

PCA.4.10.1 Modelling Requirements for Wind Turbine Generators

PCA4.10.1.1 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 **Wind Farm Power Stations** 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 **Wind Farm Power Station** scheme. The requirements of these models are as outlined in this section of the **Planning Code** Appendix.

PCA4.10.1.2 Wind Turbine Generator dynamic models

PCA4.10.1.2.1 Requirement to provide a dynamic model

Each **Wind Farm Power Station** shall provide a dynamic model, or shall provide an unambiguous reference to a dynamic model previously provided to the **TSO**, appropriate for the **Wind Farm Power Station**. If all the **Wind Turbine Generators** in the **Wind Farm Power Station** 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 **Wind Farm Power Station** and the **TSO**.

The models for **Wind Turbine Generators** and the **Wind Farm Power Station** (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 **Wind Farm Power Station** 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**.

PCA4.10.1.2.2 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 **Wind Farm Power Station** shall ensure that such updated models are provided without undue delay.

PCA4.10.1.2.3 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.

PCA4.10.1.2.4 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 **Wind Farm Power Station**.

PCA4.10.1.2.5 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 **Wind Farm Power Station** shall comply with any such request without delay. Where the **Wind Farm Power Station** 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.

PCA4.10.1.2.6 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.9.1.3** of the **General Conditions** of the **Grid Code**. The **TSO** shall consider any such application in accordance with **GC.9.1.3**, 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.9.1.4** shall apply and the **User** shall apply for a derogation under the terms of **GC.8**.

PCA4.10.1.3 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 **Wind Farm Power Station** 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 **Wind Farm Power Station**, appropriate tests shall be carried out and measurements taken at the **Wind Farm Power Station** to assess the validity of the dynamic model. The tests and measurements required shall be agreed with the **TSO**.

The **Wind Farm Power Station** 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 **Wind Farm Power Station** 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.

PCA4.10.1.4 Wind Farm Data

In order to construct a valid dynamic model of each **Wind Farm Power Station**, the following **Wind Farm Power Station** data is required:

Wind Turbine Generator (WTG) transformer

This is the transformer that connects the WTG with the internal **Wind Farm Power Station** network.

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

WTG transformer voltage ratio (kV)

WTG transformer impedance (%)

Internal Wind Farm Power Station network and corresponding data

Please describe how the **Wind Farm Power Station'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 as well as how they are connected back to the **Wind Farm Power Station** 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				

(μ F/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 **Wind Farm Power Station** 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 hysteresis characteristics, tap steps, etc.) to allow an appropriate PSS/E model to be developed.