

TRANSMISSION CODE

Energy Market Authority of Singapore

January 2014

TRANSMISSION CODE

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1 GENERAL AND ADMINISTRATIVE PROVISIONS

1.1 The Purpose of this Code

1.1.1 This *Code* sets the minimum conditions that the Transmission Licensee must meet in carrying out its obligation to provide *transmission services* and to provide non-discriminatory access to the Transmission Licensee's *transmission system*. The *Code* also describes the rights and obligations of the Transmission Licensee in respect of the provision of *transmission services*, together with the rights and obligations of the users of *transmission services*.

1.1.2 This *Code* also sets out the technical requirements to be met by those who are connected to the Transmission Licensee's *transmission system*.

1.2 To Whom this Code Applies

1.2.1 This *Code* is applicable to:

- (a) The Transmission Licensee, who is subject to and required to comply with this *Code* by a condition of its electricity licence;
- (b) Generation Licensees who are subject to and required to comply with this *Code* by a condition of their electricity licence;
- (c) A *connected person* who is required to comply with this *Code* or certain provisions of this *Code* under the terms of a *Connection Agreement* or *Retailer Use of System Agreement* with the Transmission Licensee or by a condition of its electricity installation licence; and
- (d) The *Power System Operator*, either under the provisions of this *Code* or under the terms of the *Operating Agreement*.

1.2.2 A Licensee may, by condition of its electricity licence imposed pursuant to section 9(7)(a)(iii) of the *Act*, be exempted from compliance with this *Code*, in whole or in part. A Licensee that has been so exempted shall not, subject to such conditions or restrictions as the *Authority* may determine, be required to comply with the provisions of this *Code* that are the subject of the exemption unless and until such exemption is withdrawn or modified.

1.2.3 Such *installations* in existence before the date on which this *Code* comes into force which meet the standards and specifications of the 1998 Transmission Code or have waivers from the provisions of the 1998 Transmission Code, shall be deemed to meet the provisions of this *Code* until such time as the *Authority* shall determine that the provisions of this *Code* shall be binding or an exemption under section 1.2.2 shall be given.

1.3 Definitions

1.3.1 In this *Code*, unless the context otherwise requires:

“Act” means the Electricity Act;

“active power” means the product of voltage and current and the cosine of the phase angle between them measured in units of watts and standard multiples thereof;

"*application fee*" means such fee payable by a *connection applicant* to the Transmission Licensee upon submission of a written application for a connection to the *transmission system*;

“Automatic Voltage Regulator” (AVR) means a continuously acting automatic excitation system to control the terminal voltage of a *generating unit*;

“authorised person” means an appropriately qualified *Licensed Electrical Worker* (LEW) or a staff of an electricity licensee duly authorised by the electricity licensee’s management to undertake *high voltage* electrical work;

“Authority” means the Energy Market Authority of Singapore established under the Energy Market Authority of Singapore Act;

“auxiliaries” means any item of electrical plant that is not directly a part of the boiler plant or *generating unit* of substation primary equipment, but required for the boiler plant’s, the *generating unit’s* or the substation’s primary equipment’s functional operation;

“BS” means British Standard;

“business day” means any day other than a Saturday, a Sunday or a public holiday as defined in the Interpretation Act and, where expressed by reference to the jurisdiction of a person other than Singapore, means any day other than a Saturday, a Sunday or a day on which banks are authorized or required to be closed in the jurisdiction of that person;

“Certificate of Compliance” means a document issued by an *authorised person* as required under Section 5(2) of the Electricity (Electrical Installations) Regulations 2002;

“circuit breaker” means a mechanical switching device capable of making, carrying and breaking an electricity current under normal circuit conditions, and or making and carrying for a limited time and breaking an electricity current, under specified abnormal circuit conditions including short circuit;

“Code” means this Transmission Code;

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"Combined-Cycle Plant" means a *generation facility* that consists of one or more Gas Turbines (GT); one or more boilers (or Heat Recovery Steam Generator (HRSG)) with a portion of the required energy input to the boiler provided by the exhaust gas of the GT(s) for use by the Steam Turbine(s) to produce electricity;

"common usage" means the difference between total metered electricity use in a *master-metered installation* over a period of time and the sum of all electricity use for all accounts of *sub-metered consumers* associated with the *installation* of such *sub-metered consumers* in the same *installation* over the same period of time;

"competent person" means a person who has sufficient technical knowledge or experience in working in *high voltage installations* to enable him to avoid danger when working in such *installations*;

"connect" means, in respect of a *connected person's installation*, to put into place a physical link between the relevant *connected person's installation* and the relevant *connection point*,

and "connection", "disconnection", "reconnection" and all grammatical variations thereof shall be interpreted accordingly, provided that the term "disconnection" shall be interpreted to mean the removal of the physical link or discontinuing the flow of electricity to or from an *installation*;

"connected person" means the person who controls the use of an *installation connected* directly or *connected* via the internal electrical system of another party, to the Transmission Licensee's *transmission network* or *distribution network*;

"Connection Agreement" means an agreement pertaining to conditions for connection and access to the *transmission system*, entered into between the Transmission Licensee and any person whose *installation* is connected or intended to be connected directly or indirectly to the *transmission system*, and to the terms and conditions relating to charges for *transmission services*;

"connection applicant" means, in respect of a *generation facility*, a Generation Licensee and, in respect of a consumer *installation*, a person acting through an *authorised person* but (for the avoidance of doubt) shall exclude a *sub-metered consumer*;

"connection point" means the point on the *transmission system* where the *service connection* is terminated;

"demand" means the demand of MW and MVar of electricity (i.e., both *active power* and *reactive power*);

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“distance protection” means a mode of detection of abnormal conditions and initiation of fault clearance or actuating signals or indicators that function when the circuit admittance, impedance or reactance increases or decreases beyond a pre-determined value;

“distribution network” means that part of the *transmission system* at 22kV and below;

“earthing device” means an apparatus or device provided for *earthing* purposes;

“earthing” means the provision of an electrical conductivity between one or more conductors and earth;

“electrical switch” means the *circuit breaker*, load switch or other mechanism by which load current or an electrical circuit may be broken, or by which electricity flow may be activated or deactivated;

“energise” means

- in the case of a *generation facility* or a consumer’s *installation* other than an *installation* indirectly connected to the *transmission system*, the closing of a *circuit breaker* or other *isolating device*, owned and controlled by the Transmission Licensee; or
- in the case of a consumer’s *installation* that is indirectly connected to the transmission system, the closing of a *circuit breaker* or other *isolating device* owned and controlled by the electrical installation licensee who is connected directly to the *transmission system*.

and ‘energisation’, ‘de-energisation’ and ‘re-energisation’ and all grammatical variations thereof shall be interpreted accordingly;

“Energy Management System (EMS)” means the computer system in *Power System Operator’s Control Centers* used for monitoring and controlling the *transmission network* and for monitoring and dispatching *generating units* to meet *power system demand*;

“external generation facility” means a *generation facility* located outside Singapore, and not forming part of or connected to an *external system* that is connected to the System through an *interconnector* dedicated to it. An external *generation facility* may supply its local *network* but shall not be electrically connected to an *external system* (where there are one or more other *generation facilities*);

“external party” means a person whose *external system* or *external generation facility* is connected or to be *connected* to the *transmission system* through an *interconnector*;

“external system” means an electricity system located outside Singapore, and comprising electricity generation and transmission facilities, which is connected to the *transmission system* through an *interconnector*;

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“frequency” means the number of alternating current cycles per second (expressed in Hertz) at which a *power system* is operating;

“generating station” means any *installation* used for, or for purposes connected with, the production of electricity;

“generating unit” means any apparatus used for, or for purposes connected with, the production of electricity;

“generation facility” means one or more *generating units, including its associated equipment such as switchgears, transformers and all auxiliary equipment*;

“good utility practice” means any of the practices, methods and acts engaged in or approved by a significant portion of the international electric utility industry during the relevant time period, or any of the practices, methods or acts which, in the exercise of reasonable judgement in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, *reliability, security, safety and expedition*. *Good utility practice* is not intended to be limited to the optimum practice, method or act to the exclusion of all others, but rather extends to acceptable international practices, methods and acts exercised generally by the electric utility industry under similar conditions;

“high voltage” means a voltage exceeding 1000V a.c. or 1500V d.c. between conductors, or 600V a.c. or 900V d.c. between each conductor and Earth;

“IEC” means International Electrotechnical Commission;

“installation” means any plant, apparatus, structure, equipment or thing used for the generation, transmission, supply or use of electricity;

“interconnector” means a set of feeder circuits for the transmission of electricity to or from the *transmission system* from or to an *external system* or *external generation facility* outside Singapore, and 'interconnection' shall be interpreted accordingly;

“Interruptible Load Provider” means a market participant who provides reserve from a load facility;

“isolating device” means a device for achieving isolation;

“Licensed Electrical Worker” or “LEW” means a person who holds a valid electrical worker licence permitting him to perform personally such electrical work as is specified in their licence;

“master-metered consumer” means a consumer that is responsible for the *common usage* of a *master-metered installation* which is connected to the *transmission system*;

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“master-metered installation” means an *installation* in which supply is received by a *master-metered consumer* and *sub-metered consumers*;

“network” means a section of the *transmission system* delineated from another section of the *transmission system* by a characteristic such as the voltage;

“Operating Agreement” means the agreement made between the *Power System Operator* and the Transmission Licensee or any other party, as the case may be, which gives the *Power System Operator* the authority to direct the operations of their facility in the *PSO* controlled system;

“outage” means the removal of equipment from service or unavailability for connection of equipment for any reason, and includes a forced *outage*, a planned *outage* or both, as the context may require;

“Owners Engineer” means the *generation facility* in-house professional engineer;

“Power System Operator” or “PSO” means the *Authority* acting in its capacity as the person responsible for ensuring the *security* of supply of electricity to consumers and arranging for the secure operation of the *transmission system* in accordance with the market rules and applicable codes of practice as described in section 3(3)(e) of the *Act*;

“power system” means a system comprising the *transmission* and *distribution networks*, generation and consumer *installations*, and *external systems* connected to the *transmission system*;

“protective devices” means apparatus, within the *protection system* installed for an electrical *installation* and includes, but not limited to, protective relays, instrument transformers, DC supply, wiring, trip and control and alarm circuits and ancillary equipment;

“protection system” means a combination of *protective devices* designed to secure, under predetermined conditions, usually abnormal, the disconnection of an element of the *power system* and/or to give an alarm signal;

“reactive power” means the product of voltage and current and the sine of the phase angle between them measured in units of volt-amperes reactive;

“reliability” means, in respect of electricity service, the ability to deliver electricity within *reliability* standards and in the amount desired, and means, in respect of the electricity system, the *power system* or the *transmission system*, the ability of the electricity system, the *power system* or the *transmission system* to operate within *reliability* standards in an adequate and secure manner;

“reserve” means generation capacity or load reduction capacity that can be called upon to replace scheduled energy supply that is or becomes unavailable as a result of

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an unexpected *outage*, or to augment scheduled energy as a result of unexpected *demand* or other contingencies;

“Retailer Use of System Agreement” means an agreement entered into between the Transmission Licensee and a Retail Electricity Licensee who has elected to provide its customers with a consolidated billing service in accordance with the Market Support Services Code and the Retailer Code of Conduct under which the Retail Electricity Licensee accepts liability for the payment of transmission charges owed to the Transmission Licensee by a contestable consumer that is a customer of the Retail Electricity Licensee;

“Remote Terminal Unit” or “RTU” means a multiple micro-processor based system that gathers status/analog data from field devices and performs control function on field devices. The gathered data is channeled by a modem to the host computer at the master station for further processing;

“safety coordinator” means an authorised person nominated by the Transmission Licensee and by each *connected person* to be responsible for the co-ordination of safety precautions prior to when work and/or testing is to be carried out on a *service connection* or equipment directly connected to such *service connection*;

“security” means the ability of the *power system* to withstand sudden disturbances including, without limitation, electric short circuits or unanticipated loss of equipment or components;

“service connection” means two or more insulated electrical conductors which provide, or are intended to provide, an electrical link between the *transmission system* and a *connected person's installation*;

“site responsibility schedule” means a schedule prepared by the Transmission Licensee showing the ownership, operating and safety responsibilities in respect of a *service connection*;

“site safety procedures” means the safety procedures implemented by the Transmission Licensee or by a connected person to govern work carried out in respect of a *service connection* or equipment directly connected to it;

“SS” means Singapore Standard;

“Statement of Turn-On” means a document issued by an *authorised person* as required under Section 5(4) of the Electricity (Electrical Installations) Regulations 2002;

“sub-metered consumer” means a consumer, other than a *master-metered consumer*, that receives a supply in a *master-metered installation* via the electrical system owned by a *master-metered consumer*;

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“system test” means a test carried out by a connected person, or by the Transmission Licensee which involves simulating conditions or the controlled application of irregular, unusual or extreme conditions on their system or any part of the *transmission system*, and any commissioning and acceptance tests of *generating unit*, plant and apparatus;

“total harmonic voltage distortion” means the departure of a wave form from sinusoidal shape that is caused by the addition of one or more harmonics to the fundamental, and is the square root of the sum of the squares of all harmonics expressed as a percentage of the magnitude of the fundamental *frequency*;

“transmission network” means that part of the *transmission system* operating at 66kV and above;

“transmission services” means services provided by the Transmission Licensee pursuant to section 20(2) of the *Act*;

“transmission system” means the system of interconnected electric lines owned by a Transmission Licensee for the purpose of conveying electricity;

“turn-on” means, the closing of an incoming *electrical switch* controlled by the *connected person*, to allow flow of electricity to or from the relevant *installation*, and "turn-off", and other grammatically variations of these terms, shall be interpreted accordingly;

“Under Frequency Relay” (UFR) means a continuously monitoring relay that will operate, giving an alarm or initiation signal upon measured frequency moves outside set point limit.

“unit protection” means a *protection system* which is designed to operate only for fault conditions within a clearly defined zone of the power system.

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1.4 Interpretation

- 1.4.1 Unless otherwise defined in this *Code* and appearing in italics, words and phrases shall have the meaning ascribed to them in the *Act*, and words and expressions used in this *Code* shall be construed as if the Interpretation Act (Cap.1) applied to them.
- 1.4.2 Headings are for convenience only and shall not affect the interpretation of this *Code*.
- 1.4.3 A reference in this *Code* to any statute, subsidiary legislation, proclamation, ordinance, by-law, resolution, rule, order, supplements, gazette notification or directive includes all statutes, subsidiary legislation, proclamations, ordinances, by-laws or resolutions, rules, orders, supplements, gazette notifications or directives varying, consolidating, re-enacting, extending or replacing it.
- 1.4.4 A reference in this *Code* to a document or provision of a document includes a modification or supplement to, or replacement or novation of, that document or that provision of that document, as well as any exhibit, schedule, appendix or other annexure thereto.
- 1.4.5 A reference in this *Code* to a body, whether statutory or not, which ceases to exist or whose functions are transferred to another body includes a reference to the body which replaces it or which substantially succeeds to its functions, powers or duties.
- 1.4.6 A reference in this *Code* to the word “including” or a grammatical variation thereof means “including but not limited to”.

1.5 Hierarchy of Codes

- 1.5.1 The hierarchy of codes of practice shall be as follows:
- (a) Transmission Code;
 - (b) Regulated Supply Service Code;
 - (c) Market Support Services Code;
 - (d) Metering Code; and
 - (e) Code of Conduct for Retail Electricity Licensees.
- 1.5.2 In the event of a conflict between conditions contained in more than one code of practice, the condition in the higher code of practice referred to in section 1.5.1 shall prevail.
- 1.5.3 In the event of a conflict between conditions contained in this *Code* and conditions contained in an electricity licence issued pursuant to section 9 of the *Act*, the conditions in the electricity licence shall prevail.

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1.5.4 In the event of a conflict between conditions contained in this *Code* and conditions contained in:

- (a) the market rules;
- (b) the market manuals; or
- (c) the system operation manuals;

the conditions in this *Code* shall prevail.

1.6 Modifications to This Code

1.6.1 In furtherance of the authority contained in section 16(2) of the *Act*, the process by which this *Code* may be modified from time to time by the *Authority* shall be as follows:

- (a) Before making any modification to this *Code*, the *Authority* shall:
 - (i) state that the *Authority* proposes to make a modification in the manner specified in the notice;
 - (ii) state the reasons why the *Authority* proposes to make the modification, including whether the need for the modification was the subject of a prior representation made by a Licensee or third party; and
 - (iii) specify the period from the date of the giving of the notice (not being less than 28 days) within which written representations with respect to the proposed modification may be made.
- (b) If no written representation is received by the *Authority* within the period specified in the notice referred to in section 1.6.1 (a) or if all written representations made in response to such notice are subsequently withdrawn, the *Authority* may modify this *Code* as specified in such notice.
- (c) Where the *Authority* receives any written representation under section 1.6.1(a), the *Authority* shall consider all such representations, as a whole, and may:
 - (i) reject the representations;
 - (ii) amend the proposed modification in accordance with the representations;
 - (iii) form working committee(s), with representation from Electricity Licensees, to review the proposed modification to the *Code*. The working committee shall make its recommendation on the proposed modification for the *Authority's* consideration; or

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- (iv) withdraw the proposed modification.
 - (d) The *Authority* shall, before modifying this *Code*, respond with reasons to all written representations received in respect of the modification that were not subsequently withdrawn, and advise the outcome of the *Authority's* deliberations in respect of the modification.
 - (e) A modification to this *Code* shall not come into force until such time as the *Authority* has complied with section 1.6.1(d), where applicable, and 10 *business days*, or such longer period of time as may be specified by the *Authority*, have elapsed since the date on which the *Authority* gave notice of the modification as required by section 16(2) of the *Act*.
- 1.6.2 Nothing contained in section 1.6.1 shall prohibit any Electricity Licensee or any other party from notifying the *Authority* of suggested *Code* changes.

1.7 Coming into Force

- 1.7.1 This Code shall come into force on the appointed day.

2 OPERATING AGREEMENTS

2.1 Operating Agreements

- 2.1.1 An agreement, of standard form, shall be entered into between the *Power System Operator and* the Transmission Licensee or any other party, as the case may be, which gives the *Power System Operator* the authority to direct the operations of their facility in the *PSO* controlled system.

3 RETAILER USE OF THE TRANSMISSION SYSTEM AGREEMENT

3.1 Retailer Use of System Agreement

- 3.1.1 The Transmission Licensee shall, subject to the relevant conditions of the Transmission Licence and Retail Electricity Licence, enter into a *Retailer Use of System Agreement* with any Retail Electricity Licensee who intends to provide retailer-consolidated billing services to a contestable consumer.
- 3.1.2 The conditions imposed in the *Retailer Use of System Agreement* shall be the same for all such retailers.

4 CONNECTION TO THE TRANSMISSION SYSTEM

4.1 Application for a New or Modified Generation Facility Connection – General Conditions

- 4.1.1 A *connection applicant* applying to connect its *generation facility* to the *transmission system* or modify its existing *generation facility* connected to the *transmission system* is required to submit a formal application through an *authorised person*, together with the *application fee* payable, to the Transmission Licensee. The application shall contain the information described in Appendix C. After having submitted the application, the *connection applicant* shall promptly notify the Transmission Licensee in writing of any subsequent material additions or changes to the information submitted.
- 4.1.2 Upon receipt of the application from the *connection applicant*, the Transmission Licensee:-
- (a) shall forward such application to the *Power System Operator* upon receiving the application;
 - (b) may require additional information to be submitted by the *connection applicant*;
 - (c) shall perform the necessary analysis and studies of the connection application to determine a connection scheme that does not have any adverse effect on the secure, stable and reliable operation of the *transmission system* and any other *installation*, or *external party* already connected or seeking connection to the *transmission system*;
 - (d) shall advise the *connection applicant* whether the sites identified by the *connection applicant* are suitable for new *connections*. If a *connection point* has been identified for each of the respective sites at which a *connection* may be made, the Transmission Licensee shall advise the *connection applicant* the indicative connection charges, connection scheme and the connection facilities to be provided; and
 - (e) shall ensure that any requirements expressed by the *Power System Operator* have been satisfied.
- 4.1.3 The Transmission Licensee shall forward the proposed connection scheme to the *Power System Operator*. The *Power System Operator*, upon receiving the proposed connection scheme from the Transmission Licensee:-
- (a) may require additional information to be submitted by the *connection applicant* and/or the Transmission Licensee;
 - (b) shall conduct analysis and studies to determine the impact of the proposed *connection* of the *generation facility*/modification to existing *generation facility* on the *security*, *stability* and *reliability* of the *power system*;

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(c) shall within 20 *business days* of receiving the proposed connection scheme from the Transmission Licensee, advise the Transmission Licensee whether it endorses or rejects the proposed connection scheme. If the *Power System Operator* rejects the proposed connection scheme, it shall inform the Transmission Licensee in writing of its reason(s) for such rejection; and

(d) where deemed necessary, shall advise the *connection applicant* the requirements of the proposed *generation facility* or modification to the existing *generation facility* to ensure the *security*, stability and *reliability* of the *power system*. The *connection applicant* shall confirm in writing to the *Power System Operator*, with a copy to the Transmission Licensee, its acceptance of the requirements specified by *Power System Operator* and ensure that the requirements are met.

4.1.4 The Transmission Licensee shall use its best endeavours to respond to the *connection applicant* within the following time schedule regarding the proposed connection scheme duly endorsed by the *Power System Operator*.

Connection Voltage	Time Schedule
230kV and 400kV	80-100 <i>business days</i>
66kV and below	60 <i>business days</i>

4.1.5 Upon the *connection applicant* accepting the proposed connection scheme, the Transmission Licensee shall notify the *connection applicant* of the terms and conditions of *connection* or modification to the existing *connection* and of the charges, if any, payable to the Transmission Licensee to carry out the relevant works under the *Connection Agreement*, and shall provide to the *connection applicant* a copy of the *Connection Agreement*.

4.1.6 The Transmission Licensee shall not connect any *generation facility* to the *transmission system* if the *connection applicant* fails to comply, or the Transmission Licensee determines on reasonable grounds that the *connection applicant* is not capable of complying, with the procedures and requirements for *connection* to and use of the *transmission system* set forth in this *Code* and the *Connection Agreement*.

4.1.7 The conditions for *connection* of a *generation facility* shall apply in the case of a *reconnection*.

4.2 Application for a New or Modified Consumer Installation Connection – General Conditions

4.2.1 A *connection applicant* applying to connect its consumer *installation* to the *transmission system* or modify its existing consumer *installation* connected to the *transmission system* is required to submit a formal application through an *authorised person*, together with the *application fee* payable, to the Transmission Licensee. The application shall contain the information described in Appendix B (and Appendix C, where applicable). After having submitted the application, the *connection applicant*

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shall promptly notify the Transmission Licensee in writing of any material additions or changes to the information submitted.

- 4.2.2 Upon receipt of the application from the *connection applicant*, the Transmission Licensee:-
- (a) may require additional information to be submitted by the *connection applicant*;
 - (b) shall perform the necessary analysis and studies of the connection application to determine a connection scheme that does not have any adverse effect on the secure, stable and reliable operation of the *transmission system* and any other installation, or external party already connected or seeking connection to the *transmission system*;
 - (c) shall advise the *connection applicant* of the indicative connection charges, connection scheme (including connection voltages) and the connection facilities to be provided; and
 - (d) shall ensure that any requirements expressed by the *Power System Operator* have been satisfied.
- 4.2.3 The Transmission Licensee shall forward the proposed connection scheme (where the proposed connection is to the *transmission network* or the connection of centrally dispatchable *generation facility* to the consumer's *installation*) to the *Power System Operator*. The *Power System Operator*, upon receiving the proposed connection scheme from the Transmission Licensee:-
- (a) may require additional information to be submitted by the *connection applicant* or the Transmission Licensee;
 - (b) shall conduct analysis and studies to determine the impact of the proposed *connection* of the *installation* or modification of the existing *installation* on the *security*, stability and *reliability* of the *power system*;
 - (c) shall within 20 *business days* of receiving the proposed connection scheme from the Transmission Licensee, advise the Transmission Licensee whether it endorses or rejects the proposed connection scheme. If the *Power System Operator* rejects the proposed connection scheme, it shall inform the Transmission Licensee in writing of its reason(s) for such rejection; and
 - (d) where deemed necessary, shall advise the *connection applicant* of the requirements for the *installation* or modification of the existing *installation* to ensure the *security*, stability and *reliability* of the *power system* and the *connection applicant* shall confirm in writing to the *Power System Operator*, with a copy to the Transmission Licensee, its acceptance of the requirements specified by *Power System Operator* and ensure that the requirements are met.

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4.2.4 The Transmission Licensee shall use its best endeavours to respond to the *connection applicant* (duly endorsed by the *Power System Operator*, where applicable) within the following time schedule regarding the proposed connection scheme.

Connection Voltage	Time Schedule
230kV and 400kV	80-100 <i>business days</i>
66kV	60 <i>business days</i>
22kV and below	10 <i>business days</i> (time schedule would be longer where it involves the connection of centrally dispatchable generation facility to a consumer's installation)

4.2.5 Upon the *connection applicant* accepting the proposed connection scheme, the Transmission Licensee shall notify the *connection applicant* of the terms and conditions of *connection* or modification to the existing *connection* and of the charges, if any, payable to the Transmission Licensee to carry out the relevant works under the *Connection Agreement*, and shall provide to the *connection applicant* a copy of the *Connection Agreement*.

4.2.6 The Transmission Licensee shall not connect any installation to the *transmission system* if the *connection applicant* fails to comply, or the Transmission Licensee determines on reasonable grounds that the *connection applicant* is not capable of complying, with the procedures and requirements for *connection* to and use of the *transmission system* set forth in this *Code* and the *Connection Agreement*.

4.2.7 The conditions for *reconnection* of a consumer's *installation* shall be in accordance with the requirements developed by the Transmission Licensee.

4.3 Connection Agreement

4.3.1 The Transmission Licensee shall enter into a *Connection Agreement*, that describes the terms and conditions, with any person whose facilities or equipment are or are intended to be connected, directly or through the internal electrical system of any other consumer, to the *transmission system*. The form of the *Connection Agreement* may depend upon the nature of the *installation* to be connected and the voltage level at which it is connected.

4.4 Energisation of the Service Connection

4.4.1 The *connection application* shall, no less than 14 *business days*, prior to the date on which the *energisation* of the *service connection* is to take place:-

- (a) complied fully with the safety requirements of this *Code*;

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- (b) complied fully with the technical requirements of this *Code* and shall, in particular, have submitted the data and information stipulated in Appendix B and/or Appendix C and/or Appendix D, where applicable;
 - (c) submitted to the Transmission Licensee a written request for approval to *energise* the *service connection* and the proposed date of *energisation*;
 - (d) submitted to the Transmission Licensee a written confirmation that the *installation* to be connected to the *transmission system* for which *connection* is sought conforms fully with the requirements of the *Connection Agreement*; and
 - (e) submitted to the Transmission Licensee a written confirmation that it has obtained all necessary authorisations for the construction and operation of the *installation* in accordance with the provisions of all applicable laws and regulations in the Republic of Singapore have been met;
- 4.4.2 The Transmission Licensee shall not *energise* any *service connection* unless it has, on or before the date of *energisation* of the *service connection*,:-
- (a) complied fully with the safety requirements of this *Code*;
 - (b) received approval from the *Power System Operator*, where applicable, to *energise* the *service connection*;
 - (c) is satisfied that the *connection applicant* has a contractual obligation to pay for *transmission services* in respect of the *installation*;
 - (d) is satisfied that the *connection applicant* has a contractual obligation to pay for the supply delivered to the *installation*;
 - (e) is satisfied that the provisions of the Metering Code have been met and that metering equipment, pursuant to the provisions of the Metering Code, has been installed and is fully operational; and
 - (f) received prior to *energisation*, a *Certificate of Compliance* from an *authorised person* acting on behalf of the *connection applicant*.
- 4.4.3 The Transmission Licensee shall arrange with the *connection applicant* for a joint inspection and testing of the *connection applicant's circuit breaker* and any associated apparatus attached to the *service connection*, if the Transmission Licensee considers that such inspection or testing is necessary to ensure that *energisation* of the *service connection* shall not have an adverse impact on the secure and reliable operation of the *transmission system*. The date of such joint inspection or testing shall not be less than 14 *business days* prior to the date of *energisation* of the *service connection*.
- 4.4.4 Where the Transmission Licensee is not satisfied that the *circuit breaker* or any associated apparatus referred to in section 4.4.3 is ready for *energisation*, the

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Transmission Licensee shall notify the *connection applicant* and provide reasons for its determination. The *connection applicant* shall make such changes to the *circuit breaker* and/or associated apparatus as required and shall inform the Transmission Licensee when a further inspection can take place. The Transmission Licensee and the *connection applicant* shall agree on a date for such further inspection where such date shall be no later than 14 *business days* after the *connection applicant* has completed the required modifications to the *circuit breaker* and/or associated apparatus.

- 4.4.5 Following the Transmission Licensee's acceptance of the *Certificate of Compliance* and if the Transmission Licensee is satisfied that the *circuit breaker* and all associated apparatus referred to in section 4.4.3 is ready for *energisation*, the Transmission Licensee, the *Power System Operator* (where applicable), and the *connection applicant* shall schedule a date to *energise* the *service connection*.
- 4.4.6 The Transmission Licensee shall advise the Market Support Services Licensee accordingly of the date of *energisation* of the *service connection*.

4.5 Electrical Turn-on of an Installation

- 4.5.1 In the case of an *installation* of a *connection applicant* other than an *installation* indirectly *connected* to the transmission system, following *energisation* of the *service connection*, the Transmission Licensee shall issue a *Statement of Turn-On* after which *turn-on* of the relevant *installation* may be performed. Such *turn-on* shall be effected by an *authorised person* appointed by the *connection applicant*.

4.6 Electrical Commissioning of a Generation Facility

- 4.6.1 For the commissioning of a *generation facility*, the *connection applicant* shall submit to the *Power System Operator*, 14 *business days* in advance from the date its new/repowered *generating facility* is scheduled for synchronisation to the *power system*, a tentative commissioning tests program including those tests listed in Appendix C (giving details of the schedules and the test to be carried out at various load levels) for on-load commissioning of its new/repowered *generating facility*. A final version of the commissioning program shall be established one week before the commencement of the commissioning. The *Power System Operator* shall have the authority to re-schedule any of the required tests to minimise system risk and the reason for such re-scheduling shall be given to the Generation Licensee.
- 4.6.2 The *Power System Operator* shall allow a *connection applicant* to proceed with on-load commissioning of its new/repowered *generation facility* connected to the *transmission system* if the *connection applicant* has satisfactorily complied with the following conditions:-
- (a) that the *connection applicant*, where applicable, has registered its new/repowered *generation facility* with the Market Company in accordance with the provisions laid down in the Market Rules, and it has provided the necessary *generation*

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facility information required by the Market Company as part of the Facility Registration Process;

(b) that the *connection applicant* has a commissioning program established in accordance with the provision set out in section 4.6.1 of this *Code*.

4.6.3 Upon completion of the testing and commissioning of the *generation facility*, the *connection applicant* shall submit and update the *Power System Operator* with the final site setting of the *generation facility*, as well as the testing and commissioning reports as set forth in Appendix C.

4.7 Documentation of Guidelines

4.7.1 The Transmission Licensee shall prepare, maintain and make available a document that specifies the guidelines for a *connection applicant* applying for *connection* of its consumer *installation* to the *transmission system* or for modification of an existing *installation* connected to the *transmission system*.

4.7.2 The Transmission Licensee shall file a copy of the document referred to in section 4.7.1 with the *Authority*.

4.8 Conditions for Connection of an Interconnector

4.8.1 Application for Connection of an Interconnector

The application procedures stipulated in section 4.1 shall apply for an *external party* wishing to connect to the *transmission system* through an *interconnector*.

4.8.2 Data Requirements

The *external party* shall supply to the Transmission Licensee and *Power System Operator*, such information regarding the *external system* and *external generation facility* as specified in Appendix C and/or Appendix D, as applicable.

4.8.3 Limit of Power Transfer

The power transmitted through an *interconnector* and the spinning *reserve* required to be provided (applicable to *external generation facility* only) shall not exceed the system stability, *security* and *reliability* limits or the firm transfer capability of the *interconnector*, whichever is lower, as determined by the *Authority*. The total power import through all *interconnectors* into the *transmission system* shall not be more than the limit, as determined by the *Authority*.

4.8.4 Joint Operation Committee

A Joint Operation Committee shall be formed with each of the *external parties*. The Joint Operation Committee shall comprise the *external party*, the Transmission

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Licensee and the *Power System Operator*. Regular meetings shall be conducted to update and address all system planning, operation and maintenance matters.

4.8.5 General Technical Requirement

- (a) External *generation facilities* shall be designed to ensure technical compatibility with the *power system* integrity. This shall include short circuit current contribution to the *network* and other specific requirements, which shall be determined by the Transmission Licensee and the *Power System Operator* on a case-by-case basis.
- (b) *Circuit breakers* shall be provided at both ends of the *interconnector*. Other equipment, which may be required, shall be determined by the Transmission Licensee and the *Power System Operator* on a case-by-case basis.
- (c) The number of feeder circuits forming the *interconnector* shall meet single contingency criterion.
- (d) Synchronizing facilities shall be provided at both ends of an *interconnector* by the respective parties.

4.8.6 External Generation Facilities

- (a) All *external generation facilities* shall comply with all technical requirements stated in this *Code*.
- (b) All *external generation facilities* shall be centrally dispatchable.
- (c) All *generating units* of *external parties* shall be *frequency* sensitive and shall contribute to system spinning *reserve* in the same manner as specified in Appendix F.
- (d) All *external parties* shall provide a central control system for dispatching of all their *generation facilities* in a manner such that the power transmitted through the *interconnector* shall be as instructed by real-time signals sent by the *Power System Operator*.
- (e) The *external party* responsible for an *external generation facility* shall be required to obtain approval from the *Authority* and the Transmission Licensee, if it intends to convert that *external generation facility* into an *external system*.

4.8.7 Additional Technical Requirements for *External System*

- (a) An *external party* shall provide adequate spinning *reserve* to cater for a sudden loss of the largest *generating unit* in its *external system* without causing any under *frequency* tripping of the *interconnectors* or in that *external system*. This shall allow the Area Control Error to return to zero at least every ten minutes.

- (b) An *external party* shall be responsible for *network* reinforcement and system protection in its *external system* to ensure stable and secure operation of the integrated system.
- (c) An *external party* shall be responsible for the provision of an Automatic Generation Control facility with *frequency* and tie-line biased control capability in the *external system* to enable control of power flow through the *interconnector* to be within $\pm 5\%$ tolerance.
- (d) An *external party* shall provide adequate reactive compensation in its *external system* to ensure minimum reactive and capacitive power flowing through the *interconnector*.
- (e) An *interconnector* shall be designed with adequate capacity and appropriate overload protection to cater for short time power flow in the event of sudden tripping of the largest *generating unit* in the system or in the *external system* during partial availability of the *interconnector* circuits.

4.8.8 Protection Requirements

- (a) An *external party* shall ensure that the *protection systems* on its external *generation facilities* and *interconnectors* comply with the requirements stated in section 6.3 and Appendix F or otherwise determined by the *Power System Operator* and/or the Transmission Licensee based on the specific *interconnector* facilities adopted.
- (b) An *interconnector* is to be equipped with under-*frequency* and over-current protection at each end by the respective parties. Power swing relays and out of step relays, if required, shall be installed by the *external party* within the *external system* for system stability protection purpose. The settings for the under-*frequency*, power swing relays and out of step relays shall be provided by the *Power System Operator* and the *external party*. The settings for the over-current protection shall be provided by the Transmission Licensee and the *external party*.

4.8.9 Communication Requirements

- (a) An *external party* shall, in relation to its *external system* and *external generation facilities*, install, maintain and operate two independent voice communication links between the *external party's* Network Control Centre and *Power System Operator's* Control Centre. These voice links shall be the direct lines (to be provided by an independent service provider) associated with this Control Centre and shall be used for operational purposes only. All communication equipment/links as may be required by the protective relaying scheme shall be installed and maintained by the *external party*. Where required, such equipment or links shall be compatible with the applicable communication equipment or links of the Transmission Licensee and/or the *Power System Operator*.

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- (b) An *external party* shall, in relation to its *external system* and *external generation facilities* install, maintain and operate a facsimile machine for operational purposes. Such facsimile machine shall have a dedicated telephone line and number, located in the *external party's* Network Control Centre. The *external party* and the *Power System Operator* shall inform each other of the number of their facsimile machine used for operational purposes.

4.8.10 Maintenance Requirements

- (a) An *interconnector* shall be maintained in accordance with the general guidelines stated in section 9.
- (b) Any request for shutdown of an *interconnector* shall be submitted to the *Power System Operator* for approval. The *Power System Operator* shall coordinate all switching operations relating to an *interconnector*.

4.8.11 Performance Monitoring Facilities of Interconnector:

The Transmission Licensee shall provide, install and maintain at its own cost, high-resolution recorder(s) at the *interconnector* substations in the transmission system interfacing with an external party to monitor and record the *interconnector* performance during system disturbances. The recorder shall be capable of monitoring and recording, including:

- (a) *active* and *reactive power* flow of each *interconnector*;
- (b) substation busbar voltage and *frequency*; and
- (c) *circuit breaker* and *protective devices* status.

The requirements of high-resolution recorder(s) are given in Appendix F. The Transmission Licensee, upon receiving notification from *PSO*, shall furnish such records/data in softcopy via email in the format as specified in Appendix F9.2(g) within 24 hours.

5 DISCONNECTION OR DISCONTINUANCE

- 5.1 The Transmission Licensee shall not *disconnect* any *service connection* from the *transmission system* or discontinue the supply of electricity to any *installation* except as permitted by, and in accordance with, the *Act*, its electricity licence, this *Code*, a *Connection Agreement* or *Retailer Use of System Agreement*.
- 5.2 The Transmission Licensee shall, comply with any direction of a Market Support Services Licensee to *disconnect* the *service connection* or discontinue supply to a non-contestable consumer which is given pursuant to section 24(1) of the *Act* or pursuant to the Market Support Services Code.
- 5.3 The Transmission Licensee shall only *disconnect* a contestable consumer's *service connection* or discontinue the supply of electricity to such consumers in accordance with section 24(4) of the *Act*, the terms of its *Connection Agreement* or as directed by a Market Support Services Licensee pursuant to the Market Support Services Code.
- 5.4 Where the Transmission Licensee has *disconnected* any consumer's *service connection* or discontinued the supply of electricity to any *installation* in accordance with section 5.2 or section 5.3, the Transmission Licensee shall inform the relevant consumer of such action as soon as reasonably practical.
- 5.5 Where the Transmission Licensee has *disconnected* any consumer's *service connection* or discontinued the supply of electricity to any *installation* in accordance with section 5.2 or section 5.3, the Transmission Licensee shall not *re-connect* or *re-energise* that consumer's *service connection* unless the consumer complies with the requirements of section 24(5) of the *Act* and the terms of its *Connection Agreement*.

6 OPERATING AND TECHNICAL OBLIGATIONS

6.1 Responsibilities

- 6.1.1 The transmission licensee shall maintain, operate and enable the secure operation of the *transmission system*. It shall also be responsible for the secure operation of the *distribution network* i.e. the part of the *transmission system* operating at 22kV and below.
- 6.1.2 The *Power System Operator* shall be responsible for the secure operation of the *transmission network* i.e. the part of the *transmission system* operating at 66kV and above, and all centrally dispatchable *generating units*.
- 6.1.3 The Transmission Licensee and any *connected person* shall maintain and operate its *installations* to ensure they will not cause any adverse impact to the stability, *security* and reliability of the *power system*.

6.2 Standards and Standing Operating Procedures

- 6.2.1 All plant and equipment shall:
- (a) be in compliance with all applicable technical requirements of this *Code* and shall be designed and constructed in accordance with *good utility practice*;
 - (b) be capable of operating under normal and contingency conditions of the *transmission system* as set forth in Appendix G; and
 - (c) where applicable, comply with the standards set forth in Appendix I, or such other standards as may be acceptable to the Transmission Licensee.
- 6.2.2 The *Power System Operator* shall develop a system level Standing Operating Procedure (SOP) for ensuring the secure operation of the power system in the event of natural gas supply disruption and revise the SOP from time to time, if necessary. The SOP shall be developed and revised by the *Power System Operator* in consultation with the generation licensees, gas transporter and any other relevant parties. Generation Licensees with *generation facility* that uses natural gas as the primary fuel and any other parties identified in the SOP shall comply with this SOP.

6.3 Protection

- 6.3.1 A *connection applicant* applying to be *connected* to the *transmission system* shall install *protection systems* for the *service connection* in accordance with the Transmission Licensee's requirements. No *energisation* shall occur unless the specifications of the *protection systems* for the *service connection* conform with the Transmission Licensee's requirements and that the *protection systems* have been tested and are ready for commissioning.

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- 6.3.2 Each *connection applicant* shall ensure that the *protection systems* referred to in section 6.3.1 shall be compatible with and able to be fully coordinated with the *protection systems* on the *transmission system*. The *connection applicant* shall ensure that such *protection systems* are properly set and maintained in accordance with *good utility practice*, this *Code* and the relevant *Connection Agreement*.
- 6.3.3 The Transmission Licensee and *connected person* shall ensure that their *protection systems* and operating time comply with the requirements set out in Appendix F.
- 6.3.4 For on-load commissioning or re-commissioning of the *unit protection systems* involving both the Transmission Licensee and the *connected person*, the Transmission Licensee shall be responsible for co-ordinating the commissioning or re-commissioning of the *unit protection systems* and shall determine whether the *unit protection systems* have been successfully commissioned. The *connected person* shall provide the necessary resources and actively participate in the commissioning or re-commissioning of the protection systems.

6.4 System Tests

- 6.4.1 *Systems tests* are tests to be carried out by a *connected person* or Transmission Licensee which involve simulating conditions or the controlled application of irregular, unusual or extreme conditions on the *connected person's installation*, any part of the *transmission system*, or any commissioning and acceptance tests of *generating facility*, plant and apparatus. *System tests* do not include commissioning and re-commissioning tests of a minor nature, and those which do not have an effect on the *power system*.
- 6.4.2 A *connected person* or the Transmission Licensee shall ensure that the *system test* requirements specified in Appendix E are met.

6.5 Voltages

- 6.5.1 Substation/switchhouse facilities shall be designed for use at the voltage level at the applicable *connection point*, where:
- (a) standard *transmission network* voltage levels consist of 400kV, 230kV and 66kV which may vary within $\pm 5\%$ for 400kV, and $\pm 6\%$ for 230kV and 66kV;
 - (b) standard *distribution network* voltages consist of 22kV, 6.6 kV, 400V and 230V that may vary within $\pm 6\%$; and
 - (c) transient voltage variation due to switching or tripping of *transmission system* equipment may exceed the above limit.
- 6.5.2 If an *installation* is to be connected to the *transmission system*, the Transmission Licensee shall notify the *connection applicant* of the proposed location of the connection and the voltage at the *connection point*.

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- 6.5.3 The voltage at the *connection point* shall be proposed by the Transmission Licensee based on the quantity of power to be injected or withdrawn at the *connection point* and its impact on the performance of the *power system*.

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6.6 Reactive Requirements

- 6.6.1 The Generation Licensee responsible for each *generating unit* connected to the *transmission system* shall ensure that each *generating unit* has the capability of operating at a power factor from 0.95 leading to 0.85 lagging as measured at the terminals of the *generating unit* prior to the step-up transformer.
- 6.6.2 The *connected person* in respect of any *installations* taking supply at *high voltages* shall implement power factor correction measures at their facilities, if deemed necessary by the Transmission Licensee, to maintain a power factor of no less than 0.85.

6.7 Harmonics and Power Quality

- 6.7.1 All *connected persons* shall install equipment or devices to suppress harmonics and electrical noise produced by their electrical plant if the harmonics or electrical noise produced by such plants exceed the limits specified in Appendix F.
- 6.7.2 A *connected person* shall submit to the Transmission Licensee the expected noise and harmonics levels from their electrical plant upon request by the Transmission Licensee.
- 6.7.3 A *connection applicant* or *connected person* seeking *connection* at, or upgrading a connection at 66kV or higher voltages shall submit to the Transmission Licensee the following:
- (a) the expected noise and harmonics levels from the electrical plant upon submission of the application for *connection* or for upgrading of the *connection*; and
 - (b) following *connection*, noise and harmonics levels annually or at such intervals as may be specified by the Transmission Licensee.
- 6.7.4 Any *connected person* shall at their own cost:
- (a) provide stand-by power supply or stand-by generator(s) and other means to serve their plant and *installation* if their operations cannot tolerate any failure, reduction, interruption, variation or inconsistency in the supply of electricity; and
 - (b) provide power quality devices, such as uninterruptible power supply (UPS), voltage stabiliser, voltage restorer, or any other means to serve their plant if their operations can not tolerate any voltage fluctuations or distortions in supply.

6.8 Neutral Grounding System

- 6.8.1 The Transmission Licensee shall specify the neutral grounding system required of an *installation* connected to the *transmission system*, such that the neutral grounding system of the *connection applicant's installation* are compatible with that of the *transmission system*.

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- 6.8.2 No *connection* shall occur until an *authorised person* acting on behalf of the *connection applicant*, has certified that the specifications and design of the neutral grounding system complies with the requirements of the Transmission Licensee and that those neutral grounding systems have been put in place.
- 6.8.3 If the *connection applicant* is unable to comply with the neutral grounding system requirements specified by the Transmission Licensee, the *connection applicant* shall inform and provide alternative proposals for the consideration of the Transmission Licensee. The Transmission Licensee shall evaluate such alternative proposals as the *connection applicant* may make and give its approval to such alternatives as the Transmission Licensee may accept.
- 6.8.4 No *connection* shall occur until the Transmission Licensee has approved the specifications and detailed plans of the neutral grounding system provided under section 6.8.3 and those neutral grounding system have been put in place.

6.9 Disconnecting Device

- 6.9.1 As a pre-condition for *connection*, the Transmission Licensee may require the *connection applicant* to install disconnecting devices between the *transmission system* and the connection applicant's *installation*.

6.10 Equipment Nomenclature

- 6.10.1 The Transmission Licensee shall develop and maintain a uniform system of nomenclature for equipment and apparatus that forms a part of the *transmission system*.
- 6.10.2 The Transmission Licensee shall apply the system of nomenclature referred to in section 6.10.1 to specify unique numbering and nomenclature for all equipment comprising the *transmission system*.
- 6.10.3 The Transmission Licensee shall notify the *connection applicant*, or *connected person* seeking to make a modification to an existing connection to the *transmission system*, in writing, of the nomenclature requirements and conventions to be used to identify components of the electrical plant that the person intends to install at a site, no less than six months prior to the proposed installation date of the new or modified connection.
- 6.10.4 At least three months before the proposed installation date referred to in 6.10.3, the *connection applicant* or *connected person* must provide the Transmission Licensee and the *Power System Operator* (where applicable) with:
- (a) its proposed nomenclature for the components of the electrical plant that it intends to connect to the *transmission system*;
 - (b) a single line diagram showing each *high voltage* apparatus to be connected, using the numbering and nomenclature described in 6.10.4(a);

6.10.5 The Transmission Licensee shall respond in writing to the person within one month stating whether the information provided by that person in accordance with 6.10.4 has been accepted. Acceptance shall occur if the nomenclature is clear, unambiguous, unique and consistent with the requirements and conventions referred to in 6.10.3. If the numbering and nomenclature is not acceptable then the Transmission Licensee shall provide the person with the nomenclature that must be used.

6.11 Switchhouse Facilities and Generation Facility Design

6.11.1 The *generating unit's* step-up transformers and *generating unit's* switchboard (or switchgear) for connecting the *high voltage* side of the *generating unit's* step-up transformers and the associated switching and protection/control equipment shall be designed such that no single failure/*outage* shall cause simultaneous *outage* of two or more *generating units* connected to the switchboard. All switchboards shall be designed with one-and-half breakers configuration, unless the Generation Licensees submit with justifications the use of a different switchboard configuration for the *Power System Operator's* consideration.

6.11.2 All *generating units* shall be designed such that:

- (a) the *generating unit* is based on relevant *IEC, BS* or other equivalent standards and all other requirements for operation in the *power system*. *Connection* of a *generating unit* onto the *transmission system* shall not cause any unacceptable consequences that jeopardize *power system* stability, *security* and *reliability*. Under such a case, a *generating unit* may not be permitted to be *connected* to the *power system*. For the same reasons, those permitted to be *connected* to the *power system* may not be permitted to operate under certain *power system* conditions or as base load units;
- (b) the *generating station* has Black Start Capability unless exempted by *Power System Operator*;
- (c) the short circuit current contribution to the *connection point* shall be controlled to be strictly within the limits stipulated by the Transmission Licensee;
- (d) the *generating unit* is capable of sustained operation within the *frequency* range set forth in section Appendix F; and
- (e) the *generating unit* has a minimum *frequency* response capability as set out in Appendix F.
- (f) each *generation facility* that uses natural gas as the primary fuel shall be designed with the capability of initiating on-load changeover either automatically through gas pressure setting or manually to alternate fuel that is stockpiled on-site. The fuel changeover trigger setting shall have sufficient margin above that of the *generation facility's* low gas pressure trip setting to ensure that the *generation facility* remains connected to the power system and operates at or above its minimum stable loading level during the entire process of fuel changeover

operation. The *generation facility* shall continue to supply electricity to the power system after completion of the fuel changeover process.

6.12 Remote Monitoring and Automatic Generation Control

- 6.12.1 The Transmission Licensee and Generation Licensee shall provide the remote terminal unit(s) at their substations or switchhouses, which shall provide the *Power System Operator* with remote monitoring, control and data acquisition of the equipment in the substation or switchhouse as set out in Appendix H. Facilities for remote control are required only for substations. Information required includes status of *circuit breakers*, isolators, *earthing switches*, *protection systems*, ancillary equipment and other devices or equipment as specified by the *Power System Operator*. Measurements of power flow, *frequency*, voltages, transformer taps and other quantities as specified by the *Power System Operator* are also required.
- 6.12.2 The Generation Licensee shall provide the *remote terminal unit(s)* for remote monitoring of their *generating units'* output and operating conditions as well as facilities for automatic control of generating unit's output from *Power System Operator's Energy Management System* as specified in Appendix H.
- 6.12.3 The Transmission Licensee and Generation Licensee shall provide all the equipment at their respective site, including the communication equipment. The Transmission Licensee shall provide data communication lines from the control centers of the *Power System Operator* to the transmission substation and power station switchhouses as specified by the *Power System Operator* for the purposes of real-time power system monitoring and control. All the equipment at the site shall be equipped with battery backup of at least 4-hour operation time. In addition, the AC power shall also be backed up by the standby generator at the site, if the site is equipped with such a facility.
- 6.12.4 The Transmission Licensee or Generation Licensee seeking to conduct any work on their *remote terminal unit* must submit to the *Power System Operator* for approval a written proposal that clearly states the nature, purpose and duration of the work.
- 6.12.5 The Transmission Licensee or Generation Licensee shall submit to the *Power System Operator* a test report of the commissioning of the *remote terminal unit*.
- 6.12.6 The *Interruptible Load Provider* shall provide the *Power System Operator* with real-time status and measurements at its interruptible load facility. The information shall include the status of circuit breakers and contactors, status of *UFR* (“armed” or “unarmed”) and the status of any other devices as specified by the *Power System Operator*. Measurements of power and frequency for the incoming feeders from the grid and for the designated loads within the load facility, and measurements of any other quantities as specified by the *Power System Operator* shall also be provided.

6.13 Performance Monitoring Facilities for 230kV and 400kV Substations/Switchhouses

6.13.1 The Transmission Licensee and Generation Licensee shall provide, install and maintain at their own cost, the performance monitoring facilities/transient recorders at its 230kV and 400kV substations/switchhouses. The performance monitoring facilities shall be capable of monitoring and recording the dynamic performance of its equipment during system disturbances. The Transmission Licensee and Generation Licensee shall provide such information to the *Power System Operator* upon request. The recorder shall be capable of capturing, but not limited to the following :-

- (a) substation/switchhouse busbar voltage, current and *frequency*; and
- (b) *circuit breaker* and *protection devices* status.

6.14 Performance Monitoring Facilities for Interruptible Load Facilities

6.14.1 The *Interruptible Load Provider* shall provide the *Power System Operator* with records of status and measurements before and after activation of its interruptible load facility. The records shall include the status of circuit breakers and contactors, status of *UFR* (“armed” or “unarmed”) and the status of other devices as specified by the *Power System Operator*. Records of power and frequency for the incoming feeders from the grid and for the designated loads within the load facility, and measurements of any other quantities as specified by the *Power System Operator* shall also be provided.

7 PAYMENT SECURITY

7.1 Power to Require Security

7.1.1 Subject to section 7.1.4, the Transmission Licensee may mitigate the risk of non-payment by a consumer, Generation Licensee or Retail Electricity Licensee by requiring that such person provide reasonable *security* for the payment to it of all money which may become due in respect of *transmission services*, which may include:

- (a) cash deposits;
- (b) an irrevocable letter of credit;
- (c) bankers' guarantee or other financial guarantee in form and substance acceptable to the Transmission Licensee; or
- (d) any combination of the above.

7.1.2 Without limiting the generality of section 7.1.1, the Transmission Licensee may, at its discretion, accept *security* bond ratings or other form of credit from a Generation Licensee or a Retail Electricity Licensee in lieu of the types of *security* described in section 7.1.1. In exercising this discretion, the Transmission Licensee shall not discriminate among persons with comparable risk profiles.

7.1.3 If a consumer, Generation Licensee or Retail Electricity Licensee provides *security* in the form of a cash deposit, the Transmission Licensee shall not pay interest on the deposit.

7.1.4 The maximum amount of *security* that the Transmission Licensee may require from a consumer, a Generation Licensee or a Retail Electricity Licensee shall be determined based on the Transmission Licensee's estimate of the maximum financial exposure faced by it, determined in accordance with section 7.1.5.

7.1.5 Subject to section 7.1.6, the Transmission Licensee's maximum exposure in respect of a consumer, a Generation Licensee or a Retail Electricity Licensee shall be estimated by the Transmission Licensee as follows:

Step 1: Estimate the total bill for transmission service charges for the person for an average month based on historical information; any change in conditions that would result in different use of the *transmission system*; and the rates or tariffs currently in effect.

Step 2: Multiply the amount determined in Step 1 by 1.5 (or any other amount, as approved by the *Authority*).

Step 3: Add the amount that may become due to it in respect of the provision of all or any electrical plant or main by the Transmission Licensee.

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7.1.6 Where the Transmission Licensee engages a Market Support Services Licence as an agent to collect *transmission services* charges, the maximum exposure in respect of a contestable consumer or a Retail Electricity Licensee shall be in accordance with the provisions set out in section 13 of the Market Support Services Code.

7.1.7 In establishing the level of *security* to be provided by a person, the Transmission Licensee may differentiate between classes or subclasses of consumers, Generation Licensees or Retail Electricity Licensees to the extent those classes or subclasses have different credit risks.

7.2 Failure to Provide Security

7.2.1 Where a person fails to provide the *security* required to be given prior to commencement of receipt of *transmission services* (as determined in accordance with this section 7), the Transmission Licensee:

(a) may not *energise* the *connection applicant's service connection* to the *transmission system*; or

(b) may refuse to provide or procure the provision of all or any main or electrical plant (as the case may be); or

(c) may refuse to provide that Retail Electricity Licensee with retailer-consolidated billing services (as defined in the applicable code of practice) with transmission services, and may charge contestable consumers serviced by that Retail Electricity Licensee directly for *transmission services*.

7.2.2 Where a person already receiving *transmission services* fails to give the *security* required under this section 7, the Transmission Licensee may by notice require that person, within 10 *business days* after the service of the notice, to give it reasonable security for the payment of *transmission services*. The Transmission Licensee may *disconnect* the person's *service connection*, discontinue the supply of electricity to the *installation* of that consumer, or discontinue the provision or procurement of all or any electrical plant or main for that consumer for so long as the failure continues. In case of a *disconnection* of a *service connection*, or discontinuation of supply to an *installation*, the Transmission Licensee shall advise the Market Support Services Licensee of the date and reason for the *disconnection* or discontinuation accordingly.

7.3 Updating Security Estimates

7.3.1 The Transmission Licensee shall update periodically its estimate of its financial exposure to persons to whom it is supplying *transmission services* in accordance with section 7.1.4 based on current estimates of the amounts projected to be owed to it in respect of *transmission services*.

7.3.2 The Transmission Licensee may update its estimate of its financial exposure as frequently as it wishes but no less than:

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- (a) at least once every year for a consumer or a Generation Licensee; and
 - (b) at least once every three months for a Retail Electricity Licensee.
- 7.3.3 If, as a result of an updated estimate determined under sections 7.3.1 and 7.3.2, the maximum amount of *security* in respect of a person has fallen below the amount currently held in respect of that person by more than 10 percent, the Transmission Licensee shall so notify the person as soon as possible. The person may modify its *security* arrangement with the Transmission Licensee in light of and to reflect the decrease in the maximum amount of *security*. Where the *security* held in respect of such a person is in the form of a cash deposit, the Transmission Licensee shall, if so requested by the person, return the excess amount to the person within 20 *business days* of the date of receipt of the request.
- 7.3.4 If, as a result of an updated estimate determined under sections 7.3.1 and 7.3.2, the maximum amount of *security* in respect of a person increases above the amount currently held in respect of that person by more than 10 percent, and the Transmission Licensee wished to increase the *security* requirement accordingly:
- (a) the Transmission Licensee shall immediately notify the consumer or Retail Electricity Licensee and work with the applicable party to remedy the situation; and
 - (b) if after a period of 20 *business days* after the service of such notice, an amount remains owing from the relevant party and the parties have not otherwise agreed on a remedy, the Transmission Licensee may notify the consumer or Retail Electricity Licensee that it may discontinue the supply of electricity and subsequently *disconnect* the *service connection* in respect of that consumer or Retail Electricity Licensee for so long as the amount remains owing. The Transmission Licensee shall advise the Market Support Services Licensee of the date and the reason for *disconnection* or discontinuation accordingly.
- 7.3.5 The Transmission Licensee shall, in respect of a person who is no longer receiving *transmission services*, notify the person as soon as possible of the *security* held in respect of such a person. The person may elect to get a refund of its *security* arrangement with the Transmission Licensee, and the Transmission Licensee shall, if so requested by the person, return the outstanding *security* amount to the person within 20 *business days* of the date of receipt of the request.
- 7.3.6 Where a consumer has elected to discontinue receiving *transmission services*, the Transmission Licensee shall refund the outstanding security amount within 20 *business days* of the date of receipt of the requested discontinuance.

7.4 Default Process

- 7.4.1 In the event of a default in the payment owed by a contestable consumer or a Retail Electricity Licensee to the Transmission Licensee for *transmission services*, the Transmission Licensee shall not realise on any *security* held in respect of the

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contestable consumer or a Retail Electricity Licensee until 5 *business days* have elapsed from the date of notification given pursuant to section 7.4.2.

- 7.4.2 The Transmission Licensee shall, on the *business day* following a default in payment owed by a contestable consumer or a Retail Electricity Licensee for *transmission services*, notify the contestable consumer or a Retail Electricity Licensee that payment was not received and work to remedy the situation. If the amount owing remains unpaid 10 *business days* after the date of the giving of such notice and the parties have not agreed on a remedy, the Transmission Licensee may:
- (a) in the case of the contestable consumer, notify the consumer that it shall discontinue the supply of electricity and subsequently *disconnect* the *service connection* from the *transmission system*;
 - (b) in the case of a Retail Electricity Licensee, notify the Retail Electricity Licensee that it proposes to exercise one or more of the remedies available to it under the terms of a *Retailer Use of System Agreement* entered into pursuant to section 3.1.1.
- 7.4.3 The Transmission Licensee may charge interest on any overdue amounts at such rate as may be approved by the *Authority* from time to time.
- 7.4.4 The Transmission Licensee may charge the contestable consumer or a Retail Electricity Licensee person for the costs of *disconnection* and other direct costs associated with the discontinuance of *transmission services* to the person or the recovery of payments held to be in default.
- 7.4.5 The Transmission Licensee shall advise the Market Support Services Licensee of the *disconnection* date and reason for *disconnection*.

8 TRANSMISSION SYSTEM PLANNING AND DEVELOPMENT

8.1 Responsibility

- 8.1.1 The Transmission Licensee shall be responsible for the annual development of proposals for the augmentation and expansion of the *transmission system* in accordance with guidelines and criteria set forth in this section of the Transmission Code. The plan shall take into account forecasts of *demand* made by the *Authority*, proposals for additional generation capacity or withdrawal of capacity advised by the *Authority*, requests by *Power System Operator* and proposals by consumers for forecast additional *demand*.
- 8.1.2 The Transmission Licensee, in formulating, its Ten-Year Transmission Development Plan, shall ensure that the *network* design and any addition of *network* elements shall not jeopardise the *security, reliability, stability* and adequacy of the *power system*. The Transmission Licensee shall prepare and submit, each year, a Ten-Year Transmission Development Plan to the *Authority* for approval.
- 8.1.3 To facilitate Transmission Licensee's preparation of its Ten-Year Transmission Development Plan, the *Authority* shall, provide Transmission Licensee with the rolling ten-year electricity demand by the end of May (M month) of each year and the generation planting schedule¹ for the next 10 years by the end of (M+1) month.
- 8.1.4 The *Power System Operator* shall review and revise, if necessary, the minimum security standards as detailed in Appendix G, by the end of (M+1) month, taking into consideration requirements to shutdown *network* elements for maintenance and *network* modification.
- 8.1.5 The proposals for which the Transmission Licensee is responsible shall include:
- (a) a detailed plan for the 66kV network for the next 5 years and a detailed plan for 230kV/400kV networks for the next 10 years for *transmission networks* expansion, enhancement, upgrading, replacement and re-configuration;
 - (b) mode of *transmission network* operation such as *network* configuration and parallel operation of *network* blocks;
 - (c) provision of ancillary equipment and systems to ensure system stability and *security* and that contingency requirements can be met;
 - (d) cost details and phasing of each *transmission network* development project, and total capital expenditure and basis for *distribution network* development. The Transmission Licensee shall demonstrate that the *transmission system* development is cost effective and not excessive;

¹ Generation planting schedule shall include addition of new generating units and planned generating units retirement.

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- (e) justification for any addition or changes of *transmission network* development proposals from the previous year's submission. The Transmission Licensee shall also demonstrate that these changes are cost effective and not excessive;
- (f) the Transmission Licensee shall conduct a presentation and briefing session to the *Power System Operator* and the *Authority* outlining its preliminary Ten-Year Transmission Development Plan by the end of (M+4) months; and
- (g) a report on the Ten-Year Transmission Development Plan shall be submitted to the *Power System Operator* and *Authority* by the end of (M+6) months. The report shall include:
 - (i) load flow studies of the 66kV network for the next 5 years and 230kV/400kV networks for the next 10 years (in both hardcopy and softcopy, where appropriate) comprising assumptions and basis used in the studies; load flow data and studies results including contingencies analysis; 66kV 5-yr *transmission network* expansion plan diagram; 400kV/230kV 10-yr *transmission network* expansion plan diagram; list of legends for substation abbreviations, substation bus number, actual substation name; a Singapore map indicating location of existing/proposed 400kV, 230kV, 66kV substations; and single line diagram for each proposed or modified 400kV, 230kV, 66kV substations; and
 - (ii) fault level studies (in both hardcopy and softcopy, where appropriate) comprising assumptions and basis used in the studies; sequence data and fault level report on the 3-phase and 1-phase fault for each 400kV, 230kV and 66kV substation; and consideration of fault current infeed from *interconnectors*.

8.1.6 The Transmission Licensee shall not proceed to implement any development proposal until:

- (a) it has submitted the proposal to the *Power System Operator* and *Authority* for endorsement and approval respectively; and
- (b) it has received approval from the *Authority* to proceed with the proposed development or any modified proposed development that is approved by the *Authority*.

8.1.7 The *Power System Operator* shall assess the system *security* and stability, taking into consideration the proposed generation planting schedule and the Transmission Licensee's rolling Ten-Year Transmission Development Plan. The *Power System Operator* shall, if necessary, require the Transmission Licensee to revise the Ten-Year Transmission Development Plan within one month from receipt of the plan to ensure that system *security* and stability is maintained and *network reliability* meets the *security* standards. The *Power System Operator* shall provide the Transmission Licensee with all reasonable details of such requirement. The Transmission Licensee shall revise the plan accordingly and resubmit to *Power System Operator* within two

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weeks from receipt of *Power System Operator's* comments. The *Power System Operator* shall endorse the revised Ten-Year Transmission Development Plan within two weeks from receipt of Transmission Licensee's re-submission, if it is satisfied with the plan.

- 8.1.8 The Authority, in consultation with *Power System Operator*, shall review the Transmission Licensee's Ten-Year Transmission Development Plan (endorsed by *Power System Operator*), to ensure that the Ten-Year Transmission Development Plan is not excessive based on the security standards. The *Authority* shall, if necessary, require the Transmission Licensee to revise the Ten-Year Transmission Development Plan within 1 month from receipt of *Power System Operator's* endorsed Ten-Year Transmission Development Plan, and provide the Transmission Licensee with all reasonable details of such requirement. The Transmission Licensee shall revise the plan accordingly and resubmit to the Authority within two weeks from receipt of the Authority's comments. The Authority shall use its best endeavour to approve, as soon as possible, the Transmission Licensee's re-submitted Ten-Year Transmission Development Plan if it is satisfied with the plan.

8.2 Basis for Transmission and Distribution System Planning and Development

- 8.2.1 Notwithstanding section 8.1.1, the Transmission Licensee may engage in the development proposals, at its own instigation, for the reinforcement or extension of the existing *transmission system* for reasons which include, but are not limited to:-
- (a) an increase in supply requirements of an existing licensee or consumer or Generation Licensee that already is connected to the *transmission system*; and
 - (b) the introduction of a new *connection point* or modification of an existing *connection point* between the electrical system of a consumer or Generation Licensee and the *transmission system*.
- 8.2.2 In the transmission system development proposals, the Transmission Licensee shall, *inter alia*:
- (a) make a full assessment of the costs and benefits of the various possibilities to enhance/develop the *transmission system* and recommend the most cost effective development proposal; and
 - (b) report on the impact of Use of System charges of any such development on the various classes of consumers.
- 8.2.3 Nothing in the foregoing shall prevent the *Authority* giving the Transmission Licensee authority to proceed with defined types of expansion without requiring approval for each specific proposal.

8.3 General Objectives for Transmission System Planning and Design

8.3.1 The Transmission Licensee shall plan and design the *transmission system* such that:

- (a) the *transmission network* can meet the requirements set forth in Appendix G and the *demand* levels forecast by the *Authority* while operating within the *security* limits set by the *Power System Operator* without causing system instability, cascading, or interruption of load in the event of an *outage* (whether scheduled or unscheduled) of any single *generating unit*, transmission circuit or transmission transformer within a transmission substation; and
- (b) the 22kV and 6.6kV *distribution network* can cater for single contingent *outage* of circuits.

8.4 Equipment Design Standards

8.4.1 The Transmission Licensee shall base its *transmission system* and equipment design on the standards detailed in Appendix I or international standards, such as *IEC*, *BS* and *SS* or other equivalent international standards.

9 INSPECTIONS AND MAINTENANCE

9.1 Requirements

- 9.1.1 The Transmission Licensee shall inspect, test, monitor and maintain the *transmission system* and all related facilities and equipment owned by the Transmission Licensee in order to determine whether the *transmission system* and such facilities and equipment comply with all applicable standards and requirements set forth in this *Code*, in all *Connection Agreements*, in the *Operating Agreement*, and in the market rules.
- 9.1.2 The Transmission Licensee shall perform the inspection, testing, monitoring and maintenance activities referred to in section 9.1.1 using *competent persons* adequately trained to protect both themselves and the public.
- 9.1.3 The Transmission Licensee shall rectify any defects discovered during the inspection, testing or monitoring activities referred to in section 9.1.1 within a reasonable period of time after the discovery of the defect but, in any event, within the periods of time, if any, specified in the *Operating Agreement* or any *Connection Agreement*.
- 9.1.4 The Transmission Licensee shall implement an internal review procedure to ensure that any defects identified during the inspection, testing or monitoring activities referred to in section 9.1.1 and any necessary follow-up activities have been rectified in an appropriate manner.

9.2 Application to other Licensees

- 9.2.1 Such other Licensee who may own or operate *installations* which are deemed to be a part of the *power system* shall inspect, test, monitor and maintain such *installations*, all related facilities and equipment owned by the Licensee in order to determine whether the *installation* and such facilities and equipment comply with all applicable standards and requirements set forth in this *Code*, in all *Connection Agreements*, and in the market rules.
- 9.2.2 The Licensee shall perform the inspection, testing, monitoring and maintenance activities referred to in section 9.2.1 using *competent persons* adequately trained to protect both themselves and the public.
- 9.2.3 The Licensee shall rectify any defects discovered during the inspection, testing or monitoring activities referred to in section 9.2.1 within a reasonable period of time after the discovery of the defect but, in any event, within the periods of time, if any, specified in any *Connection Agreement*.
- 9.2.4 The Licensee shall implement an internal review procedure to ensure that any defects identified during the inspection, testing or monitoring activities referred to in section 9.2.1 and any necessary follow-up activities have been rectified in an appropriate manner.
- 9.2.5 The Generation Licensee shall ensure that it has sufficient inventory of critical spares for timely replacement of faulty parts of any *generation facility* so that the *generation*

facility can be returned to service in the shortest possible time. Without prejudice to the generality of the foregoing, the Generation Licensee shall in particular ensure that each *generation facility* which is a *combined-cycle plant* or gas turbine shall have one complete set of spare air filters within Singapore at all times.

9.3 Record Keeping

- 9.3.1 With the exception of recordings made by any SCADA systems or an *Energy Management System*, the Transmission Licensee and *connected person* referred to in section 9.2 shall maintain records setting out the results of all inspections, testing, monitoring and maintenance activities referred to in section 9.1.1 for six years from the date of the inspection, testing, monitoring or maintenance activity and shall make those records available to the *Authority* upon request.
- 9.3.2 Where the *Power System Operator* uses a *Energy Management System* in the operation of the *transmission network*, it shall maintain routine monitoring records produced by the *Energy Management System* for such a period as may be agreed between the Transmission Licensee and the *Power System Operator*, and in any case for a period of not less than six years.
- 9.3.3 Where the Transmission Licensee uses a SCADA system in the operation of the *distribution network*, it shall maintain routine monitoring records produced by the SCADA system for such a period as may be agreed between the Transmission Licensee and the *Power System Operator*, and in any case for a period of not less than six years.

10 SAFETY COORDINATION, ISOLATION AND EARTHING PROCEDURES

10.1 General Principles

- 10.1.1 Safety procedures shall be adopted in respect of any *service connection* or equipment directly *connected* to it so as to ensure the safety of personnel and/or plant at any time that work and/or testing is carried out at or near the *service connection* or equipment.
- 10.1.2 The Transmission Licensee shall, in accordance with the requirements set forth in this section, coordinate the activities of persons responsible for *transmission system* testing, monitoring and maintenance or for the testing, monitoring and maintenance of facilities or equipment *connected* to the *transmission system* to ensure that when testing and maintenance is to be carried out on such facilities or equipment, all necessary isolation and *earthing* is established and maintained.
- 10.1.3 The provisions of sections 10.2 to 10.6 inclusive shall apply to *connection points* in the *transmission system*.
- 10.1.4 Safety procedures to apply in the *distribution network* for work and/or testing to be carried out at or near the service connection or equipment directly *connected* to it shall be developed by the Transmission Licensee in consultation with consumers.

10.2 Scope

- 10.2.1 The Transmission Licensee (and/or *Power System Operator*, as the case may be) and *connected person* shall co-ordinate, establish and maintain the necessary isolation and *earthing* when work and/or testing is to be carried out on the transmission or distribution system, or *connected person's* electrical system. For the purposes of this section, the term "Party" shall refer to the Transmission Licensee or the relevant *connected person*.
- 10.2.2 This section does not define the safety rules to be adopted by the Transmission Licensee or the *connected person*, but sets out procedures which shall govern the interface between them. In particular, it lays down the rules for agreeing on the safety procedures (the *site safety procedures*), which shall be adopted on either side of a *connection point* between the Transmission Licensee and *connected person*.
- 10.2.3 Where one Party is required to approve the *site safety procedures* of another Party in terms of section 10.3, such approval does not imply that the approving Party takes any responsibility for the adequacy or otherwise of the *site safety procedures*. The approval in such case only implies that there is nothing in the *site safety procedures* that negates or frustrates any provision of the *site safety procedures* of the approving Party for the relevant *connection point*.

10.3 Approval Of Site Safety Procedures

- 10.3.1 Prior to the energising of a new *service connection*, the Transmission Licensee and the *connection applicant* shall each supply the other with a copy of the *site safety procedures* which it intends to adopt on its side of the *service connection* for approval by the other party.
- 10.3.2 The Party from whom approval is sought will, within 7 days of receipt of the *site safety procedures*, send written comments to the issuing Party giving:
- (a) its approval of the *site safety procedures*; or
 - (b) its reasons for refusing to give approval and the changes which it would wish to see to enable it to grant approval.
- 10.3.3 If the Party from whom approval is sought requires more stringent isolation and/or *earthing* provisions then, to the extent that these provisions are not unreasonable, the other Party shall make such changes to its *site safety procedures* as soon as is reasonably practicable.
- 10.3.4 If, subsequent to the approval of any *site safety procedure*, the issuing Party wishes to change any provision of the procedure, it shall prepare a version of the procedure showing the original text and clearly indicating the changes required to this text and shall seek approval of this procedure as if this procedure had not been previously approved. Subject to the provisions of the following paragraph, the revised procedure shall not be implemented until the necessary approvals have been received.
- 10.3.5 If an approved *site safety procedure* has been found to be unsound, revisions to this procedure (only to the extent that these are required to ensure the safety of personnel or plant) may be implemented immediately, subject only to the *safety coordinators* of the other Party or Parties having been informed of these changes and having confirmed that the changes do not increase the risk to their own personnel or plant and are understood.
- 10.3.6 Operational procedures for work on *transmission system* and equipment connected to the *transmission system* should not be less stringent than the requirements and rules as detailed in Transmission Licensee's "Rules for the Control and Safe Operation of High & Medium Voltage Apparatus", copies of which can be obtained from the Transmission Licensee.

10.4 Safety Coordinators

- 10.4.1 Prior to the energising of a *service connection* the *connected person* and Transmission Licensee will, in respect of the *service connection*, appoint an *authorised person* to act as *safety coordinator*, and a second *authorised person* to act as *safety coordinator* at any time that the first named *authorised person* is unavailable.

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- 10.4.2 The Transmission Licensee and the *connected person* shall inform each other, in writing and without delay, of the identity of the *authorised persons* appointed by them as *safety coordinators*. In the event of an intention to replace the *authorised person* appointed as *safety coordinator*, the other party to the *service connection* shall be notified of the identity of the new *safety coordinator* without delay.
- 10.4.3 The *safety coordinator* shall be responsible for co-ordination of all matters concerning safety (but not limited to the approval of *site safety procedures*). A *safety coordinator* may be responsible for more than one *service connection*.

10.5 Isolation And Earthing Principles

10.5.1 Without prejudice to the need to prepare and agree on *site safety procedures* for each *service connection*, the Transmission Licensee and each *connected person* shall adopt isolation and *earthing* principles no less stringent than those outlined below.

10.5.2 Isolation facilities shall be provided as follows:

- (a) where isolation is achieved by means of an *isolating device*, the isolating position shall be maintained in such a way as to minimise the risk of inadvertent, accidental or unauthorised operation and that when put in this position, a notice or “tag” to that effect shall be attached; and
- (b) clearance to work on any apparatus which requires such isolation to be achieved shall only be issued when the procedure in preceding section has been completed.

10.5.3 *Earthing* facilities shall be provided as follows:

- (a) where *earthing* is achieved by means of an *earthing device*, the *earthing* position shall be maintained in such a way as to minimise the risk of inadvertent, accidental or unauthorised operation and that when put in this position, a notice or “tag” to that effect shall be attached; and
- (b) clearance to work on any apparatus which requires this *earthing* to be achieved shall only be issued when the procedure in section 10.5.2 (a) has been completed.

10.5.4 Notwithstanding the above, any proposal relating to the addition, replacement or removal of transmission network equipment shall be forwarded by the party requesting the work to the *Power System Operator*, and no addition, replacement or removal of equipment shall be undertaken until the *Power System Operator* has approved such action in writing.

10.5.5 Notwithstanding the above, for any proposal for switching, taking out of equipment or putting in of equipment, the *safety coordinator* shall forward to the Transmission Licensee or *Power System Operator*, where applicable, their proposal for final clearance in writing before the switching can be carried out.

10.6 Supervision of Contract Work in Transmission Installations

- 10.6.1 For work in *energised* switchhouses and substations at voltages of 66kV and above, the Transmission Licensee and *connected person* shall ensure that contract personnel working in such *installations* are competent to work in such *installations*.
- 10.6.2 Owners of *installations* at voltages of 66kV and above shall ensure that their contractors' staff are properly supervised by a Supervisor who is either an experienced specialist from the manufacturer's works or a *competent person* who has had considerable and sufficient experience in carrying out such works in *installations* at voltages of 66kV and above. The contractors' supervisor shall be present whenever any work is carried out in an *energised installation*, at voltages of 66kV and above, by the contractor.

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APPENDIX A

This Appendix has been left intentionally blank.

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APPENDIX B DEMAND AND LOAD DATA REQUIREMENTS

B1 Demand Data Requirements for Planning Purposes

B1.1 Each person who has entered into a *Connection Agreement* or who wishes to enter into a *Connection Agreement*, other than a Generation Licensee, for *connection* of their *installation* to the *transmission system*, or each retail electricity licensee who has entered into a *Retailer Use of System Agreement* or who wishes to enter into a *Retailer Use of System Agreement*, shall provide to the Transmission Licensee the following information with respect to growth in *demand* by those *installations*:

- (a) anticipated increases in *demand*; and
- (b) a breakdown in the increases referred to in section B.1.1(a) by type of load.

B1.2 Each *connected person*, other than a Generation Licensee, shall provide to the Transmission Licensee the following information with respect to developments at that *installation* that are anticipated to increase *demand* by 5 MW or more:

- (a) Location of the development;
- (b) Anticipated maximum active and *reactive power demand* of the development;
- (c) Projected *demand* growth associated with the development over the life of the development;
- (d) Type of load;
- (e) Typical daily load pattern; and
- (f) Typical annual maximum *demand* pattern.

B2 Particular Load Information

B2.1 Each *connected person*, other than a Generation Licensee, whose load includes motors or fluctuating load or voltage sensitive load that, in the view of the Transmission Licensee, have the potential to have an adverse impact on the operation of the *power system* shall provide to the Transmission Licensee the following information:

- (a) The capacity, starting current and supply voltage of any large motors;
- (b) The capacity, anticipated load fluctuation and supply voltage of plant at such *installation*;

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- (c) The capacity and supply voltage of voltage sensitive plant or equipment causing harmonics and phase imbalance;
- (d) *Protective devices* proposed for the *installation*; and
- (e) Such additional detailed data with respect of their proposed *connection point* as the Transmission Licensee may require to facilitate the *connection*.

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APPENDIX C GENERATING UNIT REQUIREMENTS

C1 Preliminary Generating Unit Data to be Submitted for Consideration of Connection to the Transmission System

Each Generation Licensee responsible for the *generation facility* and seeking connection to the *transmission system* shall provide the information required in accordance with the format set forth in C.1.1 to C.1.3 of this Appendix.

C1.1 General

- (a) Names of *generation facilities*.
- (b) Total generation capacity (MW & MVA).
- (c) Brief description of the configuration of the *generation facilities* including types of *generation facilities* (steam, gas turbine or combined cycle) and number for each type.
- (d) Schedule date of commissioning for each *generation facility*.
- (e) Total power required for *auxiliaries*.
- (f) Internal load intended to be supplied by proposed *generation facility*, if any.

C1.2 For each *generation facility*

- (a) Name of *generation facility*.
- (b) Type of unit (steam, gas turbine or combined cycle).
- (c) Rated capacity in MW & MVA.
- (d) Maximum available output in MW.
- (e) Minimum stable load in MW.
- (f) Short circuit current contribution at the point of common coupling and basis of computation.
- (g) Power required for *auxiliaries*.

C1.3 *Generating unit* performance parameters

- (a) Name of *generation unit*.
- (b) Unit Number.
- (c) *Generating Unit*
 - Manufacturer _____
 - Rated terminal voltage _____ kV
 - Rated MVA Capacity _____ MVA

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- Rated power factor
 - Over-excited (lagging) _____
 - Under-excited (leading) _____
- Short-circuit ratio at rated voltage and current _____
- Direct axis short-circuit time constants
 - Transient (T_d') _____ seconds
 - Sub-Transient (T_d'') _____ seconds
- Direct axis open-circuit time constants
 - Transient (T_{do}') _____ seconds
 - Sub-Transient (T_{do}'') _____ seconds
- Quadrature axis open-circuit time constants
 - Transient (T_{qo}') _____ seconds
 - Sub-Transient (T_{qo}'') _____ seconds
- Direct axis synchronous reactance (X_d)
 - Unsaturated _____ %
- Direct axis transient reactance (X_d')
 - Unsaturated _____ %
 - Saturated _____ %
- Direct axis sub-transient reactance (X_d'')
 - Unsaturated _____ %
 - Saturated _____ %
- Quadrature axis unsaturated reactance
 - Synchronous (X_q) _____ %
 - Transient (X_q') _____ %
 - Sub-transient (X_q'') _____ %
- Potier reactance (X_p) _____ %
- Leakage reactance (X_l) _____ %
- Negative phase sequence reactance (X_2) _____ %
- Zero phase sequence reactance (X_0) _____ %

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- Armature winding short-circuit Time constant (T_a) _____ seconds
 - Main field current at no load and rated voltage _____ Amps
 - Main field current at full load, rated voltage and rated power factor overexcited _____ Amps
 - Resistance of main field windings at operating temperature of ____°C ____ Ohms
 - Machine damping factor (K_D) _____
 - “Turbine + *Generating Unit*” Inertia Constant (H) _____ MW * seconds / MVA
 - Saturation curves
 - To indicate the corresponding field current values at 1.0 pu and 1.2 pu of terminal voltage on the air-gap and open circuit curves.
 - V-curve
 - Reactive capability curve
 - Factory test reports and field test result, if any
- (d) *Generating unit* step-up transformer
- Rated MVA Capacity _____ MVA
 - Rated voltage
 - Primary _____ kV
 - Secondary _____ kV
 - Nominal voltage ratio, primary/secondary _____
 - Positive sequence impedance at
 - Maximum tap _____ %
 - Minimum tap _____ %
 - Nominal tap _____ %
 - Zero phase sequence impedance _____ %
 - Tap changer range + _____ %
- _____ %
 - Tap changer step size _____ %
 - Tap changer type on load / off load
 - Winding connection and Vector Group _____
 - Magnetising curve

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- Earthing resistor of transformer (if any)
 - At Primary side _____
 - At Secondary side _____
- (e) Excitation System
 - Voltage regulator model name: _____
 - Functional description and block diagram showing transfer function of individual element of the excitation system and the Automatic Voltage Regulator.
 - The setting and block diagram showing transfer function of individual element of the minimum and maximum excitation limiters.
 - The setting of limiters is to be plotted in the *Generating Unit Reactive Capability Curve*.
 - Exciter saturation data, if available (or applicable).
 - Commissioning tests or other field test results.
- (f) Power System Stabilizer (PSS)
 - Functional description and block diagram showing transfer function of individual element of the PSS
 - Report on methodology in deriving the PSS setting, including simulation results and tuning procedures
 - Commissioning tests or other field test results
- (g) Steam Turbine Units
 - Rated MW Capacity
 - Power fraction for High Pressure (HP), Intermediate Pressure (IP) and Low Pressure (LP) turbines.
 - Control design
 - Functional description and block diagram showing transfer function of individual element of the governor/turbine/boiler
 - Test data/report:
 - Control and intercept valve curves:
 - position vs. signal
 - valve opening vs. signal
 - Closing/opening speed tests

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- Load rejection tests
- Load step response tests
- *Frequency* response tests
- General boiler control strategy, including:
 - Whether constant or variable pressure
 - If constant pressure, boiler follow, turbine follow, or coordinated control
 - If coordinated control, *frequency* and pressure biases
 - If variable pressure, pressure and control valve position as a function of load level
- (h) Gas Turbine Units (Open Cycle and Closed Cycle)
 - Rated MW Capacity
 - Performance data and curves:
 - Power vs. Fuel Consumption
 - Exhaust Temperature vs. Fuel Consumption
 - Power vs. Ambient Temperature
 - Power vs. Speed
 - Inlet Guide Vane effects
 - Control design
 - Functional description and block diagram showing transfer function of individual element of gas turbines units (including effect of Ambient Temperature) in PSSE format
 - Test data/report:
 - Load rejection tests
 - *Frequency* response tests
- (i) Steam Turbine Units on Combined Cycle
 - Rated MW Capacity
 - Power fraction for High Pressure (HP), Intermediate Pressure (IP) and Low Pressure (LP) turbines.
 - Control Design
 - Functional description and block diagram showing transfer function of individual element of the steam turbine units

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- Control strategy following outages of one or more gas turbine units
- Steam unit power vs. exhaust temperature, air flow and power of gas turbine units
- Test data/report:
 - Load rejection tests
 - Change in steam turbine unit output for a sudden change in gas turbine unit output (including gas turbine unit outage)
- (j) *Generating Unit* Protection - Functional description and settings of *generating unit* protection including:
 - Loss of excitation relays
 - CT ratio
 - VT ratio
 - Setting
 - Under-frequency relay setting
 - Over-frequency relay setting
 - Other relay setting such as under-voltage protection for auxiliary equipment eg. Motor etc

All data to be provided shall be in per unit magnitude with MVA base specified. *Generating unit* and *generating unit's* step-up transformer data shall be provided in Rated MVA Capacity base.

- C1.4 The following references give examples of the required modelling detail and structure. Modelling information that includes block diagrams must use standard symbols for blocks such as integration blocks, summation blocks, and so forth, as used in these references. When necessary, written material explaining the functions of equipment controls shall also be provided.

Block Diagram Symbols for Dynamic Systems

1. “Conventions for Block Diagram Representation”, IEEE Transactions on Power Systems, Vol. PWRS-1, No. 3, August 1986, pp. 95-100.

Automatic Voltage Regulators and Power System Stabilizers

- (a) “IEEE Recommended Practice for Excitation Systems for Power Stability Studies”, IEEE Standard 421.5-1992.

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- (b) “Computer Models for Representation of Digital-Based Excitation Systems”, IEEE Transactions on Energy Conversion, Vol. 11, No. 3, September 1996.

Governor, Prime Mover, Energy Source

1. “Dynamic Models for Fossil Fueled Steam Units in Power System Studies”, IEEE Transactions on Power Systems, Vol. 6, No. 2, May 1991.
2. “Dynamic Models for Combined Cycle Plants in Power System Studies”, IEEE Transactions on Power Systems, Vol. 9, No. 3. August 1994.
3. “Simplified Mathematical Representation of Heavy-Duty Gas Turbines, “Journal of Engineering for Power, October 1983, Vol. 105.
4. “Simplified Mathematical Representation of Single Shaft Gas Turbines”, Turbomachinery International, July/August 1992.
5. “Boiler Models for System Dynamic Performance Studies”, IEEE Transactions on Power Systems, Vol. 6, No. 1, February 1991.

C2 Commissioning Test Schedule

Each Generation Licensee responsible for a *generation facility* to be *connected* to the *transmission system* shall provide the information required in accordance with sections C.2.1 to C.2.3 of this Appendix.

C2.1 Date *generating unit* is expected to synchronise to the transmission system.

C2.2 Date *generating unit* is expected to commence commercial operation.

C2.3 Commissioning Test Schedules: All test schedules to indicate date, time and unit’s output profile as well as low / medium / high risks of machine outage

- (a) Excitation Tests
- (b) Load Rejection Tests
- (c) Load Swing Tests
- (d) On Load Trip Tests
- (e) Combustion Tests
- (f) Performance Tests
- (g) Load Runback Tests
- (h) HP/LP Heater Tests

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- (i) Power System Stabiliser Tests
- (j) Vacuum Loss Runback Tests
- (k) Governor Valve Linearing Tests
- (l) Boiler Feed-pump Runback Tests
- (m) FDF Runback Tests
- (n) Cold/Warm/Hot Start Tests
- (o) Automatic Generation Control Tests
- (p) Spinning Reserves Capability Tests
- (q) Others

C3 Black Start Generating Unit Capability Data

Each Generation Licensee responsible for a facility *connected* to the *transmission system* shall provide the information required in this section.

- (a) Name & Location of Black Start *generating unit*:
- (b) Type of *generating unit*: Diesel/Gas
- (c) Unit Number
- (d) Manufacturer
- (e) Model
- (f) Rated Terminal Voltage: _____ kV
- (g) Rated MVA capacity: _____ MVA
- (h) Rated Power Factor
 - Over-excited (lead)
 - Under-excited (lag)
- (i) Time from Notification given to Synchronisation: _____ Hours
- (j) Start-up curve (from Synchronisation to Minimum Stable Load)
 - Time from minimum stable load to full load: _____ Hours
 - Maximum Ramp Rate: _____ MW/min
- (k) Capability Curve:
 - Reactive Power Capability Curve
 - Factory Test Reports and field test result, if any
- (l) Black Start capability test report shall include the following

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- Detailed Single Line Diagram of the Station/Unit Board, *Auxiliaries*, Emergency diesel *generating units* & Black-Start *generating units* connection
- Detailed Test Procedures, from Initial isolation from the Transmission System, start-up of Black-Start *Generating Unit(s)* till synchronisation to the Transmission System.
- Records of key timing, load (both real & reactive power) profile, voltage profile of black start *generating unit(s)* during run-up of *auxiliary* equipment, etc.

C4 Centrally Dispatched Generating Unit Minimum Capability Requirements

C4.1 All *generating units* of gross generating capacity exceeding 10MW or registered with the Energy Market Company as a *generation registered facility* shall be centrally dispatched. All centrally dispatchable *generating units*, shall be designed to have the following capabilities except where the Generation Licensees declare with technical justifications that certain capabilities are technically not possible and submit such request together with its supporting reasons for *PSO* consideration.

(a) Load Following Capability

All *generating units* shall be designed such that they can follow system load.

(b) Voltage and Reactive Control

Each *generation unit* should provide suitable *automatic voltage regulating* equipment compatible with the *network* for controlling the voltage specified in section 6.5.1 of this Code.

- the excitation system must be operated only in its constant terminal voltage mode of operation, with any constant *Reactive Power* output control mode or constant power factor output control always disabled, unless otherwise agreed with *PSO*;
- the response of the excitation system shall be fast and well damped. For open circuit step response of 5% step change in voltage reference, the *Generating unit* terminal voltage shall reach 90% of its final value within 1 second and have a maximum Settling Time of 5 seconds. Settling Time is defined as the time taken for the *generating unit* terminal voltage to settle and stay within an error band of $\pm 1\%$ of its increment value;
- settling time following any disturbance that causes an excitation limiter to operate shall be within 5 seconds;

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- droop compensation of up to $2/3$ of the *generating unit's* step-up transformer reactance should be provided;
- excitation limiters shall not interfere with the proper operation of the *generating unit*.

(c) Contingency Availability

The *generation facility* should be able to perform the following operations during contingencies:

- Coming on line.
- Adjusting generation output.
- Remaining in operation and connected to the *transmission system*.
- Coming off-line where *generating unit* would contribute to overloading facilities or over generation conditions.

(d) Two-Shifting Capability

All *generating units* shall be designed with two-shifting capability for normal daily operations.

(e) Governor Response and Spinning Reserve

The Generation Licensee's *generating unit* shall be designed to possess the following capabilities:

- all *generating units* shall be *frequency* sensitive;
- capable of responding automatically to normal variation in the system *frequency* of $\pm 0.5\text{Hz}$;
- releasing the spinning *reserve* in the manner required by the *PSO* under the Market Rules and tested as per the verification tests stipulated in the System Operation Manual; and
- the speed governor must meet the following minimum requirements:
 - the speed governor must be capable of being set so that it can operate with governor droops within the range of 3% to 5%.

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- the speed governor deadband shall be within the range of ± 0.05 Hz. However, the governor shall respond to full *frequency* deviation once system *frequency* deviation exceeds this deadband;
- where a *generating unit* becomes part of an electrical island i.e. is isolated from the rest of the system, but is still supplying loads in the island, the speed governor must be able to contribute its share to maintain *frequency* in the island, unless *PSO* considers, on a reasonable ground, that it is technically not feasible;

(f) *Contingency Reserve Capability*

For *generating unit* providing *contingency reserve*, it must be capable of meeting a minimum ramp rate in order to achieve 10% of its Rated MW Capacity within 10 minutes, and shall be subjected to verification tests stipulated in the System Operation Manual.

(g) *Protective Relay Systems*

The protective relay systems for the Generation Licensee's *generating facility* switchgear, transformers and related equipment should be adequate to prevent equipment damage for contingencies occurring both within the *generating station* and outside the *generating station* on the *transmission system*. The Generation Licensee shall be responsible for the operation & maintenance of each protective relay system within the *generating station*. Reference is given in Appendix F.

(h) *Performance Monitoring Facility*

The Generation Licensee shall provide, install and maintain at its own cost high-resolution recorder(s) for monitoring and assessment of performance including speed governor's *frequency* response of each *generating unit* by *Power System Operator*. The recorder shall be capable of capturing, but not limited to the following:

- the transient and dynamic response of each of the *generating unit* in terms of real and reactive power output (MW and MVar);
- the voltage (Volt) and *frequency* (Hz) at the *generating unit* terminal; and
- the system voltage (Volt) at the high tension side of the *generating unit's* step-up transformer.

The requirements of high-resolution recorder(s) are given in Appendix F. The Generation Licensee, upon receiving notification from *PSO*, shall furnish such records/data in softcopy via email in the format as specified in Appendix F9.2(g) within 24 hours.

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(i) Remote Monitoring and Automatic Generation Control

The Generation Licensee shall make provision at their facility for remote monitoring of the *generating units*' output and switchhouse equipment loading and operating conditions etc. as well as automatic control of generation output from *Power System Operator's EMS*.

(j) Power System Stabilizer (PSS)

For each *generating unit* with Rated MW Capacity at or above 60MW, a PSS shall be incorporated to provide additional damping of power oscillations. Proper operation of the PSS shall be confirmed by test. The preferred input signal for the PSS is accelerating power which can be synthesized from measured electrical power and speed. PSS transducers (i.e., for measuring input signals) shall be linear over their operational range and its time constant shall not exceed 100 milliseconds. *Power System Operator* shall make available the system characteristic to Generation Licensees for tuning of PSS. Generation Licensees shall submit a report incorporating the methodology in deriving the setting of the PSS parameters, as well as the tuning techniques, to *PSO* for review before implementation on site.

C5 Generating Unit does not meet all the Minimum Capability Requirements

Generating units which are centrally dispatchable having some but not all the required capabilities as stated in section C.4 (a) to (j) may not be permitted to be connected to the *transmission system* in order not to jeopardize system stability, *security* and *reliability*. For the same reasons, those permitted to be connected to the *transmission system* may not be permitted to operate under certain system conditions or as base load units.

C6 Additional Requirements for A Combined-Cycle Plant With Multi-shaft Configuration For Consideration As Multiple Independent Generation Facilities

C6.1 This Appendix states the additional requirements for a *Combined-Cycle Plant* with multi-shaft configuration seeking to register as multiple independent *generation facilities*. A *Combined-Cycle Plant* with multi-shaft (n+n+1) configuration comprises n gas turbines (GTs), n heat recovery steam generators (HRSGs) and one steam turbine (ST), may seek to register as multiple independent *generation facilities*, where each *Generation Facility* may comprise of either

- i. only one *Generating Unit*; or
- ii. more than one *Generating Unit*.

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- C6.2 The Generation Licensee shall at its own cost, engage an independent specialist consultant other than its *Owners Engineers* and Engineering, Procurement & Construction (EPC) contractors, to conduct detailed design review, witness site verification tests, and certify that the *Combined-Cycle Plant* is in compliance with Appendix C6.3.
- C6.3 The verification tests shall be conducted and meet the acceptance criteria stipulated in the System Operation Manual.
- C6.4 The independent specialist consultant shall ensure a detailed test plan is prepared based on its detailed knowledge of the *Combined-Cycle Plant* from the design review conducted. Where the Generation Licensee wishes to use a new technology or additional tests, it may request discussion with the *Power System Operator* in respect of revising the existing testing methods or procedures to demonstrate meeting the performance requirements stipulated in Appendix C 6.3.
- C6.5 The Generation Licensee is required to submit to *the Power System Operator* the design review report together with the proposed test plan at least six months before the site verification tests.
- C6.6 Generation Licensee is required to conduct additional tests identified by *the Power System Operator*, if any, to demonstrate compliance with the requirement stipulated in Appendix C6.3.
- C6.7 The Generation Licensee is required to submit to the *Power System Operator*, a final report duly certified by its independent specialist consultant and the Generation Licensee. The report shall state all site test results recorded, and conclude whether the *Combined-Cycle Plant* is in compliance with the requirements stipulated in Appendix C6.3. In addition, the report shall also include details of any improvements recommended by the independent specialist consultant in the course of its review for the *Combined-Cycle Plant* to comply with the requirements.
- C6.8 Upon receipt of the report, the *Power System Operator* shall use its reasonable endeavors to complete the review of the final report submitted within 20 business days. Upon the *Power System Operator's* acceptance of the submitted report, the Generation Licensee shall submit standing capability data of the *Combined-cycle Plant* to the *Power System Operator* for approval to operate as multiple independent *Generation Registered Facility*.
- C6.9 However, during normal operation, if the outage of any single element/functional system of the *Combined-Cycle Plant* causes any of the following:

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- i. tripping of more than one *generation facility*; or
- ii. loss in generation of more than the active output power of largest generation facility of the *Combined-Cycle Plant*;

The PSO may notify Energy Market Company of any change to the system risk attributable to one or more *generation facilities* of the *Combined-Cycle Plant*. On *PSO's* notification, Energy Market Company shall, in accordance with the Market Rules, determine risk and operating reserve requirement taking into account such change in system risk. The Generation Licensee shall identify the cause of tripping, take necessary remedial actions and re-test to verify its compliance to the requirements stipulated in Appendix C6.3. A detailed report shall be submitted to the *PSO*. Upon the *PSO's* acceptance of the submitted report, the *PSO* shall notify EMC of the revised system risk attributable to such *generation facilities*. Energy Market Company shall, in accordance with the Market Rules, determine risk and operating reserve requirements taking into account such change in system risk.

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APPENDIX D OPERATION INFORMATION ON EXTERNAL SYSTEM AND THE EXTERNAL GENERATION FACILITIES

D1 The following information and data relating to *external systems* and *external generation facilities* shall be updated and submitted by the *external party* to Transmission Licensee and *Power System Operator*, upon application for interconnection and subsequently by the end of February of each calendar year or upon any material change in the data previously submitted.

D1.1 *External system*

The information to be submitted shall cover the then current year and the following ten year period and shall include the following:

- (a) Actual and projected system *demand*
- (b) Daily and yearly typical *demand* profile
- (c) Generation installed capacities, types and locations
- (d) Criteria of system spinning *reserve* provision and spinning *reserve* allocation and composition in terms of type of *generating units*
- (e) Intended power transfer through the *interconnector*
- (f) Complete *network* diagram showing the connection of existing and future *generating unit* and active /reactive loads at substations
- (g) Complete *generating unit* models and parameters
- (h) Complete *network* data
- (i) An equivalent of the *external system* as seen from the *connection point* of the *interconnector*
- (j) A single-line diagram of the switchgear panels and *protection system* for the *interconnector* including settings at the *interconnector* substation in the *external system*

The data submitted shall be in both softcopy and hardcopy.

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D1.2 External Generation Facilities

The information to be submitted shall cover the then current year and the following ten year period and shall include the following:

- (a) Actual and projected active and reactive *demands* in local *network* including daily and yearly load profile, if applicable
- (b) Complete *network* diagram showing the connection of existing and future *generating units*
- (c) Complete *generating unit* models and parameters
- (d) Complete *network* data, if applicable
- (e) A single-line diagram of the switchgear panels and *protection system* for the *interconnector* including settings at the *interconnector* substation of the *external generation facility*.

D2 The following operation information shall be provided to the Power System Operator:

- (a) For *external system*, criteria for spinning *reserve* provision, allocation and composition in terms of type of *generating units* and response capability
- (b) After every incident of *generating unit outage* in the *power system* or in the *external systems / external generation facilities*, the following information shall be provided: -
 - Local system active and reactive *demand* before and after the incident
 - Generation unit commitment in the *external system* before and after the incident
 - *Active* and *reactive power* output curves for each *generating unit*
 - Protective relay settings on the *interconnector*
 - Settings of key system and plant control parameters such as setting of tie-line biased load *frequency* control
 - System *frequency* curve
 - Voltage profile and variation curves if it deviates from the nominal voltage range

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- Under-*frequency* relay settings and locations and amounts of load shed
- (c) The following operation information shall be provided to the *Power System Operator* and Transmission Licensee after every incident of *generating unit outage* or equipment *outage* /fault in the *external system* / *external generation facilities*:
- Location and type of equipment *outage* and cause of *outage*
 - If *outage* is due to equipment fault, the nature of the fault
 - *Active* and *reactive power* flow or fault current through the *interconnector* during the incident
 - Settings of protection system on the *interconnector*

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APPENDIX E TEST REQUIREMENTS FOR GENERATION FACILITIES, TRANSMISSION FACILITIES, CONSUMER INSTALLATIONS AND EXTERNAL SYSTEMS

E1 Obligations

E1.1 *Connected persons* and the Transmission Licensee shall conduct tests in respect of electrical plant connected or intended to be connected to the *high voltage* part of the *power system* in accordance with the requirements of this Appendix.

E2 New Electrical Plant

E2.1 All new electrical plant to be *connected* to the *power system* shall be fully tested at site, if applicable, in accordance with the *BS, IEC, SS* or international standards.

E2.2 The test circuit, methodology and procedures of any off-load pre-commissioning or on-load commissioning tests pertaining to electrical plant shall be in accordance with the Transmission Licensee's and/or *Power System Operator's* requirements, where applicable. Where the *connected person* or the Generation Licensee or the Transmission Licensee, as the case may be, wish to use a new technology, the proposing party may request discussion in respect of revising the existing testing methods or procedures to suit the latest proven development in technology.

E3 Existing Electrical Plant

E3.1 Any existing electrical plant which have been disconnected from the *power system* for repair, inspection, testing or any other reason shall be subject to the applicable off-load functional and proofing tests, and on-load re-commissioning tests where applicable.

E3.2 When requesting reconnection to the *power system*, the *connected person or* Transmission Licensee seeking reconnection shall provide to the *Power System Operator* and/or the Transmission Licensee, where applicable, reports of all tests conducted in accordance with *BS, IEC, SS* or international standards.

E4 Procedure on Submission of Proposal to Conduct a System Test

E4.1 Nature and Purpose

- (a) The person seeking to conduct a *system test* must submit to the *Power System Operator* and/or the Transmission Licensee, where applicable, a written proposal that clearly states the nature and purpose of the tests of the electrical plant that is the subject-matter of the proposal.

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E4.2 Identification and Situation of Electrical Plant Involved

- (a) The person submitting a proposal pursuant to section E.4.1 must include in the proposal a clear description and detailed single line diagram(s) sufficient to identify the electrical plant that is the subject-matter of the proposal and indicate the potential risks associated with the *system test*.
- (b) The *Power System Operator* and/or the Transmission Licensee, where applicable, shall assess the proposal submitted to it under this section E.4.1 and shall notify the person submitting the proposal within 14 *business days* as to whether it approves the *system test* and any conditions upon which such approval has been granted. If approval is not granted, the party that disapproves the *system tests* shall provide to the person submitting the proposal the reasons for such non-approval.

E5 Test Panel And Supervision

E5.1 Test Panel

- (a) In the situation where the party approving the *system test* determines that a proposed *system test* in respect of which approval has been granted under section E.4 may adversely affect the secure, stable and reliable operation of the *power system*, a test panel comprising the *Power System Operator*, the Transmission Licensee and the person submitting the proposal pursuant to section E.4 shall be convened to implement and supervise the proposed *system test*.
- (b) The person submitting the proposal pursuant to section E.4 shall be the coordinator of the test panel. The coordinator is responsible for coordinating the performance of the *system tests* and shall be responsible for ensuring that proper and accurate entries are made of the test results in the relevant test reports.
- (c) The test panel established pursuant to section E.5.1 (a) shall be responsible for ensuring that the *system test* is performed in a proper manner and in accordance with the specified methodology and procedures.

E5.2 Witnessing by the *Power System Operator* and/or the Transmission Licensee

- (a) Where the *Power System Operator* and/or the Transmission Licensee, where applicable, is satisfied that a proposed *system test* in respect of which approval has been granted under section E.4 shall not affect the secure, stable and reliable operation of the *power system*, the *Power System Operator* and/or the Transmission Licensee, where applicable, at its discretion, may or may not send a

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representative to witness and supervise the performance of the proposed tests by the person submitting the proposal pursuant to section E.4.

- (b) The person submitting the proposal pursuant to section E.4 and performing the *system test* shall ensure that only qualified and *competent persons* are permitted to perform the *system test*.
- (c) The person submitting the proposal pursuant to section E.4 and performing the *system test* shall be responsible for ensuring that proper and accurate entries are made of the test results in the relevant test reports.
- (d) The *Power System Operator* may notify the Transmission Licensee or Generation Licensees of the performance of system test where such system test, in the opinion of the *Power System Operator* may have an impact on the Transmission Licensee's or Generation Licensees' operation.
- (e) The Transmission Licensee, with inputs from the *Power System Operator*, where applicable, may notify third parties (excluding Generation Licensees) of the performance of the *system test* where such *system test*, in the opinion of the *Power System Operator* or the Transmission Licensee, may have an impact on third parties' operation.

E6 Submission of Report

- E6.1 The coordinator of the test panel established pursuant to section E.5.1 (b), if any, or the person submitting the proposal pursuant to section E.4 and performing the *system test*, as the case may be, shall be responsible for compiling and submitting the report setting forth the results of the *system test* to the *Power System Operator* and/or the Transmission Licensee, where applicable.
- E6.2 The report referred to in section E.6.1 shall include a description of the electrical plant being tested, a description of the *system test* performed, the results of the *system test* and any recommended actions stemming from the tests.

E7 Postponement or Cancellation of Proposal

- E7.1 Once a proposal has been submitted pursuant to section E.4, any change in the date or time scheduled for performance of the *system test* that is the subject-matter of the proposal shall require the approval of the *Power System Operator* and/or the Transmission Licensee, where applicable. A request to change the date or time scheduled for the performance of the *system test* shall be submitted to the *Power System Operator* and/or the Transmission Licensee, where applicable, no less than 24 hours prior to the original time scheduled for the performance test. The person

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requesting for any change in the date or time schedule shall specify the reasons for the change and shall indicate the new date and time at which the *system test* is proposed to be performed. The *Power System Operator* and/or the Transmission Licensee, where applicable, shall only grant its approval to a change in the date or time scheduled for performance of a *system test* where it is satisfied that unforeseeable problems or problems outside the control of the person submitting the proposal have arisen such as to warrant the change. Where the *Power System Operator* and/or the Transmission Licensee, where applicable, does not approve a change in the date or time scheduled for performance of a *system test*, the *system test* shall be cancelled and a new proposal must be submitted in respect of the *system test* in order for the *system test* to be performed.

- E7.2 Where the *Power System Operator* and/or the Transmission Licensee, where applicable, approves a change in the date or time scheduled for the performance of a *system test* under section E.7.1, it shall notify the Transmission Licensee and/or the *Power System Operator* accordingly of the proposed new date and time at which the *system test* is proposed to be performed.
- E7.3 The *Power System Operator* and/or the Transmission Licensee, where applicable, may stop, delay or cancel the performance of a *system test* at any time if it determines that performance of the *system test* may adversely affect the stability, *security* and *reliability* of the *power system*. The *Power System Operator* and/or the Transmission Licensee, where applicable, shall so notify the person responsible for performing the *system test* and shall work with him to determine a new date and time at which performance of the *system test* shall not adversely affect the stability, *security* and *reliability* of the *power system*.

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APPENDIX F SPECIFIC OPERATING AND TECHNICAL REQUIREMENTS FOR GENERATION, TRANSMISSION AND CONSUMER INSTALLATIONS

F1 General Conditions for Generation Facilities

F1.1 Generation Licensee shall notify the PSO and Transmission Licensee at least 3 months before initial *energisation* and start-up testing of a *generation facility*. The Transmission Licensee shall not *connect* a *generation facility* unless the Generation Licensee has notified the Transmission Licensee within the applicable time to permit this testing.

F1.2 Generation Licensee shall operate the *installation* with all of its protective devices in service at all times.

F1.3 Generation Licensee shall submit validated parameters and models which include:

- (a) *generating unit*;
- (b) excitation system including excitation limiters;
- (c) power system stabiliser;
- (d) governor / turbine / prime mover;
- (e) boiler controls.

The parameters and models shall be validated via site tests for their *generating units*. The method of testing shall be designed to cover the linear and non-linear responses of the *generating unit*. The parameters and models are considered validated when the computer simulation results match the site test results. Simulation and site test results shall be overlaid on the same plots using the same scales.

Upon completion of site tests, Generation Licensee shall, within 1 month, submit the report comprises validated parameters, models together with the computer simulation results, and site test results to *PSO*.

F1.4 The design and operation of an *installation* shall not cause adverse impact on the integrity of the *transmission system*.

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F2 Quality Assurance Conditions for Generation Facilities, Transmission Facilities and Consumer Installations

F2.1 Voltage Fluctuation

- (a) *Connected person* shall ensure that the operation of their *installations* shall not cause voltage fluctuation at a point of common coupling to exceed 3% of the nominal voltage for step changes.
- (b) The planning limits for voltage fluctuation caused by connected person, e.g. owner of an arc furnace, shall be in accordance with the requirements set out in Engineering Recommendation P28 of UK.

F2.2 Harmonics

- (a) The owner of an *installation* shall ensure that starting surges or harmonics generated by *connected persons*' and Transmission Licensee's equipment at the *installation* must not cause the maximum *total harmonic voltage distortion* at the point of common coupling to exceed the following:
 - (i) At 400kV, a *total harmonic voltage distortion* of 1.5 percent with no individual odd harmonic greater than 1.0 percent and no individual even harmonic greater than 0.5 percent;
 - (ii) At 230kV, a *total harmonic voltage distortion* of 1.5 percent with no individual odd harmonic greater than 1.0 percent and no individual even harmonic greater than 0.5 percent;
 - (iii) At 66kV, a *total harmonic voltage distortion* of 3.0 percent with no individual odd harmonic greater than 2.0 percent and no individual even harmonic greater than 1.0 percent; and
 - (iv) At 22kV and 6.6 kV, a *total harmonic voltage distortion* of 4.0 percent with no individual odd harmonic greater than 3.0 percent and no individual even harmonic greater than 2.0 percent.
 - (v) At 400V and 230V, a *total harmonic voltage distortion* of 5.0 percent with no individual odd harmonic greater than 4.0 percent and no individual even harmonic greater than 2.0 percent.

F2.3 Phase Imbalance

- (a) Planned *outages* or operation of an *installation* shall not cause the maximum negative phase sequence component of the phase voltage to exceed 1 percent.

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F3 Protection Systems

F3.1 The Transmission Licensee and *connected person* shall ensure that *protection systems* for its *installation* and the *service connection* applicable thereto shall meet the minimum requirements set forth in this section F3.

F3.2 All *transmission system protective devices* / schemes shall be suitable for the *installations* and the *service connection* being protected. In addition, busbar and breaker fail protection shall be provided for *installations* connected to the 400kV, 230kV of the transmission system and Transmission Licensee's 66kV source stations.

F3.3 The *protective device* for *unit protection* installed at the *installation* side of the *service connection* shall be the same make and model as the *protective device* installed on the Transmission Licensee's side of the *service connection*. For the *distribution network*, the *protective devices* for *unit protection* are subjected to approval by the Transmission Licensee.

F3.4 The Transmission Licensee and *connected person* shall ensure that the fault clearance times of the main *protective devices* on the *installation* and on the *service connection* from fault current inception to the *circuit breaker* arc extinction, shall not be more than the following:

- (a) 80 ms at 400kV;
- (b) 100 ms at 230kV; and
- (c) 140 ms at 66kV.

Where fault clearance requires the opening of the remote *circuit breaker* via inter-trip, the overall fault clearance time may be increased by up to 20 ms.

F3.5 In the event that the *circuit breaker*, forming part of the main *protective devices* referred to in section F3.4, fails to interrupt the fault current, breaker fail protection provided by the Transmission Licensee and *connected person* shall operate with a fault clearance time (from fault current inception to the *circuit breaker* arc extinction) not slower than 300ms.

F3.6 For a Generation Licensee, the back-up *protection systems*, i.e. overcurrent and earth fault, installed shall be capable of withstanding, without tripping, the loading incurred during the clearance of a fault in the *transmission system* by breaker fail protection or another back-up *protection system*.

F3.7 Loss of excitation protection is to be provided for each *generating unit*. Where deemed necessary by the PSO, pole-slipping protection should also be provided.

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- F3.8 The *connected person* shall ensure that their protective current transformers shall be of the applicable accuracy class necessary to meet the protective relay requirements.
- F3.9 All necessary communication equipment/links as may be required by the protective relaying scheme shall be installed. Where required by the Transmission Licensee, such equipment or links shall be compatible with the applicable communication equipment or links of the Transmission Licensee.
- F3.10 Depending on the length of *service connection*, the general requirements for transmission line protection which shall be satisfied by the *connected persons* or Transmission Licensee are as follows:
- (a) 400kV
 - Two current differential protection
 - One *distance protection*
 - (b) 230kV
 - One current differential or phase comparison protection
 - One *distance protection* or a second current differential with integrated *distance protection*
 - (c) 66kV
 - One or two current differential protection, depending on points of connection in the *network*
 - One IDMTL overcurrent/earth fault protection

F4 Communication Equipment at a Generation Facility

- F4.1 The Generation Licensee shall install, maintain and operate two independent voice communication links between the Generation Licensee's Power Plant control room and *Power System Operator's* Control Centre. These voice links shall be the "hot line" and UHF wireless communication, and shall be used for system operational purposes only. All necessary communication equipment/links as may be required by the protective relaying scheme shall be installed and maintained by the Generation Licensee. Where required, such equipment or links shall be compatible with the applicable communication equipment or links of the Transmission Licensee and/or the *Power System Operator*.

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F4.2 The Generation Licensee shall install, maintain and operate a facsimile machine used for operational purposes, with a dedicated telephone line and number, located in the Generation Licensee's *generation facility* control room. The Generation Licensee and the *Power System Operator* shall inform each other of the telephone number of the facsimile machine used for operational purposes.

F5 Communication Equipment at a Substation Other than a Generation Facility.

F5.1 For *transmission network* substations, should the *Power System Operator* consider it necessary, the Transmission Licensee or the *connected person*, as the case may be, shall install, maintain and operate a voice communication link between the substation and *Power System Operator's* Control Centre.

F6 Frequency Range of Generating Unit

F6.1 The *generating unit* shall be capable of sustained operation within the system *frequency* range which is normally controlled within the limits of 49.5Hz – 50.5Hz and, in exceptional circumstances, it could rise to 52Hz or fall to 47Hz.

F6.2 The *generating unit* shall operate within the frequencies range of 52 Hz to 47 Hz in accordance to the following:

<u>Frequency Range</u>	<u>Requirement</u>
• 52 Hz – 47.5 Hz	Continuous operation is required
• 47.5 Hz – 47 Hz	<i>Generating unit</i> is required to remain in operation for at least 20 seconds each time <i>frequency</i> falls below 47.5Hz

F7 Primary and Secondary Reserve Requirement

F7.1 This section states the minimum spinning *reserve* requirement in terms of primary and secondary *reserve* for each *generating unit* which has a Completion Date after 1 January 2000.

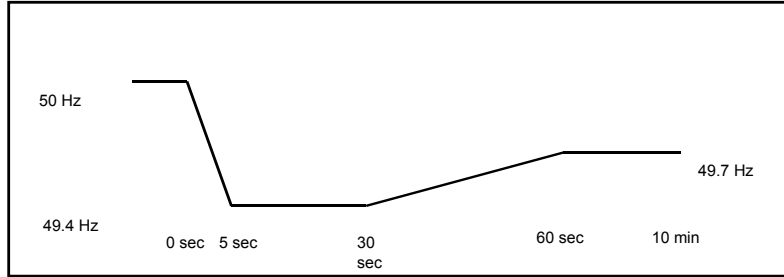
F7.2 For each *generating unit* which has a Completion Date before 1 January 2000 must endeavour to meet the minimum spinning *reserve* requirement subject to and in accordance with the provisions of section F.8, otherwise Generation Licensee shall submit the achievable spinning *reserve* capability to *PSO* for consideration.

F7.3 Nothing in this appendix is intended to prevent a *generating unit* from being designed to provide spinning *reserve* in excess of the minimum requirement specified below.

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F7.4 Frequency Response Profile

F.7.4.1 The ability of a *generating unit* to release primary and secondary *reserves* is measured by artificially subjecting the *generating unit* to a test whereby “measured” *frequency* is of the form as illustrated in the following figure:



F.7.4.2 *Primary Reserve* is defined as the change in MW output of the *generating unit* automatically by governor action in response to this change in *frequency*, measured at 8 seconds and sustainable for an additional 22 seconds. If the change in MW output measured at 8 seconds is not sustained for the period of 22 seconds, the *primary reserve* is the minimum change in MW output reached during that period.

F.7.4.3 *Secondary Reserve* is defined as the change in MW output of the *generating unit* automatically by governor action in response to this change in *frequency*, measured at 30 seconds and sustainable for an additional 9 minutes and 30 seconds. If the change in MW output measured at 30 seconds is not sustained for the period 9 minutes and 30 seconds, the *secondary reserve* is the minimum change in MW output reached during that period.

F.7.4.4 The primary and secondary *reserve* release capability shall be verified via test procedure stipulated in the System Operation Manual.

F8 Spinning Reserve Requirements of Frequency Sensitive Plant

F8.1 Each *generating unit* must be capable of providing minimum primary and secondary *reserves* as follows:

	<i>Generating unit</i> MW Output as a % of Rated MW capacity	Primary <i>reserve</i> as a % of Rated MW Capacity	Secondary <i>reserve</i> as a % of Rated MW Capacity
(i)	90	5	6
(ii)	75 to Minimum Stable Load	8	10

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- F8.2 The primary and secondary *reserve* requirements for each *generating unit* MW output between 75% and 90% of its rated MW Capacity shall be linearly extrapolated from the requirements for the *generating unit* MW outputs at 75% and 90% of its rated MW Capacity². Additional details are provided in the System Operation Manual.
- F8.3 Each *generating unit* must be capable of providing minimum contingency *reserve* of 10% of its Rated MW Capacity² within 10 minutes and shall be verified through test stipulated in the System Operation Manual.

F9 Requirements for High Resolution Recorder for Performance Monitoring and Assessment of the Generation Facilities and Interconnectors

- F9.1 The high resolution recorder installed shall be suitable for both dynamic and transient recording. The recorder shall be able to set at minimum sampling rate of 50Hz and 1kHz for dynamic and transient recording respectively. The basic signal to be recorded / monitored includes, but not limited to, the following:

For Generating Units

(a) Dynamic Recording

- *Active power* (MW)
- *Reactive power* (MVar)
- *Bus frequency* at connecting Substation
- Power system stabilizer output
- AGC pulses

Additional Signals for Steam Unit

- Load Limiter Position
- MW Demand Control Signal

Additional Signals for Gas Turbine Unit

- Ambient and Exhaust Temperatures

² For *Combined-Cycle Plant*, Rated MW capacity shall be based on aggregated declared Rated MW Capacity of each *generating unit*.

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- Fuel Demand Signals or Fuel Flow
- (b) Transient Recording
 - *Generating Unit* Terminal Voltage (LV –side)
 - *Generating Unit* Terminal Voltage (HV-side)
 - *Generating Unit* Field Voltage
 - *Generating Unit* field current

For Interconnectors

- *Active power* (MW) and *reactive power* (MVar) flow of each interconnector
- Substation busbar voltage and *frequency*
- *Circuit breaker* and protection devices status

F9.2 Specifications of Recorder

- (a) Sample Rate
 - Min 50Hz - 1kHz
- (b) Resolution
 - Analog Signals: 12 bits or 0.025% of full scale
 - *Frequency*: ± 5 mHz
- (c) Trigger Type
 - Maximum *frequency* / voltage
 - Minimum *frequency* / voltage
 - Rate of rising or falling of *frequency* / voltage
- (d) Pre-trigger Length
 - 30 second minimum for dynamic recording
 - 0.5 second minimum for transient recording

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- (e) Event Storage Capacity
 - 400 events minimum
- (f) Event length
 - Minimum 15 minutes for dynamic recording
 - Minimum 5 second for transient recording
- (g) Event Data Format
 - ASCII or
 - Spreadsheet
 - IEEE Comtrade
- (h) Time Stamping
 - A Global Position Satellite (GPS) clock shall be provided for time synchronisation and shall have a minimum resolution of 1 msec.
- (i) Software
 - The software of the recorder shall have at least the capability to compute R.M.S values for voltage, current, *active power*, *reactive power* and power factor.

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APPENDIX G SECURITY FOR THE TRANSMISSION SYSTEM

G1 Scope

G1.1 This appendix states the *security* requirements for the *transmission system* to cover the normal system operating conditions and three categories of contingencies as defined below:

- (a) System normal operating conditions where
 - (i) the voltage magnitudes at all *energised* busbars at any switchhouse or substation are within the equipment ratings;
 - (ii) the MVA flows on all *network* elements are within the equipment ratings
 - (iii) all *interconnector* are being operated within the equipment ratings;
 - (iv) the *frequency* at all *energised* busbars of the *transmission system* is within the normal operating *frequency* band; and
 - (v) all *network* elements are in service;
- (b) Single contingency conditions or more probable contingencies where a single *generating unit*, single transformer, single circuit or single reactor at the same substation or switchhouse is on forced or planned *outage*.
- (c) Less probable contingencies covering the following:
 - (i) loss of two *network* items of equipment in the system either simultaneously or consecutively;
 - (ii) loss of one busbar section of any transmission substation;
 - (iii) loss of largest *generating unit* and one transmission element either simultaneously or consecutively;
- (d) Extreme contingencies involving *outage* of either a generating station, an entire transmission substation/switchboard or a number of transmission circuits installed in the same trench/tunnel compartment/structure.

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G2 Planning Criteria

G2.1 The planning criteria of the *transmission system* shall be as follows:-

- (a) Under normal system operating conditions, all equipment shall operate within their normal thermal ratings;
- (b) Under single contingency conditions, all equipment shall, as far as possible, operate within their maximum continuous ratings and voltage limits immediately after the contingency. There should not be any power interruption, prolonged excessive overloading on the remaining *network*, inability in system voltage regulation, cascading of more than one network element or system instability;
- (c) Under less probable contingencies with normal fault clearing if applicable, the *power system* shall not suffer from voltage collapse, cascading of more than one *network* element, or system instability. Switching of *network* or adjustment of *generating units'* output may be necessary to relieve any *network* overloading. Load shedding may be activated to ensure system *security* and stability; and
- (d) Under extreme contingencies, the *power system* shall maintain steady state and dynamic stability. Means such as progressive automatic load shedding shall be provided to limit the impact of such severe disturbances.

G2.2 The 400kV and 230kV *network* shall be planned to cater for probable generation distribution in the system.

G2.3 Under normal system operating condition, i.e. all *service connections* to the *generation facility* are available, the *service connections* shall be adequate to export the *generation facility* total installed generation capacity. Under the system operating condition where one *generation facility's service connection* is not available (scheduled or unscheduled), the remaining *generation facility's service connection(s)* shall be able to export 90% of its total installed generation capacity. Adequate *generation facilities' service connections* shall be provided to ensure system *security*, stability and *reliability*. Prolonged *outage* of two *generation facilities' service connections* shall not result in system being unable to meet the *demand*.

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APPENDIX H EMS MONITORING AND TELEMETERY INTERFACE REQUIREMENTS

H1 General Requirements

H1.1 All generation and transmission facilities that are required to interface to the *Energy Management System (EMS)* of the *PSO* shall provide several or all of the following functions:

- (a) SCADA functions
- (b) Automatic Generation Control (AGC) functions

H2 Remote Terminal Equipment

H2.1 *Remote Terminal Units (RTU)* shall be provided as the field equipment to interface to the *EMS* system. The provision of this equipment shall meet the following requirements:

- (a) Each substation or switchhouse shall have a dedicated *RTU* with the condition that the *RTU* shall not have more than 2000 status points and not more than 200 measurement points. Should the number of status or measurement points exceed these limits then a second *RTU* shall be provided. Notwithstanding this if the retrieval of the entire database of the *RTU* by the *EMS* exceeds 30 seconds then a second *RTU* shall be provided.
- (b) An AGC station shall have a dedicated *RTU* with the condition that the *RTU* shall not be controlling more than 4 *generating units* or a total of more than 1000MW. Should the number of *generating units* or total generating capacity exceeded this, then a second *RTU* shall be provided.

H2.2 Each dedicated *RTU* (new or replacement of existing *RTU*)³ shall be equipped with a Global Position Satellite (GPS) equipment for time synchronization and shall have a minimum resolution of 1 msec.

H3 Communications Requirements

H3.1 Communications between the remote terminal equipment and the *EMS* shall be through 2-wire telephone line or pilot wire. The equipment shall communicate using V.34 analog lease-line modems or X.27 optical modems. The modems at the *EMS* will

³ With effect from 10/10/2007

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operate as originator while the remote terminal equipment modems will operate as answerer.

H3.2 The remote terminal equipment must be capable of communicating with the control centres (Power System Control Centre and the Backup Control Centre) of the *PSO*. To achieve this, the *RTU* must be dual-ported and has separate independently-routed communication routes to the control centres. The *RTU* shall transmit information to the *EMS* at both centres simultaneously on both channels. The *EMS* shall determine which channel's information to use. The *RTU* shall be capable of receiving information and commands from the *EMS* at either channel; the *EMS* shall determine which channel to use. As such both channels at the *RTU* shall be available at all times.

H3.3 It is the responsibility of the Transmission Licensee and Generation Licensee to provide all the equipment at the remote site including the communication equipment and the communication line up to the surge arrestor located at the *PSO* control centres.

H4 Monitoring and Telemetry Requirements

H4.1 Substation and Switchhouse

The status of the following equipment shall be provided:

- (a) All *circuit breakers*;
- (b) All isolators;
- (c) All earth switches;
- (d) Local/Remote status;
- (e) Protection devices, substation *auxiliaries* and equipment, equipment alarms; and
- (f) Other status, as required.

The following measurements shall be provided:

- (a) Phase (yellow phase) voltage of all station buses;
- (b) *Frequency* of all station buses (applicable only to switchhouses and substations with synchronisation facilities);
- (c) MW and MVar of all circuits;

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- (d) MW and MVar of high and low voltage sides of all transformers (with the exception of low voltage side of 66/22kV transformers);
- (e) MVar of all reactors;
- (f) Transformer taps (with the exception of 66/22 kV transformers); and
- (g) Other quantities, as required.

For substations, the following remote control facilities shall be provided:

- (a) Circuit Breakers;
- (b) Transformer taps raise or lower (with the exception of 66/22 kV transformers); and
- (c) Other equipment, as required.

H4.2 AGC Station

The status of the following equipment shall be provided:

- (a) *Generating unit circuit breakers;*
- (b) Local/Remote status;
- (c) Load limiter status; and
- (d) Emergency Shutdown Valve (ESDV) and the status of all valves on the Onshore Receiving Facility (ORF) and natural gas transmission pipeline supplying natural gas to the generation facility.
- (e) Pressure and gas flow at ORF and natural gas transmission pipeline supplying natural gas to the generation facility.
- (f) Other quantities, as required

The following measurements shall be provided:

- (a) MW and MVar of all *generating units;*
- (b) Unit terminal voltage of all *generating units;*
- (c) High/Low Limits of load limiter;
- (d) *Frequency at generating unit terminal;* and

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- (e) Other quantities, as required.

The following remote control facilities shall be provided:

- (a) *Generating unit* raise or lower control; and
- (b) Other equipment, as required;

H5 Data Representations

H5.1 Double Bit Status

The status of all components such as all *circuit breakers*, isolators and local/remote indications are 2-bit representations:

- (a) “00” or “11” represents undefined status while “01” represents “opened or local” and “10” represents “closed or remote”.
- (b) The 2-bits shall be derived from 2 actual relays and must not be calculated or derived from a 1-bit value.
- (c) A combined single value shall be provided for 3-phase equipment e.g. the indication for the CB shall be for all the 3 phases and not for a single phase.

H5.2 Single Bit Status

The statuses of all earthing switches (for new or replacement of existing RTUs)⁴ and alarms are 1-bit representation:

- (a) “0” represents “opened or normal” while “1” represents “closed or alarm”.

H5.3 Measurements

All measurements are represented by 16-bit values:

- (a) Range values are –32767 to +32767 or 0 to 65535.
- (b) For substations and switchhouses, power flowing out is positive. For *generating units*, power flowing out is considered positive.
- (c) MW and MVar values for *generating units* are gross values taken before the *generating unit* step up transformer.

⁴ With effect from 10/10/2007

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H6 Communication Protocol

The communication protocol between the remote terminal equipment and the *EMS* shall be the *IEC 870-5-101*. Specific requirements of the protocol are as follow:

- (a) All statuses are reported to the *EMS* spontaneously while measurements are periodically scanned.
- (b) The *RTU* shall be capable of communicating in both the balanced (default) and unbalanced mode.
- (c) The V.34 analog modems shall be capable of operating in the range from 1,200bps to 19,200bps (default is 19,200bps) and the X.27 optical modems capable of operating in the range from 1,200bps to 57,600bps (default is 57,600bps).
- (d) The link check between the *EMS* and the remote equipment is carried out every 10 seconds.
- (e) AGC raise and lower pulses use *IEC* type 48 and is a number ranging from -10 to +10. The relation between the pulse number and the MW value is dependent on the ramp rate and is determined during commissioning.
- (f) Transformer raise/lower uses *IEC* type 47.
- (g) All time stamping shall be carried out at the remote and not at the *EMS*. At the remote, the time stamping shall be carried out at the source where the event takes place.
- (h) Changes to the physical layer, link layer and common Address of ASDU parameters as defined in the *IEC 870-5-101* standards shall not require re-entry and/or retesting of the IOA of all the individual status points and measurement points.

H7 Performance Standards

H7.1 Availability Requirements

- (a) Monitoring and control functions at the *RTU* shall have a minimum availability of 99.9%.
- (b) Communication between the *EMS* and the *remote terminal unit(s)* shall meet the monitoring and control availability requirement in (a) above. In addition each of the redundant communication link shall have an availability of at least 95.0%.

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H7.2 Response Requirements

The following performance standards shall, on a continual basis, be achieved for all telemetry requirements:

- (a) Any change in the status in the field shall be reported spontaneously to the *EMS* within 1 seconds of the change.
- (b) All measurements shall be updated periodically. With the exception of AGC parameters, the updating cycle shall be 10 seconds. AGC parameters such as *generating unit* MW and MVar and busbar *frequency* shall be updated every 2 seconds.
- (c) AGC pulses from the *EMS* to the *generating units* are transmitted every 4 seconds.

H8 Information and Data Submittals

The following information and data is required:

- (a) Description of *RTU*, make, model etc.
- (b) Single line diagram. Information on the naming convention used shall be clearly described. The diagram shall show the equipment, protection and telemetry points.
- (c) All points and alarms, which are available for monitoring and control, shall be submitted to the *PSO* for review and approval. The list shall include grouped alarms and their component alarms.
- (d) Compliance table with the *IEC 870-5-101* Interoperability List (Appendix H10)
- (e) *IEC 870-5-101* Protocol Information Object Address Assignments (Appendix H11)
- (f) Equipment characteristics and parameters such as impedance, rating etc.
- (g) Accuracy figures for CT, PT and A/D converters.
- (h) Conversion factors from raw measurements to engineering values.

H9 Testing and Commissioning

The following requirements are needed for testing and commissioning:

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- (a) To facilitate AGC testing, a mechanism (software or hardware) is needed to isolate the AGC signals from the turbine control.
- (b) Copies of all commissioning tests are to be submitted.
- (c) The Transmission Licensee or Generation Licensee shall have qualified personnel on site during commissioning to confirm and verify all data sent to the *EMS*.
- (d) Copies of all final as-built drawings, parameters and data are to be submitted.

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H10 IEC 870-5-101 Interoperability List

Physical Layer	(Network Specific Parameters)	
	Network Configuration	Point-to-Point and Party-Line
	Transmission Speed (Control/Monitor Direction) V.24	(all speeds from 1200 to 19200 (default) bps) RS232
	Transmission Speed (Control/Monitor Direction) X.27	(all speeds from 1200 to 57600 (default) bps) RS485
Link Layer	(Network Specific Parameters)	
	Link Transmission Procedure	Balanced (default) and Unbalanced Transmission # of repeats = 0 - 255 / default = 2
	Address Field of the link	2 octets, Unstructured
	Frame Length	max 255 octets
Application Layer	(System Specific Parameters)	
	Transmission mode for application data	Mode 1 (Least Significant Octet first)
	Common Address of ASDU (Application Service Data Unit)	2 octets, Unstructured
	Information Object Address	3 octets, Structured. Least significant octet = bit no, 2-3 octet = telegram address
	Cause of Transmission - monitoring transmission	1 octet
	(1) Periodic, cyclic (only for cyclic measured values w/o time tag)	X
	(2) Background scan	
	(3) Spontaneous	X
	(4) Initialised	
	(5) Request or Requested	X
	(6) Activation	
	(7) Activation Confirmation	X
	(8) Deactivation	
	(9) Deactivation Confirmation	
	(10) Activation Termination	X
	(11) Return information caused by a remote command	X
	(12) Return information caused by a local command	
	(13) File Transfer	
	(20) Interrogated by general interrogation	X
	(21-36) Interrogated by Group 1 to 16	
Selection of Standard ASDUs	(Station Specific Parameters)	

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<i>Process Information in Monitor Direction</i>		
M_SP_NA_1 (1)	Single-point information	X
M_SP_TA_1 (2)	Single-point information with time tag	X
M_DP_NA_1 (3)	Double-point information	X
M_DP_TA_1 (4)	Double-point information with time tag	X
M_ST_NA_1 (5)	Step position information	X
M_ST_TA_1 (6)	Step position information with time tag	X
M_BO_NA_1 (7)	Bitstring of 32 bits	
M_BO_TA_1 (8)	Bitstring of 32 bits with time tag	
M_ME_NA_1 (9)	Measured value, normalized value	X
M_ME_TA_1 (10)	Measured value, normalized value with time tag	X
M_ME_NB_1 (11)	Measured value, scaled value	
M_ME_TB_1 (12)	Measured value, scaled value with time tag	
M_ME_NC_1 (13)	Measured value, short floating point value	
M_ME_TC_1 (14)	Measured value, short floating point value with time tag	
M_IT_NA_1 (15)	Integrated Totals	X
M_IT_TA_1 (16)	Integrated Totals with time tag	X
M_EP_TA_1 (17)	Event of protection equipment with time tag	
M_EP_TB_1 (18)	Packed start events of protection equipment with time tag	
M_EP_TC_1 (19)	Packed output circuit information of protection equipment with time tag	
M_PS_NA_1 (20)	Packed single-point information with status change detection	
M_ME_ND_1 (21)	Measured value, normalized value without quality descriptor	
<i>Process information in control direction</i>		
C_SC_NA_1 (45)	Single Command	X
C_DC_NA_1 (46)	Double Command	X
C_RC_NA_1 (47)	Regulating Step Command	X
C_SE_NA_1 (48)	Set point command, normalized value	X
C_SE_NB_1 (49)	Set point command, scaled value	
C_SE_NC_1 (50)	Set point command, short floating point value	
C_BO_NA_1 (51)	Bit-string of 32 bit	
<i>System information in monitor direction</i>		
M_EI_NA_1 (70)	End of initialisation	X
<i>System information in control direction</i>		
C_IC_NA_1 (100)	Interrogation command	X
C_CI_NA_1 (101)	Counter interrogation command	

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C_RD_NA_1 (102)	Read command	
C_CS_NA_1 (103)	Clock synchronization command	
C_TS_NB_1 (104)	Test command	
C_RP_NC_1 (105)	Reset process command	
C_CD_NA_1 (106)	Delay acquisition command	
<i>Parameter in control direction</i>		
P_ME_NA_1 (110)	Parameter of measured value, normalized value	
P_ME_NB_1 (111)	Parameter of measured value, scaled value	
P_ME_NC_1 (112)	Parameter of measured value, short floating point value	
P_AC_NA_1 (113)	Parameter activation	
<i>File transfer</i>		
F_FR_NA_1 (120)	File ready	
F_SR_NA_1 (121)	Section ready	
F_SC_NA_1 (122)	Call directory, select file, call file, call section	
F_LS_NA_1 (123)	Last section, last segment	
F_AF_NA_1 (124)	Ack file, ack section	
F_SG_NA_1 (125)	Segment	
F_DR_TA_1 (126)	Directory	
Basic Application Functions	(System or Station Specific Parameters)	
<i>Station initialisation</i>	(Station specific parameter)	
	Remote initialisation	
<i>General interrogation</i>	(System or Station Specific Parameters)	
<i>Clock synchronization</i>	(Station specific parameter)	
<i>Command Transmission</i>	(Object specific parameter)	
	Direct command transmission	X
	Direct set point command transmission	X
	Select and execute command	X
	Select and execute set point command	
	C_SE ACTTERM used	
	Qualifier for Command Transmission:	
	(0) no additional definition (individual command o/p pulses to be parameterised in the RTU)	X
	(1) Short pulse duration (Circuit-breaker) (duration determined by a system parameter in outstation)	X
	(2) Long pulse duration (duration determined by a system parameter in outstation)	X
	(3) Persistent output	

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<i>Transmission of integrated totals</i>	(Station or Object specific parameter)	
	Counter request	
	Counter freeze without reset	
	Counter freeze with reset	
	Counter reset	
	General request counter	
	Request counter group 1 to 4	
<i>Parameter loading</i>	(Object specific parameter)	
	Threshold value	
	Smoothing factor	
	Low limit for transmission of measured value	
	High limit for transmission of measured value	
<i>Parameter activation</i>	(Object specific parameter)	
	Act/ Deact of persistent cyclic or periodic transmission of the addressed object	
<i>File Transfer</i>	(Station specific parameter)	
	File transfer in monitor direction	
	File transfer in control direction	
Quality Descriptor:		
<i>For Single, Double point & Measured value information:</i>		
	BL: Blocked / Not Blocked	
	SB: Substituted / Not Substituted	
	NT: Not Topical / Topical (I.e. Not Renewed / Renewed)	X
	IV: Invalid / Valid	X
	OV: Overflow / No Overflow (only for Measured Value)	X

H11 IEC 870-5-101 Protocol Information Object Address Assignments

H11.1 The IEC 870-5-1 on the EMS System is implemented as follows:

- All Addresses are structured and comprised of 24-bits wide made up of 3 octets (lower, middle and upper).
- Addresses will be made of 2 parts. A 16-bit portion comprising of the lower and middle octet and the 8-bit higher octet.

H11.2 Format of the addresses is as follows:

0000000000000000/00000000	-	Binary
000000/000	-	Decimal

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The special Addresses “000000/000” and “65536/255” are not used.

- H11.3 The address for the IEC Protocol range from 10000/65535. The address range from 000001/000 to 9999/255 is reserved for the REDAC to IEC Mapping. The remainder of the address range is allocated to the different types of signals as follows:

Word	Octet
Sequential Running Number from 0 to 65536 in decimal. Type of Message, e.g. Analog, Status, Alarm, etc. Range 10,000 to 40,000 in decimal. See below for Assignment of Range for various types of messages.	Bay or Diameter Number of Switch-Gear Supervised by the Substation Control System. (Range 1 to 255 in decimal). Range 100-255 used for busbar and bus-section bays. Range 0 used for general substation equipment e.g. DC Board.

In general the lower and middle octet is arranged in the following format:

Address Range	Type
10,000 – 20,000	Indications / Alarms
20,000 – 30,000	Control
30,000 – 40,000	Measurements
65,000 – 65535	System Alarms

- H11.4 Detailed range assignments are as follows:

Type	Range	Default IEC Signal Types
<i>Circuit Breaker</i> Status (Monitor Direction)	10,000 to 10999	4
<i>Circuit Breaker</i> Status (Control Direction)	20,000 to 20999	46, Select + Execute
Isolating Switch Status (Monitor Direction)	11,000 to 11999	4
Isolating Switch Status (Control Direction)	21,000 to 21999	46, Select + Execute
Earth Switch Status (Monitor Direction)	12,000 to 12999	4
Earth Switch Status (Control Direction)	22,000 to 22999	46, Select + Execute
Local/Remote Status (Monitor Direction)	13,000 to 13999	4
Local/Remote Status (Control Direction)	23,000 to 23999	46, Select + Execute

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Type	Range	Default IEC Signal Types
Other Switches Status (Monitor Direction)	14,000 to 14999	2/4
Other Switches Status (Control Direction)	24,000 to 24999	45/46, Direct/Select + Execute
Transformer Tap Changer (Monitor Direction)	15,000 to 15999	6
Transformer Tap Changer (Control Direction)	25,000 to 25999	47, Select + Execute
AGC Commands/Setpoints	26,000 to 26999	48, Direct
Voltage Measurement	30,000 to 30999	9
Real Power Measurement	31,000 to 31999	9
<i>Reactive Power</i> Measurement	32,000 to 32999	9
Current Measurement	33,000 to 33999	9
<i>Frequency</i> Measurement	34,000 to 34999	9
General Analog Measurement	35,000 to 35999	9
Energy Measurement	36,000 to 36999	15
Protection Alarms with Tripping	16,000 to 16,999	2
Protection Alarms without Tripping	17,000 to 17,999	1
General Alarms	18,000 to 18,999	1
General Messages	19,000 to 19,999	1
Computer System/ <i>RTU</i> Alarm or Messages	65,000 to 65,535	1

H11.5 IOA Assignment Guide:

The Transmission Licensee or Generation License shall assign the *RTU* signals to the appropriate WORD ranges and submit a list of the typical IOA assignments and parameters for in-principle approval. All alarms, including those that are to be grouped shall be submitted for review and approval by the *PSO*. For information, the following guidance should be adopted in the IOA assignments:

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- (a) In general, similar type of *RTU* signals shall have the same WORD address. Only the OCTET address should differ according to the Bay or Diameter Number of Switch-Gear

E.g. *Circuit Breaker 1-152 SF6 1st Threshold Alarm - IOA 18001/1*
Circuit Breaker 9-152 SF6 1st Threshold Alarm - IOA 18001/9

- (b) The last 3 digits of the WORD address for switchgear status shall follow the device number of the switchgear.

E.g. *Circuit Breaker Status1052 - IOA 10000/10*
Isolator Status 10-289 - IOA 11002/10
Circuit Breaker Status10-352 - IOA 10003/10

- (c) Control Direction and Monitor Direction WORD addresses must differ by a value of exactly 10000.

E.g. *CB10-252 IOA Monitor Direction - 10002/10*
IOA Control Direction - 20002/10

- (d) The last 3 digits of the WORD address for measurements shall follow the device number of the measured switchgear isolator and busbar:

E.g. *Isolator 10-489 MW measurements - IOA - 31004/10*
BusBar 1 kV Measurements - IOA - 30001/10

- (e) Protection Alarms with Tripping signals includes signals which indicate a trip command has been sent to the *circuit breakers*.

E.g. *Circuit Breaker Fail Operated Alarm*
Master Trip Operated Alarm
CB Pole Discrepancy Operated
Transformer Bucholtz Operated
SF6 2nd Threshold Alarm (If alarm indicates a tripping signal)

- (f) Protection Alarms without Tripping signals includes signals associated with the non-functioning of the protection relays.

E.g. *Protection Relay Fail*
Trip Circuit Supervision Operated Alarm
Protection Relay Test-switch on

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- (g) General Alarms signals includes other alarm signals that are neither Protection Alarms with Tripping or without Tripping.

- E.g. SF6 1st Threshold
 - Oil Pressure Low

- (h) Computer System/RTU Alarm or Messages includes signals associated with the RTU or SCS.

- E.g. Channel Buffer Overflow
 - Digital Input Card faulty

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APPENDIX I TECHNICAL STANDARDS FOR FACILITIES

I1 Design Standards and Practices For Transmission Facility and Generation Facility

	400KV	230KV	66KV
I1.1 Switchgear			
1) Rated short circuit current	Min. 63 kA	Min. 63 kA	Min. 40 kA
2) Rated duration of short circuit	1 sec	1 sec	3 sec
I1.2 Transformers			
1) Transformation ratio	400/230kV	230/66kV	66/22kV
2) Transformer Vector Group	Yyond11	Yyond11	Yyond11
3) Neutral grounding	Solid grounding	Solid grounding at 230kV side and through 19.5 Ω Neutral resistor grounding at 66kV side.	Grounded through 6.5 Ω Neutral resistor grounding at 22kV side.
I1.3 Reactors			
1) Maximum Capacity	150 MVar	100 MVar	--
I1.4 Switchboard			
1) Switchboard configuration	One and half breakers for switchhouse and 400kV substation.	One and half breakers for switchhouse and 230kV portion of 400/230kV substation. Conventional double busbar for all others.	Conventional double busbar for switchhouse and substations.

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I2 List of Standards

The equipment shall be designed, manufactured and tested generally in accordance with the latest revision of the following standards except where specifically directed otherwise:-

I2.1 Switchgear :-

<u>Items</u>	<u>Standard</u>
Switchgear	IEC 60298 IEC 60694
Circuit Breakers	IEC 62271-100 BS 5311
AC Disconnectors (isolators)	IEC 62271-102 BS 5253
Busbars	BS 159
Current Transformers	IEC 60044 BS 7626 BS 3938 SS 318
Voltage Transformers	IEC 60186 IEC 60044 BS 7625 BS 3941
Instrument Transformers	IEC 60044-6
Insulators	IEC 60273 IEC 60660
Bushings	IEC 60137 BS 223
Relays	IEC 60255 BS 5992
Instruments	BS 89

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<u>Items</u>	<u>Standard</u>
Earthing	IEC 62271-102 CP 1013 SS CP16
Motors	BS 2613 BS 5000 Part II BS 3979
Control Gear	IEC 60694 IEC 60298 BS 5424 Part I
Wires and Wiring	IEC 60332 Part I BS 6231
Inductive Load Switching	IEC 61233
Surge Arresters	IEC 60099-4
Sulphur Hexafluoride (SF6)	IEC 60376 BS 5207 BS 5209
High Voltage Test Techniques	IEC 60517 BS 923
Test Procedure	ANSI/IEEE C37.09
Cable Connections	IEC 60859
Solid Dielectric Power Cables	IEC 60502
Enclosures	IEC 60517 IEC 60529 CENELEC EN50 052 CENELECEN50 064 CENELECEN50 068 CENELEC EN50 069
Sound Level Meters	IEC 60651

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I2.2 Transformers :-

<u>Items</u>	<u>Standard</u>
Transformers	IEC 60076 IEC 60722 IEC 60354 SS 404
Power Transformers	IEC 60076 BS 171
Transformer Oil	BS 148 BS 5730
Tap Changers	BS 4571
High Voltage Test Technique	IEC 60060 BS 923
Precision Sound Level Meters	IEC 60651
Measurement of Transformer Sound Levels	IEC 60076-10
Earthing	SS CP16
Motor	BS 2613
High voltage bushings	BS 223
Current transformers	BS 7626 BS 3938 SS 318
Neutral Ground Resistor	IEEE 32

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12.3 Cables :-

<u>Items</u>	<u>Standard</u>
Nominal cross-sectional areas and composition of conductors	IEC 60228
Extruded solid dielectric insulated power cables for rated voltage from 1kV to 30kV	IEC 60502
Common test methods for insulating and sheathing materials of electric cables	IEC 60811
Electrical test methods for electric cables	IEC 60885
Impulse tests on cables and their accessories	IEC 60230
Calculation of the continuous current rating of cables	IEC 60287
XLPE insulation power cables for rated voltages of up to 600/1,000V	SS 324
Tests on oil-filled and gas-pressure cables and their accessories	IEC 60141-1
Tests for power cables with extruded insulation	IEC 60840 IEC 60502
Enclosures (degree of protection)	IEC 60529
Cable Connections	IEC 60859
Pipe threads where pressure tight joints are made on threads	ISO 7-2
Specifications of impregnated-paper-insulated low and medium pressure self contained oiled-filled cable	AEIC No. CS4

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<u>Items</u>	<u>Standard</u>
Specifications of impregnated paper and laminated paper polypropylene insulated cable	AEIC No. CS2
Standard for copper busbar, rod and shapes	ASTM B187
Standard specification for soft or Annealed copper wire	ASTM B3

IEC stands for International Electrotechnical Commission Publication, BS stands for British Standard, CP stands for British Standard Code of Practice and SS CP stands for Singapore Standard Code of Practice.

If the specifications conflict in any way one or more of the above standards, the specifications shall have precedence and shall govern.

Where the number of the IEC or BS Standard is not specifically stated above, the IEC or BS Standard used shall be the one most appropriate to the class of equipment, material or work done specified by the Contractor.