MODIFICATION PROPOSAL FORM

DYNAMIC MODELS

FORM GC1, PROPOSAL OF MODIFICATION TO GRID CODE.

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MODIFICATION PROPOSAL ORIGINATOR TELEPHONE NUMBER:	01-2370122	**DATE:**	20/08/13
MODIFICATION PROPOSAL ORIGINATOR E-MAIL ADDRESS:	david.cashman@eirgrid.com	**MODIFICATION PROPOSAL NUMBER (EIRGRID USE ONLY)**	**MPID239**
GRID CODE SECTION(S) AFFECTED BY PROPOSAL:	**Planning Code Appendix Introduction, PC.A4, PC.A5, PC.A6**		
GRID CODE VERSION :	**4.0**		

MODIFICATION PROPOSAL DESCRIPTION **(MUST CLEARLY STATE THE DESIRED AMENDMENT, ALL TEXT/FORMULA CHANGES TO THE GRID CODE. THE REQUIRED REASON FOR THE MODIFICATION MUST STATED. ATTACH ANY FURTHER INFORMATION IF NECESSARY.)**	Current data and dynamic model requirements for **Users** are not well defined for the different **User** technologies that are now connected to the Grid. The modification aims to specify clearly the data requirements for each **User** type including the introduction of a new section for data requirements for **Controllable WFPS**. In addition to this a new section outlining the dynamic model requirements for all **Users** is introduced in the modification. This section outlines the requirements for **Users** to supply dynamic **Models**, supporting documentation and the software formats of the **Models**. Accurate **Models** are fundamental to the planning and operation of the power system. As the system is operated with higher levels of non-synchronous generation this requirement becomes ever more important. There are several areas in the DS3 programme that are reliant on accurate modelling and studies. It is through modelling and studies that operational policies will be informed and updated. In addition to this on-line security assessment informs control centre operation in near real time and is dependent on accurate and credible **Models**. The overall aim of the modification is to standardise data and dynamic model requirements for all **Users**, irrespective of technology type, and also to bring the specifications for **Users** into line with the current requirements of the **TSO**.
IMPLICATION OF NOT IMPLEMENTING THE MODIFICATION	The current data and dynamic model requirements that currently exist will remain in place. These requirements are not balanced for all technology types currently connected to the Grid. Currently there are significant knowledge gaps in some **Models** provided to the **TSO**. Without the updated data and dynamic model requirements the **TSO** will be hindered in its ability to accurately assess the security of the system. This will directly impact the ability of the **TSO** to plan and operate the system efficiently and securely.
Please submit the Modification Proposal by fax, post or electronically, using the information supplied above	
EIRGRID REVIEWER	

EIRGRID ASSESSMENT	

PROPOSED GLOSSARY DEFINITION (NEW):

Model:

A software representation of a **User System** and/or **Plant** provided to the **TSO** for the purposes of **Power System** simulation.

PROPOSED CHANGE TO PCA

INTRODUCTION

This appendix specifies data to be submitted to the **TSO** by **Users** or prospective **Users** of the **Transmission System**. The requirement to provide data is governed by the Planning Code (PC4.2, PC4.3, PC4.4, PC5 and PC6).

The specific data requirements depend on whether the **User** is a **Customer** or a **Generator** or **Interconnector** or more than one combined. PC.A1 and PC.A2 apply to all **Users**. PC.A3 applies to demand **Users**. PC.A4 applies to **Generators**. PC.A5 applies ~~**to Interconnectors**~~ to **Controllable WFPS.** ~~and~~ PC.A6 applies to **Interconnectors.** PC.A7 applies to **Dispatchable Demand Customers**. PC.A8 refers to the dynamic **Model** requirements for **Users**.

Any material changes to the data specified in PC.A3,~~ or~~ PC.A4, PC.A5, PC.A6 or PC.A7 must be notified to the **TSO** as soon as practicable.

PC.A4: Generator Data Requirements

PC.A4.1 General Details

Each **Generator** shall submit to the **TSO** detailed information as required to plan, design, construct and operate the **Transmission System**.

Station Name	______
Number of Generating units	______
Primary Fuel Type / Prime Mover (e.g. gas, hydro etc.)	______
Secondary Fuel Type (e.g. oil)	______
Generation Export Connection Capacity Required (MW)	______

PC.A4.2 Treatment of Generator Data

* data item which must be provided by the applicant and which shall be treated as **Preliminary Project Data** as discussed in **PC 6.3.**

§ data item which, if not provided by the applicant as **Preliminary Project Data,** will be estimated by the **TSO** at the applicant's sole risk. The **TSO** puts the applicant on notice that this data estimate shall be treated as **Preliminary Project Data** as discussed in **PC 6.3**.

Once the **Connection Offer** has been formally accepted by the prospective **User** all data shall be provided by the **User** and treated as **Committed Project Planning Data** as discussed in **PC 6.4**.

Following the **Operational Date** or **Modification Date** as appropriate, all data requirements as listed in this appendix shall be submitted by the **User** to the **TSO** and shall be treated as **System Planning Data** as discussed in **PC 6.6**. This will include confirming any estimated values assumed for planning purposes and replacing them by validated actual values and by updated estimates for future **Forecast Data**.

PC.A4.3 Generator Operating Characteristics and Registered Data

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

* For thermal plant, provide a functional block diagram of the main plant components, showing boilers, alternators, any heat or steam supplies to other processes etc. indicate whether single shaft or separate shaft.

For each individual unit, on **Primary Fuel** and on **Secondary Fuel where applicable**, fill in the following:

Unit Number ____

Registered Capacity (MW) ____

Fuel ____

	Symbol	Units
* Normal Maximum Continuous Generation Capacity:		MW
* Normal Maximum Continuous Export Capacity		MW
Primary Fuel Switchover Output		MW
Secondary Fuel Switchover Output		MW
* Power Station auxiliary load		MW
§ Power Station auxiliary load		Mvar
* Maximum (Peaking) Generating Capacity		MW
* Maximum (Peaking) Export Capacity		MW
* Normal Minimum Continuous Generating Capacity		MW
* Normal Minimum Continuous Export Capacity		MW
* Generator Rating:	Mbase	MVA
* Normal Maximum Lagging Power Factor		Mvar
* Normal Maximum Leading Power Factor		Mvar
§ Governor Droop	R	
§ Forbidden zones		MW
§ Terminal Voltage adjustment range		kV
§ Short Circuit Ratio		
§ Rated Stator Current		Amps
* Number of available hours of running at Registered Capacity from on-site fuel storage stocked to its full capacity		

Description	
§ Capability Chart showing full range of operating capability of the generator including thermal and excitation limits.	Diagram
§ Open Circuit Magnetisation Curves	Graph
§ Short Circuit characteristic	Graph
§ Zero power factor curve	Graph
§ V curves	Diagram

	Symbol	Units
§ Time to synchronise from warm		Hour
§ Time to synchronise from cold		Hour
§ Minimum up-time		Hour
§ Minimum down-time		Hour
§ Normal loading rate		MW / min
§ Normal deloading rate		MW / min
§ Can the generator start on each fuel		
§ Ability to change fuels on-load		
§ Available modes (lean burn, etc.)		
§ Time to change modes on-load		
§ Control range for **AGC** operation		MW
Other relevant operating characteristics not otherwise provided....		

§ **Reserve Capability**

Primary Spinning Reserve

Secondary Spinning Reserve

Tertiary Reserve

Give details of reserve capability of the generator in different operating modes: Unit co-ordinating, turbine follow, recirculation, base load, etc.

What reserve, if any, is available when the unit is off load?

CCGT Installation Matrix

This matrix is a look up table determining which **CCGT Unit** will be operating at any given MW **Dispatch** level. This information will be applied for planning purposes and for scheduling, **Dispatch** and control purposes as covered in the **SDC**s unless by prior agreement with the **TSO.**

As an example of how the matrix might be filled out, consider a sample unit with a total capacity of 400 MW made up of two 150 MW combustion turbines and one 100 MW steam turbine. In this case, the following ranges might be specified

0 MW to 50 MW	GT1
50 MW to 170 MW	GT1 and ST
170 MW to 400 MW	GT1 and GT2 and ST

Please insert MW ranges and tick the boxes to indicate which units are synchronised to deliver each MW range at the following atmospheric conditions: Temperature 10°C, Pressure 1.01 bar and 70% Humidity.

CCGT INSTALLATION	**CCGT UNIT AVAILABLE**					
OUTPUT USABLE	1st GT	2nd GT	3rd GT	1st ST	2nd ST	3rd ST
	OUTPUT USABLE					
Unit MW Capacity →	*e.g. 150*	*150*	-	*100*	-	-
Total MW Output Range ↓						
[ ] MW to [ ] MW						
[ ] MW to [ ] MW						
[ ] MW to [ ] MW						
[ ] MW to [ ] MW						
[ ] MW to [ ] MW						
[ ] MW to [ ] MW						

PC.A4.4 Generator Parameters

	Symbol	Units
* direct axis Synchronous reactance	X_d	% on rating
* direct axis Transient reactance saturated	$X'_{d\ sat}$	% on rating
* direct axis Transient reactance unsaturated	$X'_{d\ unsat}$	% on rating
* Sub-transient reactance unsaturated	$X''_d = X''_q$	% on rating
§ quad axis Synchronous reactance	X_q	% on rating
§ quad axis Transient reactance unsaturated	$X'_{q\ unsat}$	% on rating
§ Negative Phase Sequence Synchronous reactance	X_2	% on rating
§ Zero phase sequence reactance	X_0	% on rating

* Turbine generator Inertia constant for entire rotating mass	H	MW s/MVA

§ Stator resistance	Ra	% on rating
§ Stator Leakage reactance	X_L	% on rating
§ Poiter reactance	X_P	% on rating

Generator Time Constants

	Symbol	Units
§ Direct axis open Circuit Transient	Tdo’	sec
§ Direct axis open Circuit sub-Transient	Tdo’’	sec
§ Quad axis open Circuit Transient	Tqo’	sec
§ Quad axis open Circuit sub-Transient	Tqo’’	sec
§ Direct axis short Circuit Transient	Td’	sec
§ Direct axis short Circuit sub-Transient	Td’’	sec
§ Quad axis short Circuit Transient	Tq’	sec
§ Quad axis short Circuit sub-Transient	Tq’’	sec

PC.A4.5 § **Mechanical Parameters:**

Provide, where appropriate and justified, mechanical parameters of the **Generator** that affect the dynamic performance of the **Generator**. This may include the stiffness of the shaft, a multi-mass model of the **Plant** components, torsional modes or mechanical damping.

PC.A4.65 § **Excitation System:**

Provide ~~Fill in the following~~ parameters ~~or~~ and supply a Laplace-domain control block diagram ~~in accordance with IEEE standard excitation models~~ (or as otherwise agreed with the **TSO**) completely specifying all time constants and gains to fully explain the transfer function from the compensator or generator terminal voltage and field current to generator field voltage. These parameters may include but are not limited to:

Description	Symbol	Units
Excitation system type (AC or DC)		Text
Excitation feeding arrangement (solid or shunt)		Text
Excitation system Filter time constant	Tr	sec
Excitation system Lead time constant	Tc	sec
Excitation system Lag time constant	Tb	sec
Excitation system Controller gain	Ka	
Excitation system controller lag time constant	Ta	sec
Excitation system Maximum controller output	Vmax	p.u.
Excitation system minimum controller output	Vmin	p.u.
Excitation system regulation factor	Kc	
Excitation system rate feedback gain	Kf	
Excitation system rate feedback time constant	Tf	sec

PC.A4.76 § **Speed Governor System:**

Supply a Laplace-domain control block diagram and associated parameters ~~in accordance with IEEE standard~~ of prime mover models for thermal and hydro units (or as otherwise agreed with the **TSO**) completely specifying all time constants and gains to fully explain the transfer function for the ~~governor~~ **Governor Control System** in relation to ~~frequency~~ **Frequency** deviations and setpoint operation.

PC.A4.87 § Control Devices (including Power System Stabilisers) and Protection Relays

Please Supply any additional Laplace domain control diagrams and associated parameters for any outstanding control devices including **Power System Stabiliser** or special protection relays in the generating unit, which automatically impinge on its operating characteristics within 30 seconds following a system disturbance and which have a minimum time constant of at least 0.02 seconds.

PC.A4.98 § Environmental Impact

CO_2	tonne CO_2 / tonne fuel
	Unit CO_2 removal efficiency
SO_2	tonne SO_2 / tonne fuel
	Unit SO_2 removal efficiency
NO_X	tonne NO_X / exported MWh curve

PC.A4.109 § Pumped Storage

Reservoir Capacity	MWh pumping
Max Pumping Capacity	MW
Min Pumping Capacity	MW
Efficiency (generating / pumping ratio)	%

PC.A4.10 § Wind Turbine Generators and Mains Excited Asynchronous Generators

State whether turbines are Fixed Speed or Variable Speed:

Please pProvide manufacturer details on electrical characteristics and operating performance with particular reference to Flicker and Harmonic performance.

Please pProvide details of the anticipated operating regime of generation, i.e. continuous, seasonal etc. List the anticipated maximum export level in MW for each calendar month, and indicate how generation would vary over a typical 24 hour period during the month of maximum export.

Give details of expected rapid or frequent variations in output, including magnitude, max rate of change expected, frequency and duration.

For **Mains Excited Asynchronous Generators**, please state:

	Units
How the generator is run up to synchronous speed	
Magnitude of inrush / starting current	Amps

~~Duration of inrush / starting current~~	~~ms~~
~~Starting / paralleling frequency~~	~~Hz~~
~~Power factor on starting~~	
~~Reactive power demand at zero output ('no load')~~	~~kvar~~

~~Give details of reactive power compensation to be installed~~

~~PC.A4.10.1 MODELLING REQUIREMENTS FOR WIND TURBINE GENERATORS~~

~~PC.A4.10.1.1 INTRODUCTION~~

~~The **TSO** requires suitable and accurate dynamic models for all **Generators** connected to, or applying for a connection to, the transmission system in order to assess reliably the impact of the **Generator's** proposed installation on the dynamic performance and security and stability of the **Power System**.~~

~~Modelling requirements for thermal and hydro **Generators** are processed on the identification by the applicant of the relevant PSS/E library model and the provision of the applicable data parameters in the current, appropriate application form. Where there are no suitable library models available, specially written models are supplied. These are known in PSS/E as "user-written models".~~

~~Currently (September 2004) there are no suitable PSS/E library models for **Wind Turbine Generators**. As a result, the **TSO** requires **Controllable WFPSs** greater than 5MW to provide specially written models and associated data parameters specific to the **Wind Turbine Generators** and any associated controls and reactive compensation equipment to be used in the applicant's **Controllable WFPS** scheme. The requirements of these models are as outlined in this section of the **Planning Code** Appendix.~~

~~PC.A4.10.1.2 WIND TURBINE GENERATOR DYNAMIC MODELS~~

~~PC.A4.10.1.2.1 Requirement to provide a dynamic model~~

~~Each **Controllable WFPS** shall provide a dynamic model, or shall provide an unambiguous reference to a dynamic model previously provided to the **TSO**, appropriate for the **Controllable WFPS.** If all the **Wind Turbine Generators** in the **Controllable WFPS** are not identical, the model shall incorporate separate modules to represent each type of **Wind Turbine Generator**. Appropriate data and~~

parameter values must be provided for each model. The model shall be provided in PSS/E format, or in such other format as may be agreed between the **Controllable WFPS** and the **TSO.**

The models for **Wind Turbine Generators** and the **Controllable WFPS** (computer software based on a mathematical representation of the behaviour of the machine) must be able to calculate how quantities such as **Active Power** output, **Reactive Power** output, turbine speed etc. vary as factors such as the **Voltage** at the **Connection Point** change. They must take account of the inherent characteristics of the machines and the actions of the **WTG** control systems and any relevant **Controllable WFPS** control systems.

The models provided shall be treated as **Preliminary Project Planning Data, Committed Project Planning Data** or **System Planning Data** as appropriate**,** as set out in **PC.6** of the **Planning Code.**

PC.A4.10.1.2.2 Computer environment

These models must run on the PSS/E software for the Irish network. They must not require a simulation time step of less than 5ms. Details of the current PSS/E version, computer platform, compiler version etc, will be provided by the **TSO** upon request. The **TSO** may from time to time request that the models be updated to be compatible with changes in the **TSO's** computing environment. Each **Controllable WFPS** shall ensure that such updated models are provided without undue delay.

PC.A4.10.1.2.3 Features to be represented in the dynamic model

The dynamic model must represent the features and phenomena likely to be relevant to angular and **Voltage** stability. These features include but may not be limited to:

a) the electrical characteristics of the **Generator**;
b) the separate mechanical characteristics of the turbine and the **Generator** and the drive train between them;
c) variation of power co-efficient with pitch angle and tip speed ratio;
d) blade pitch control;
e) converter controls;
f) reactive compensation;
g) protection relays.

PC.A4.10.1.2.4 Model aggregation

For computational reasons, it is essential that the models of individual **WTGs** can be aggregated into a smaller number of models, each representing a number of **WTGs** at the same site. A representation of the collector network may be included in the aggregate model of the **Controllable WFPS.**

PC.A4.10.1.2.5 Model documentation

The model should be fully documented. The documentation should describe in detail the model structure, inputs, outputs and how to set up and use the model and should be based on the documentation of standard PSS/E library models.

The **TSO** may, when necessary to ensure the proper running of its complete system representation or to facilitate its understanding of the results of a dynamic simulation, request additional information concerning the model, including the source code of one or more routines in the model. The **Controllable WFPS** shall comply with any such request without delay. Where the **Controllable WFPS** or any other party (acting reasonably) designates such information as confidential on the basis that it incorporates trade secrets, the **TSO** shall not disclose the information so designated to any third party.

PC.A4.10.1.2.6 Time to Comply

Where a **User** requires reasonable time to develop the necessary model or models so as to comply fully with all the provisions in this section **PCA 4.10.1.2**, the **User** may apply to the **TSO** to be deemed compliant with the provisions of **PCA 4.10.1.2** on the basis of **GC.10.1.3** of the **General Conditions** of the **Grid Code.** The **TSO** shall consider any such application in accordance with **GC.10.1.3,** and if the **TSO** is satisfied as to the **User's** programme for developing and testing the necessary dynamic model, the **TSO** may, for so long as the **TSO** is so satisfied, treat the **User** as being in compliance with the provisions of this section**.** If the **TSO** decides, acting reasonably, that it is not satisfied as to the **User's** programme for developing and testing the necessary dynamic model and that the **User** cannot be deemed to be in compliance with **PCA 4.10.1.2**, the provisions of **GC.10.1.4** shall apply and the **User** shall apply for a derogation under the terms of GC.9.

PC.A4.10.1.3 VALIDATION OF MODEL

All models provided to the **TSO** for use in dynamic simulations must be validated. The **TSO** must be satisfied that the behaviour shown by the model under simulated conditions is representative of the behaviour of the real equipment under equivalent conditions.

For validation purposes the **Controllable WFPS** shall ensure that appropriate tests are performed and measurements taken to assess the validity of the dynamic model. Where the validity of the model has not been confirmed prior to the commissioning of the **Controllable WFPS,** appropriate tests shall be carried out and measurements taken at the **Controllable WFPS** to assess the validity of the dynamic model. The tests and measurements required shall be agreed with the **TSO.**

The **Controllable WFPS** shall provide the **TSO** with all available information showing how the predicted behaviour of the dynamic model to be verified compares with the actual observed behaviour of a prototype or production **WTG** under laboratory conditions and/or actual observed behaviour of the real **WTG** as installed and connected to a transmission or distribution network.

If the on-site measurements or other information provided indicate that the dynamic model is not valid in one or more respects, the **Controllable WFPS** shall provide a revised model whose behaviour corresponds to the observed on-site behaviour as soon as reasonably practicable.

The conditions validated should as far as possible be similar to those of interest, e.g. low short circuit level at **Connection Point**, close up, severe faults, nearby moderate faults, remote faults, **Voltage** excursions, **Frequency** excursions, large wind speed variations.

PC.A4.10.1.4 WIND FARM DATA

In order to construct a valid dynamic model of each **Controllable WFPS**, the following **Controllable WFPS** data is required:

Wind Turbine Generator (WTG) transformer

This is the transformer that connects the WTG with the internal **Controllable WFPS** network.

Rating of **WTG** transformer (MVA or kVA)

WTG transformer voltage ratio (kV)

WTG transformer impedance (%)

Internal **Controllable WFPS** network and corresponding data

Please describe how the **Controllable WFPS's** internal network structure (collector network) will be laid out (by means of a single line diagram or other description of connections). The description should include a breakdown of how the individual **WTGs** are connected together aswell as how they are connected back to the **Controllable WFPS** substation. Please specify different cable or overhead line types and the individual length of each section of circuit.

	Type1	Type2	Type3	Extend Table as approp-riate
Total length (m)				
Conductor cross section area per core (mm)				
Conductor type (Al, Cu, etc)				

~~Type of insulation~~

~~Charging capacitance~~

~~(µF/km)~~

~~Charging current~~

~~(Ampere/km)~~

~~Positive sequence~~

~~resistance~~

~~(R1 Ohm/km)~~

~~Positive sequence~~

~~reactance (X1 Ohm/km)~~

~~Grid connected transformer~~

~~This is the transformer that is connecting the **Controllable WFPS** site with the **Distribution/Transmission System (equivalent to the Generator Transformer of a conventional power station)**. Data is required for this transformer as follows:~~

~~Rating of grid transformer (MVA or kVA)~~

~~Transformer **Voltage** ratio (kV)~~

~~Transformer impedance (%)~~

~~Reactive compensation installed at site~~

~~Number of inductive devices~~

~~Indicate for each device the inductive **Mvar** capability. If the device has more than one stage please indicate the number of stages and the **Mvar** capability switched in each stage i.e. 0.5 **Mvar** in 5 steps etc.~~

~~Number of capacitive devices~~

~~Indicate for each device the Capacitive **Mvar** capability. If the device has more than one stage please indicate the number of stages and the **Mvar** capability switched in each stage i.e. 0.5 **Mvar** in 5 steps etc.~~

~~Method of voltage/reactive power control applied to each controllable reactive compensation device. This information should be provided in sufficient detail (e.g. transfer function block diagram, control system gain/droop, deadband and hysterisis characteristics, tap steps, etc.) to allow an appropriate PSS/E model to be developed.~~

PC.A4.11 § *Generator Transformer*

	Symbol	Units
Number of windings		
Vector Group		
Rated current of each winding		Amps
Transformer Rating		MVA_{Trans}
Transformer nominal LV voltage		kV
Transformer nominal HV voltage		kV
Tapped winding		
Transformer Ratio at all transformer taps		
Transformer Impedance at all taps[1]		% on rating MVA_{Trans}
Transformer zero sequence impedance at nominal tap	Z_0	Ohm
Earthing Arrangement including neutral earthing resistance & reactance		
Core construction (number of limbs, shell or core type)		
Open circuit characteristic		Graph

PC.A4.12 Generator Forecast Data

PC.A4.12.1 § Expected Maintenance Requirements

Expected Maintenance Requirements weeks / year

PC.A4.12.2 § Forecast Availability of Registered Capacity

Apart from the expected scheduled maintenance requirements,

Availability of Registered Capacity	Reason	Available Exported MW	Time %
Registered Capacity			
Restricted Rating			
Forced outage probability			

[1] For Three Winding Transformers the HV/LV1, HV/LV2 and LV1/LV2 impedances together with associated bases shall be provided.

Total	100%

Reasons for restricted rating might include poor fuel, loss of mill, loss of burners, hydro flow restrictions, etc.

PC.A4.12.3 § Energy Limitations

Daily	GWh
Weekly	GWh
Monthly	GWh
Annual	GWh

PC.A4.12.4 § Hydro Expected Monthly GWh

January	GWh
February	GWh
March	GWh
April	GWh
May	GWh
June	GWh
July	GWh
August	GWh
September	GWh
October	GWh
November	GWh
December	GWh

PC.A4.13 § Generator Aggregators

For each **Generator Aggregator**, the following information shall be provided:

(i) Name of **Generator Aggregator** group;

(ii) Total **Generation Capacity** at their **Connection Points** of all **Generation Units** being aggregated (MW) (**Aggregated Maximum Export Capacity**);

For each **Generator Site** within the **Generator Aggregator** group, the following information shall be provided:

(iii) Location;

(iv) **Registered Capacity**; and

(v) Name of the **Transmission Station** to which the **Generation Site** is normally connected.

PC.A5: Controllable WFPS Data Requirements

All information for **Controllable WFPS** connection applications shall include details of the **Transmission System Connection Point**. This shall include details listed in **PC.A2.1**, **PC.A2.2** for the **Connection Point**. The minimum technical, design and operational criteria to be met by **Controllable WFPS** are specified in the **Connection Conditions**.

PC.A5.1 § Wind Turbine Generators and Mains Excited Asynchronous Generators

State whether turbines are Fixed Speed or Variable Speed:

~~Please p~~Provide manufacturer details on electrical characteristics and operating performance with particular reference to Flicker and Harmonic performance.

~~Please pProvide details of the anticipated operating regime of generation, i.e. continuous, seasonal etc. List the anticipated maximum export level in MW for each calendar month, and indicate how generation would vary over a typical 24 hour period during the month of maximum export.~~

~~Give details of expected rapid or frequent variations in output, including magnitude, max rate of change expected, frequency and duration.~~

For **Mains Excited Asynchronous Generators**, ~~please~~ state:

	Units
How the generator is run up to synchronous speed	
Magnitude of inrush / starting current	Amps
Duration of inrush / starting current	ms
Starting / paralleling frequency	Hz
Power factor on starting	
Reactive power demand at zero output ('no load')	kvar
Give details of reactive power compensation to be installed	

PC.A5.2 Wind Turbine Generator parameters

Provide electrical parameters relative to the performance of the **Wind Turbine Generator**. This may include but is not limited to parameters of electrical generator, power electronic converters, electrical control and/or protection systems. Laplace diagrams and associated parameters shall be provided to the **TSO** where appropriate.

PC.A5.3 Mechanical parameters of the WTG

Provide mechanical parameters relative to the performance of the **Wind Turbine Generator**. This may include but is not limited to the drive train characteristics of the **WTG**, the stiffness of the shaft of the **WTG** and/or a multi-mass model of the **WTG** components. Laplace diagrams and associated parameters shall be provided to the **TSO** where appropriate.

PC.A5.4 Aerodynamic performance of the WTG

Provide details on the aerodynamic performance of the **Wind Turbine Generator**. This may include but is not limited to variation of power co-efficient with tip speed ratio and **WTG** blade pitch angle, aerodynamic disturbance from **WTG** tower, **WTG** blade pitch control and high and low wind speed performance of the **WTG**. Laplace diagrams and associated parameters shall be provided to the **TSO** where appropriate.

PC.A5.5 Wind Turbine Generator transformer

Provide details of the transformer that connects the **WTG** with the internal **Controllable WFPS** network. This may include but is not limited to the rating of **WTG** transformer (MVA or kVA), the **WTG** transformer voltage ratio (kV) or the **WTG** transformer impedance (%).

PC.A5.6 Reactive compensation

Provide details of any additional reactive compensation devices and control systems employed by the **Controllable WFPS**. This shall include **Mvar** capability, the number of stages in the device and the **Mvar** capability switched in each stage and any control or protection systems that influence the performance of the **Controllable WFPS** at the **Connection Point**. Laplace diagrams and associated parameters shall be provided to the **TSO** where appropriate.

PC.A5.7 Controllable WFPS control and protection systems

Provide details of any control or protection systems that affect the performance of the **Controllable WFPS** at the **Connection Point.** This shall include any systems or modes of operation that activate during system **Voltage** or **Frequency** excursions including Low **Voltage** Ride Through (FRT), High **Voltage** Ride Through, Low **Frequency** Response and High **Frequency** Response. The transition between **Controllable WFPS** control modes shall also be specified. Laplace diagrams and associated parameters shall be provided to the **TSO** where appropriate.

PC.A5.8 Grid connected transformer of Controllable WFPS

Provide details of the transformer that connects the **Controllable WFPS** site with the **Distribution/Transmission System (equivalent to the Generator Transformer of a conventional power station)**. This shall include but is not limited to rating of grid transformer (MVA or kVA), transformer **Voltage** ratio (kV), transformer impedance (%), transformer tap changing control and no-load losses.

PC.A5.9 Internal network of Controllable WFPS

Provide details of the **Controllable WFPS's** internal network structure (**Collector Network**) and lay out (by means of a single-line diagram or other description of connections). This shall include but is not limited to a breakdown of how the individual **WTGs** are connected together as well as how they are connected back to the **Controllable WFPS** substation. Please specify different cable or overhead line types and the individual length of each section of circuit.

	Type1	Type2	Type3	Extend Table as appropriate
Total length (m)				
Conductor cross section area per core (mm)				
Conductor type (Al, Cu, etc)				
Type of insulation				
Charging capacitance (µF/km)				
Charging current (Ampere/km)				
Positive sequence resistance (R1 Ohm/km)				
Positive sequence reactance (X1 Ohm/km)				

PC.A5.10 Flicker and harmonics

Provide details of harmonic or flicker contribution from the **Controllable WFPS** that may affect the performance of the **Controllable WFPS** at the **Connection Point.** This may include harmonic current injections and phase angles associated with the **Controllable WFPS**. Details of any additional AC filter devices shall also be provided by the **Controllable WFPS** to the **TSO.**

PC.A5.11 Short Circuit Contribution

Provide details of the single-phase to ground, phase-phase and three-phase to ground short circuit contribution from the **Controllable WFPS** at the **Connection Point.** The **Controllable WFPS** shall provide the **TSO** with the single-phase and three-phase short circuit contribution for rated conditions, i.e. maximum output from the **Controllable WFPS** with all **WTGs** and any additional devices in the **Controllable WFPS** contributing to the short circuit current. The **Controllable WFPS** shall also provide the single-phase to ground, phase-phase and three-phase to ground short circuit contribution from an individual **WTG.** Signature plots of the short circuit contribution from an individual **WTG** shall also be supplied by the **Controllable WFPS**.

PC.A6~~5~~: Interconnector Data Requirements

All information for **Interconnector** connection applications shall include details of the **Transmission System Connection Point** and external **Transmission System Connection Point**. This shall include details listed in **PC.A2.1, PC.A2.2** for each **Connection Point**. The minimum technical, design and operational criteria to be met by **Interconnectors** are specified in the **Connection Conditions**.

PC.A6~~5~~.1 Interconnector Operating Characteristics and Registered Data

The Minimum technical, design and operational criteria to be met by **Interconnectors** are specified in the **Connection Conditions**.

For an **Interconnector** the following shall be provided for specified temperature conditions:

(i) **Interconnector Registered Capacity**

(a) **Interconnector Registered Import Capacity** for import to the **Transmission System** (MW);

(b) **Interconnector Registered Export Capacity** for export from the **Transmission System** (MW).

Interconnector Registered Capacity figures (a) and (b) above shall include transmission power losses for the **Interconnector** and be considered **Registered Data.**

(ii) General Details

(a) single line diagram for each converter station;

(b) proposed **Transmission** connection point;

(c) **Control Facility** location;

(d) **Interconnector Operator** details.

(iii) Technology details

(a) **Interconnector** technology type (i.e. current or voltage source technology);

(b) DC network cable or overhead line type & characteristics i.e. length, resistance (R), reactance (X), susceptance (B);

(c) rated DC Network Voltage/pole (kV);

(d) number of poles and pole arrangement;

(e) earthing / return path arrangement;

(f) short circuit contribution (three phase to ground, single line to ground, phase to phase);

(g) **Interconnector** losses (**MW** / **Mvar**);

i. converter station;

ii. line circuits;

iii. house load demand;

iv. losses on de-block at minimum transfer;

v. total losses at max import / export.

(h) overload capability including details of any limitations i.e. time, temperature;

(iv) AC filter reactive compensation equipment parameters

(a) total number of AC filter banks;

(b) type of equipment (e.g. fixed or variable);

(c) single line diagram of filter arrangement and connections;

(d) **Reactive Power** rating for each AC filter bank, capacitor bank, or operating range of each item or reactive compensation equipment, at rated voltage;

(e) performance chart (PQ), showing **Reactive Power** capability of the **Interconnector**, as a function of **Interconnector Registered Capacity** transfer.

(f) harmonic and/or flicker contribution from the **Interconnector** that may affect the performance of the **Interconnector** at the **Connection Point**.

(v) **Interconnector** power electronic converter and control systems ~~model~~

~~(a) the **TSO** requires suitable and accurate dynamic models for **Interconnectors** connected to, or applying for a connection to, the **Transmission System** in order to assess reliably the impact of the installation on the dynamic performance and security and stability of the **Power System**. Modelling requirements are processed on the identification by the applicant of the relevant PSS/E library model and the provision of the applicable data parameters in the appropriate application form;~~

(a) ~~transfer function block diagram including~~ parameters related to the power electronic converters. ~~representation of the control systems of each **Interconnector** converter and **Interconnector** converter station, for both the rectifier and inverter modes. A suitable model would feature the electrical characteristics of the **Interconnector**, the output of these would~~ **Interconnector** converter characteristics to be represented may include but is not limited by the following; converter firing angle, modulation index, Valve winding voltage, DC Voltage, DC Current as the output variables;

(b) transfer function block diagram representation including parameters of the **Interconnector** transformer tap changer control systems, including time delays;

(d) transfer function block diagram representation including parameters of AC filter and reactive compensation equipment control systems, including any time delays;

(e) transfer function block diagram representation including parameters of any **Frequency** and/or load control systems;

(f) transfer function block diagram representation including parameters of any small signal modulation controls such as power oscillation damping controls or sub-synchronous oscillation damping controls, which have not been submitted as part of the above control system data;

(g) transfer block diagram representation including parameters of the **Active Power** control, DC **Voltage** control, **AC Voltage** control and **Reactive Power** control at converter ends for a voltage source converter for both the rectifier and inverter modes.

(h) transfer block diagram representation including parameters of any control modes that affect the performance of the **Interconnector** at the **Connection Point** which have not been submitted as part of the above control system data. Features to be represented shall include but are not limited to the following; start-up sequence, shutdown sequence, Normal operating mode, VSC control mode, Island mode and Emergency Power control.

(vi) **Interconnector** Transformer;

	Symbol	Units
number of windings		
vector Group		
rated current of each winding		A

transformer rating		MVA_{Trans}
transformer nominal LV voltage		kV
transformer nominal HV voltage		kV
tapped winding		
transformer ratio at all transformer taps		
transformer impedance at all taps[1]		% on rating MVA_{Trans}
transformer zero sequence impedance at nominal tap	Z_0	Ohm
earthing arrangement including neutral earthing resistance & reactance		
core construction (number of limbs, shell or core type)		
open circuit characteristic		graph

PC.A7~~6~~: Dispatchable Demand Customers

For each **Dispatchable Demand Customer**, the following information shall be provided:

(a) name of **Demand Side Unit**;

(b) location of **Demand Site(s)**;

(c) the name of the **Transmission Station**(s) to which the **Demand Site(s)** is/are normally connected;

(d) total **Demand Side Unit MW Capacity (MW)**;

(e) **Demand Side Unit MW Capacity** available from on-site **Generation** (MW);

(f) **Demand Side Unit MW Capacity** available from avoided **Demand** consumption (MW);

(g) annual **Demand Side Unit Energy Profile**.

For each **Dispatchable Demand Customer** which represents an **Aggregated Demand Site**, the following additional information shall be provided:

(h) **Demand Side Unit MW Capacity** per **Individual Demand Site** (MW);

(i) **Demand Side Unit MW Capacity** from **Generation** per **Individual Demand Site** (MW);;

[1] For Three Winding Transformers the HV/LV1, HV/LV2 and LV1/LV2 impedances together with associated bases shall be provided.

(j) **Demand Side Unit MW Capacity** from avoided **Demand** consumption per **Individual Demand Site** (MW);

(k) **Demand Side Unit Export Capacity** per **Individual Demand Site** (MW);

(l) **Demand Side Unit Import Capacity** per **Individual Demand Site** (MW);

(m) annual **Demand Side Unit Energy Profile** per **Individual Demand Site** (MW).

PC.A8: Modelling Requirements For Users

PC.A8.1 Introduction

The **TSO** requires suitable and accurate dynamic **Models** for all **Users** connected to, or applying for a connection to, the **Transmission System,** in order to assess the impact of the proposed installation on the transient and dynamic performance, and security and stability of the **Power System** for a range of timeframes, disturbances and system conditions. The **TSO** bases the safe and secure design and operation of the **Power System** on the **Models** provided by the **Users**. All **Users** of the **Power System** shall provide suitable **Models** of their **Plant** in a timeframe and manner specified by the **TSO** in this **Grid Code.**

PC.A8.2 Model Capabilities

The **Users** shall supply **Models** that shall be capable of representing the behaviour of the **Plant** in balanced, root mean-square, positive phase-sequence, time-domain studies and where specified, electromagnetic transient and harmonic studies. The detail to be represented in the **Models** shall be specified by the **TSO** in this **Grid Code**.

The balanced, root mean-square positive phase-sequence time-domain **Model** shall include all material elements that affect the **Active Power** and **Reactive Power** output of the **Plant** with respect to changes or excursions in **Voltage** and **Frequency** at the **Connection Point.** The **Model** shall include all electrical and mechanical phenomena, where applicable, that impact on the **Active Power** and **Reactive Power** output of the **Plant** for sub-transient, transient and synchronous dynamics up to and including **Primary Operating Reserve** and **Secondary Operating Reserve** timeframe.

The three-phase electromagnetic transient **Model** shall include all material aspects of the **Plant** that affect the symmetrical and asymmetrical voltage and current outputs from the **Plant.** The **Model** shall represent phenomena that materially affect the **Voltage** and **Frequency** at the **Connection Point** over timeframes of sub-cycles up to 500 cycles including but not limited to switching of power electronic devices, transformer saturation or equipment energisation.

PC.A8.2.1 Model Aggregation

The **TSO** requires the **Model** to represent the operation of the **User's Plant** at the **Connection Point** and therefore it is essential that the **Models** of individual **Generation Units** can be aggregated into a smaller number of **Models**, each representing a number of **Generation Units** at the same **Site**. If all **Generation Units** in the **User Site** are not identical, the **Model** shall account for this by accurately representing the overall performance of the **User's Plant** at the **Connection Point**. A representation of the collector network and any additional equipment such as **Reactive Power** compensation may be included in the aggregate **Model** of the **User's Plant. Models** for the simulation studies must be single lumped **Models**, scalable for different **Active Power** outputs as seen at the **Connection Point**.

PC.A8.3 Model Documentation and Source Code

Users are obliged to provide appropriate balanced, root mean-square positive-phase sequence time-domain **Models** and three-phase electromagnetic transient **Models** in accordance with specifications in this **Grid Code**. The **TSO** requires that sufficient information be provided by the **User** to allow for **Models** to be redeveloped in the event of future software environment changes or version updates. All **Models** must be accompanied with appropriate documentation with sufficient detail as specified by the **TSO**, such agreement not to be unreasonably withheld. The **User** shall provide information including, but not limited to, a full description of the **Model** structure and functionality, Laplace diagrams or other suitably understandable information. The **User** may also choose to provide the **TSO** with detailed **Model** source code. The **Models** shall be provided in a software format as specified by the **TSO**. Alternatively, the **User** may provide an unambiguous reference to a standard open-source **Model**, such as a standard IEEE **Model**, or to a dynamic **Model** previously submitted to the **TSO** provided this **Model** accurately reflects the **User's Plant**.

The **TSO** may, when necessary to ensure the proper operation ~~running~~ of its complete system representation or to facilitate its understanding of the results of a dynamic simulation, request additional information concerning the **Model**, this may includeing **Model** documentation or the source code of one or more routines in the model. The **User** shall comply with any such request without delay.

PC.A8.4 Confidentiality

The dynamic **Models**, supporting documentation and associated data are provided to the **TSO** in order to carry out its duties to meet its statutory and legal requirements. In that regard the **TSO** is entitled to share the information with third party consultants, other **TSO**s or **DSO**s working for or with the **TSO** to perform co-ordinated operational and/or planning studies.

Where the **User** or any other party, acting reasonably, designates such information as confidential on the basis that it incorporates trade secrets, the obligation will be with the **TSO** to ensure the confidentiality of data shared with other **TSO**s or **DSO**s working for or with the **TSO** to perform co-ordinated operational and/or planning studies. Where such data is shared with third party consultants working for or with the **TSO** such third party consultants will be obliged to carry out any activities will be subject to stringent confidentiality agreements.

It is the responsibility of the **User** to provide the dynamic **Models**, supporting documentation and associated data to the **TSO**. Where the **User** or any other party, acting reasonably, designates such information as confidential on the basis that it incorporates trade secrets, the **TSO** will accept the dynamic **Models**, supporting documentation and associated data from a third party manufacturer provided the third party manufacturer agrees to enter into the **TSO's** standard confidentiality agreement for **Users**. In the event that the manufacturer cannot agree to this confidentiality contract, the **User** shall be responsible for the provision of the dynamic **Models**, supporting documentation and associated data to the **TSO**.

PC.A8.5 Time to comply

The **User** shall provide a **Model** of the **User's Plant** in accordance with **PC.6.6.1**. Where a **User** requires reasonable time to develop the necessary **Model** or **Models** so as to comply fully with all the provisions in this section **PC.A8.2** and **PC.A8.3**, the **User** may apply to the **TSO** to be deemed compliant with the provisions of **PC.A8.2** and **PC.A8.3** on the basis of **GC.10.1.3** of the **General Conditions** of the **Grid Code.** The **TSO** shall consider any such application in accordance with **GC.10.1.3,** and if the **TSO** is satisfied as to the **User's** programme for developing and testing the necessary dynamic model, the **TSO** may, for so long as the **TSO** is so satisfied, treat the **User** as being in compliance with the provisions of this section**.** If the **TSO** decides, acting reasonably, that it is not satisfied as to the **User's** programme for developing and testing the necessary dynamic **Model** and that the **User** cannot be deemed to be in compliance with **PC.A8.2** and **PC.A8.3**, the provisions of **GC.10.1.4** shall apply and the **User** shall apply for a derogation under the terms of **GC.9**.

PC.A8.6 Validation of Model

All **Models** provided to the **TSO** for use in dynamic simulations must be validated. The **TSO** must be satisfied that the behaviour shown by the **Model** under simulated conditions is representative of the behaviour of the real equipment under equivalent conditions.

For validation purposes the ~~**Controllable WFPS**~~ **User** shall ensure that appropriate tests are performed and measurements taken to assess the validity of the dynamic **Model**. Where the validity of the **Model** has not been confirmed prior to the commissioning of the ~~**Controllable WFPS**~~ **User's Plant,** appropriate tests shall be carried out and measurements taken at the ~~**Controllable WFPS**~~ **Users** site to assess the validity of the dynamic **Model**. The tests and measurements required shall be agreed between the **User** and the **TSO.**

The ~~**Controllable WFPS**~~ **User** shall provide the **TSO** with all available information showing how the predicted behaviour of the dynamic **Model** to be verified compares with the actual observed behaviour of a prototype or production **User System** ~~**WTG**~~ under laboratory conditions and/or actual observed behaviour of the real **User System** ~~**WTG**~~ as installed and connected to a transmission or distribution network.

The **User** shall simulate the dynamic **Models** such that **Model** outputs can be compared against measurements from **Grid Code** compliance testing to ensure appropriate responses from the **Model**. Tests may include but are not limited to Steady State Reactive Capability, **Voltage** Control & **Reactive Power** Stability, Low **Voltage** Ride Through (FRT), High **Voltage** Ride Through, Low **Frequency** Response and High **Frequency** Response. The tests and measurements required shall be agreed between the **User** and the **TSO.** The **TSO** shall provide sufficient information on system conditions at the **User's Connection Point** to allow for the **User** to conduct their studies.

After commissioning, the **User** shall provide the **TSO** with documentation comparing the predicted behaviour of the balanced, root mean square, positive phase-sequence time-domain **Models** against the tested performance. If no significant changes are required to the **Model** structure the **TSO** shall update the three-phase electromagnetic transient **Model** based on the parameters submitted by the **User** provided the **TSO** has sufficient access to update the relevant **Model** parameters. The **TSO** shall also perform studies and ongoing validation to ensure that **Models** submitted by the **User** are representative of the **User's Plant** throughout its operational lifetime.

If the on-site measurements, **Grid Code** compliance tests or other information provided indicate that the dynamic **Model** is not valid in one or more respects, the ~~**Controllable WFPS**~~ **User** shall provide the revised dynamic **Model**, source code and documentation whose behaviour corresponds to the observed on-site behaviour as soon as reasonably practicable, but in any case no longer than 30 **Business Days** after the conclusion of the **Grid Code** compliance tests.

PC.A8.7 Maintenance of Model

All **Models** provided to the **TSO** must be maintained and updated to accurately reflect the operational performance of the **User's Plant** over the lifetime of the **Plant**. The **User** shall inform the **TSO** of any changes to the **Plant** which may materially affect the accuracy of the dynamic **Model** in predicting the **Active Power** and **Reactive Power** output of the **Plant** with respect to changes or excursions in **Voltage** and **Frequency** at the **Connection Point.** In this case the **User** shall re-submit the parameters associated to the dynamic **Model** or fully re-submit the dynamic **Model** of the **Plant**. Changes which shall be reported to the **TSO** may include but are not limited to alterations in **Plant** protection settings, modifications to **Plant** controller settings and alterations to governor droop or **Plant Frequency** response. In the event of scheduled **Plant** outages or maintenance the **User** must provide appropriate **Model** updates in advance of the scheduled outage.

Updates of the dynamic **Model** version shall be supplied by the **User** to the **TSO** in a timeframe agreed with the **TSO**.

The **TSO** is entitled to alter, modify and adjust **Model** parameters or data for the purposes of better reflecting **Plant** behaviour with respect to observed operational performance over the life of the **Plant**. The **TSO** shall inform the **User** of any **Model** changes prior to implementing these in their **System Models**.

PC.A8.8 Software Environment and Model Usability

The **User** must provide **Models** in software packages as defined by the **TSO**. Details of the current software version, computer platform, compiler version~~,~~ and **Model** usability guidelines~~ etc~~, will be provided by the **TSO** upon request and shall be published on the **TSO**'s website. The **TSO** may from time to time request that the **Models** be updated to be compatible with changes in the **TSO's** computing environment, namely software version and/or compiler version. Each **User** shall ensure that such updated **Models** are provided without undue delay or in any event, within 30 **Business Days** of the date of the request. The **User** shall provide **Models** in the software formats as defined by the **TSO**, or additionally in such other format as may be agreed between the **User** and the **TSO**. Changes in the software format requirements for **Models** shall be subject to the **Grid Code** revision process defined in **GC.7**.

All **Models**, irrespective of software format, shall be accompanied by a sample case such that the **Model** can be tested before being integrated into the **Model** of the Irish network in the respective software environment. The sample case shall~~ould~~ include the **User's Plant** model, grid transformer and any other associated equipment connected to an infinite bus via an impedance that is appropriate to represent the **Connection Point**.