Northern Ireland

Transmission System Security and Planning Standards

Security and Quality of Supply Standard (NI)

September 2015
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SONI Ltd
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.

![Diagram of the onshore transmission system with a directly connected power station](image)

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 stations 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 stations 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 system 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 circuits connecting the cable offshore transmission circuits 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 circuits 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 circuits 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.

![Offshore Transmission System Diagram]

**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 circuits routed to different onshore substations or to separate busbar sections at the same onshore substation, those AC offshore transmission circuits 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

Background conditions

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;
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;

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

<table>
<thead>
<tr>
<th>Group Demand</th>
<th>Initial system conditions</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact system</td>
<td>With single planned outage</td>
<td></td>
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</table>

<table>
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<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 300 MW</td>
<td>Immediately</td>
<td>Maintenance Period Demand</td>
</tr>
<tr>
<td></td>
<td>Group Demand</td>
<td></td>
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<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 60 MW to 300 MW</td>
<td>Immediately</td>
<td>Maintenance Period Demand</td>
</tr>
<tr>
<td></td>
<td>Group Demand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within 3 hours</td>
<td>Group Demand</td>
</tr>
<tr>
<td></td>
<td>Group Demand</td>
<td></td>
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</table>

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<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
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<tbody>
<tr>
<td>Over 24 MW to 60 MW</td>
<td>Within 15 minutes</td>
<td>Group Demand minus 20 MW</td>
</tr>
<tr>
<td></td>
<td>Within 3 hours</td>
<td>Group Demand</td>
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<td></td>
<td>Group Demand</td>
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<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 8 MW to 24 MW</td>
<td>Within 15 minutes</td>
<td>Group Demand minus 8 MW</td>
</tr>
<tr>
<td></td>
<td>Within 3 hours</td>
<td>Group Demand</td>
</tr>
<tr>
<td></td>
<td>Group Demand</td>
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<table>
<thead>
<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 1 MW to 8 MW</td>
<td>Within 3 hours</td>
<td>Group Demand minus 1 MW</td>
</tr>
<tr>
<td></td>
<td>In repair time</td>
<td>Group Demand</td>
</tr>
<tr>
<td></td>
<td>Group Demand</td>
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<table>
<thead>
<tr>
<th>Group Demand</th>
<th>Intact system</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1 MW</td>
<td>In repair time</td>
<td>Group Demand</td>
</tr>
<tr>
<td></td>
<td>Nil</td>
<td></td>
</tr>
</tbody>
</table>

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

At ACS peak demand with an intact system

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:

Stressed Case Dispatches

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.

Economic Dispatch

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 that for economic operation there should be no constraint of economic generation.

Planned system and generation outages

5.2 During an outage of one or more in merit 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).

5.3 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

5.4 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 which will be examined on a case by case basis.

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>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>370kV</td>
<td>410kV</td>
</tr>
<tr>
<td>275 kV</td>
<td>261kV</td>
<td>289kV</td>
</tr>
<tr>
<td>110 kV</td>
<td>105kV</td>
<td>120kV</td>
</tr>
</tbody>
</table>

Table 6.1 Assumed Pre-fault planning voltage limits

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>
<thead>
<tr>
<th>Transmission secured fault or switching event</th>
<th>Voltage fall</th>
<th>Voltage rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following loss of single circuit</td>
<td>-6%</td>
<td>+6%</td>
</tr>
<tr>
<td>Following loss of double circuit overhead line</td>
<td>-10%</td>
<td>+6%</td>
</tr>
<tr>
<td>Operational switching less frequent than specified in ER P28</td>
<td>-3%</td>
<td>+3%</td>
</tr>
<tr>
<td>Operational switching covered by ER P28</td>
<td>In accordance with ER P28</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2 The voltage step change limits in planning timescales
<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>380kV (95%)</td>
<td>410 kV (102.5%)</td>
</tr>
<tr>
<td>275 kV</td>
<td>248kV (90%)</td>
<td>289 kV (105%)</td>
</tr>
<tr>
<td>110 kV</td>
<td>Note 3</td>
<td>115 kV (105%)</td>
</tr>
<tr>
<td>&lt;110kV</td>
<td>Note 3</td>
<td>105%</td>
</tr>
</tbody>
</table>

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 stations* 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 stations 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.

Offshore Platforms (AC and DC)

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 Transformer on an offshore platform

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 DC Converters on an offshore platform

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 **Busbars and Switchgear on an offshore platform**

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*.

**Offshore Cable Circuits (AC and DC)**

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.

**Overhead Line Sections (AC and DC)**

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 stations 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 stations 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 dispatch using 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.
Table 8.1 Minimum planning supply capacity following secured events

<table>
<thead>
<tr>
<th>Group Demand</th>
<th>Initial system conditions</th>
<th>With single planned outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 1MW to 12MW</td>
<td>Within 3 hours&lt;br&gt;Group Demand minus 1 MW&lt;br&gt;In repair time&lt;br&gt;Group Demand</td>
<td>Nil</td>
</tr>
<tr>
<td>Up to 1MW</td>
<td>In repair time&lt;br&gt;Group Demand</td>
<td>Nil</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>400kV</td>
<td>-10%</td>
<td>+5%</td>
</tr>
<tr>
<td><strong>Note 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 400kV down to 110kV inclusive</td>
<td>-10%</td>
<td>+10%</td>
</tr>
<tr>
<td>Less than 110kV</td>
<td>-6%</td>
<td>+6%</td>
</tr>
</tbody>
</table>

Notes:
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.
# Terms and Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Peak Demand</td>
<td>The estimated unrestricted winter peak demand (MW and MVar) on the Northern Ireland transmission system for the <em>average cold spell</em> (ACS) condition. This represents the demand to be met by <em>power stations</em> and <em>generating units</em> directly connected to the Northern Ireland transmission system or embedded in the Distribution System, and by electricity imported into the <em>onshore transmission system</em> from external systems across external <em>interconnections</em> (and which is not adjusted to take into account demand management or other techniques that could modify demand).</td>
</tr>
<tr>
<td>Annual Load Factor</td>
<td>The ratio of the actual energy output of a generating unit, CCGT module or <em>power station</em> (as the case may be) to the maximum possible energy output of that generating unit, CCGT module or <em>power station</em> (as the case may be) over a year. It is often expressed in percentage terms.</td>
</tr>
<tr>
<td>Authority</td>
<td>This means the Utility Regulator established by the Energy (Northern Ireland) Order 2003.</td>
</tr>
<tr>
<td>Average Cold Spell (ACS)</td>
<td>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.</td>
</tr>
<tr>
<td>Bulk Supply Point (BSP)</td>
<td>A point at which the onshore <em>transmission system</em> connects to the <em>distribution system</em>. For the avoidance of doubt this point will generally be at a 110/33kV substation and the interface will be the 33kV transformer terminals.</td>
</tr>
<tr>
<td>Busbar</td>
<td>The common connection point of two or more transmission circuits.</td>
</tr>
<tr>
<td>Constraint</td>
<td>The pre-fault or post fault reduction in the output of a generator away from the economic dispatch.</td>
</tr>
<tr>
<td>Corrective Action</td>
<td>Manual and automatic action taken after an outage or switching action to assist recovery of satisfactory system conditions; for example, tapchanging or switching of plant.</td>
</tr>
<tr>
<td>Credible demand sensitivities</td>
<td>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.</td>
</tr>
<tr>
<td>DC Converter</td>
<td>Any apparatus used as part of the Northern Ireland Transmission System to convert alternating current electricity to direct current electricity, or vice-versa. A <em>DC Converter</em> is a standalone operative configuration at a single site comprising one or more converter bridges,</td>
</tr>
</tbody>
</table>
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.

**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).

**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.

**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.

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.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Interconnected Transmission System (MITS)</td>
<td>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.</td>
</tr>
<tr>
<td>Maintenance Period Demand</td>
<td>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.</td>
</tr>
<tr>
<td>Marshalling Substation</td>
<td>A substation which connects circuits from more than two line routes.</td>
</tr>
<tr>
<td>Network Operator</td>
<td>A person with a system directly connected to the onshore transmission system to which customers and/or power stations (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.</td>
</tr>
<tr>
<td>Offshore</td>
<td>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.</td>
</tr>
<tr>
<td>Offshore Generating Unit</td>
<td>Any apparatus, which produces electricity including, a synchronous offshore generating unit and non-synchronous offshore generating unit and which is located in offshore waters.</td>
</tr>
<tr>
<td>Offshore Grid Entry Point Capacity (OffGEP Capacity)</td>
<td>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 points of an offshore transmission system</td>
</tr>
<tr>
<td>Offshore Platform</td>
<td>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.</td>
</tr>
<tr>
<td>Offshore Power Station</td>
<td>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.</td>
</tr>
<tr>
<td>Offshore Power Station Demand Group</td>
<td>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.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Offshore Supply Point (OSP)</td>
<td>A point of supply from an offshore transmission system to an offshore power station.</td>
</tr>
<tr>
<td>Offshore Transmission Circuit</td>
<td>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.</td>
</tr>
<tr>
<td>Offshore Transmission System</td>
<td>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.</td>
</tr>
<tr>
<td>Onshore Generating Unit</td>
<td>Any apparatus which produces electricity including a synchronous generating unit and non-synchronous generating unit but excluding an offshore generating unit.</td>
</tr>
<tr>
<td>Onshore Power Station</td>
<td>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.</td>
</tr>
<tr>
<td>Onshore Transmission Circuit</td>
<td>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 circuits.</td>
</tr>
<tr>
<td>Onshore Transmission Licensee</td>
<td>As set out in the Licenses.</td>
</tr>
<tr>
<td>Onshore Transmission System</td>
<td>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.</td>
</tr>
</tbody>
</table>
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 stations 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 exceedence of power quality limits as set out in Engineering Recommendations G5/4-1, P16, P28 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 points 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.

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.

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

Part 1 – Onshore Transmission System

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 circuits 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 circuits 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 circuits from two or more offshore platforms, 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 circuits 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 circuits 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.
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:

<table>
<thead>
<tr>
<th>Unit type</th>
<th>Proportion of installed capacity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind generation</td>
<td>Minimum level consistent with recent performance, e.g. 5%</td>
</tr>
<tr>
<td>Tidal</td>
<td>Minimum level consistent with recent performance, e.g. 0%</td>
</tr>
<tr>
<td>Steam turbines</td>
<td>Maximum level consistent with recent performance, e.g. 100%</td>
</tr>
<tr>
<td>CCGTs</td>
<td>Maximum level consistent with recent performance, e.g. 100%</td>
</tr>
</tbody>
</table>

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 Economic Dispatch

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.
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 events 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.