Associated projects

This document contains information about associated projects, which are based fully, or partly on the database contents or has contributed to the development of the Database on Wind Characteristics.

- Database on Wind Characteristics (JOR3-CT95-0061)
- Database on Wind Characteristics (IEA Annex XVII)

Research projects

- NewGust (JOR3-CT98-0239)
- Validity of the Assumption of Gaussian Turbulence, finished

Master thesis, Ph.D. thesis

- Development of a mass-consistent diagnostic wind model for wind energy applications (WIMO)

Joule project

Contract JOR3-CT95-0061

Executive summary

Vast amounts of wind data have been measured in many different locations. Of the thousands of hours of time series collected, only a tiny proportion is available for use by the wind turbine and wind engineering communities. This report describes the project of collecting a small but representative portion of these data and making them available on the World Wide Web.

In order to implement a suitable search system we have constructed a database for the detailed registration of field measurements, ranging in scope from the administrative level down to the mounting details of individual sensors. Wind data are quality checked according to a number of different criteria such as presence of spikes, noise and trends. Subsequently data are indexed using a variety of parameters, including conventional statistics and extremes, turbulence intensity, gust, acceleration and wind shear.

A wide variety of wind climates and terrain types are represented together with significant amounts of data measured in and close to wind farms. Data have a typical temporal resolution of 1-20 Hz and as such are intended for design and simulation studies (not wind resource applications). Emphasis has been gived to ensure a high level of documentation of the measurement setups which are included in the database. Furthermore, a search and data selection system has been developed that fully utilizes interactive nature of the World Wide Web.

After quality control and indexing, the actual wind data are copied in a standard format to CD-ROM's. All CD-ROM's reside in a juke box containing up to 150 disks, giving a capacity of around 100 GB (with present CD technology). The juke box is accessible via ftp which also allows direct downloading of data files from a web browser.

Data are provided by all the participants of the project, covering most of the countries of the European Union. By spring 1999 we have gathered and included approximately 50.000 hours of wind speed measurements representing more than 20 sites.

As an indication of the applicability of the database, we can refer to two projects that are allready benefiting from this rich resource, The Joule NEWGust project, coordinated by Delft University of Technology, uses wind data from the database to verify and calibrate theoretical models for gust shape. A Danish funded project uses wind

time series to examine the precise form of the high sped tails of the wind speed distribution and determine how much these deviate from Gaussian form. This has particular relevance to fatigue loading of the wind turbines.
In conclusion it should be remembered that the database coordinators welcome offers of new data. We consider the Database on Wind Characteristics to be the natural repository for many of the numerous existing and future wind datasets. This project is partially financed by the European Commission under the DG XII Non-Nuclear Energy Programme, Contract JOR3-CT95-0061.

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IEA Annex XVII

1. BACKGROUND

In 1996, the EU-DG XII (JOULE) project 'Database on Wind Characteristics' was started. The project was concluded at the end of 1998. In this project 14 institutes from 13 different European countries participated in building a database containing a large number of measured wind time series representing many different terrain types and wind climate systems, for the purpose of providing wind turbine designers with easy access to quality controlled field data in a standardized format. The data consist of rapid sampling rate time series (1-20Hz) to be used for simulations and definitions of load cases. The JOULE project has provided a unique database of wind measurements, together with tools to enable access and simple analysis through an Internet connection using the World-Wide-Web. Larger quantities of data will be forwarded to the user on CD-ROMs by surface mail. The database contains data from most European countries, and is expected to be widely used by wind turbine engineers during the design process of wind turbines.

As a follow-up to the JOULE project, it is recommended to initiate this Annex with the purpose of:

a. Extending the database with meteorological data from countries outside of Europe;
b. In exchange for the input of data, making available the use of the whole data set for countries outside of Europe; and
c. Maintaining the database;

The value of such a database will, of course, increase when representative data from as many countries as possible become available to as many of the worlds wind turbine designers as possible.

2. OBJECTIVES

The objectives of this Task are to:

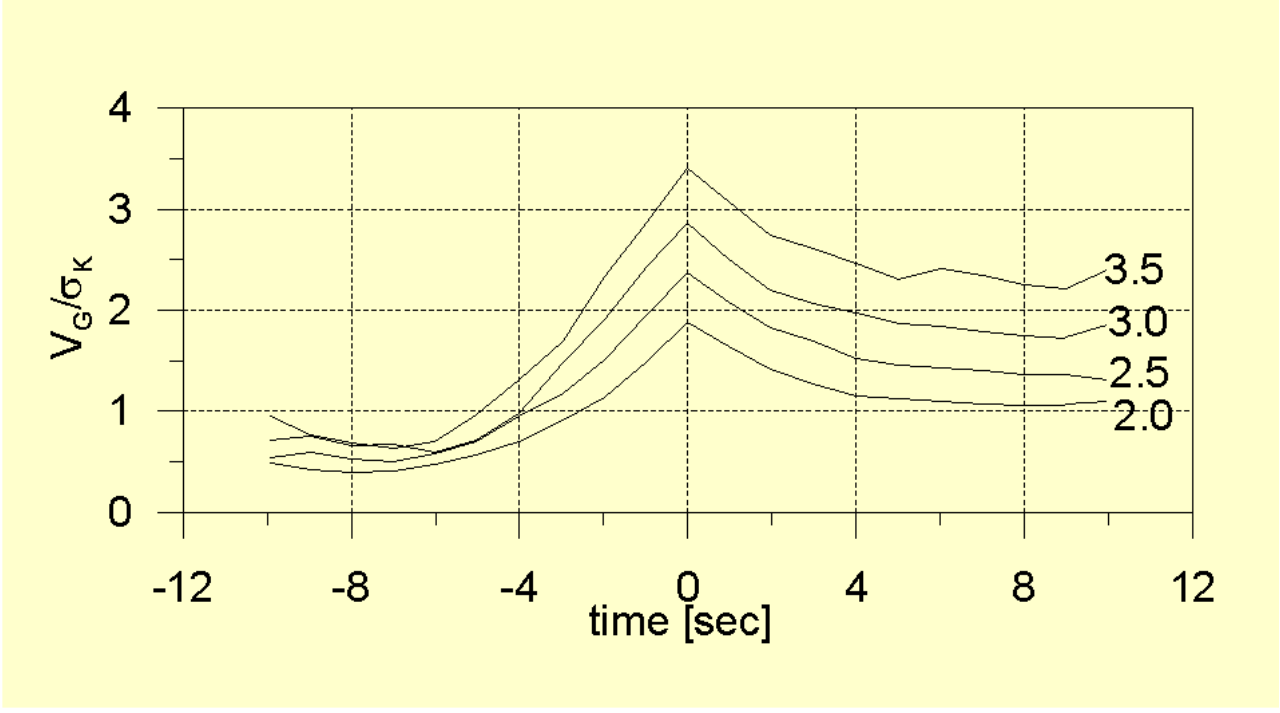
a. Maintain the database in order to ensure that the data, as well as the hardware and software will also be on-line and available after the end of the JOULE project;
b. Extend the database developed in the JOULE-project;
c. Disseminate the knowledge of the database and the possibilities for use of the data material.

Modeling of extreme gusts for design calculations (NewGust)

Joule Contract: JOR3-CT98-0239

Introduction

For design load calculations of wind turbines it is necessary to determine the fatigue loads as well as the extreme loads. Up to now simple deterministic and coherent gusts (e.g. a cosine gust) have been used to determine the extreme response. The shape, amplitude and duration specified for these discrete events remain rather arbitrary and largely invalidated. This is in contrast the fatigue analysis, which is conventionally rely on synthetic stochastic wind field reflecting the stochastic properties of natural turbulence.
The main objective of the NewGust project to achieve a realistic and verified description of extreme gusts based on (stochastic) properties of the wind. From theoretical considerations it has been demonstrated that the shape of extreme gust is (very) sharp, which is in contrast with the gust shapes given in the present standards. Only longitudinal turbulence component will be considered, and consequently no account is given on wind direction changes.



Example of averaged gust shapes based on appr. 3000 gusts, recorded in the wind speed range 7 - 9 m/s,Site = Cabauw, h= 40 m, VG/sK = normalised gust size

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Acknowledgement

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Validity of the Assumption of Gaussian Turbulence (In Danish)

Abstract

Wind turbines are designed to withstand the impact of turbulent winds, which fluctuations usually are assumed of Gaussian probability distribution. Based on a large number of measurements from many sites, this seems a reasonable assumption in flat homogeneous terrain whereas it may fail in complex terrain. At these sites the wind speed often has a skew distribution with more frequent lulls than gusts. In order to simulate aerodynamic loads, a numerical turbulence simulation method was developed and implemented. This method may simulate multiple time series of variable not necessarily Gaussian distribution without distortion of the spectral distribution or spatial coherence. The simulated time series were used as input to the dynamic response simulation program Vestas Turbine Simulator (VTS). In this way we simulated the dynamic response of systems exposed to turbulence of either Gaussian or extreme, yet realistic, non-Gaussian probability distribution. Certain loads on turbines with active pitch regulation were enhanced by up to 15% compared to pure Gaussian turbulence. It should, however, be said that the undesired effect depends on the dynamic system, and it might be mitigated by optimization of the wind turbine regulation system after local turbulence characteristics.

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Ph.D. Thesis:

Development of a mass-consistent diagnostic wind model for wind energy applications
University: UniversidadComplutense de Madrid (Spain)
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A mass-consistent diagnostic wind model (WIMO) has been developed for wind energy applications (mainly in complex terrain). The main features about WIMO are that it is bi-dimensional, runs in the micro-scale, incorporates two interpolation methods (Inverse of the squared distance and minimum curvature Spline), and does not change the initial values during the mass-conservation process. There are two versions of WIMO, one in Fortran 90 and other in Visual Basic.
It has been evaluated in three wind data campaigns. The Lammefjord data from the ´Database on wind characteristics´ was used to check if there were any structural errors in the code, and to quantify how the interpolation and conservation processes improved the results. The Crete campaign was used to compare the performance of both interpolation methods with data taken in an atmospheric boundary layer wind tunnel.

Finally, wind data from the Askervein campaign was simulated with a well-known mass-consistent model (MATHEW) and WIMO. MATHEW´s EMS were three times bigger and two orders of magnitude slower than WIMO.