

**EirGrid plc**  
**HVDC Interconnectors**  
**Proposed Modifications to the Grid Code**  
**23 April 2009**

It is proposed to amend the Grid Code by adding in the text in blue and by deleting the text in red strikethrough:

**PC PLANNING CODE**

**PC.3 SCOPE**

The **Planning Code** applies to the **TSO** and to the following **Users**:

- (a) **Generators** and **Generator Aggregators** with **Registered Capacity** greater than 10 MW;
- (b) all **Generators** connected to the **Transmission System**;
- (c) **Distribution System Operator**;
- (d) **Transmission Asset Owner**; ~~and~~
- (e) **Demand Customers** including both **Dispatchable Demand Customers** and **Demand Side Units**; ~~and~~
- (f) **HVDC Interconnectors**.

The above categories of **User** will become bound by the **Planning Code** prior to generating, distributing or consuming electricity, as the case may be, and references to the various categories (or to the general category) of **User** should, therefore, be taken as referring to a prospective **User** in that role as well as to **Users** actually connected.

**PC.A4.14 HVDC Interconnector Characteristics and Registered Data**

Minimum requirements for **HVDC Interconnector** operating conditions are specified in the **Connection Conditions**.

For an **HVDC Interconnector** fill in the following:

**Registered Capacity** for import to the Transmission System (MW) \_\_\_\_\_

**Registered Capacity** for export from the Transmission System (MW)

\_\_\_\_\_

## **CC CONNECTION CONDITIONS**

### **CC.3 SCOPE**

The **Connection Conditions** apply to the **TSO** and to the following **Users**:

- (a) **Generators** with **Registered Capacity** greater than 2MW;
- (b) The **Distribution System Operator**;
- (c) **Demand Customers**; ~~and~~
- (d) **Dispatchable Demand Customers**; and
- (e) The **HVDC Interconnectors**.

in relation to their connection to the **Transmission System**.

### **CC.5 PLANT DESIGNATIONS**

**CC.5.3** The **TSO's** standard practice currently requires that, unless otherwise agreed with the **TSO**, the following standard designations apply:

- (a) **Generation Units**  
**and HVDC Interconnectors:** for hydro and wind: G1, G2 etc.  
for thermal: U1, U2 etc.  
for HVDC: I1, I2 etc.
- (b) **Generator transformers** at 400 kV; T4001, T4002 etc.  
(i.e. transformers for at 220 kV; T2001, T2002 etc.  
**Generation Unit** production) at 110 kV; T101, T102 etc.  
**and HVDC Interconnector transformers**

### **CC.7.2.5 Grid Connected Transformers**

**CC.7.2.5.5** A **HVDC Interconnector Transformer** shall be designed such that the **Reactive Power** capability is possible over the full range of **Transmission System Voltages** (specified in CC.7.5.1.1 (d)). The **TSO** and an **HVDC Interconnector** owner will liaise on matters related to the **HVDC Interconnector Transformer** at the design stage.

**CC.7.2.5.6** **HVDC Interconnector Transformer** windings shall be connected in star

(with the star point or neutral brought out) on the higher **Voltage** side and in delta on the lower **Voltage** side or as agreed with the TSO.

## **CC.7.5 HVDC Interconnector**

CC.7.5.1 The conditions specified in this section of the code apply to all **HVDC Interconnectors** connected to or connecting to the **Transmission System**.

CC.7.5.1.1 Each **HVDC Interconnector**, shall, as a minimum, have the following capabilities:

- (a) operated and remain connected to the **Transmission System** at **Transmission System Frequencies** within the range 47.5Hz to 52.0Hz ;
- (b) remain synchronised to the **Transmission System** at **Transmission System Frequencies** within the range 47.0Hz to 47.5Hz for a duration of 30 seconds required each time the Frequency is below 47.5Hz;
- (c) remain synchronised to the **Transmission System** at normal rated output at **Transmission System Voltages** within the ranges specified in CC.8.3.2 for step changes in **Transmission System Voltage** of up to 10%;
- (d) sustained operation in accordance with the **Reactive Power** capability referred to in OC4.8 at **Transmission System Voltages** within the ranges specified in CC.8.3.2, unless otherwise specified;
- (e) remain synchronised during and following **Voltage** dips at the **HV** terminals of the **HVDC Interconnector Transformer** of 95% of nominal **Voltage** (5% retained) for duration 0.2 seconds and **Voltage** dips of 50% of nominal **Voltage** (i.e. 50% retained) for duration of 0.6 seconds. Following the fault clearance the **HVDC Interconnector** should return to pre-fault conditions;
- (f) all **HVDC Interconnectors** should be able to operate within all normal operating characteristics at a minimum short circuit level at the **Connection Point** of 1000 MVA;
- (g) remain synchronised to the **Transmission System** during a negative phase sequence load unbalance in accordance with IEC 60034-1;
- (h) have support triggers to allow the HVDC Interconnector to provide **System Services** as outlined in OC4.8;
- (i) in Emergency capable of reversing the power flow on the Interconnector from maximum capability in one direction, or part thereof, to maximum capability in the other direction within five seconds, up to ten times during the life of the plant and no more than twice times in any given twelve

months;

- (j) **HVDC Interconnector Minimum Load** not greater than the lesser of 3% of **Registered Capacity** or 50 MW;
- (k) **HVDC Interconnector Ramp-up Capability** not less than the greater of 5% of **Registered Capacity** per minute or 10 MW per minute, when the **HVDC Interconnector** is in the **Normal Dispatch Condition**;
- (l) **HVDC Interconnector Ramp-down Capability** not less than the greater of 5% of **Registered Capacity** per minute or 10 MW per minute, when the **HV DC Interconnector** is in the **Normal Dispatch Condition**;
- (m) **Forbidden Zones** within the lesser range of between + and - 3% of **Registered Capacity** or 30 MW in either flow direction;
- (n) **Block Load for an HVDC Interconnector** not greater than the lesser of 3% of **Registered Capacity** or 30 MW in either flow direction.

CC.7.5.1.2 **Users** shall install **HVDC Interconnector** controllers that comply with OC4.8. **Users** shall not change frequency or load related control settings of **HVDC Interconnector** controllers without agreement with the **TSO**.

CC.7.5.1.3 Where the **TSO** approaches an **HVDC Interconnector**, the **HVDC Interconnector** will co-operate with the **TSO** in the development of procedures and facilities to improve the response of each **HVDC Interconnector** during conditions of system stress. This shall be subject to the agreement of the **HVDC Interconnector** that the procedures are consistent with secure operation of the **HVDC Interconnector's Plant**, such agreement not to be unreasonably withheld.

CC.7.5.3 A **Grid Connection Point** shall be provided by **HVDC Interconnector** at circuit breakers identified by the **TSO** or as agreed with the **TSO**.

CC.7.5.4 The **HVDC Interconnector** will connect to the plant under the following conditions:

- (a) **Transmission System Frequency** within the limits 48.0 to 52.0 Hz;

- (b) **Transmission System Voltage** within the limits as specified in CC.8.3.2, notwithstanding CC.7.5.6;
- (c) **Transmission System** impedance at the point of connection.

CC.7.5.5 Each **HVDC Interconnector** must be fitted with a fast acting proportional speed governor and unit load controller or equivalent control device to provide **Frequency** response under normal operating conditions in accordance with OC4. The governor must be designed and operated to the appropriate

- (a) European Standards; or
- (b) In the absence of a relevant European Standards, such other standard which is in common use within the European Union

as at the time when the installation of which it forms a part was designed. Normal governor regulation shall be between 3% and 5% as specified by the TSO.

CC.7.5.6 All **HVDC Interconnectors** (excluding current source technology) shall be capable of contributing to control of **Transmission System Voltage** by continuous modulation of **HVDC Interconnector Voltage** by means of a suitable continuously acting **Automatic Voltage Regulation (AVR)** which shall comply with **BS4999 part 140**, or equivalent European Standards and the characteristics of which have been accepted by the **TSO** prior to the **Connection Date**, such acceptance not to be unreasonably withheld.

CC.7.5.7 The **HVDC Interconnector** station owner must ensure that the reversal of flow capabilities are provided for such that the average **Ramp Rate** from maximum registered export to minimum registered import or maximum registered import to maximum registered export of at least 10 MW per minute. For the avoidance of doubt this aggregate **Ramp Rate** will include any time needed to pass through deadbands or **Forbidden Zones** of operation.

CC.7.5.8 Damping Control Facilities for **HVDC Interconnectors**:

- (a) **HVDC Interconnector** owners must ensure that any of their **HVDC Interconnector** will not cause a sub-synchronous resonance problem on the **Transmission System**. Each **HVDC Interconnector** is required to be provided with sub-synchronous resonance damping control facilities.
- (b) Each **HVDC Interconnector** is required to be provided with power oscillation damping or any other identified additional control facilities.

**CC.10.13 HVDC Interconnector**

CC.10.13.1 **HVDC Interconnector** shall provide:

- (a) differential protection on the **HVDC Interconnector Transformer**. The connections between the **Grid Connection Point** circuit breaker and the **HV** terminals of the **HVDC Interconnector Transformer** shall be included in the protected zone of this differential protection.
- (b) backup protection (to the **Transmission System**) on **HVDC Interconnectors**. The **TSO** acting reasonably shall require one or more of the following to be installed: **HVDC Interconnector** overcurrent protection, voltage controlled **HVDC Interconnector** overcurrent protection or **HVDC Interconnector** distance protection;
- (c) under frequency protection; and
- (d) **HVDC Interconnector** loss of excitation protection.

CC.10.13.2 The **TSO** may require an individual **HVDC Interconnector**, to install additional protection and/or control schemes, where the **TSO** can reasonably show that it is prudent or necessary to do so. These schemes may include but are not limited to the following:

- (a) **HVDC Interconnector** over/under-voltage protection.
- (b) **HVDC Interconnector** over-frequency protection.
- (c) **HVDC Interconnector** transformer neutral displacement voltage detection.
- (d) loss-of-mains protection (rate of change of frequency or vector shift).
- (e) **HVDC Interconnector** pole slip protection.
- (f) **Power System** stabiliser.

CC.10.13.3 Distance protection shall be provided by the **TSO** on the **Grid Connection Point** circuit breaker of **HVDC Interconnector Transformers**.

**CC.12 SIGNALS TO BE PROVIDED BY USERS**

CC.12.2

(s), (t), (u)... are applicable to **HVDC Interconnector** owners:

- (s) +/-MW and +/-Mvar at alternator terminals of the **HVDC Interconnector** ;
- (t) kV at **HVDC Interconnector Transformer LV** terminals;

(u) **HVDC Interconnector Transformer** tap position;

**OC**                      **OPERATIONAL CONDITIONS**

**OC2**                      **OPERATIONAL PLANNING**

**OC2.3**                    **SCOPE**

Operational Planning applies to the **TSO** and to the following, each of which is a **User** under this OC2:

- (a)     **Generators** which for the purposes of OC2 includes all **Generators** with **Registered Capacity** greater than 5 MW or which are subject to **Central Dispatch**;
- (b)     **Generator Aggregators**;
- (c)     **Dispatchable Demand Customers**; ~~and~~
- (d)     The **Distribution System Operator (DSO)**; and
- (e)     **HVDC Interconnectors**.

**OC4**                      **SYSTEM SERVICES**

**OC4.2**                    **SCOPE**

OC4.2.1                OC4 applies to the **TSO** and to the following, each of which is a **User** under this OC4:

- (a)     **Grid Connected Generators** with **Registered Capacity** greater than 2MW;
- (b)     **Demand Customers**; ~~and~~
- (c)     The **Distribution System Operator (DSO)**; ~~and~~
- (e)     **HVDC Interconnectors**.

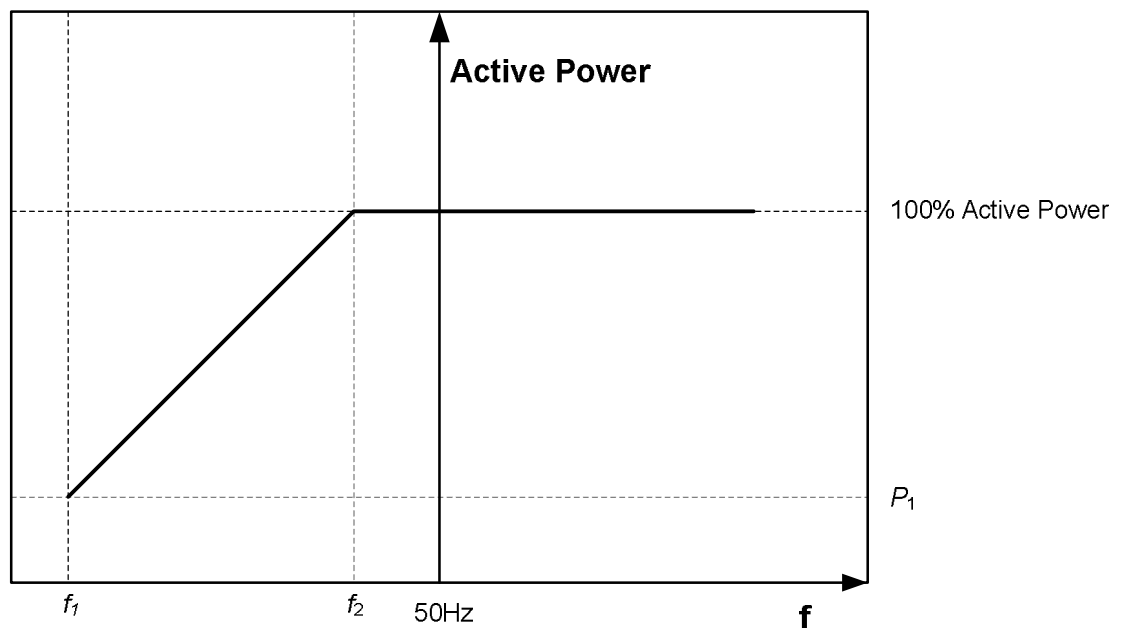
**OC4.8**                    **System Services for an HVDC Interconnector**

OC4.8.1                Introduction

OC4.8.1.1             An **HVDC Interconnector** joins two or more **Power System** to another **User System**. It is capable of providing system services to both systems. This clause sets out the minimum standards of **System Services** for an **HVDC Interconnectors**. It does not preclude **HVDC Interconnector** providing services beyond these requirements.

## OC4.8.2 HVDC Interconnector Frequency Control

OC4.8.2.1 An HVDC Interconnector must be capable of maintaining its Active Power input (i.e. when operating in a mode analogous to Generation) into the Transmission System at a level not lower than the amount determined by the linear relationship shown in the figure below for System Frequency changes within the range  $f_1$  to  $f_2$  Hz, such that if the System Frequency drops to  $f_1$  Hz the Active Power input decreases by no more than  $100 - P_1$  where  $P_1$  is the lower active power limit as a percentage of the active power output before the frequency change event.



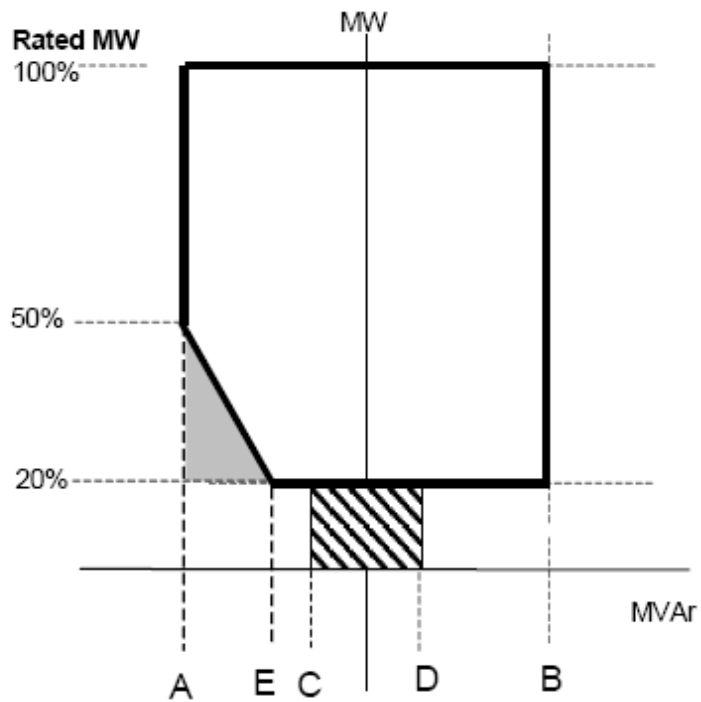
Settings for each of  $f_1$ ,  $f_2$  and  $P_1$  shall be specified by the TSO at least 60 Business Days prior to the HVDC Interconnector's scheduled Operational Date. The HVDC Interconnector shall be responsible for implementing the appropriate settings during Commissioning.

Alterations to these settings may be requested in real-time by the TSO and the implementation of the settings shall commence within 10 seconds of receipt of the signal from the TSO.

OC4.8.2.2 At the Grid Connection Point the Active Power output under steady state conditions of any HVDC Interconnector directly connected to the Transmission System should not be affected by voltage changes in the normal operating range specified by more than the change in Active Power

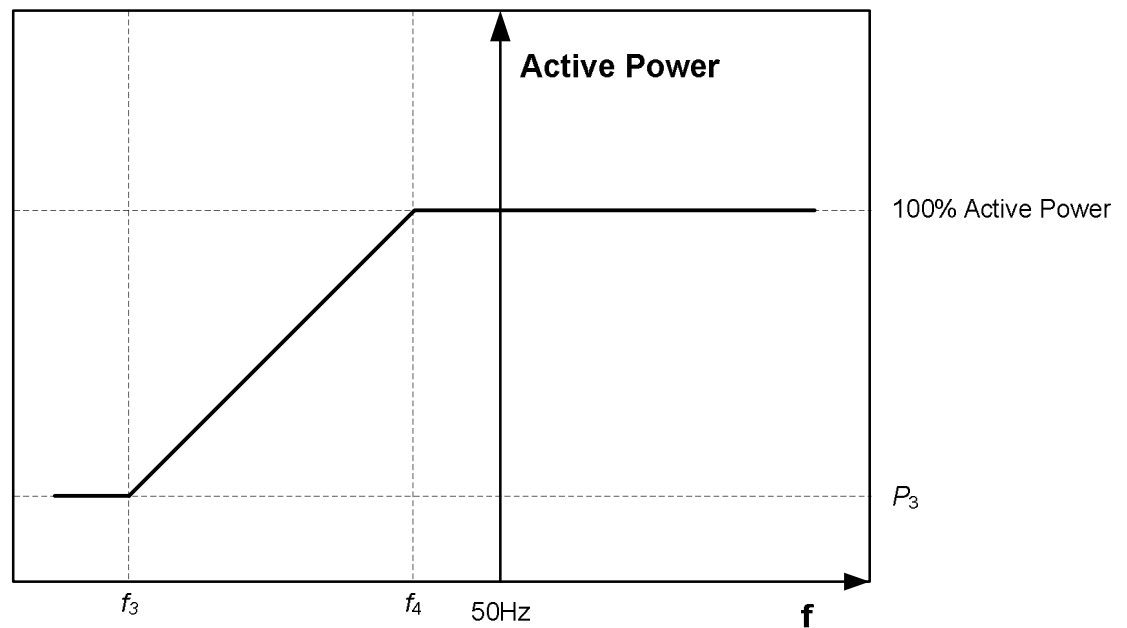
losses at reduced or increased voltage. The **Reactive Power** output under steady state conditions should be fully available at normal operating range.

- OC4.8.2.3 Each **HVDC Interconnector** must be capable of:
- a) contributing to Frequency control by continuous modulation of **Active Power** supplied to the **Transmission System**;
  - b) contributing to voltage control by continuous changes to the **Reactive Power** supplied to the **Transmission System**;
- OC4.8.2.4 The **Frequency Deadband** for all **HVDC Interconnectors** should be no greater than 0.03Hz (for the avoidance of doubt,  $\pm 0.015\text{Hz}$ );
- OC4.8.2.5 There is a requirement for a continuously-acting automatic control system to provide control of the voltage (or zero transfer of **Reactive Power** as applicable) at the **Grid Connection Point** without instability over the entire operating range of the **HVDC Interconnector**.
- OC4.8.2.6 **HVDC Interconnector** must be capable of maintaining zero transfer of **Reactive Power** at the **Grid Connection Point** at all **Active Power** output levels under steady state voltage conditions. The steady state tolerance on **Reactive Power** transfer to and from the **Transmission System** expressed in MVar shall be no greater than 5% of the Rated MW.
- OC4.8.2.7 An **HVDC Interconnector** (excluding current source technology) must be capable of supplying Rated MW output at any point between the limits 0.95 Power Factor lagging and 0.95 Power Factor leading at the Grid Entry Point.



- Point A is equivalent (in MVar) to: 0.95 leading **Power Factor** at **Rated MW** output
- Point B is equivalent (in MVar) to: 0.95 lagging **Power Factor** at **Rated MW** output
- Point C is equivalent (in MVar) to: -5% of **Rated MW** output
- Point D is equivalent (in MVar) to: +5% of **Rated MW** output
- Point E is equivalent (in MVar) to: -12% of **Rated MW** output

OC4.8.2.7 An **HVDC Interconnector** must be capable of maintaining its **Active Power** input (i.e. when operating in a mode analogous to **Demand**) from the **Transmission System** at a level not greater than the amount determined by the linear relationship shown in the figure below for **System Frequency** changes within the range  $f_3$  to  $f_4$  Hz, such that if the **System Frequency** drops to  $f_1$  Hz the **Active Power** input decreases by more than  $100 - P_3$  where  $P_3$  is the upper active power limit as a percentage of the active power output before the frequency change event.



Settings for each of  $f_3$ ,  $f_4$  and  $P_3$  shall be specified by the **TSO** at least 60 **Business Days** prior to the **HVDC Interconnector's** scheduled **Operational Date**. The **HVDC Interconnector** shall be responsible for implementing the appropriate settings during **Commissioning**.

Alterations to these settings may be requested in real-time by the **TSO** and the implementation of the settings shall commence within 10 seconds of receipt of the signal from the **TSO**.

**OC7 INFORMATION EXCHANGE**

**OC7.1.3 SCOPE**

OC7.1.3.1 OC7.1 applies to the **TSO** and to **Users**, which term in OC7.1 means:-

- (a) **Generators;**
- (b) **Dispatchable WFPSs;**
- (c) **Distribution System Operator;**
- (d) **Demand Customers; and**
- (e) **Dispatchable Demand Customers; and**
- (f) **HVDC Interconnectors.**

**OC7.2.3 SCOPE**

OC7.2.3.1 OC7.2 applies to the **TSO** and to **Users**, which term in OC7.2 means:

- (a) **Generators;**
- (b) **Dispatchable WFPS;**
- (c) **Distribution System Operator;**
- (d) **Demand Customers; and**
- (e) **Dispatchable Demand Customers; and**
- (f) **HVDC Interconnectors.**

**OC7.2.4.6 HVDC Interconnector**

OC7.2.4.6.1 The **HVDC Interconnector** contact locations and personnel referred to in this Section OC7.2.4.2 shall be notified by the **HVDC Interconnector** to the **TSO** prior to connection and thereafter updated as appropriate.

OC7.2.4.6.2 The **HVDC Interconnector** is required to provide a **Control Facility**. The **HVDC Interconnector** shall ensure acting in accordance with **Good Industry Practice** that the **Control Facility** is staffed at appropriate staffing levels at all times.

OC7.2.4.6.3 The **Control Facility** shall be staffed by a **Responsible Operator(s)** who shall respond to communications from the **TSO** without undue delay (except where otherwise provided for by agreement between the **HVDC Interconnector** and

the **TSO**, such agreement not to be unreasonably withheld) and are of suitable experience and training and are authorised to perform the following functions on behalf of the **HVDC Interconnector**:

- (a) to accept and execute **Dispatch Instructions**;
- (b) to receive and acknowledge receipt of requests, for amongst other matters, operation outside the **Declared** values of **Availability**, **Ancillary Service** capability, or **Operating Characteristics** of the **HVDC Interconnector** during **System Emergency Conditions**.

OC7.2.4.6.4 At any point in time, a single person shall be designated by the **HVDC Interconnector** and notified to the **TSO** as the **Responsible Manager**. The **Responsible Manager** shall be responsible for dealing with the **TSO** on matters relating to the **Grid Code** other than as provided for in OC7.2.4.2.2 and OC7.2.4.2.3. In the event that the **Responsible Manager** is not a person on duty at the **Control Facility**, then the **Responsible Manager** must be capable of being contacted from the **Control Facility** at all times, and in the event that the **TSO** issues a request to the **Control Facility** requiring the **Responsible Manager** to contact the **NCC**, the **Responsible Manager** shall comply with the request without undue delay and in any case within 15 minutes of the request.

OC7.2.4.6.5 The **Responsible Manager** shall be authorised by the **HVDC Interconnector** to perform the following functions on behalf of the **HVDC Interconnector**:

- (a) to make estimates in accordance with **Good Industry Practice** as to the available **Availability**, **Ancillary Service** capability and **Operating Characteristics** of the **HVDC Interconnector**;
- (b) to make **Declarations** for the **HVDC Interconnector**;
- (c) to communicate with respect to issues regarding **Outages** of each **HVDC Interconnector**.

The **HVDC Interconnector** may, from time to time, notify a replacement contact location and personnel which meets the foregoing requirements.

OC7.2.5.3.4 For **HVDC Interconnector**, **SCADA** remote terminal equipment shall also be required at the **Control Facility** for the transmission of signals and indications to and from the **NCC**. The signals and indications which must be provided by **HVDC Interconnector** for transmission by **SCADA** equipment to

the **NCC** are the signals and indications referred to under **Connection Conditions** together with such other information as the **TSO** may from time to time, by notice to **HVDC Interconnector**, reasonably require. Condition monitoring equipment should be installed on the **HVDC Interconnector** cable to allow for operation management of the **HVDC Interconnector** link;

## **OC8 OPERATIONAL TESTING**

### **OC8.3 SCOPE**

OC8 applies to the **TSO** and to all **Users**, which term in this OC8 means:

- (a) **Generators** which includes all **Generators** with units with **Registered Capacity** greater than 5 MW and **Generator Aggregators**;
- (b) **Dispatchable Demand**;
- (c) The **Distribution System Operator**; ~~and~~
- (d) **Demand Customers**; ~~and~~
- (e) **HVDC Interconnectors**.

## **OC9 EMERGENCY CONTROL AND POWER SYSTEM RESTORATION**

### **OC9.3 SCOPE**

OC9 applies to the **TSO** and to all **Users**, which term in this OC9 means:

- (a) **Generators** which for the purposes of OC9 includes all **Generators** with **Registered Capacity** greater than 5 MW;
- (b) The **Distribution System Operator**; ~~and~~
- (c) **Demand Customers** including **Dispatchable Demand Customers**; ~~and~~
- (d) **HVDC Interconnectors**.

**OC10 MONITORING, TESTING AND INVESTIGATION**

**OC10.3 SCOPE**

OC10 applies to the **TSO** and to the following **Users**

- (a) **Generators** which, for the purposes of OC10, include all **Generators** with **Generation Unit(s)** subject to **Central Dispatch** or with **Generation Unit(s)** that have a total **Registered Capacity** greater than 4 MW on a single **Site**;
- (b) The **Distribution System Operator**;
- (c) **Suppliers**;
- (d) **Demand Customers**;
- (e) **Dispatchable Demand Customers** in respect of their **Demand Side Units**; ~~and~~
- (f) **Generator Aggregators** in respect of the **Generation Units** which they represent; ~~and~~
- (g) **HVDC Interconnectors**.

**OC11 SAFETY CO-ORDINATION**

**OC11.3 SCOPE**

OC11 applies to the **TSO** and to the following **Users**:

- (a) **Generators**;
- (b) the **Distributor System Operator**;
- (c) **Demand Customers**;
- (d) **Dispatchable Demand Customers**;
- (e) the **TAO**; ~~and~~
- (f) agents of **the TSO** or agents of any **User** (as defined in OC 11.3 (a), (b), (c) and (d)); ~~and~~
- (g) **HVDC Interconnectors**.

Changes to Glossary:

<b>Block Load for an HVDC Interconnector</b>	The level of output, in either flow direction, that an <b>HVDC Interconnector</b> immediately produces following <b>Synchronisation</b> . For avoidance of doubt, <b>Block Load</b> can equal 0 MW and can be different in either flow direction.
<b>Forbidden Zones</b>	A <b>MW</b> range within which a <b>Generator or HVDC Interconnector</b> cannot operate in a stable manner due to an inherent technical limitation of the apparatus or plant.
<b>HVDC Interconnector</b>	<b>DC</b> electrical transmission system as a means for the bulk transmission of electrical power from one User system to another.
<b>HVDC Interconnector's Plant</b>	An <b>HVDC Interconnector</b> station subject to <b>Central Dispatch</b>
<b>HVDC Interconnector Transformer</b>	A transformer whose principal function is to provide the interconnection between the <b>HVDC Interconnector</b> and the Network and to transform the <b>HVDC Interconnector</b> voltage to the Network voltage.
<b>Grid Connection Point</b>	The point at which a <b>Generating Unit</b> or a <b>CCGT Installation</b> or a <b>CCGT Unit</b> or an <b>HVDC Interconnector</b> or a <b>Customer</b> or an <b>External System</b> , is directly connected to the <b>Transmission System</b> .
<b>HVDC Interconnector Ramp-down Capability</b>	The rate of decrease of an <b>HVDC Interconnector</b> . <b>Ramp-down Capabilities</b> apply over the output/ input range from its <b>Registered Capacity</b> to <b>Minimum Load</b> .
<b>HVDC Interconnector Ramp-up Capability</b>	The rate of increase of an <b>HVDC Interconnector</b> . <b>Ramp-up Capabilities</b> apply over the output/ input range from its <b>Minimum Load</b> to <b>Registered Capacity</b> .
<b>HVDC Interconnector Registered Capacity</b>	The maximum <b>Capacity</b> , in either flow direction, expressed in whole MW, that an <b>HVDC Interconnector</b> can deliver on a sustained basis, without accelerated loss of equipment life, at the <b>Connection Point</b> .