TRANSCO ELECTRICITY TRANSMISSION SYSTEM SECURITY STANDARD

Issue 1
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Approved by: Regulation & Supervision Bureau

TABLE OF CONTENTS

SECTION 1
INTRODUCTION

ROLE & SCOPE

1.1. Pursuant to Condition 19 of the Transmission License, this document sets out a set of criteria and methodologies which the Abu Dhabi Transmission & Despatch Company (Transco) shall use in the planning, developing, operation and maintenance of the *Transco Transmission System*.

1.2. The Transmission Code contains additional criteria covering more detailed and other aspects of quality of supply. The Transmission Code should therefore be read in conjunction with this document.

1.3. External interconnections between the *Transco Transmission System* and external systems are covered by separate agreements which will normally be consistent with this Standard.

1.4. If inadequate capability of equipment or systems not owned by Transco is identified while considering secured events defined in this standard, the licensed operator will be notified and reinforcement or alternative operation of Transco system to alleviate inadequacies will be undertaken where it is agreed by Transco and the licensed operator affected.

1.5. Existing *Transco Transmission System* may not be fully compliant with this standard initially as parts of the system were built to a different standard. For any existing demand points designed previously to a lower level of security, Transco shall for each demand point meet with the relevant lincensed operator(s) and jointly agree on a documented approach. A list of non-compliant network including demand points shall be prepared by Transco and submitted to the Regulation and Supervision Bureau. Derogations for specified time period shall be sought from the Regulation and Supervision Bureau for all non compliant network.

1.6. While it is the requirement for transmission capacity to meet the planning criteria, it does not follow that the transmission capacity should be reduced to meet only minimum requirement of the criteria.

1.7. Transco under its License obligations is required to prepare security standards from time to time for its transmission system. This issue of the

standard becomes effective on 1st March 2005. Future changes to this standard will be made in accordance with Transco's obligations. Implementation of these changes will require the approval of the Regulation and Supervision Bureau.

DOCUMENT STRUCTURE

1.8. This Standard contains technical terms and phrases specific to the transmission systems and the Electricity Sector in Abu Dhabi. The meanings of some terms and phrases in this Standard may also differ from those commonly used and for this reason a Glossary and Definitions has been included in Section 5.

1.9. The criteria and methodologies making up this Standard have been presented according to the functional parts of the *Transco Transmission System* to which they primarily apply. These parts are the *Generation Points of Connection* at which *Power Stations* feed the *Main Interconnected Transmission System* (*MITS*) through the remainder of the *MITS* to the *Demand Supply Points* where demand is connected. The parts are illustrated schematically in **Figure 1.1**.

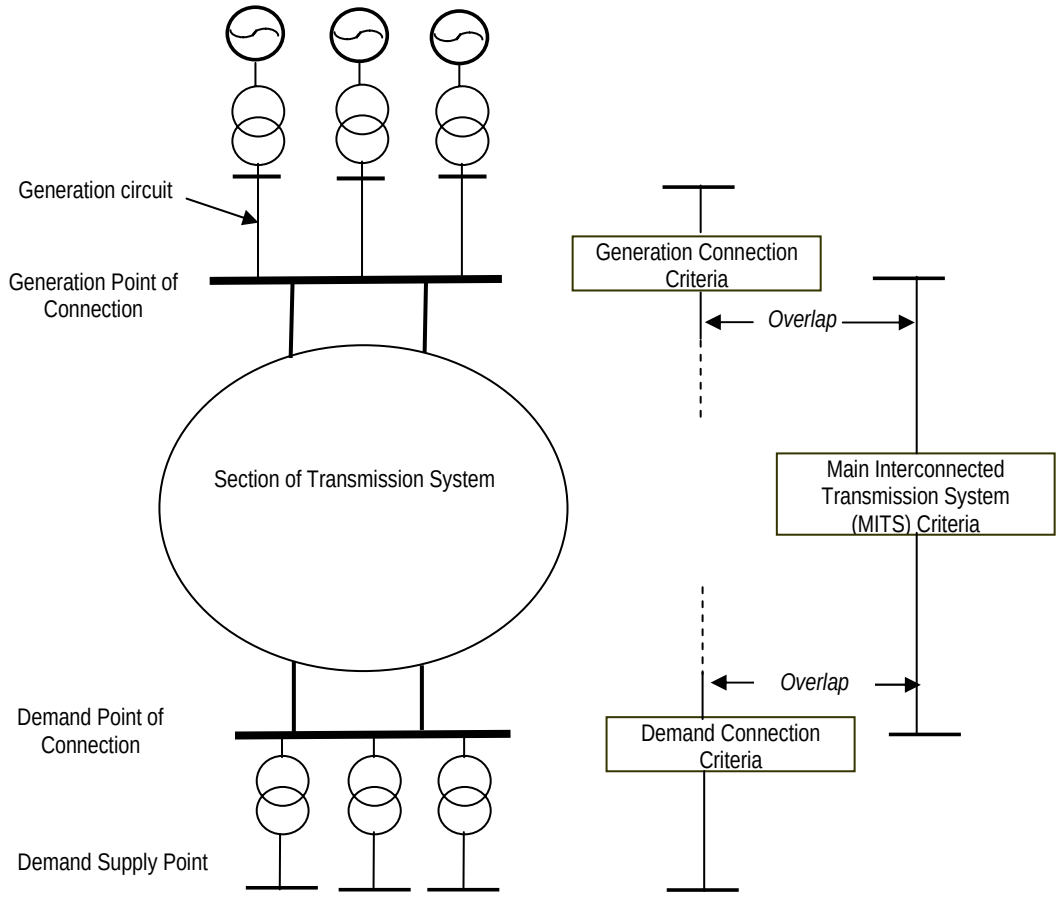

Figure: 1.1 Transmission System connected to generation and distribution sites

1.10. Section 1 explains the role and scope of this document under statutory obligations.

1.11. Section 2 deals with the generation connection criteria which cover the connections which extend from *Generation Points of Connection* and reach into the *MITS*. The criteria also cover the risks affecting the *Transco Transmission System* arising from the *Generation Circuits*.

1.12. Section 3 defines the criteria for the *MITS which* extends from the *Generation Points of Connection* through to the *Demand Points of Connection* on the high voltage side of the Grid Station/Primary substation transformers.

1.13. Section 4 gives the demand connection criteria and covers the connections which extend from the lower voltage side of the Grid Station / Primary substation transformers and again reach into the *MITS*.

1.14. Section 5 gives 'Glossary and Definitions' explaining the technical terms and phrases specific to transmission systems in general and the Electricity Sector in Abu Dhabi in particular.

1.15. As illustrated in **Figure 1.1**, there will be some parts of the *Transco Transmission System* where more than one set of criteria may apply. In such places the requirements of all relevant criteria must be met.

1.16. In each of Sections 2, 3 and 4, first planning and then operational criteria are set out. The planning criteria set out the requirements of the *Transmission Capacity* for the *Transco Transmission System*. The planning criteria also require consideration to be given to the operation and maintenance and so refer to the associated operational criteria. The operational criteria are to be used in real time and in the development of plans for using the *Transco Transmission System* to permit satisfactory operation.

SECTION 2

GENERATION CONNECTION CRITERIA

INTRODUCTION

2.1. This Section presents the planning and operational criteria relating to the connection of *Power Stations* to the *Transco Transmission System*. The criteria in this Section will also apply to connections of a *Demand Supply Point* through which *Power Stations* embedded within a customer's network export to *Transco Transmission System*.

2.2. In those parts of the *Transco Transmission System* where the criteria of Section 3 and/or 4 also apply, those criteria must also be met.

PLANNING CRITERIA

2.3. Generation connections shall satisfy the deterministic criteria set out in paragraphs 2.5 to 2.10. Variations to the design of connections, for example to reflect the particular characteristics of a *Power Station*, may be accommodated subject to the conditions detailed in paragraphs 2.12 and 2.13 and the guidelines given in Appendix C.

2.4. The generation connection planning criteria comprise two parts as follows:

i. criteria which determine the maximum *Loss of Power Infeed* for a set of *Secured Events*, and

ii. criteria which determine *Transmission Capacity* required to avoid unacceptable network conditions for a set of *Secured Events*.

Limits to Loss of Power Infeed Risks

2.5. The *Loss of Power Infeed* resulting from a *Secured Event* shall be calculated as follows:

- the sum of *Registered Capacities* of the *Generating Units* disconnected by the event; plus
- the planned import from any external systems disconnected by the same event, less
- the *Forecast Minimum Demand* disconnected from the system by the same event.

2.6. Generation connections shall be planned such that, starting with an *Intact System*, the following conditions shall be satisfied:

i. No *Loss of Power Infeed* shall occur due to *Fault Outage* of any single *Transmission Circuit*;

ii. No *Loss of Power Infeed* shall occur due to the arranged outage of a single section of *Busbar*;

iii. The *Loss of Power Infeed* shall not exceed the *Normal Infeed Loss Risk* following a *Fault Outage* of a single *Generation Circuit*; (NB: the maximum size of a generating unit shall be decided by the generation Planner taking into account generation economic despatching for electricity and water both in high and low load seasons).

iv. The *Loss of Power Infeed* shall not exceed the *Normal Infeed Loss Risk* following the *Fault Outage* of any single section of Busbar.

v. The *Loss of Power Infeed* shall not exceed the *Infrequent Infeed Loss Risk* following:

- the *Fault Outage* of any single *Transmission Circuit* during the arranged outage of any other single *Transmission Circuit*;
- the concurrent *Fault Outage* of any two *Transmission Circuits*;
- the *Fault Outage* of any single section of *Busbar* during the arranged outage of any other single section of *Busbar*;
- the *Fault Outage* of any single *Busbar* coupler circuit breaker or *Busbar* section circuit breaker, or
- the *Fault Outage* of any *Busbar* coupler circuit breaker or *Busbar* section circuit breaker during the arranged outage of any single section of *Busbar*.

2.7. The maximum length of overhead line connections in a *Generation Circuit* for *Generating Units* which are directly connected to the *Transco Transmission System* shall not exceed 4km.

Generation Connection Capacity Requirements

2.8. The *Transmission Capacity* from a *Power Station* shall be planned against the following background conditions:

i. the active power output of the *Power Station* shall be set equal to its *Registered Capacity*, and with corresponding full leading or lagging reactive power output; and

ii. conditions on the *Transco 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 cycle, typical *Power Station* operating regimes and typical arranged transmission equipment outage patterns.

2.9. The *Transmission Capacity* for the connection of a Power Station shall be planned such that for the background conditions described in paragraph 2.8 prior to any fault there shall not be any of the following:

- equipment loadings exceeding normal rating;
- voltages outside the *Pre-fault Planning Voltage limits* or *Insufficient Voltage Performance Margins*; or
- *System Instability.*

2.10. The *Transmission Capacity* for the connection of a *Power Station* shall also be planned such that for the background conditions described in paragraph 2.8 and for the *Secured Event* of a *Fault Outage* of any of the following:-

i. a single *Transmission Circuit*, a reactive compensator or other reactive power provider;

ii. a section of *Busbar*; or

iii. a single *Transmission Circuit* with the planned outage of another transmission circuit, a *Generating Unit*, a reactive compensator or other reactive power provider;

there shall not be any :-

- *Loss of Supply Capacity* (except as permitted by the demand connection criteria explained in Section 4);
- *Unacceptable Overloading* of any *Primary Transmission Equipment*;
- *Unacceptable Voltage Condition*s or *Insufficient Voltage Performance Margin*s; or
- *System Instability.*

Switching Arrangements

2.11. Appendix A at the end of the document gives guidelines for substation configurations and switching arrangements. These guidelines provide an acceptable way towards meeting the criteria. However, other configurations and switching arrangements meeting those criteria are also acceptable.

Variations to Connection Design

2.12. Variations to the generation connection design requested by a User is permissible if it meets the requirements of paragraphs 2.5 to 2.10 and must not either immediately or in the foreseeable future:

i. reduce the security of the *Transco Transmission System* to below the minimum planning criteria specified in Section 3; or

ii. 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 4, unless specific agreements are reached with affected customers; or

iii. compromise Transco's ability to meet other statutory obligations or license obligations.

2.13. 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 paragraph 2.12 (i) to (iii) are no longer satisfied, then alternative arrangements and/ or agreements must be put in place to meet the Standard.

OPERATIONAL CRITERIA

2.14. The operational criteria for generation connections are the same as the operational *MITS* criteria, which are set out in Section 3, paragraph 3.10 – 3.12.

SECTION 3

MAIN INTERCONNECTED TRANSMISSION SYSTEM CRITERIA

INTRODUCTION

3.1. This Section presents the planning and operational criteria for the *Main Interconnected Transmission System* (*MITS*).

3.2. In those parts of the *Transco Transmission System* where the criteria of Section 2 and/or 4 also apply, those criteria must also be met.

PLANNING CRITERIA

3.3. In planning the *MITS,* the design has to satisfy the minimum deterministic criteria detailed in paragraphs 3.5 to 3.9.

3.4. Variations to the design of the *Transmission System* is permissible provided they can be economically justified. Guidance on such justification is given in Appendix C.

Minimum Transmission Capacity Requirements

3.5. In order to apply the minimum security criteria, the background conditions stated below shall be initially set up:

i. The total installed capacities of all the *Power Stations* normally exceed the expected *Annual Peak Demand* by an amount equal to the *Plant Margin*. Therefore scaling of the registered capacities of the power stations is required to match the generation and demand figures. Import from external systems, if any, should be deducted from the *Annual Peak Demand* before scaling to estimate the generation required to meet the demand. The condition arising from the scaling of the capacities, as stated above, is termed as the *Planned Transfer Condition*. The scaling shall be in accordance with the technique explained in Appendix B;

ii. For the *Intact System*, power flows shall be set to those arising from the *Planned Transfer Condition*, described above, prior to any fault;

iii. Sensitivity cases on the conditions described in (ii) of this paragraph shall comprise generating units with output equal to their registered capacities such that the required power transfers are approximated by selection of individual units;

iv. Conditions on the *Transco Transmission System shall be set to those which ought reasonably to be foreseen* to arise in the course of a year of operation

such as forecast demand cycle, typical *Power Station* operating regimes and typical arranged transmission equipment outage patterns. Rearrangement of transmission outages and appropriate reselection of generating units from those expected to be available may be considered in order to satisfy the minimum security criteria;

v. The reactive power availability shall be set according to that which ought reasonably to be expected to arise taking into account machine performance chart. In the absence of realistic data, the expected available capability shall not exceed 90% of the Transmission Code specified capability or 90% of assumed capability as appropriate.

3.6. The minimum *Transmission Capacity* of the *MITS* shall be planned such that, for the background conditions described in paragraphs 3.5 above, for normal system operation, there shall not be:-

- equipment loadings exceeding its normal rating;
- voltages outside the *Pre-fault Planning Voltage Limits* or *Insufficient Voltage Performance Margins*;
- *System Instability.*

3.7. The minimum *Transmission Capacity* of the *MITS* shall also be planned such that for the background conditions described in paragraph 3.5 and for the *Secured Event* of a *Fault Outage* of any of the following:-

i. a single *Transmission Circui*t, a reactive compensator or other reactive power provider;

ii. a section of *Busbar;*

iii. a 400kV *Double Circuit Overhead Line* feeding Abu Dhabi island; or

iv. during the *Maintenance Period*, any single *Transmission Circuit* with the prior outage of another *Transmission Circuit*, *Generating Unit*, reactive compensator or other reactive power provider,

there shall not be any :-

- *Loss of Supply Capacity* (except as permitted by the demand connection criteria explained in Section 4);
- *Unacceptable Overloading* of any *Primary Transmission Equipment*;
- *Unacceptable Voltage Conditions* or *Insufficient Voltage Performance Margins*; or
- *System Instability.*

3.8. In addition to the above, the system shall also be planned such that the operational switching does not cause *Unacceptable Voltage Conditions*.

Switching Arrangements

3.9. Appendix A at the end of the document gives guidelines for substation configurations and switching arrangements. These guidelines provide an acceptable way towards meeting the criteria. However, other configurations and switching arrangements meeting those criteria are also acceptable.

OPERATIONAL CRITERIA

3.10. The *MITS* shall be operated under prevailing system conditions such that for the *Secured Event* of a *Fault Outage* of any of the following:-

i. a single *Transmission Circui*t, a reactive compensator or other reactive power provider;

ii. a 400kV *Double Circuit Overhead Line* feeding Abu Dhabi island;

iii. a section of *Busbar;* or

iv. a *Loss of Power Infeed* not exceeding the *Normal Infeed Loss Risk*,

there shall not be any:-

- *Loss of Supply Capacity* (except as permitted in demand connection criteria in section 4);
- Unacceptable high or low frequency conditions;
- *Unacceptable Overloading* of any *Primary Transmission Equipmen*t;
- *Unacceptable Voltage Conditio*ns; or
- *System Instability.*

Post-fault Restoration of System Security

3.11. Following the occurrence of a secured event, measures shall be taken to re-secure the system to the above operational criteria as soon as reasonably practicable.

Authorised Variations From The Operational Criteria

3.12. The principles of these operational criteria shall be applied at all times except in special circumstances where Transco may need to give instruction to the contrary to preserve overall system integrity.

SECTION 4

DEMAND CONNECTION CRITERIA

INTRODUCTION

4.1. This Section presents the planning and operational criteria which is a set of deterministic criteria for the connection of *Demand Groups* to the *Transmission Syste*m.

4.2. In a Primary Substation (132/11kV) or a Grid Station (220/33kV), Transco jurisdiction is limited to the *Primary Transmission Equipment* on the high voltage side of the transformers and the transformers and hence security related to the outages of the above is only considered in this document.

PLANNING CRITERIA

4.3. In planning demand connections, the design has to satisfy the minimum deterministic criteria detailed in paragraphs 4.5 to 4.8.

4.4. Variations to the design of demand connections are permissible provided they can satisfy the conditions detailed in paragraph 4.11 or they can be economically justified. Guidance on economic justification is given in Appendix C.

Demand Connection Capacity Requirements

4.5. The connection of a particular *Demand Group* shall meet the criteria set out in paragraphs 4.6 to 4.8 under the following background conditions:

i. when there are no arranged outages, the demand of the *Demand Group* shall be set equal to *Group Demand*;

ii. when there is an arranged outage, the demand of the *Demand Group* shall be set equal to the *Maintenance Period Demand*;

iii. the ability to transfer demand from one *Demand Group* to another declared by *DISCOs* shall also be considered taking account of any restrictions on the timescales in which the transfer capacity applies.

4.6. The *Transmission Capacity* for the connection of a *Demand Group* shall be planned such that, for the background conditions described in paragraph 4.5, under *Intact System* conditions, there shall not be any of the following:

- Equipment loadings exceeding the normal rating;

- Voltages outside the *Pre-Fault Planning Voltage Limits* or *Insufficient Voltage Performance Margins*; or
- *System instability*.

4.7. The *Transmission Capacity* for the connection of a *Demand Group* shall also be planned such that for the background conditions described in paragraph 4.5 and for the arranged outage of a single *Transmission Circuit* or a single section of high voltage *Busbar*, there shall not be any of the following:

- Loss of Supply Capacity,
- Unacceptable overloading of any primary transmission equipment
- Voltages outside the *Pre-fault Planning Voltage Limits* or *Insufficient Voltage Performance Margins*; or
- *System instability*.

4.8. The *Transmission Capacity* for the connection of a *Demand Group* shall also be planned such that for the background conditions described in paragraph 4.5 and for the *Secured Event* of a *Fault Outage of any of the following* :-

- a single *Transmission Circuit* under *Intact Syste*m; or
- during the *Maintenance Period*, a single *Transmission Circuit* with the single arranged outage of another *Transmission Circuit*, a *Generating Unit*, a reactive compensator or other reactive power provider,

there shall not be any of the following:-

- a *Loss of Supply Capacity* not complying with the provisions set out in **Table 4.1**;
- unacceptable overloading of any primary transmission equipment;
- unacceptable voltage conditions or *Insufficient Voltage Performance Margins*; or
- *System instability*.

4.9. In practice a loss of supply may occur in some cases due to planning / operational considerations on the distribution system. An example of this is at a 220/33kV Grid Station with 3 x140MVA transformers where in order to control the fault levels, the 33kV busbar is normally planned to be operated split with two 220/33kV transformers feeding one section of *Busbar* and the third transformer feeding the other section. A forced outage of the single transformer will lead to loss of supply totaling its pre-fault loading. Since the other two healthy 220/33kV transformers have enough additional capacity to feed the disconnected demand, supply to the disconnected load can be restored by closing the appropriate bus coupler or bus section circuit breaker.

Switching Arrangements

4.10. Appendix A at the end of the document gives guidelines for substation configurations and switching arrangements which provide an acceptable way towards meeting the criteria. However, other configurations and switching arrangements meeting those criteria are also acceptable.

Variations to Connection Design

4.11. Variations to the demand connection design requested by a User is permissible if it does not other than in respect of the demand customer requesting the variation, either immediately or in the foreseeable future:

i. reduce the security of the *MITS* to below the minimum planning criteria specified in Section 3; or

ii. 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 2, unless specific agreements are reached with affected customers; or

iii. compromise Transco's ability to meet other statutory obligations or license obligations.

4.12. 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 paragraph 4.11(i) to (iii) are no longer satisfied, then alternative arrangements and/ or agreements must be put in place to meet this Standard.

OPERATIONAL CRITERIA

4.13. For *Group Demand* exceeding 150 MW, the operational security criteria for the *MITS* shall apply.

4.14. For *Group Demand* up to 150 MW, under prevailing system conditions with no local system outages and prevailing system conditions with a local system outage during *Maintenance Period*, for the secured event of fault outage of any of the following:

i. a single *Transmission Circuit*, a reactive compensator or other reactive power provider;

ii. a *Loss of Power Infeed* not exceeding the *Normal Infeed Loss Risk*,

there shall not be any of the following:-

- *Loss of Supply Capacity* not complying with the provisions set out in **Table 4.1**

- *Unacceptable high or low frequency Conditions*;
- *Unacceptable Overloading* of any *Primary Transmission Equipment*;
- *Unacceptable Voltage Conditions*; or
- *System Instability.*

Post-Fault Restoration of System Security

4.15. Following the occurrence of *Secured Event* measures shall be taken to re-secure the system to the above operational criteria as soon as reasonably practicable. To this end it is permissible to put operational measures in place pre-fault to facilitate the speedy restoration of system security.

Authorised Variations From The Operational Criteria

4.16. The principles of these operational criteria shall be applied at all times except in special circumstances where Transco may need to give instruction to the contrary to preserve overall system integrity.

4.17. Exceptions to the above criteria may be required where variations to the connection designs as per paragraph 4.11 to 4.12 have been agreed.

Table 4.1

Minimum Planning Supply Capacity Following Secured Events [3]

Group Demand (MW)	**Initial System Conditions**	
	Intact System	**With Single Arranged Outage**
Over 150 MW	Immediately [1] *Group Demand*	Immediately [1] *Maintenance Period Demand*
27 – 150 MW	Immediately [1] *Group Demand*	5 minutes [2] *Maintenance Period Demand*
Up to 27 MW	Subject to DISCOs system security criteria	Subject to DISCOs system security criteria

Notes:

[1] A loss of supply not exceeding 5 minutes may be acceptable if this leads to significant economies.

[2] For sites where economies prohibit the provision of a third *Transmission Circuit* the *Maintenance Group Demand* may be lost for the necessary time to restore outage.

[3] For existing demand connection points where this standard is not met, refer to paragraph 1.5.

SECTION 5
GLOSSARY AND DEFINITIONS

Introduction

This Section defines and explains some of the key terms and phrases that may appear in this Standard.

ADWEA

Abu Dhabi Water and Electricity Authority.

Annual Peak Demand

The level of peak demand due to a particular combination of weather elements occurring usually during July-September of the year which has a 50% chance of being exceeded due to weather variation alone.

Busbar

The common connection point of two or more *Transmission Circuits*.

Cyclic Rating

The load carrying capability of an item of equipment in excess of its nominal rating which can be achieved given the expected daily load cycle of the equipment. Such additional capability will normally arise as a result of the thermal inertia of the equipment.

Demand Group

A site or group of sites which collectively take power from the *Transco Transmission System.*

Demand Supply Point

A point of supply from the *Transco Transmission System* to *DISCOs* or *Non-Embedded Customers*.

Demand Point of Connection

For the purpose of defining the boundaries between the *MITS* and *Demand Supply Point* transformer circuits, the *Demand Point of Connection* is taken to be the *Busbar* clamp in the case of air insulated switchgear, gas zone separator in the case of gas insulated switchgear, or other equivalent point as may be determined by Transco for new types of switchgear.

DISCO

A User of *Transco Transmission System* holding a distribution license.

Double Circuit Overhead Line

A transmission line which consists of two circuits sharing the same towers for at least one span.

Fault Outage

This is an unplanned outage of a *Transmission Circuit* or a section of *Busbar*. For the purpose of assessing the existence of *System Instability* a *Fault Outage* shall be taken to include a three phase fault (or faults) with clearance times consistent with the fault location together with the worst single failure in the main protection system (for example, failure of a relay communication channel). For *Transmission Circuits* the three phase fault shall be taken to be at any location along the faulted circuit.

Forecast Minimum Demand

This is the minimum demand level expected at a *Demand Supply Point*. Unless more specific data are available, this is the expected demand at the time of the annual minimum Transco demand as provided under the Electricity Transmission Code. In the case of a group of *Demand Supply Points*, the demand diversity within the group should be taken into account.

Generating Unit

Any apparatus which produces electricity.

Generation Circuit

The sole electrical connection between one or more *Generating Units* and the *Main Interconnected Transmission System*, i.e. a radial circuit which if removed would disconnect the *Generating Units*.

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 air insulated switchgear, gas zone separator in the case of gas insulated switchgear, or other equivalent point as may be determined by Transco for new types of switchgear.

Generator

A person who generates electricity under licence in Abu Dhabi Emirate.

Group Demand

The forecast maximum demand for the *Demand Supply Point* provided in accordance with the requirements of the Transmission Code by the *DISCOs* or other directly connected customers taking demand from the *Transco Transmission System*.

Infrequent Infeed Loss Risk

That level of *Loss of Power Infeed* risk which is covered over long periods operationally by frequency response to avoid a deviation of system frequency outside the range of 49.5Hz to 50.5Hz for more than 60 seconds. For network design and planning purposes and until reviewed this is 800MW.

Insufficient Voltage Performance Margins

For all time periods 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 the following conditions:

- a 5% increase in demand above the *Annual Peak Demand* figures;
- the unavailability of any single reactive compensator or other reactive power provider; or.
- the loss of any one automatic switching system or any automatic voltage control system for on- load tap changing.

Intact System

This is the *Transco Transmission System* with no *System Outages* i.e. with no arranged outages (e. g. for maintenance) and no unplanned outages (e. g. fault).

Loss of Power Infeed

The output of a *Generating Unit* or a group of *Generating Units* or the import from external systems disconnected from the system by a *Secured Event*, less the demand disconnected from the system by the same *Secured Event*.

Loss of Supply Capacity

This is the reduction in the supply capacity at a *Demand Supply Point* as a result of Transco's failure to maintain the potential to provide the supply capacity in full. For the avoidance of doubt, where Transco does maintain the potential to provide a supply but, following an

outage, demand is lost because of circuit configurations not under the control of Transco, that lost supply does not constitute *Loss of Supply Capacity*.

Main Interconnected Transmission System (MITS)

This comprises all the 400kV, 220kV and 132kV elements of the *Transco Transmission System* but excludes *Generation Circuits*, transformer connections to lower voltage systems and external interconnections between the *Transco Transmission System* and external systems.

Maintenance Period Demand

This is the demand level experienced at a *Demand Supply Point* 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. Unless better data are available this should be 50% of the *Group Demand*.

Maintenance Period

This is the period of the year typically from November to April during which maintenance of transmission equipment is normally undertaken.

Non- Embedded Customer

A customer except Discos acting in its capacity as such, receiving electricity direct from the *Transco Transmission System* irrespective of from whom it is supplied.

Normal Infeed Loss Risk

That level of *Loss of Power Infeed* risk which is covered over long periods operationally by frequency response to avoid a deviation of system frequency by more than 0.5Hz. For network design and planning purposes and until reviewed this is 400MW.

Operational Inter tripping

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 High or Low Frequency Conditions* for any *Secured Event*.

Planned Transfer Conditions

This is defined by scaling the *Registered Capacities* of all directly connected *Power Stations* and large embedded *Power Stations* to equal the *Annual Peak Demand* minus imports from external systems. This scaling shall follow the straight scaling technique and, where the *Plant Margin* exceeds 20%, also follow the ranking order technique. These two techniques are described in Appendix B.

Plant Margin

The amount by which the total installed capacity of directly *connected Power Stations* and large embedded *Power Stations* exceeds the net amount of the *Annual 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 *Annual Peak Demand* minus the total imports from external systems.

Power Station

An installation comprising one or more *Generating Units* (even where sited separately) owned and/ or controlled by the same *Generato*r, which may reasonably be considered as being managed as one *Power Station*.

Pre- Fault Planning Voltage Limits

Pre-fault voltages shall be planned to remain within ±5% of nominal voltages at 400kV, 220kV and 132kV.

Prevailing System Conditions

These are conditions on the *Transco Transmission System* prevailing at any given time and will therefore normally include arranged outages (e.g. for maintenance) and unplanned outages(e.g. fault).

Primary Transmission Equipment

Any equipment installed on the *Transmission System* to enable bulk transfer of power. This will include *Transmission Circuit*s, *Busba*rs, and switchgear.

Registered Capacity

In the case of a *Generating Unit* other than that forming part of a CCGT module, the normal full load capacity of a *Generating Unit* as declared by the *Generato*r, less the MW consumed by the *Generating Unit* through the *Generating Unit's* unit transformer when producing the same (the resultant figure being expressed in whole MW).

Secured Event

A contingency which would be considered for the purposes of assessing system security and which must not result in the remaining *Transco 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 within the requirements of the Transmission Code may be utilised to maintain overall *Transco 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.

System Instability

System Instability means:

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 initial peak deviations.

ii) pole slipping - where one or more synchronous *Generating Units* lose synchronism with the remainder of the system; or

iii) voltage collapse - where progressive, fast or slow, voltage decrease or increase develops such that it can lead to partial or total system blackout.

System Outage

This includes an arranged outage (e. g. for maintenance) or an unplanned outage (e.g. fault) of *Transmission Circuits* or *Busbar* sections

Thermal Rating

The maximum apparent power flow (MVA) which may be permitted to flow on a circuit under specific conditions (e. g. ambient/ seasonal temperature). For the purpose of the planning criteria in this document the following ratings apply:-

i) Circuit- breakers: continuous rating

ii) Transformers: the appropriate *Cyclic Rating* based on a 24 - hour load cycle.

iii) Underground cables: the appropriate *Cyclic Rating* based on a 24 - hour load cycle

iv) Overhead Lines: continuous seasonal rating.

For operational purposes appropriate equipment short term ratings may be applied during post- fault conditions.

Transco Transmission System

The system consisting (wholly or mainly) of high voltage electric lines (132kV and above) owned or operated by Transco and used for the transmission of electricity from one *Power Station* to a substation or to another *Power Station* or between substations or to or from any external interconnection, and includes equipment owned or operated by Transco in connection with the transmission of electricity.

Transmission Capacity

The ability of a network to transmit electricity. It does not include the use of *Operational Inter tripping*.

Transmission Circuit

Part of the *Transco Transmission System* between two or more circuit breakers which includes, for example, transformers, reactors, cables and overhead lines but excludes *Busbar*s and *Generation Circuits*.

Unacceptable Overloading

The overloading of any *Primary Transmission Equipment* beyond its *Thermal Rating*. Due allowance shall be made for agreed time related and pre - fault dependent load cycles.

Unacceptable Voltage Conditions

These are conditions where:

- *Steady State* Voltages, in planning timescales, are below 10% or above 5% of the nominal voltage at 400kV, 220kV and 132kV;
- *Steady State* Voltages*, in operational timescales, are below 10% or above 10% of the nominal voltage at 400kV, 220kV and 132kV; or
- Following a *Secured Event* or system switching the resultant voltage (after all the generator AVR and SVC actions and transient decay have taken place but before any other automatic or manual tap-changing and switching actions) is below 10% or above 5% of the nominal voltage at 400kV, 220kV and 132kV.

  * Note: Voltages between 5% and 10% above nominal voltage shall not last longer than 15 minutes unless abnormal conditions prevail.

Unacceptably High or Low Frequency Conditions

The system frequency will be controlled within the limits of 49.9Hz and 50.1Hz under normal *Steady State* conditions and within the limits of 51.5Hz and 48.5Hz under disturbed *Steady State* conditions. However under disturbed conditions, system frequency could transiently rise to 53Hz or fall to 47Hz.

Conditions where system frequency falls outside the above limits are considered to be unacceptable.

APPENDICES

Appendix A

Guidance on Substation Configurations and Switching Arrangements

Appendix B

Straight Scaling and Ranking Order Techniques for Modeling Planned Transfer Conditions

Appendix C

Guidance on Economic Justification.

APPENDIX A

GUIDANCE ON SUBSTATION CONFIGURATIONS AND SWITCHING ARRANGEMENTS

A1 The key factors which must be considered when planning a substation include:

i. Security and Quality of Supply

Relevant criteria are presented in Sections 2, 3 and 4.

ii. Extendibility

The design should fully cover future need (at least for a period of 5 years from substation commissioning) and allow for the forecast need for future extensions.

iii. Maintainability

The design must take account of the practicalities of maintaining the substation and associated circuits.

iv. Operational Flexibility

The physical layout of individual circuits and groups of circuits must permit the required power flow control.

v. Protection Arrangements

The design must allow for adequate protection of each system element. This should include maintenance and testing of protection relays for any circuit without causing any risk of trip to other circuits.

vi. 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.

vii. 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.

viii. Cost.

A2 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

A3 In accordance with the planning criteria for generation connection set out in Section 2, *Generation Point of Connection* substations should:-

i. have a double *Busbar* design (i. e. with main and reserve *Busbars* such that *Generation Circuits* and *Transmission Circuits* may be selected to either);

ii. have sufficient *Busbar* sections to permit the requirements of paragraph 2.6 (Section 2) to be met without splitting the substation during maintenance of *Busbar* sections;

iii. 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;

iv. have *Generation Circuits* and *Transmission Circuits* disposed between *Busbar* sections such that the main *Busbar* may be operated split for fault level control purposes; and

v. have sufficient facilities to permit the transfer of *Generation Circuits* and *Transmission Circuits* from one section of the main *Busbar* to another.

Grid Substations (400/220kV, 400/132kV & 220/132kV)

A4 Grid Substations connecting circuits from more than two line routes should:-

i. have a double *Busbar* design (i.e. with main and reserve *Busba*rs such that *Transmission Circuits* may be selected to either);

ii. have sufficient *Busbar* sections to permit the requirements of paragraphs 2.6 (Section 2) and 3.7 (Section 3) to be met;

iii. have *Transmission Circuits* disposed between *Busbar* sections such that the main *Busbar* may be operated split for fault level control purposes; and

iv. have sufficient facilities to permit the transfer of *Transmission Circuits* from one section of the main *Busbar* to another.

Other Grid Substations should be treated similar to *Demand Point of Connection Substations.*

Demand Point of Connection Substations (220/33kV & 132/11kV)

A5 *Demand Point of Connection Substations* should normally be of a double busbar design. However, other designs which meet the planning criteria for demand connection set out in Section 4 may be acceptable.

APPENDIX B

STRAIGHT SCALING AND RANKING ORDER TECHNIQUES FOR MODELLING PLANNED TRANSFER CONDITIONS

STRAIGHT SCALING TECHNIQUE

B1 In this technique, all directly connected *Power Stations* and large embedded *Power Stations* on the system at the time of the *Annual Peak Demand* are considered contributory and their output is calculated by applying a scaling factor to their *Registered Capacity* such that their aggregate output is equal to the forecast *Annual Peak Demand* minus total imports from external systems. Thus,

$$\text{The output of a contributory Power Station} = \frac{\textit{Power Station Registered Capacity}}{1 + \textit{Plant Margin}}$$

where the *Plant Margin* is expressed as a decimal fraction of the total amount of the *Annual Peak Demand* minus the total imports from external systems.

RANKING ORDER TECHNIQUE

B2 In some circumstances apparent future *Plant Margins* may exceed 20%. The ranking order technique maintains the output of directly connected *Power* Stations and embedded *Large Power Stations,* considered more likely to operate at times of *Annual Peak Demand*, at more realistic levels and treats those less likely to operate as non - contributory.

B3 This is achieved by ranking all directly connected *Power Stations* and large embedded *Power Stations* in order of likelihood of operation at times of *Annual Peak Demand*. Those *Power Stations* considered least likely to operate at peak are progressively removed and treated as non - contributory until a margin of 20% or just below is achieved. The output of the remainder is then calculated using the same scaling method as used in the straight scaling technique described in the equation above.

APPENDIX C

GUIDANCE ON ECONOMIC JUSTIFICATION

C1 These guidelines may be used to assist in the:

i. economic justification of investment in transmission equipment and/ or purchase of services such as reactive power in addition to that required to meet the planning criteria of Sections 2 or 3;

ii. evaluation of any expected additional operational costs or investments resulting from a proposed variation in connection design stated in Section 2 and 4

C2 Guidelines:

i. additional investment in transmission equipment and/ or the purchase of services 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.

ii. the assessment of expected operational costs and the potential reliability implications shall normally require simulation of the expected operation of the *Transmission System* in accordance with the operational criteria set out in Sections 2 and 3 of the Standard.

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

- transmission power losses;
- frequency response;
- reserve;
- reactive power requirements; and
- system constraints, and may also include costs arising from:
- rearrangement of transmission maintenance times; or
- modified or additional contracts for other services.

iv. all costs should take account of future uncertainties

v. the evaluation of unreliability costs expected from operation of the *Transco Transmission System* shall normally take account of the number and type of customers affected by supply interruptions and use appropriate information available to facilitate a reasonable assessment of the economic consequences of such interruptions.