GH website, 2000

Home

Welcome to Garrad Hassan & Partners Ltd

WIND ENERGY CONSULTANTS

Welcome to Garrad Hassan & Partners Ltd

Garrad Hassan is a leading international consultancy providing independent expert advice on all aspects of wind energy to a world-wide client base.

An introduction to Garrad Hassan

Garrad Hassan and Partners Ltd (GH) was formed in 1984 to answer the growing need for independent expert advice on wind energy. Through over 50 staff GH provides consultancy on all aspects of wind including wind turbine design, measurement and modelling, wind farm design, resource assessment, electrical engineering and strategic studies, and is the world leader in the provision of technical advice to the f sector as Bank's and Owner's Engineer. GH has undertaken over 500 assignments world-wide and is typically active in 15 to 20 countries through an international network of offices co-ordinated from the head Bristol (UK).

GH has also developed three market-leading wind energy products - BLADED for Windows – Wind Turbine Design Tool which is the industry standard simulation package for wind turbine design and analysis, T-M integrated system for wind turbine condition monitoring, and WindFarmer software for wind farm analysis, de ...ation and impact modelling. GH's wind farm Supervisory, Control and Data Acquisition (S system is due for release in 2000.

GH is wholly owned by its directors and has no equity stake in any wind turbine or wind farm - its advice is i

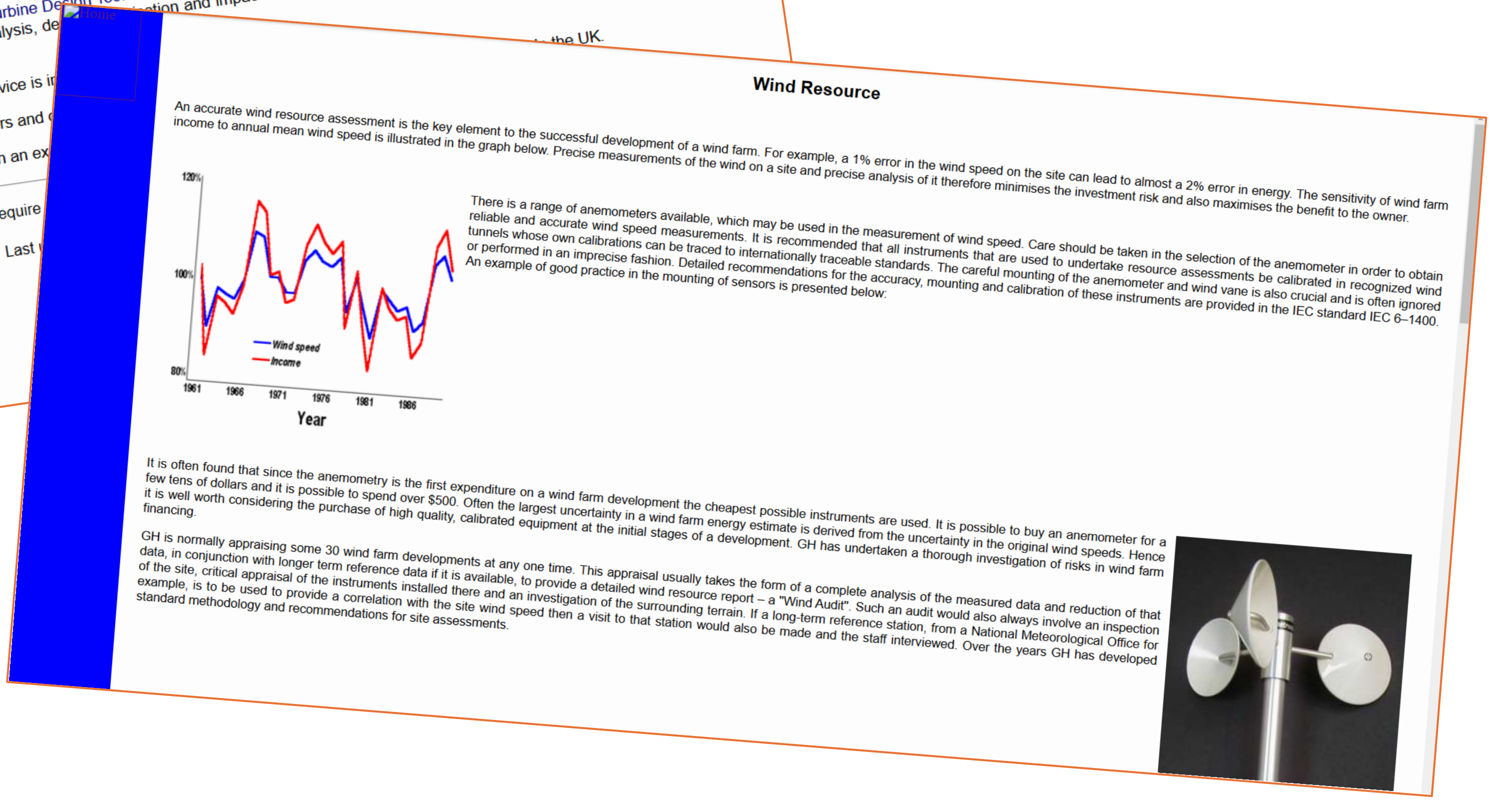
GH counts among its clients all major wind turbine manufacturers and most major wind farm investors and

GH counts among its clients all major wind turbine manufacturers and most major wind farm investors and

In April 2000 GH won the Queen's Award for International Trade - an award given to companies with an ex ... the UK.

Please email us at the following address if you require

Last



Home

Wind Resource

An accurate wind resource assessment is the key element to the successful development of a wind farm. For example, a 1% error in the wind speed on the site can lead to almost a 2% error in energy. The sensitivity of wind farm income to annual mean wind speed is illustrated in the graph below. Precise measurements of the wind on a site and precise analysis of it therefore minimises the investment risk and also maximises the benefit to the owner.

There is a range of anemometers available, which may be used in the measurement of wind speed. Care should be taken in the selection of the anemometer in order to obtain reliable and accurate wind speed measurements. It is recommended that all instruments that are used to undertake resource assessments be calibrated in recognized wind tunnels whose own calibrations can be traced to internationally traceable standards. The careful mounting of the anemometer and wind vane is also crucial and is often ignored or performed in an imprecise fashion. Detailed recommendations for the accuracy, mounting and calibration of these instruments are provided in the IEC standard IEC 6–1400. An example of good practice in the mounting of sensors is presented below:

It is often found that since the anemometry is the first expenditure on a wind farm development the cheapest possible instruments are used. It is possible to buy an anemometer for a few tens of dollars and it is possible to spend over $500. Often the largest uncertainty in a wind farm energy estimate is derived from the uncertainty in the original wind speeds. Hence it is well worth considering the purchase of high quality, calibrated equipment at the initial stages of a development. GH has undertaken a thorough investigation of risks in wind farm financing.

GH is normally appraising some 30 wind farm developments at any one time. This appraisal usually takes the form of a complete analysis of the measured data and reduction of that data, in conjunction with longer term reference data if it is available, to provide a detailed wind resource report – a "Wind Audit". Such an audit would also always involve an inspection of the site, critical appraisal of the instruments installed there and an investigation of the surrounding terrain. If a long-term reference station, from a National Meteorological Office for example, is to be used to provide a correlation with the site wind speed then a visit to that station would also be made and the staff interviewed. Over the years GH has developed standard methodology and recommendations for site assessments.

Indian Mesa

2001

ASSESSMENT OF THE WIND REGIME AND ENERGY CAPTURE OF THE PROPOSED INDIAN MESA II WIND FARM

Client	**Enron Wind Corp**
Contact	Jay Godfrey
Document No	2624/BR/02
Issue No	A
Status	FINAL
Classification	Client's Discretion
Date	17 January 2001

Author:

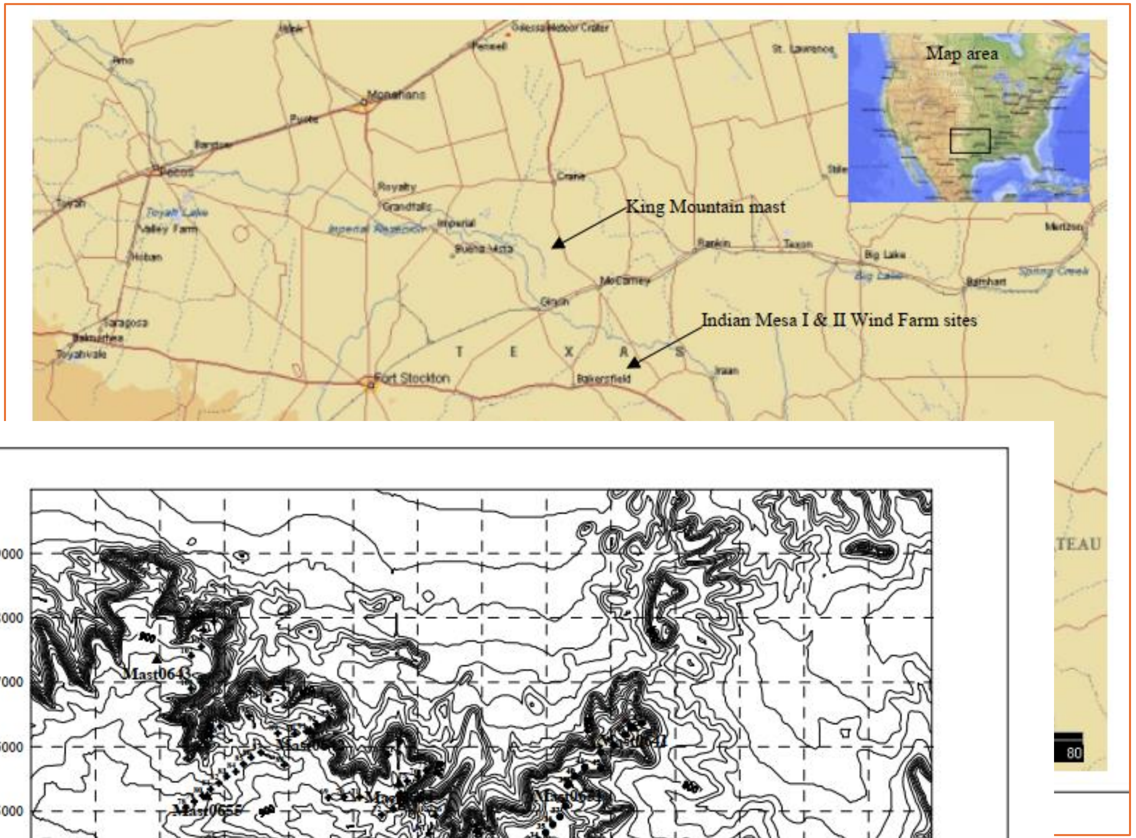
A Schwarz

Checked by:

A J Tindal

Approved by:

A D Garrad



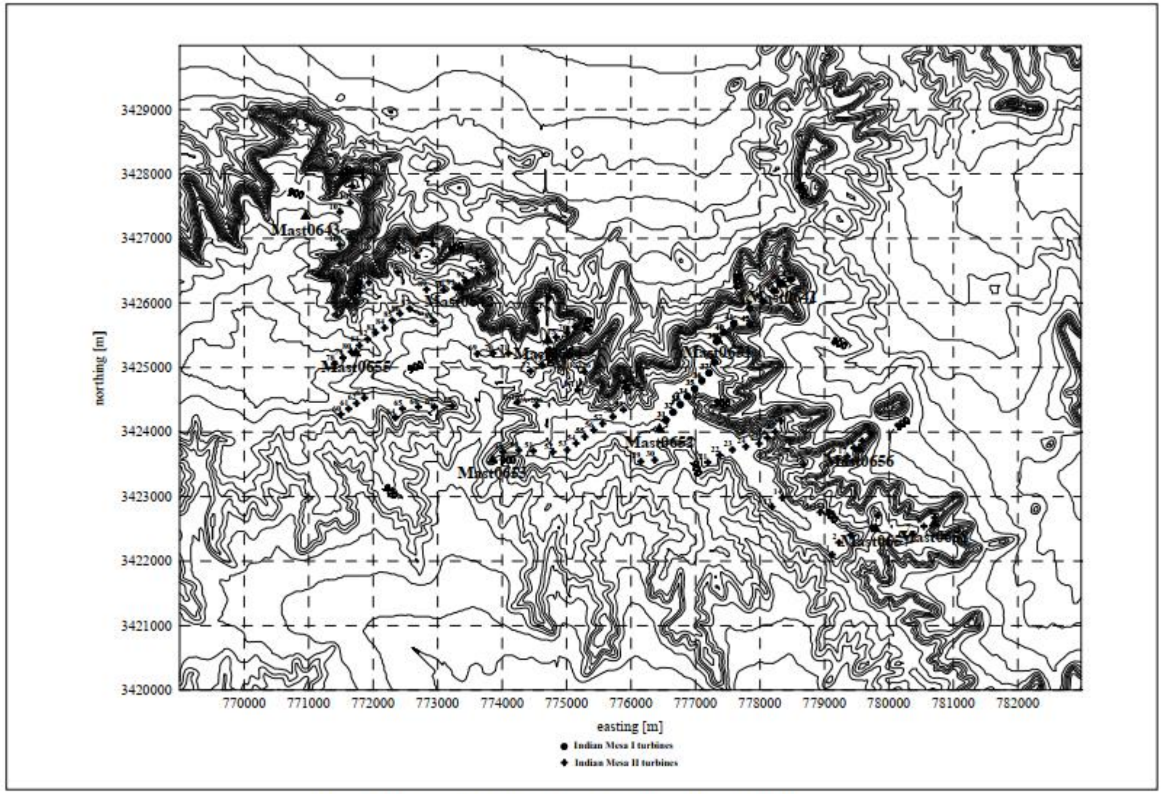


Figure 5.1 Layout of the proposed Indian Mesa Wind Farm.

1997

EC THERMIE project

De-risking wind power finance

UNDERSTANDING THE RISKS OF FINANCING WIND FARMS

RES
WE

Action Nr: STR-0939-1996-GB   Starting Date: 01-Feb-97   ONGOING

Aims and objectives

The main aims of the project is to reduce the cost of wind generated electricty. It has the following intermediate aims and objectives :
- To minimise the cost of money available to wind farm developers by allowing banks to make a realistic estimate of risk.
- To identify and quantify all the uncertainties associated with the inputs to the economic analysis of a wind farm development.
- To assess the impact of the uncertainties on lay financial indicators for a range of example projects.
- To investigate methods of reducing the risk associated with the project.
- To provide a handbook which can be used for risk analysis of wind farm projects.

Description

The first task of the project is to identify areas of risk to a wind farm project. The broad areas of risk have been defined and include the following: Sponsor/completion; Technology, Input/Supply; Offtake/Sales, Operating, Approvals/Environmental risk, Insurance, Financial risks.

Each of the risk areas will be assessed in detail as part of the second task. Progress has been made in the formation of a database addressing the different forms of financing which have been employed in real wind farm projects and in the establishment of a "risk register". An appropriate methodology has been identified and has been employed on example wind farms.

Expected Results

It is envisaged that one of the main achievements of the project will be to improve the understanding of the risks associated with wind farm projects such that improved risk management techniques can be employed. The production of a hand book which can be used for risk analysis of wind farm projects will play important role in the dissemination of the findings of the project. The findings of the project are expected ultimately to reduce the cost of wind generated electricity.This will assist the increased penetration of wind energy providing increased business opportunities for all organisations active in the wind energy field. The project participants expect new business opportunities to arise as a result of the study.
It is envisaged that the results of this project will have a direct positive impact on the number of wind energy developments which are successfully financed. It is also expected that improved risk management strategies will improve the performance of future wind farms.

- Business-Mission
- Seminar
- Workshop
- Exhibition-stand
- Conference
- Training
- Exhibition
- Publication
- Audit-assessment
- Study
- Electronic Catalogu
- **Other**

Finance

EU Support: 185.585 ECU   Eligible cost: 274.650 ECU

Contact

Co-ordinator: GARRAD HASSAN AND PARTNERS LIMITED
Address: THE COACH HOUSE, FOLLEIGH LANE, LONG ASHTON
BS18 9JB BRISTOL
UNITED KINGDOM

Responsible: ANDREW GARRAD
Tel: 44 1275 394 361
Fax: 44 1275 394 361
Email:

Participants: BAYERISCHE VEREINSBANK AG — DEUTSCHLAND
ENERNOVA NOVAS ENERGIES S.A. — PORTUGAL
HAMBROS BANK LIMITED — UNITED KINGDOM

1999 European Wind Energy Conference, 1–5 March 1999, Nice, France pp496–499

UNDERSTANDING THE RISKS OF FINANCING WIND FARMS

Peter Raftery, Andrew Tindal, Garrad Hassan and Partners Ltd,
The Coach House, Folleigh Lane, Long Ashton, Bristol, BS18 9JB,UK
Marc Wallenstein, Bayerische Hypo-und Vereinsbank,
AG Am Tucherpark 180311, Munich, GERMANY
Jonathan Johns, Ben Warren, Ernst & Young, UK
Broadwalk House, Southernhay West, Exeter EX1 1LF
Mr F Dias Vaz, Enernova Novas Energias, S.A.,
Av Sidonio Pais 24 -2°Dt°, 1050 Lisboa, Portugal

ABSTRACT: Garrad Hassan have co-ordinated a research project under the CEC Thermie programme to assess the risks associated with wind farm projects. The other members of the project team were Bayerische Hypo und Vereinsbank, Ernst & Young and Enernova Novas Energias S.A.. All potential sources of risk to a potential wind farm project have been assessed and from this a register of risks has been developed. From a detailed investigation of the various risk elements, it was possible to identify those which can be effectively mitigated, for instance through appropriate contractual structuring, and those which lend themselves to statistical quantification. A probabilistic analysis methodology for the financial modelling of wind farms has been developed. This model allows Monte Carlo analyses to be undertaken assigning statistical distributions rather than discrete values to key input parameters. From this analysis the resultant distributions of the financial indicators of key importance to the decision maker are calculated. From the results of the probabilistic analysis conclusions are drawn with regard the input parameters with greatest influence on the financial performance of a wind farm. Furthermore a risk management handbook has been written which provides recommendations for the effective management of risk within wind farm developments.

Keywords: Wind Farm, Economics, Statistical Analysis, Cost analyses

1 INTRODUCTION

An inter-disciplinary team has been assembled to assess the risks associated with investment in wind energy projects. This investigation has involved five main tasks which are summarised below:

- To identify all the uncertainties associated with financing a wind farm development
- To determine which uncertainties lend themselves to quantification using statistical techniques and which do not.
- To quantify uncertainties associated with inputs to an economic assessment of a wind farm development
- To develop a model which will allow assessment of the impact of these uncertainties on key project financial indicators.
- To investigate methods of reducing the risk associated with a wind farm project.

The partners in this project were Garrad Hassan & Partners, a leading independent wind energy consultancy, who have performed due diligence work for banks on many wind farm projects; Bayerische Hypo und Vereinsbank and Ernst and Young, who have both been involved with the financing of many wind farm developments; and Enernova Novas Energias S.A, a Portuguese utility with a strong interest in promoting wind farms. The project team was constructed to include organisations with experience of both technical and financial aspects of wind energy projects to allow assessments of risks from both of these perspectives.

A full report of the work undertaken is currently being finalised [1]. This report provides a more complete description of the work which has been undertaken.

2 IDENTIFICATION AND CLASSIFICATION OF RISKS

The broad areas of risk, as perceived by a provider of debt in a project financed development, can be conveniently presented as a risk register summarised within the following categories:

- Sponsor / completion risk
- Technology risk
- Energy production risk
- Offtake / sales risk
- Operating risk
- Regulatory risk
- Insurance risk
- Financial risk
- Country risk

From a detailed investigation of the various risk elements, it was possible to identify those which can be effectively mitigated, for instance through appropriate contractual structuring, and those which lend themselves to statistical quantification. It was found that thé energy production risk, and to a lesser extent the technology, operating and financial risks, benefit from statistical assessment while the other areas of risk lend themselves to mitigation through the due diligence procedure and through appropriate assignment of risk within the project contract structure.

PROJECT NAME	SIZE	CLIENT
1999-2000		
Foote Creek IV, USA	17.2MW	Clarica Life Insurance Company/Probyn & Company
Bourlari Spata, Greece	8.58MW	Aeoliki Parka Kykladon – Bourlari Anonymi
La Carracha, Spain	49.5MW	Hypovereinsbank
Plana de Jarreta, Spain	49.5MW	Hypovereinsbank
IVPC 4, Italy	330 MW	Mediocredito Centrale
Oak Creek, Repower, USA	20 MW	M&N Windpower, Mees Pierson
Lake Benton II, USA	103.5 MW	Mees Pierson, Credit Suisse First Boston
Storm Lake I, USA	112.5 MW	Mees Pierson, Credit Suisse First Boston
Storm Lake II, USA	80.25 MW	Mees Pierson, Credit Suisse First Boston
Castelfranco, Italy	30 MW	Filippe Sanseverino srl, Mediocredito Centrale
Os Corvos/Coucepenido, Spain	33 MW	BBV
Xistral, Phase 1, Spain	60 MW	Chase Manhattan
Desebro, Spain	15 MW	Dehesa del Coscojar
1998-1999		
WestWinds, Palm Springs, USA	43 MW	Cinergy Global Power
Foote Creek, Wyoming, USA	25 MW	Mees Pierson
Apollo, Hawaii	10 MW	Probyn & Co
Phases I-IV Xistral, Spain	240 MW	Chase Manhattan
Fonte Tortosa, Spain	30 MW	BBV
Os Corvos/Coucepenido, Spain	33 MW	Chase Manhattan Bank
Cabazon, California, USA	40 MW	Mees Pierson
Le Nordais, Canada	100 MW	Mutual Life of Canada

1997-1998		
Drumlough Hill, Ireland	5 MW	WindMaster Developments
Cape Verde	3 MW	World Bank
IVPC, Italy	165 MW	National Westminster Bank
Haverigg II, UK	3 MW	Triodos Bank
NSP II Lake Benton, USA	107 MW	Mees Pierson
Vila Lobos, Portugal	10 MW	Midlands Power International
Mynydd Gorddu, UK	10 MW	Mees Pierson (Zond)
Sant'Agata, Montefalcone, Anzano/Monteleone, Alberona, San Giorgio/Molinara, Italy	165 MW	Babcock & Brown (IVPC)
1996-1997		
Lynch Knoll, UK	500 kW	Triodos Bank
Putlur, India	20 MW	NEDPOWER
Pena Suar, Portugal	10 MW	Tararua Wind Power (CentralPower Generation Ltd and Merrill International, (NZ) LTD)
Fonte de Mesa, Portugal	10 MW	Hidrorumo Projecto Y Gestao
1995		
Dyffryn Brodyn	10 MW	Hambros Bank
Caton Moor, UK	3 MW	Hambros Bank
1993		
Taff Ely, UK	10 MW	Hambros Bank
1991		
Ovenden Moor, UK	10 MW	Yorkshire Water/Yorkshire Electricity

A major constraint for the industry in its search for project finance debt is the negative image which much of the banking market currently has about wind power.

Lenders recall the early days of the Californian wind rush and the many losses which followed*; for those who know a little more about the industry, the spectre of Kenetech continues to haunt them.*

Yet as the need for project finance grows across the wind sector, so too will the need for banks willing to lend into the market.

Michael Davies, MeesPierson, 1998 (EWEA newsletter)

GH as 3rd party consultants for Banks in Europe and the US

1991 – 1997 (Lake Benton)

BLADED

For Windows: 1996

(devt started in the 80s)

EC JOULE project

A Design Tool for Wind Turbine Performance and Loading

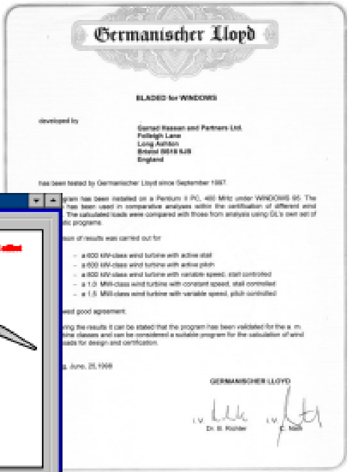
GARRAD HASSAN

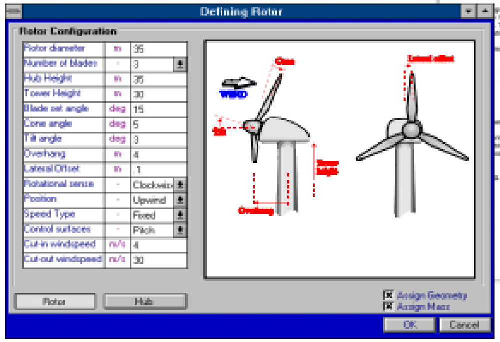
Bladed for Windows is an integrated package which allows the user to carry out the full range of performance and loading calculations required for the design and certification of wind turbines, both onshore and offshore. The programs have been extensively validated against measured data from a wide range of turbines.

BLADED for Windows

The Garrad Hassan approach to the calculation of wind turbine performance and loading has been developed over the last fifteen years. The main aim of this development has been to produce reliable tools for use in the design and certification of wind turbines.

The Windows-based graphical user interface and on-line help facility makes ***Bladed for Windows*** easy and convenient to use. It is the "industry standard" for wind turbine design calculations. ***Bladed for Windows*** supports calculations of combined wind and wave loading, with full aeroelastic and hydroelastic modelling. ***Bladed for Windows*** has been validated by Germanischer Lloyd for the calculation of wind turbine loads for design and certification.





Turbine Model

Rotor

- 1, 2 or 3 blades
- Fixed or teetered hub
- Tilt, cone and delta-3 angles
- Upwind or downwind orientation
- Full and partial span pitch or aileron control
- Clockwise or anticlockwise rotation
- Teeter restraints

Drive train

- Stiff or torsionally flexible shafts
- Flexible mountings on gearbox or pallet
- Alternative shaft brake positions

Generator

- Fixed speed and two-speed induction
- Electrical model for voltage variations and network interactions
- Variable speed and variable slip models

IEA TEM#28 (1996)

BLADED for Windows

Over the last three years Garrad Hassan have been developing the Wind Turbine Design Tool under Joule contract to the CEC. The Design Tool, known as BLADED for Windows, is based on the validated computer programs referred to above but with an extremely user-friendly, Windows based user interface. The user interface is designed to allow the user to enter the relevant data to describe the turbine and the required calculations in a rapid and straightforward way, with graphical aids available on the screen where appropriate to ensure clarity. Example data entry screens are given in Figures 2, 3, 4 and 5.

References

1. Quarton D C, Wastling M A, Garrad A D and Hassan U, "The calculation of wind turbine loads - a frequency or time domain problem?", Proceedings of British Wind Energy Conference, Nottingham, 1992.
2. Veers P S, "Three dimensional wind simulation", SAND88 - 0152, Sandia National Laboratories, March 1988.
3. Engineering Sciences Data Unit, "Characteristics of atmospheric turbulence near the ground. Part II: Single point data for strong winds", ESDU 74031, 1974.
4. Wilson R E and Lissaman P B, "Aerodynamic performance of wind turbines", Oregon State University, June 1976.
5. Prandtl L and Tietjens O G, "Applied Hydro- and Aeromechanics", Dover Publications Inc., 1957.
6. IEC 1400-1, Wind turbine generator systems - Part1: Safety requirements, First edition, 1994-12.
7. Leishman J G and Beddoes T S, "A semi-empirical model for dynamic stall", Journal of the American Helicopter Society, July 1989.

Large offshore wind study for the EC.

1993 - 1995

EC JOULE project

- Study of offshore wind energy in the EC : Joule I (Jour 0072)
  Germanischer LLoyd AG | TIBKAT | 1995
- Study of offshore wind energy in the ec : Joule 1 (Jour 0072) / Germanischer Lloyd ... H. G. Matthies; A. D. Garrad ...: Executive summary : offshore wind turbines
  Germanischer LLoyd AG | TIBKAT | 1993
- Study of offshore wind energy in the ec : Joule 1 (Jour 0072) / Germanischer Lloyd ... H. G. Matthies; A. D. Garrad ... ; Vol. 4: The dynamic loading of offshore wind turbines
  Germanischer LLoyd AG | TIBKAT | 1994
- Study of offshore wind energy in the ec : Joule 1 (Jour 0072) / Germanischer Lloyd ... H. G. Matthies; A. D. Garrad ... ; Vol. 1: Offshore wind energy potential in the EC
  Germanischer LLoyd AG | TIBKAT | 1993
- Study of offshore wind energy in the ec : Joule 1 (Jour 0072) / Germanischer Lloyd ... H. G. Matthies; A. D. Garrad ... ; Vol. 3: Preliminary guidelines for certification of offshore wind energy converters
  Germanischer LLoyd AG | TIBKAT | 1994
- Study of offshore wind energy in the ec : Joule 1 (Jour 0072) / Germanischer Lloyd ... H. G. Matthies; A. D. Garrad ... ; Vol. 2: Review of existing informaiton on offshore construction, erection and maintenance
  Schellin, T. E. / Germanischer LLoyd AG | TIBKAT | 1994