transmission system.
Insufficient Voltage Performance Margins	In all timescales and in particular the post-fault periods (i.e. before, during and after the automatic controls take place), there are insufficient voltage performance margins when the following occurs: i) *voltage collapse*; ii) over-sensitivity of system voltage; or iii) unavoidable exceedance of the reactive capability of generating units such that accessible reactive reserves are exhausted; under any of the following conditions: i) *credible demand sensitivities*; ii) the unavailability of any single reactive compensator or other reactive power provider; or iii) the loss of any one automatic switching system or any automatic voltage control system for on-load tap changing.
Intact System	This is the Northern Ireland transmission system with no system outages i.e. with no *planned outages* (e.g. for maintenance) and no *unplanned outages* (e.g. subsequent to a fault).
Interface Point (IP)	A point at which an offshore transmission system, which is directly connected to an *onshore transmission system*, connects to the *onshore transmission system*. The *Interface Point* is located at the *first onshore substation* which the *offshore transmission circuits* reach onshore. The default point of connection, within the *first onshore substation*, is taken to be the *busbar* clamp in the case of an air insulated substation, gas zone separator in the case of a gas insulated substation, on either the lower voltage (LV) *busbars* or the higher voltage (HV) *busbars* as may be determined by the relevant transmission licensee. Normally, and unless otherwise agreed, if the offshore transmission owner owns the *first onshore substation*, the *interface point* would be on the HV *busbars* and, if the *first onshore substation* is owned by the onshore transmission owner, the *interface point* would be on the LV *busbars*.
Variable Generation	Generation from a source of energy that is not continuously available due to some factor outside direct control. The variable generation may be quite predictable, for example, tidal power, but cannot be dispatched in the normal way.

Largest Single Infeed	The largest block of generation consisting of a single large unit, a group of units, or an interconnector importing, connected to the all-island power system via a single transmission circuit, currently fixed at 500MW.
Local System Outage	In the context of a *demand group* or *offshore power station demand group*, a planned outage or *unplanned outage* local to a *demand group* or *offshore power station demand group*, as the case may be, such that it has a direct effect on the supply capacity to that *demand group* or *offshore power station demand group*. In the context of planning generation connections, a planned outage local to a *power station* such that it has a direct effect on the generation connection capacity requirements for that *power station.*
Loss of Power Infeed	The output of a generating unit or a group of generating units or the import from an *interconnected system* disconnected from the system by a *secured event*, less the demand disconnected from the system by the same *secured event*. For the avoidance of doubt if, following such a *secured event*, demand associated with the normal operation of the affected generating unit or *generating units* is automatically transferred to a supply point which is not disconnected from the system, e.g. the station board, then this shall not be deducted from the total *loss of power infeed* to the system. For the purpose of the operational criteria, the *loss of power infeed*, includes the output of a single generating unit, CCGT or DC Link lost as a result of an event. In the case of an *offshore generating unit* or group of *offshore generating units*, the *loss of power infeed* is measured at the *interface point*, as appropriate.
Loss of Supply Capacity	This is the allowable reduction in the supply capacity at a *Grid Supply Point, Bulk Supply Point* or *offshore supply point* as a result of *planned outages* and/or *secured events*. For the avoidance of doubt, where the transmission licensee do maintain the potential to provide a supply but, following an outage, demand is lost because of circuit configurations not under the control of the transmission licensees, that lost supply does not constitute *loss of supply capacity*.
Main Interconnected Transmission System (MITS)	This comprises all the 400kV, 275kV and 110kV elements of the onshore meshed transmission system but excludes *generation circuits*, transformer connections to *demand groups* and any offshore transmission systems radially connected to the *onshore transmission system*.
Maintenance Period Demand	This is the demand level experienced at a GSP and is the maximum demand level expected during the normal maintenance period. This level is such that the period in which maintenance could be undertaken is not unduly limited.
Marshalling Substation	A substation which connects circuits from more than two line routes.

Network Operator	A person with a system directly connected to the *onshore transmission system* to which customers and/or *power station*s (not forming part of that system) are connected, acting in its capacity as an operator of that system, but shall not include a person who operates an external system.
Offshore	Means wholly or partly in offshore waters of Northern Ireland, and when used in conjunction with another term and not defined means that the associated term is to be read accordingly.
Offshore Generating Unit	Any apparatus, which produces electricity including, a synchronous *offshore generating unit* and non-synchronous *offshore generating unit* and which is located in *offshore* waters.
Offshore Grid Entry Point Capacity (OffGEP Capacity)	The cumulative *registered capacity* of all *offshore power stations* connected at a single *offshore grid entry point* and/or the cumulative *registered capacity* of all offshore *power stations* connected to all the *offshore grid entry point*s of an *offshore* transmission system
Offshore Platform	A platform, located in *offshore* waters, which contains plant and apparatus associated with the generation and/or transmission of electricity including high voltage electrical circuits which form part of an *offshore* transmission system and which may include one or more *offshore grid entry points.*
Offshore Power Station	An installation, located in *offshore* waters, comprising one or more *offshore generating units* (even where sited separately) owned and/or controlled by the same *generator*, which may reasonably be considered as being managed as one *offshore power station*.
Offshore Power Station Demand Group	An *offshore* site or group of *offshore* sites located on an *offshore platform*/s which collectively take power from the remainder of an *offshore* transmission system for the purpose of supplying *offshore power station* demand.
Offshore Supply Point (OSP)	A point of supply from an *offshore* transmission system to an *offshore power station*.
Offshore Transmission Circuit	Part of an *offshore* transmission system between two or more circuit-breakers which includes, for example, transformers, reactors, cables, overhead lines and *DC converters* but excludes *busbars* and onshore transmission circuits.
Offshore Transmission System	A system consisting (wholly or mainly) of high voltage lines of 110kV or greater owned and/or operated by an *offshore* transmission licensee and used for the transmission of electricity to or from an *offshore power station* to or from an *interface point*, or to or from another *offshore power station* and includes equipment, plant and apparatus and meters owned or operated by an transmission licensee in connection with the transmission of electricity. An *offshore*

	transmission system extends from the *interface point* to the *offshore grid entry point*/s and may include plant and apparatus located onshore and *offshore*. For the avoidance of doubt, the *offshore transmission systems* (within territorial waters), together with the *onshore transmission system*, form the Northern Ireland transmission system.
Onshore Generating Unit	Any apparatus which produces electricity including a synchronous generating unit and non-synchronous generating unit but excluding an *offshore generating unit*.
Onshore Power Station	An installation comprising one or more onshore *generating units* or wind farm *power station*(even where sited separately) owned and/or controlled by the same *generator*, which may reasonably be considered as being managed as one onshore *power station*.
Onshore Transmission Circuit	Part of the *onshore transmission system* between two or more circuit-breakers which includes, for example, transformers, reactors, cables and overhead lines but excludes *busbars*, *generation circuits* and *offshore transmission circuit*s.
Onshore Transmission Licensee	As set out in the Licenses.
Onshore Transmission System	The onshore system consisting (wholly or mainly) of the high voltage electric lines used for the transmission of electricity from one onshore *power station* to a substation or to another *power station* or between substations or to or from *offshore* transmission systems or to or from any *interconnections* and includes any plant and apparatus and meters owned or operated by *transmission licensee* within Northern Ireland in connection with the transmission of electricity. For the avoidance of doubt, the *onshore transmission system*, together with the *offshore transmission systems* form the Northern Ireland *transmission system*.
Operational Intertripping	The automatic tripping of circuit breakers to remove *generating units* and/or demand. It does not provide additional *transmission capacity* and must not lead to *unacceptable frequency conditions* for any *secured event*. Where *operational intertripping* is used to remove potential overloads there should be adequate redundancy and/or supervisory systems and regular testing. The use of *Operational Intertripping* from multiples of *transmission circuits* on the MITS to multiples of *generators* over long distances or using complex third party communication equipment should be avoided.
Planned Outage	An outage of one or more items of primary transmission apparatus and/or generation plant, initiated by manually instructed action which has been subject to the recognised Northern Ireland transmission system operator area outage planning process.

Plant Margin	The amount by which the total installed capacity of directly connected *power stations* and embedded large *power station*s exceeds the net amount of the *ACS peak demand* minus the total imports from external systems. This is often expressed as a percentage (e.g. 20%) or as a decimal fraction (e.g. 0.2) of the net amount of the *ACS peak demand* minus the total imports from external systems.
Power Station	Means an *onshore power station* or an *offshore power station*.
Pre-Fault Planning Voltage Limits	The voltage limits for use in planning timescales for circumstances before a fault.
Pre-fault Rating	The specified pre-fault capability of transmission equipment. Due allowance shall be made for specific conditions (e.g. ambient/seasonal temperature), agreed time-dependent loading cycles of equipment and any additional relevant procedures.
Prevailing System Conditions	These are conditions on the Northern Ireland *transmission system* prevailing at any given time and will therefore normally include *planned outages* and *unplanned outages*.
Primary Transmission Equipment	Any equipment installed on the Northern Ireland *transmission system* to enable bulk transfer of power. This will include *transmission circuits*, *busbars*, and switchgear.
Registered Capacity	a) In the case of a *Generating Unit*, the normal Full Load capacity in MW measured as at the Connection Point b) In the case of a Wind Farm Power Station, the normal Full Load capacity of the collection of one or more wind turbines, each being a *Generating Unit*, in MW measured as at the Connection Point. c) In the case of a *power station*, the maximum amount of active power deliverable by the *power station* at the GEP.
Secured event	A contingency which would be considered for the purposes of assessing system security and which must not result in the remaining Northern Ireland *transmission system* being in breach of the security criteria. *Secured events* are individually specified throughout the text of this Standard. It is recognised that more onerous unsecured events may occur and additional operational measures may be utilised to maintain overall Northern Ireland *transmission system* integrity.
Steady State	A condition of a power system in which all automatic and manual *corrective actions* have taken place and all of the operating quantities that characterise it can be considered constant for the purpose of analysis.

Supergrid	That part of the Northern Ireland *transmission system* operated at a nominal voltage of 275kV and above.
System Instability	i) poor damping - where electromechanical oscillations of *generating units* are such that the resultant peak deviations in machine rotor angle and/or speed at the end of a 20 second period remain in excess of 15% of the peak deviations at the outset (i.e. the time constant of the slowest mode of oscillation exceeds 12 seconds); or ii) pole slipping - where one or more transmission connected synchronous *generating units* lose synchronism with the remainder of the system to which it is connected For the purpose of assessing the existence of *system instability*, a *fault outage* is taken to include a solid three phase to earth fault (or faults) anywhere on the Northern Ireland *transmission system* with an appropriate clearance time. The appropriate clearance time is identified as follows: i) On the 275kV system clearance times consistent with the fault location together with the worst single failure in the main protection system should be used; ii) elsewhere, clearance times should be consistent with the fault location and appropriate to the actual protection, signalling equipment, trip and interposing relays, and circuit breakers involved in clearing the fault.
Transfer Capacity	That circuit capacity from adjacent *demand groups* which can be made available within the times stated in Table 3.1
Transient Time Phase	The time within which fault clearance or initial system switching, the transient decay and recovery, auto switching schemes, *generator* inter-tripping, and fast, automatic responses of controls such as *generator* AVR and SVC take place. Load response may be assumed to have taken place. Typically 0 to 5 seconds after an initiating event.
Transmission Capacity	The ability of a network to transmit electricity. It does not include the use of *operational intertripping* except in respect of paragraph 2.13 in Section 2, paragraph 0 in Section 4 and paragraphs 7.7 to 7.12 & 7.15 in Section 7.
Transmission Circuit	This is either an *onshore transmission circuit* or an *offshore transmission circuit*.
Transmission Licensee	The holder of a license from the *Authority* to participate in transmission in Northern Ireland.
Transmission System	Has the same meaning as the term “licensee’s transmission system” in the Transmission licence of a *Transmission licensee*.

Unacceptable Frequency Conditions	These are conditions where: i) the *steady state* frequency falls outside the statutory limits of 49.8Hz to 50.2Hz; ii) a transient frequency during a transmission system disturbance falling outside the limits of 48Hz to 52Hz; iii) a transient frequency during an exceptional transmission system disturbance falling outside the limits of 47Hz to 52Hz; iv) any transient frequency deviation which does not recover to within 49.8Hz to 50.2Hz within 60 seconds.
Unacceptable Overloading	The overloading of any *primary transmission equipment* beyond its specified time-related capability. Due allowance shall be made for specific conditions (e.g. ambient/seasonal temperature), pre-fault loading, agreed time-dependent loading cycles of equipment and any additional relevant procedures.
Unacceptable power quality	The exceedance of power quality limits as set out in Engineering Recommendations G5/4-1, P16, P28/2 and P29 as published by Energy Networks Association. For G5/4-1 suitable filters may be required within a User's System.
Unacceptable Voltage Conditions	Voltages out with those specified in section 6, Voltage Limits in Planning and Operating the *onshore transmission system* and/or outside the limits specified in Section 9 Voltage Limits in Planning an *Offshore Transmission System*).
Unplanned Outage	An outage of one or more items of primary transmission apparatus and/or generation plant, initiated by manually instructed action which has not been subject to the recognised Northern Ireland *transmission system* operator area outage planning process.
User System	Any system owned or operated by a user of the Northern Ireland *transmission system* other than a *transmission licensee* comprising: a) *generating units*; and/or b) systems consisting wholly or mainly of electric circuits used for the distribution of electricity from *bulk supply points* or *offshore supply point*s or *generating units* or other entry points to the point of delivery to customers or other users. and plant and/or apparatus connecting: c) the system described above; or d) non-embedded customers' equipment;

to the Northern Ireland *transmission system* or to the relevant other *user system*, as the case may be.

The *user system* includes any remote transmission assets operated by such user or other person and any plant and/or apparatus and meters owned or operated by the user or other person in connection with the distribution of electricity but do not include any part of the Northern Ireland *transmission system*.

Voltage collapse	Where progressive, fast or slow voltage decrease or increase develops such that it can lead to either tripping of *generating units* and/or loss of demand
Voltage Step Change	The difference in voltage between that immediately before a *secured event* or operational switching and that at the end of the *transient time phase* after the event.

A Appendix A Recommended Substation Configuration and Switching Arrangements

<u>Part 1 – *Onshore Transmission System*</u>

A.1 The recommendations set out in paragraphs A.2 to A.6 apply to the *onshore transmission system*

A.2 The key factors which must be considered when planning the *onshore transmission system* substation include:

A.2.1 Security and Quality of Supply - Relevant criteria are presented in Sections 2, 3 and 4.

A.2.2 Extendibility - The design should allow for the forecast need for future extensions. This is expected to preclude the future use of mesh type substations.

A.2.3 Maintainability - The design must take account of the practicalities of maintaining the substation and associated circuits.

A.2.4 Operational Flexibility - The physical layout of individual circuits and groups of circuits must permit the required power flow control.

A.2.5 Protection Arrangements - The design must allow for adequate protection of each system element.

A.2.6 Short Circuit Limitations - In order to contain short circuit currents to acceptable levels, *busbar* arrangements with sectioning facilities may be required to allow the system to be split or re-connected through a fault current limiting device.

A.2.7 Land Area - The low availability and/or high cost of land particularly in densely populated areas may place a restriction on the size and consequent layout of the substation.

A.2.8 Cost

A.3 Accordingly the design of a substation is a function of prevailing circumstances and future requirements as perceived in the planning time phase. This appendix is intended as a functional guidance for substation layout design and switchgear arrangements. Variations away from this guidance are permissible provided that such variations comply with the requirements of the criteria set out in the main text of this Standard.

Generation Point of Connection Substations

A.4 In accordance with the planning criteria for generation connection set out in Section 2, *generation point of connection* substations with a planned capacity exceeding 150MVA should:

A.4.1 have a double *busbar* design (i.e. with main and reserve busbars such that *generation circuits* and *onshore transmission circuits* may be selected to either);

A.4.2 have sufficient *busbar* sections to permit the requirements of paragraph 2.6 to be met without splitting the substation during maintenance of *busbar* sections;

A.4.3 have sufficient *busbar* coupler and/or *busbar* section circuit breakers so that each section of the main and reserve *busbar* may be energised using either a *busbar* coupler or *busbar* section circuit breaker;

A.4.4 have *generation circuits* and *onshore transmission circuits* disposed between *busbar* sections such that the main *busbar* may be operated split for fault level control purposes; and

A.4.5 have sufficient facilities to permit the transfer of *generation circuits* and *onshore transmission circuits* from one section of the main *busbar* to another.

Marshalling Substations

A.5 *Marshalling substations* should:-

A.5.1 have a double *busbar* design (i.e. with main and reserve *busbars* such that *onshore transmission circuits* may be selected to either);

A.5.2 have sufficient *busbar* sections to permit the requirements of paragraphs 2.6, 4.6 and 0 to be met;

A.5.3 have *onshore transmission circuits* disposed between *busbar* sections such that the main *busbar* may be operated split for fault level control purposes; and

A.5.4 have sufficient facilities to permit the transfer of *onshore transmission circuits* from one section of *busbar* to another.

Grid Supply Point Substations

A.6 In accordance with the planning criteria for demand connection set out in Section 3, GSP substations configurations range from a single transformer teed into an *onshore transmission circuit* to a four switched mesh substation or a double *busbar* substation. The choice and need for the extendibility will depend on the circumstances as perceived in the planning time phase.

Part 2 – *Offshore Transmission Systems*

A.7 The recommendations set out in paragraphs A.7 to A.13 apply to *offshore transmission systems.*

A.8 The key factors which must be considered when planning an *offshore transmission system* substation include:

A.8.1 Security and Quality of Supply - Relevant criteria are presented in Sections 7 and 8.

A.8.2 Maintainability - The design must take account of the practicalities of maintaining the substation and associated circuits.

A.8.3 Operational Flexibility - The physical layout of individual circuits and groups of circuits must permit the required power flow control.

A.8.4 Protection Arrangements - The design must allow for adequate protection of each system element.

A.8.5 Short Circuit Limitations - In order to contain short circuit currents to acceptable levels, *busbar* arrangements with sectioning facilities may be required to allow the system to be split or re-connected through a fault current limiting reactor.

A.8.6 Available Area –The high cost of the *offshore platform* may place a restriction on the size and consequent layout of the substation.

A.8.7 Cost.

A.9 Accordingly the design of a substation is a function of prevailing circumstances and future requirements as perceived in the planning time phase. This appendix is intended as a functional guidance for substation layout design and switchgear arrangements. Variations away from this guidance are permissible provided that such variations comply with the requirements of the criteria set out in the main text of this Standard.

Offshore Transmission System Substations

Offshore GEP Substations (on an *Offshore Platform*)

A.10 In accordance with the planning criteria for *offshore* generation connection set out in Section 7, the substation should:

A.10.1 have sufficient *busbar* sections to permit the requirements of paragraph 7.8 to be met without splitting the substation during maintenance of *busbar* sections; and

A.10.2 have sufficient *busbar* coupler and/or *busbar* section circuit breakers so that each *busbar* section may be energised using either a *busbar* coupler or *busbar* section circuit breaker

IP Substations

A.11 In accordance with the planning criteria for *offshore* generation connection set out in Section 7, the substation should:

A.11.1 have a double *busbar* design (i.e. with main and reserve *busbars* such that *offshore generation circuits* owned by the *generator* and *offshore transmission circuit*s may be selected to either);

A.11.2 have sufficient *busbar* sections to permit the requirements of paragraph 7.13 to be met without splitting the substation during maintenance of *busbar* sections;

A.11.3 have sufficient *busbar* coupler and/or *busbar* section circuit breakers so that each section of the main and reserve *busbar* may be energised using either a *busbar* coupler or *busbar* section circuit breaker; and

A.11.4 have sufficient facilities to permit the transfer of *offshore generation circuits* owned by the *generator* and *offshore transmission circuit*s from one section of the main *busbar* to another.

Marshalling Substations

A.12 The following recommendations apply to *offshore marshalling substations*, which interconnect *offshore transmission circuit*s from two or more *offshore platform*s, where *offshore grid entry points* are located, and the *first onshore substation*, where the *interface point* or is located.

A.13 *Marshalling Substations* should:

A.13.1 have a double *busbar* design (i.e. with main and reserve *busbars* such that *offshore transmission circuit*s may be selected to either);

A.13.2 have sufficient *busbar* sections to permit the requirements of Section 7 to be met;

A.13.3 have *transmission circuits* disposed between *busbar* sections such that the main *busbar* may be operated split for fault level control purposes; and

A.13.4 have sufficient facilities to permit the transfer of *offshore transmission circuit*s from one section of *busbar* to another.

Offshore Supply Point Substations

A.14 *Offshore supply point* substations should be designed to meet the requirements of Section 8. The actual design will depend on the circumstances as perceived in the planning time phase.

B Appendix B Circuit Complexity on the *Onshore Transmission System*

B.1 This appendix defines restrictions to be applied by the *transmission licensee* when *onshore transmission circuits* are designed, constructed or extended. These restrictions are intended to ensure that the time required to isolate and earth circuits in preparation for maintenance work is kept to a minimum and is not disproportionate to the time required to carry out maintenance work. The restrictions also limit the potential for human error.

B.2 This appendix is divided into two parts. The first defines those restrictions that apply to *transmission circuits* on the *supergrid* part of the MITS. The second gives guidance on those restrictions that may be applied to *transmission circuits* on that part of the MITS operated at a nominal voltage of 110kV.

Restrictions for *transmission circuits* on the *supergrid*

B.3 The three restrictions to be applied to *transmission circuits* on the 275kV part of the MITS are as follows.

B.3.1 The facilities, for the isolation and earthing of *transmission circuits* and Transmission Equipment, shall not be located at more than three individual sites;

B.3.2 The normal operational procedure, for the isolation and earthing of *transmission circuits* and Transmission Equipment, shall not require the operation of more than five circuit-breakers; and

B.3.3 No more than three transformers shall be connected together and controlled by the same circuit breaker.

B.4 A site, in this context, is defined as being where the points of isolation at one end of a *transmission circuit* are within the same substation such that only one authorised person is required, at the site, to enable the efficient and effective release and restoration of the circuit.

B.5 If the design of a substation is such that two circuit-breakers of the same voltage are used to control a circuit (e.g. in a mesh type of substation), for the purposes of the above restrictions the two circuit-breakers are to be considered as a single circuit breaker. This also applies where duplicate circuit-breakers control a circuit including those used for *busbar* selection.

B.6 Switch disconnectors that are not rated for fault breaking duty should not be included in the design of new *transmission circuits* and substations for the purpose of reducing complexity. Where the extension of an existing *transmission circuit* includes an existing switch disconnector and that switch disconnector is not rated for fault breaking duty, that switch disconnector can be considered for use in planned switching procedures only.

B.7 For the purposes of restriction in B.3.3 a transformer which includes two low voltage windings in its construction shall be considered as single transformer.

Guidance for *transmission circuits* operated at a nominal voltage of 110kV

B.8 The restrictions recommended below should be regarded as being in general the limits of good planning. The majority of 110kV circuits do not reach this limit nor will they be expected to do so.

B.9 Any proposals which would result in these limits being exceeded should be fully explained and agreed with operational engineers.

B.10 Care must be observed in the application of these recommendations to “Active Circuits” to ensure that protective gear clearance times and discrimination are satisfactory and that the security of lower voltage connected generation is not unduly prejudiced.

Restriction A

B.11 The normal operating procedure or protective gear operation for making dead any 110 kV circuit shall not require the opening of more than seven circuit-breakers. These circuit-breakers shall not be located on more than four different sites.

B.11.1 The circuit-breakers to be counted include all those which connect the circuit to other parts of the system.

B.11.2 In a mesh or similar type substation, two circuit-breakers of the same voltage in the mesh controlling a circuit count as one circuit-breaker.

B.11.3 Where a circuit is controlled by two circuit-breakers which select between main and reserve *busbars*, these count as one circuit-breaker.

B.11.4 Switching isolators are not regarded as circuit-breakers for the purpose of this restriction.

Restriction B

B.12 Not more than three transformers shall be banked together on any one circuit at any one site.

B.12.1 A transformer with two lower voltage windings counts as one transformer.

Restriction C

B.13 No item of equipment shall have isolating facilities on more than four different sites.

B.13.1 Isolating facilities will normally be provided by means of circuit-breakers and their associated isolators.

B.13.2 Points of isolation on a circuit within an agreed reasonable walking distance to permit the efficient and effective use of one authorised person only at those points during the release and restoration of the circuit shall be regarded as being on one site.

B.13.3 Switching isolators having a “fault make, load break” capability shall be regarded as circuit-breakers for the purpose of this restriction.

C Appendix C Modelling of Stressed Case Dispatches

C.1 **Use of operating margin case – winter peak demand only**

For the purposes of assessing the capability of the main interconnected transmission system and generation circuits under the conditions of the loss of generation elsewhere on the all-island *transmission system* or Northern Ireland transmission system, generators should be dispatched as follows:

Unit type	Proportion of installed capacity %
Wind generation	Minimum level consistent with recent performance, e.g. 5%
Tidal	Minimum level consistent with recent performance, e.g. 0%
Steam turbines	Maximum level consistent with recent performance, e.g. 100%
CCGTs	Maximum level consistent with recent performance, e.g. 100%

If plant margins connected to the all island *transmission system* or the Northern Ireland *transmission system* are sufficiently reduced then a case operating OCGT plant may also be considered.

The Net Transfer Capacity limits for North / South circuits will be respected.

C.2 **High wind and tidal cases – winter peak and summer minimum demand**

The *transmission system* should be assessed for the case of maximum wind. The proportion of installed wind generation capacity that should be studied shall not exceed:

- 70% for summer valley;
- 80% for summer peak;
- 90% for winter peak.

It may be acceptable to use proportions differing from above however these must be backed by statistical data that the proportions are reasonable.

Tidal generation shall be dispatched at 100%

Other generators will be dispatched according to economic dispatch and respecting minimum generating limits.

The Net Transfer Capacity limits for North / South circuits will be respected.

During the above dispatches no more than three conventional generating sets will be run in Northern Ireland.

For the all island dispatch the rules regarding the limits of system non-synchronous penetration (SNSP) should be respected, currently 50%.

C.3 **Long term outage of generation case**

Apart from the normal expected retirement of *generating units* in future years the capability of the Northern Ireland *transmission system* to meet demand and provide secure connection to variable generation under *secured events* should be tested for the event of the long term outage of a single *generating unit*, CCGT module or power station (where a common mode failure event is identified).

For the above case in particular parts of the *transmission system* which depend on *generating units* to support voltage should be tested under the case where the unit is out due to long term repairs.

The Net Transfer Capacity limits for North / South circuits will be respected.

C.4 **Long term loss of interconnector case**

The generation should be economically dispatched assuming the long term outage of one interconnector.

D Appendix D Modelling of EconomicDispatch

D.1 **Conventional generators should be dispatched all island according to:**

- Economic dispatch as calculated by appropriate software;
- Net Transfer Limits on North South circuits should be respected;
- System non synchronous penetration limits respected;
- Flows on non-synchronous interconnectors should be typical;
- Wind generation shall be dispatched (as a % of installed capacity) at 5% and 90% for the winter and autumn peak cases and 80% for summer peak case (or as determined by statistical analysis);
- Tidal generation shall be dispatched at 100% of installed capacity.

E Appendix E Guidance on Economic Justification

E.1 These guidelines may be used to assist in the:

E.1.1 economic justification of investment in transmission equipment such as reactive power in addition to that required to meet the planning criteria of Sections 2, 3, 4, 7 or 8.

E.1.2 economic justification of the rearrangement of typical *planned outage* patterns and appropriate re-selection of *generating units*, for example through balancing services; and

E.1.3 evaluation of any expected additional operational costs or investments resulting from a proposed variation in connection design under the provisions of paragraphs 2.14 to 2.18 and/or paragraphs 3.12 to 3.15 and/or paragraphs 7.21 to 7.24.

E.2 **Guidelines:**

E.2.1 additional investment in transmission and/or the purchase of services, in addition to the minimum security requirements, would normally be justified if the net present value of the additional investment and/or service cost are less than the net present value of the expected operational or unreliability cost that would otherwise arise.

E.2.2 the assessment of expected operational costs and the potential reliability implications shall normally require simulation of the expected operation of the Northern Ireland *transmission system* as part of the all island *transmission system.*

E.2.3 due regard should be given to the expected duration of an appropriate range of prevailing conditions and the relevant *secured event*s under those conditions.

E.2.4 the operational costs to be considered shall normally include those arising from:

- transmission power losses;
- frequency response;
- system constraints,

and may also include costs arising from:

- rearrangement of transmission maintenance times; or
- modified or additional contracts for other services.

E.2.5 all costs should take account of future uncertainties

E.2.6 the evaluation of unreliability costs expected from operation of the Northern Ireland *transmission system* shall normally take account of the number and type of customers affected by supply interruptions, for example Value of Lost Load (VOLL) and use appropriate information available to facilitate a reasonable assessment of the economic consequences of such interruptions.