

## CHAPTER 5 TASK XXI

# DYNAMIC MODELS OF WIND FARMS FOR POWER SYSTEMS STUDIES

### 1.0 INTRODUCTION

The worldwide development of wind power installations now includes planning of large-scale wind farms ranging in magnitudes of 100 MW, as well as application of wind power to cover a large fraction of the demand in isolated systems. As part of the planning and design of such systems, it is well established that the stability of the electrical power system needs to be studied. The studies are commonly conducted using commercially available software packages for simulation and analysis of power systems. These packages normally facilitate a set of well-developed models of conventional components, such as fossil fuel-fired power stations and transmission network components; whereas models for wind turbines or wind farms are not standard features. Hence, users are left to build their own wind farm models. This is not trivial and certainly not efficient. Rather, a coordinated effort is expected to enhance progress, and consequently, Task XXI under the IEA Wind Implementing Agreement was proposed and approved in April 2002 with SINTEF Energy Research of Norway as the Operating Agent.

### 2.0 OBJECTIVES AND STRATEGY

This task is carried out on a cost- and task-shared basis. The participants contribute with financial support to the Operating Agent and carry out activities, supply information, and join meetings as required to meet the task objectives.

The overall objective is to assist the planning and design of wind farms by facilitating a coordinated effort to develop wind farm models suitable for use in combination with software packages for simulation and analysis of power system stability. The effort comprises the following immediate objectives and activities:

- Establish an international forum for exchanging knowledge and experience within the field of wind farm modeling for power system studies
- Develop, describe, and validate wind farm models. (The wind farm models are expected to be developed by individual participants of the task, whereas the description and validation will be coordinated by the task, which helps provide state-of-the-art models and pinpoint key issues for further development.)
- Set-up and operate a common database for benchmark testing of wind turbine and wind farm models as an aid for securing good-quality models.

### 3.0 PROGRESS IN 2005

The task has participants from nine countries (Denmark, Finland, Ireland, the Netherlands, Norway, Portugal, Sweden, the United Kingdom, and the United States) with research institutes and universities carrying out work to develop and test wind farm models, as well as doing grid studies in cooperation with wind turbine manufacturers

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and electric utilities. In total, participants in the Task are expected to contribute with more than 20 person-years of work effort.

Cooperation within the task is through sharing of measurement data, model descriptions, and discussions at meetings. A total of seven task meetings have been arranged so far with two meetings held in 2005. The first was hosted by INETI in Portugal in June, and in November by ECN in the Netherlands. Model developments are ongoing among participants, including both fixed- and variable-speed technologies and by using various software tools (Matlab/Simulink, PSSE, SIMPOW, DIgSILENT and EMTDC). An internet "e-room" has been established for sharing documents and measurement data among the participants of the task. The database part of the e-room contains measurements mainly from fixed-speed wind turbines, but also a small collection of measurements from variable speed wind turbines. Benchmark testing of models is ongoing. Such tests include both validation against measurements and model-to-model comparisons, and they con-

sider dynamic operation during normal, fault-free conditions and response to grid fault. See Figure 1 and 2 for examples.

A topic of high interest is the ability of wind turbines to ride through temporary grid faults, hence, contributing to grid stability. Detailed numerical models may be used to assess such abilities, but these models must be validated against measurements to provide confidence. A proposal emerging as a spin-off from Task XXI is to update IEC 61400-21 (Measurements and assessment of power quality characteristics of grid connected wind turbines, ed. 1, 2001) to specify requirements for such testing. This work is now ongoing, expecting a first committee draft of IEC 61400-21, ed. 2, to be out by the beginning of 2006. Hence, in the future, wind turbine manufacturers may refer to standard test certificates for demonstrating performance under grid transients, and also these same test certificates may be used for validating dynamic models of wind farms for power system studies.

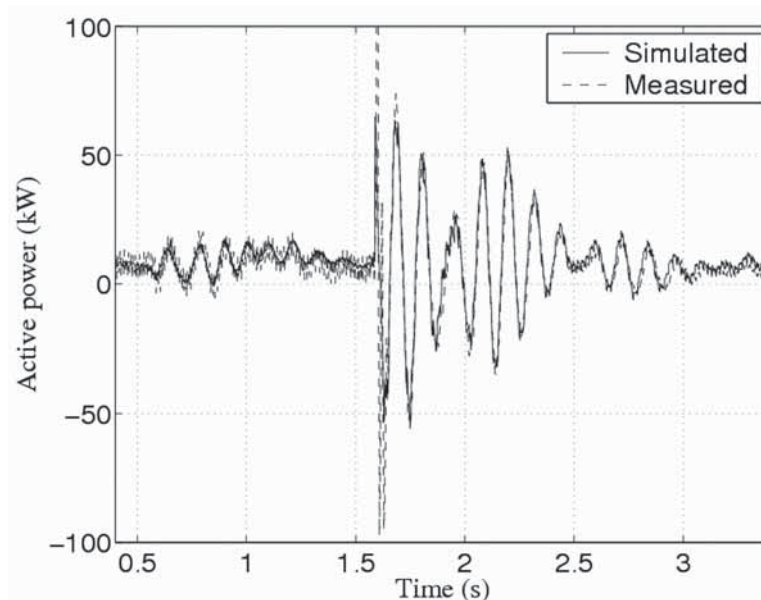


Figure 1 Power spectral density (PSD) of measured and simulated active power output from fixed speed, stall controlled wind turbine during normal operation.

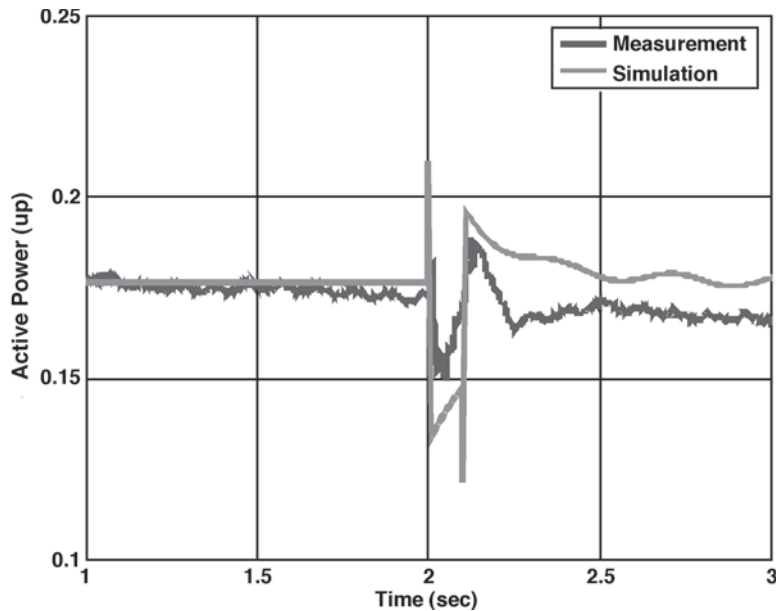



Figure 2 Time-series of measured and simulated active power output from variable speed wind turbine subject to a voltage dip.

#### 4.0 PLANS FOR 2006 AND BEYOND

Task XXI was originally scheduled to close by the end of 2005, but has been extended to mid 2006. Plans for 2006 include organization of a workshop as part of EWEC'06 (European Wind Energy Conference & Exhibition, Athens, Greece 27 February - 2 March 2006). The workshop will include presentations by all participants of the

task and will be an excellent opportunity to disseminate results and getting feedback for final reporting. Additional information about Task XXI can be found on the Internet at <http://www.energy.sintef.no/wind/IEA.asp>.

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