

An **Energy3 Services Ltd.**
White Paper



Wind Data Analysis & Verification Reports

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31st May 2010



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Introduction

Energy3 have developed a Wind Data Analysis & Verification reporting tool. This tool was specifically designed for the Wind Energy Industry to improve the quality and accuracy of data collected from remote wind monitoring sites. It achieves this by interrogating the data to identify any erroneous values as well as helping to identify the possible cause of the fault. This allows data performance to be evaluated and corrective actions to be taken thus minimising data loss. This in turn helps to improve the cost effectiveness of a wind monitoring program. The tool accepts raw data in any format (CSV, tab delimited, space delimited, etc). The final product of the report is a PDF document which contains both a data validation and wind resource report.

Problem Statement

There are many commercially available Wind Resource Analysis software packages. In general, these software packages only provide a reporting and/or analysis capability. However; operational problems occur when the data received has erroneous values or is incomplete. In these cases, the analyst needs to identify what data is invalid and ascertain what actions need to be taken to ensure the integrity of future data collection. The Energy3 tool delivers this capability, enabling the analyst to more efficiently undertake further energy yield analysis, and for the wind monitoring equipment to be repaired and maintained in a cost effective manner.



Data Collection

Data can be collected from a variety of different dataloggers (such as NRG, Campbell Scientific, Unidata, Nomad, EOL) using the appropriate remote communications software. Almost any datalogger can be interrogated if a remote connection is possible using cellular, radio or satellite communications. Data can be downloaded internationally if required. Data is collected on a customer specified schedule (most commonly weekly). At the time the data download is carried out the following checks are performed:

- Real time values checked to ensure all sensors all are functioning correctly.
- Battery voltage is checked.
- The datalogger clock is checked to ensure no time anomaly exists.
- The period of data collected is checked to ensure no data is missing.
- Memory space on the datalogger is sufficient to ensure future recording.

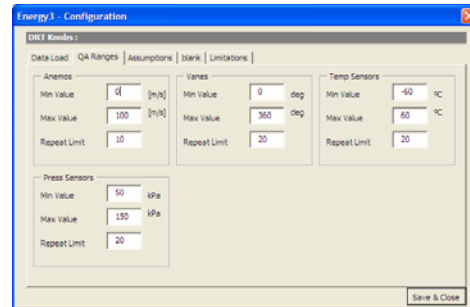
Data Validation

A data validation is carried out on a customer specified schedule (most commonly weekly).

The data validation involves an automatic rigorous check of each individual data value. The validation process checks for:

- Data values out of range
- Repeating data values
- Missing data values
- Comparison of similar data types to ensure they are within a certain agreement (e.g. two wind vanes at different heights should read within 20° of each other at all times.)

All boundary values in the validation tool are customisable using the Configuration Menu:



Benefit 1

The recovery rate of data collected is analysed to ensure no data is missing. The extended recovery rate is also analysed to examine how much of the collected data is actually valid.

Benefit 2

The accuracy of the data is validated for further use in other software packages such as Wind Farm, WASP, Meteodyn, etc. Data is not manipulated or changed in any way; however; the data validation tool flags any suspect or missing data.

Benefit 3

Faulty sensors can be identified easily allowing repair and maintenance to be carried out and minimise data loss.

Benefit 4

Further identification of non-evident issues with sensors e.g. sticky bearings, worn potentiometers, boom movement, riming etc,

A sample of the weekly data validation report is shown below:

Weekly Data Validation Report						
Mast Identification	% Data Recovery	% Data Validated	Instrument Status	Battery Status	Comms Status	Issues/Notes
Big Hill 1	100	100	Green	Green	Green	OK
Big Hill 2	100	98	Green	Yellow	Green	Low Battery Power noted
Windy Gully A	100	100	Green	Red	Green	Battery very low
Windy Gully B	50	50	Yellow	Green	Green	Intermittent 50m anemometer
Windy Gully C	100	75	Green	Green	Yellow	Intermittent access to data
Puffer Gap	100	100	Green	Green	Green	OK
Wind Blower	0	0	Green	Red	Red	No comms available

Data Reporting

The data reporting tool creates a full, detailed report on many key aspects of a wind resource study.

Each site to be reported on has a “header” file associated with it which details all aspects of the sites details for the report. The header file contains the following information:

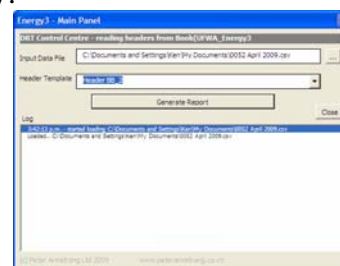
- Data structure/Column index (e.g. column 1 = date/time; column 2 = Average wind speed at 60m; column 3 = Standard Deviation of wind speed at 60m, etc)
- Sensor identification
- Sensor height
- Data units (e.g. m/s, degrees, kPa)
- Instrument height
- Datalogger channel for each instrument
- Serial number of each instrument
- Slope and offset for each instrument (and any processing of slope and offset in the datalogger program)
- Boom azimuth
- Horizontal and vertical distance of boom / instrument from tower
- Row number for start of data (e.g. data starts in row 3 of the CSV file)

- Project, Site & Location names
- Client details / contact person
- Site GPS Coordinates, elevation, datum and zone
- Datalogger type and serial number
- Modem type, serial number and calling number
- Mast type, height and installation date
- Time zone (e.g. GMT+12)

The above header details are utilised every time the report is run for a particular site. This allows the reports to be easily populated with the correct information and avoids having to define and enter details every time a report is run.

The header files once created can be easily edited but in general do not require modification unless changes are made to the site.

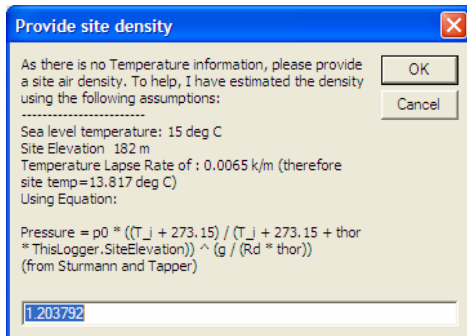
To run a Wind Data Analysis and Verification Report, a data set is loaded in to memory:



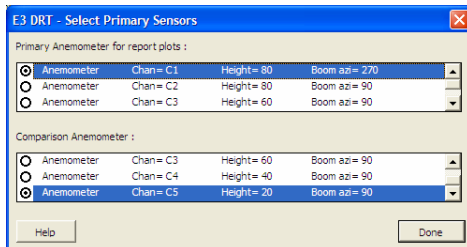
The data file can be in a variety of formats including CSV, space or tab-delimited. Once the data file is loaded in to memory the appropriate header is selected. When the report begins to run, user input is required regarding:

- *Site Air Density* – The user can utilise temperature and pressure sensors (if fitted to the mast) to allow

the tool to calculate a site air density value. If no temperature or pressure sensors are fitted, the user can enter a specified air density value, or rely on a calculation using the site elevation data specified in the Site Header:



- *Primary and secondary anemometers* - for wind shear and turbulence analysis:



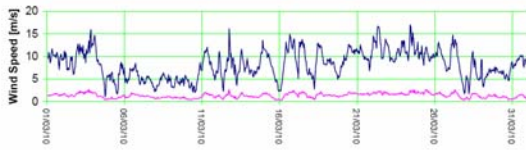
Once the user has input the above variables, the tool will run and produce the draft report. The report is fully editable allowing post processing changes to be made if required. Details and comments can also be inserted in to text boxes to allow the user to enter specific comments or identify and outline any issues observed for the final report. The tool reports on the following aspects:

- Report information (client, project, contact person, site location & name, report number)
- Mast Summary Details (mast type/height, logger type, coordinates, elevation, datum, zone, time zone, date of installation, & first data record)
- Instrument configuration and parameters (instrument type, height, datalogger channel, azimuth, slope and offset)
- Logging configuration (logging period i.e. 10 minute data, average, standard deviation, maximum, minimum, gust)
- Data recovery and extended data recovery rates – the data recovery rate indicates the completeness of the data set, whereas the extended data recovery rate indicates the percentage of ‘valid’ data within the data set.
- Wind Statistics Summary:
 - Minimum, average and maximum wind speeds
 - Gust speeds
 - Average standard deviations
 - Turbulence intensity
 - IEC Turbulence intensity
 - Wind Power Density
- Environmental Statistics Summary
 - Temperature, pressure, humidity, rainfall, air density (average, maximum & minimum reported where available)



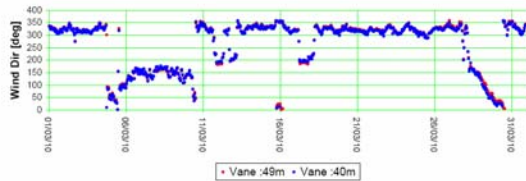
- Time Traces of wind speeds and standard deviations (primary and comparison anemometers)

Time Traces of Wind Speed and Standard Deviation 50m



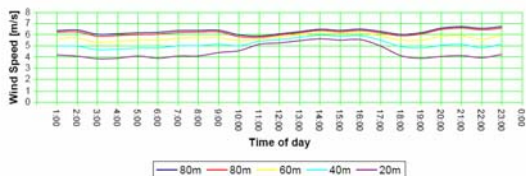
- Time traces of temperature and standard deviation
- Time trace of Wind Directions

Time Trace of Wind Directions (49m 40m)

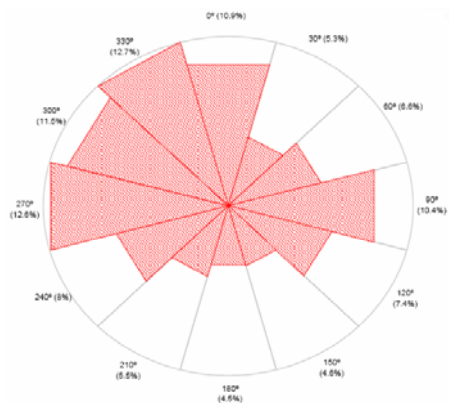


- Diurnal wind speed trace

Diurnal Patterns of Wind Speed (all levels)

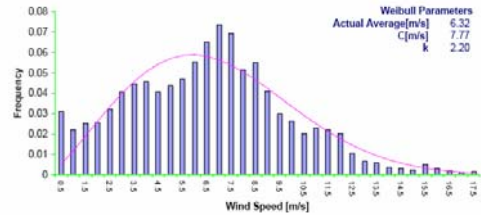


- Wind Rose



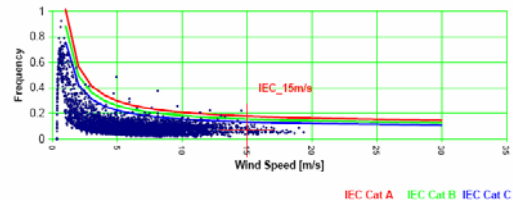
- Wind Speed Frequency Distribution and Weibull Curve

Wind Speed Distribution and Weibull Curve 80m



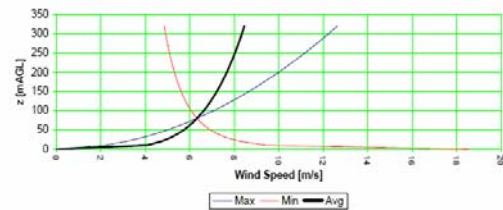
- Turbulence Intensity Plot (including IEC classification)

Turbulence Intensity Distribution 80m

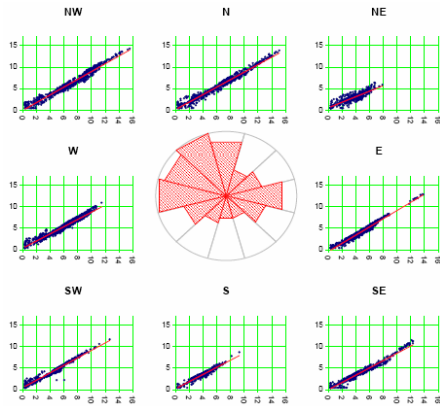


- Wind Shear Ranges (including average maximum and minimum scenarios plotted)

Wind Shear Ranges



- Directional Wind Shear Components
- Inter-sensor correlation of Wind Shear Components for primary and secondary anemometers



Data Warehousing

Data that is collected is stored on a central server. This server is backed up daily to network attached storage (NAS) drives. Off-site backups are performed weekly. Data can also be stored on the internet to provide a non-physical remote backup device if required.

This setup provides secure and robust storage ensuring data is not lost even in the event of fire.

Data Delivery

Data (raw data, processed data and reported data) can be delivered to the client at any defined time interval or upon request. Data can be delivered via email, FTP or other storage medium depending on data set size and client preference.

Data validation reports are delivered to the customer and specific issues noted so as an action plan can be established if repair or replacement of instruments is required.

Integration

The suite of services available (downloading, validation, reporting and

delivery) can be easily integrated in to any number of wind resource studies. Data can be managed from multiple sites, datalogger types and international locations. Raw data can be provided to the client at any stage to integrate in to other Wind Analysis Software.

Summary

Energy3 have developed the Wind Data Analysis and Verification Reporting Tool to provide a robust assurance that data is monitored effectively, data integrity is maximized, and any faults with the data monitoring equipment reported immediately. The costs of data collection can be significant; deployment of a rigorous data validation and analysis procedure ensures that the money spent on wind measurement is not wasted, and that wind engineers and developers record and use accurate data. Energy3 have the capability to integrate this tool with data collection and validation for any number of clients and masts both locally and internationally.