logicenergy
LIVE MONITORING

MAKE WIND PAY

Wind Logging

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General aspects of Wind Logging
TABLE OF CONTENTS

Page #

1.0 GENERAL INFORMATION

The following document summarises a number of important aspects relating to wind measurement for wind energy generation. The information is based on years of experience, consultation with wind energy experts, real recorded data and information given by wind turbine manufacturers.

2.0 INTRODUCTION

2.1 General description

The following tips should make it easier to achieve the best results possible when logging wind and carrying out energy and economic predictions for wind turbines. We have attempted to summarise what aspects to take into account when buying equipment, and what mistakes to avoid when, and during installation.

2.2 Most common questions

For how long do I need to log wind?
It is strongly advised to log for a least a year.

How accurate needs to be my equipment?
Anemometers need to be at least 1% accurate and with a resolution of 0.1m/s. Class 1 anemometers will come with a traceable certificate confirming the accuracy of the anemometer and wind vane.

A small economic wind sensor tends to have a +/-5% accuracy, however these are often calibrated with +/-5% accuracy measurement equipment[1]. To add to this, weather conditions vary ±20% from year to year.

What do all these tolerances mean in terms of ROI? It means that if not using accurate equipment, energy calculations can easily deviate from **72% to a 132%.** This is without taking into consideration the quality and sitting of the wind mast.
A wind turbine is a big investment and you should make a well informed decision. The same way a potential site can be overestimated on energy, it can be underestimated losing a potential site or customer.

Sampling rate, average logging…?

- Sampling rate is how often the wind monitoring equipment measures wind speed, the sampling rate should be as fast as possible and no less than every 3 seconds.
- Average logging is the frequency the wind logger records the data on to its memory as average, maximum wind speed, etc.

How often does data needs to be recorded: every 10 seconds, 1 minute or 10 minutes?

- 10 seconds is often used in research for wind turbines to acquire a very accurate profile of the wind and the response of the wind turbine to it. Also for in detail analysis of wind profiles.
- 1 minute is best for small scale wind turbines for a few kW
- 10 minutes is often used in bigger wind turbines where towers are +25 meter high and the wind turbulences are much less likely to occur than at the typical 10-25 meters height of the small wind turbines.

For small scale wind turbines [+2kW] a difference in recording data every minute or every 10 minutes can have a significant impact, as small wind turbines change their rotational speed much quicker than those turbines used in big wind farms.

[1] 1% accuracy: In UK there're only 1 or 2 certifications centres that can product a real <1% accuracy report.

Why record wind direction?
It is possible to only log wind speed to get a quick idea but to really find the location, the blade specifications for the wind turbine, etc it is very important to have wind rose as it will define much better the wind profile on the site.

Where is the best place to install a wind logging kit?
As far as possible from any obstacle and as close as possible to the planned wind turbine spot. Installing anemometers on top of a barn or house is not a good idea.

What type and height of wind mast should be used?
A good quality wind mast and strong support lines is very important. Over time, and after strong winds the anchor points for the wind mast will seize a little bit making the top of the mast bend back and forward on the wind direction. This could cause bad readings on the wind speed.

- Wind masts should be no less than 10 meter height, the higher the better

I have got all this wind data, what do I do with it?
We recommend always letting a professional analyse wind data, there're many aspects of it that cannot be automated and a qualified person should revise the data and produce a report before seeking funding.

How can I convert wind speed into energy available at my site?
This is a lot simpler than people think, just do a frequency distribution of the wind speed data and multiply the number of hours by the power curve of the wind turbine to be installed. See Section 7.0 for more details.

3.0 THE COST OF ACCURACY & RELIABILITY

3.1 General demands

The quality demands, accuracy and reliability of measuring equipment needed for wind energy generation and profit prognosis applications are much higher than those used in meteorological, agricultural or general scientific analysis. A small deviation of the results leads to large miscalculations and builds up the risk of the economically non-viable operation of the planned investment

For this reason, data has to be recorded for at least 12 months and it is crucial to select the correct choice of sensors and installation of the measuring systems. **Mistakes here will add larger tolerances on the end results.**

If you plan to seek professional wind expert advice later for site analysis, you should provide accurate measuring results, and demonstrate the correct set-up of the measuring system.

3.2 Example

<table>
<tr><th colspan="3">Typical measurement adapted to small scale wind kit measurement</th></tr>
<tr><td>Correct measurement

10 m = 5.01 m/s
15 m = 5.73 m/s</td><td>The result is a roughness length of 0.56 m or a wind speed in 18m height of 6.05 m/s</td><td>A Gaia-Wind with 11kW power and a hub height of 18m will produce on this site per year:

32.4MWh</td></tr>
<tr><td>Possible deviations

10 m = 4.81 m/s
15 m = 5.93 m/s
• no calibration
• wrong fitting
• skew wind
•</td><td>The result is a roughness length of 1.753 m or a wind speed in 18m height of 6.43 m/s</td><td>A Gaia-Wind with 11kW power and a hub height of 18m will produce on this site per year:

36MWh</td></tr>
<tr><td colspan="2">Error at 10m = -0.2 m/s (- 4.19%)
Error at 15m = +0.2 m/s (+ 3.5%)</td><td>Energy overestimation

11.11%</td></tr>
</table>

Table.1

With the Feed In Tariff [**FIT**] at 23p per kWh plus the electricity bought from the grid (usually about 10p for domestic use) = 33p per kWh x (36MWh – 32.4MWh) = **£1,188 per year!!** Imagine when installing a 50kW wind turbine.

4.0 COMMON AVOIDABLE MISTAKES

4.1 Wrong anemometer

You want to measure the unrestricted horizontal component of the wind stream because this is what is relevant for energy generation. Wind sensors with small cups and a sharp-edged body often have trouble with skew winds and turbulence caused by tower and traverses. Even calibration cannot help much in these cases.

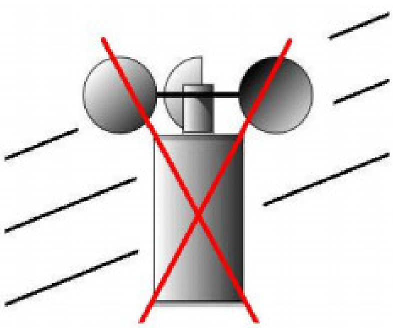

Fig.1

Even some high accuracy developed anemometers do not meet the requirements for accurate energy prognosis. Tolerances specified by the manufacturers can lead to unacceptable deviations in the profit calculations. You only get the necessary reliability of the forecast if each anemometer is calibrated separately in a wind tunnel.

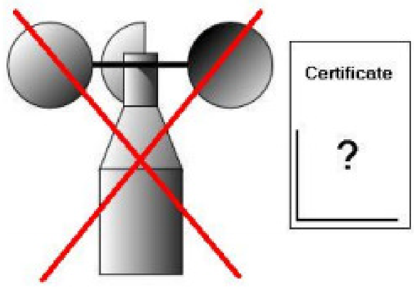

Fig.2

Low cost anemometers tend to suffer from a “drag” effect over time. This means that the economic materials used on its construction will have an effect on their reliability. Accuracy at manufacturing point, won’t be the same few months later. Some of the symptoms are:

- Over time it will take more wind to get the anemometer rotating.
- With light breezes the wind vane may be rotating and the anemometer will generally not be rotating.

If you are trying a new anemometer without a long term track record name, it is advised you install this anemometer together with a well known and respected anemometer so you can compare results over a long period of time.

4.2 Wrong traverses

- Close to the tower and traverses there is always turbulence and shading, which can have a negative effect on the measurements. The boom itself must have a minimum length.
- The highest and most important anemometer should be streamed upon from all directions without obstacles on a top position. A second anemometer can be installed at a lower height used mainly to find wind roughness/shear

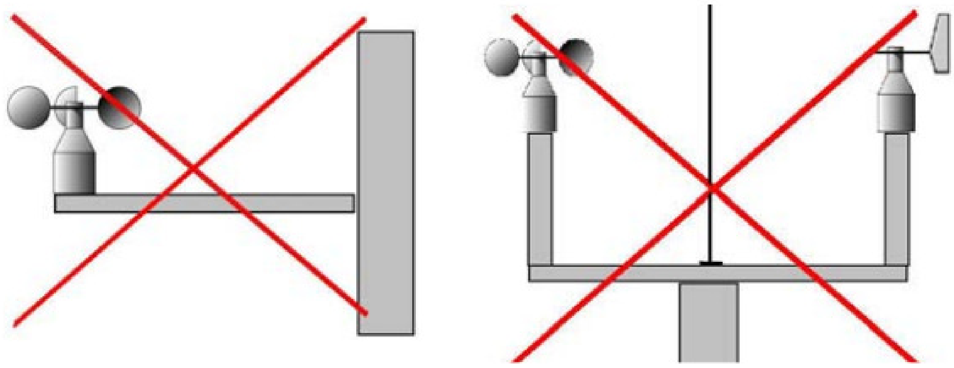

Fig.3

4.3 Wrong measuring heights

- Data from anemometers that are shaded by houses, trees or other obstacles is unsuitable
- Anemometers fitted too near to each other give inadequate data for the calculation of the height profile, since the difference between the two results is too small.

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5.0 CHOICE OF SENSORS

5.1 Anemometers

Cup anemometers are the standard way of measuring

The key features are the linearity of the electronic signal and the insensibility of the anemometer to turbulence and skew winds caused by tower or traverses. Wind speed transmitters with a large cups and a bigger radius show much better attributes.

Fig.4

Opto-electronic transformers and AC-generators have proved to be the most suitable transducers for its robustness.

5.2 ANEMOMTER CALIBRATON

Anemometer manufacturers guarantee a certain accuracy for their products, for example +/-0.3 to 0.5m/s (or 3 to 5% for speeds above 15m/s). The measurements usually are sufficient for all needs on weather forecast and industrial processes.

FOR A RELIABLE PROGNOSIS IN WIND ENERGY THIS TOLERANCE IS NOT ACCEPTABLE!

When using non calibrated anemometers you may have bad luck to get an anemometer which operates at the limits of the tolerance range. The consequences of the resulting wrong measurements have already been described. We recommend using anemometers with a certificate.

The results of each anemometer calibration are presented in a calibration report, which describes precisely which aspects of the performance of the anemometer have been measured.

In really well-designed measuring projects the anemometers will be calibrated a second time after use: this makes sure that there have been no changes while measuring.

5.3 Wind vanes

For wind direction, potentiometer sensors are being used more because of its 1º resolution and low power consume. It is important to keep in mind that the out-going-signal has to cover a full 360º without gaps. Because they have only a very simple potentiometer, economic wind vanes often show a big north-gap. These “low cost” sensors can also have only a limited safe-life, because the electro-mechanical material used in their construction, are not durable enough.

Fig.5

The data logger also has to have suitable software to averaging the results, so that the “north jump” can be accounted for: the average of 350º and 10º should result in “North” and not 180º!

5.4 NOT ADVISABLE

COMBINED WIND TRANSMITTER
Never use a combined wind transmitter for wind energy prognosis, that is an anemometer and wind vane on the same boom. The combination means that the anemometer is not streamed on freely. The proximity of the boom and of the vane can have direct effect on the measuring data.

NOT ADVISABLE: ULTRASONIC ANEMOMETERS
Ultrasonic anemometers are also combined sensors. They are more difficult to calibrate since it must be done depending on wind direction. Also their power requirements are quite high and would make it impossible to work together with an stand alone wind logger for long periods of time.

NOT ADVISABLE: PROPELLER ANEMOMETER
Their main problem is the continuous pendulum-movement when the wind often changes. That influences the measurement of the wind power.

6.0 WIND MAST SIZES AND HEIGHTS

The ideal approach would be to measure the wind speed at the hub height of the wind turbine that is to be installed.

Ideally you will measure wind speeds at two heights. So the height profile on this location is determined [Zo[2]], which can be used to calculate the wind speed at other heights.
Since the calculation with a logarithmic formula represents only idealized wind circumstances and the difference of the average speeds in different heights is small, this implies:

- The use of individual calibrated anemometers with a low sensitivity against skew winds
- The lower anemometer must be fitted high enough to avoid influences by obstacles (bushes, houses, etc)
- The wind direction on a location needs to be monitored only once. The wind vane should be fitted about 1.5m below the top of the tower in order not to influence the top-anemometer.

On a simple location with no obstacles, a measuring tower with calibrated anemometers at two different heights is sufficient but in more complex areas the lower anemometer needs to be fitted higher. In order to provide minimum spacing between anemometers, the top anemometer needs to be positioned higher.

The wind direction sensor should be fitted about 1.5m below the top anemometer.

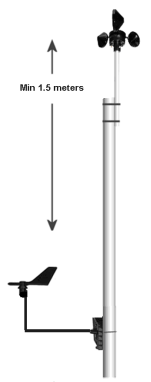


Fig.7

[2] Zo: roughness length

6.1 SETTING UP THE TOWER

The most important rules for the best possible tower-build-up:

- All wind sensors must be fitted absolutely vertically.
- Traverses keep the sensors as far away as possible from shaded or turbulent areas.
- Top-anemometer is to be placed centrally on the top of the tower. It must be streamed on from all directions without obstruction. For the last piece of the mast you should choose a diameter which is similar to the shaft of the anemometer's shaft.
- The lower anemometer(s) should be fitted on a vertical pipe attached to a traverse, so that the anemometer stays 30 to 60cm over the traverse. A traverse under the anemometer can influence measuring. The fitting must be such that the anemometer lies at a 45º angle to the main wind direction, which is usually known approximately.
- With a cylindrical tower, the length of the traverse should be at least 7 times the tower diameter. If you use a framework structure for the mast of 15cm, you should choose a traverse length of round about 1m.
- The wind vane needs to be fitted as high as possible on a traverse but at least 1.5m below the top anemometer.
- Cables must be fixed to the tower with intervals of 1 meter. Be sure that no loose cables are flying in the wind as these can lead to damage in the course of long-term operations.

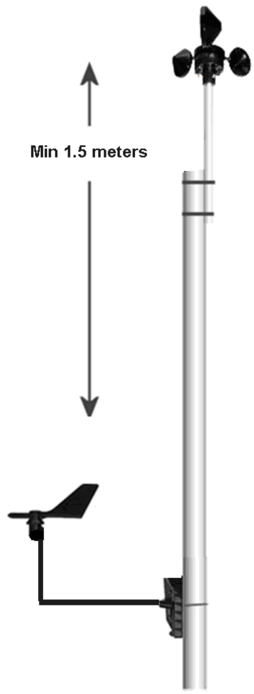


Fig.8

Spiral wraps sensor cables around the tower, one wrap per tube joint. The spiral promotes vortex shedding and reduces natural frequency oscillations of the tower. Use electrical tape to tape the sensor cables and ground cab to the tower every few meters. Also tape cables to the tower above and below each guy ring. Where the cables cross each guy ring, protect the cables by wrapping them with a thick layer of electrical tape as shown below.

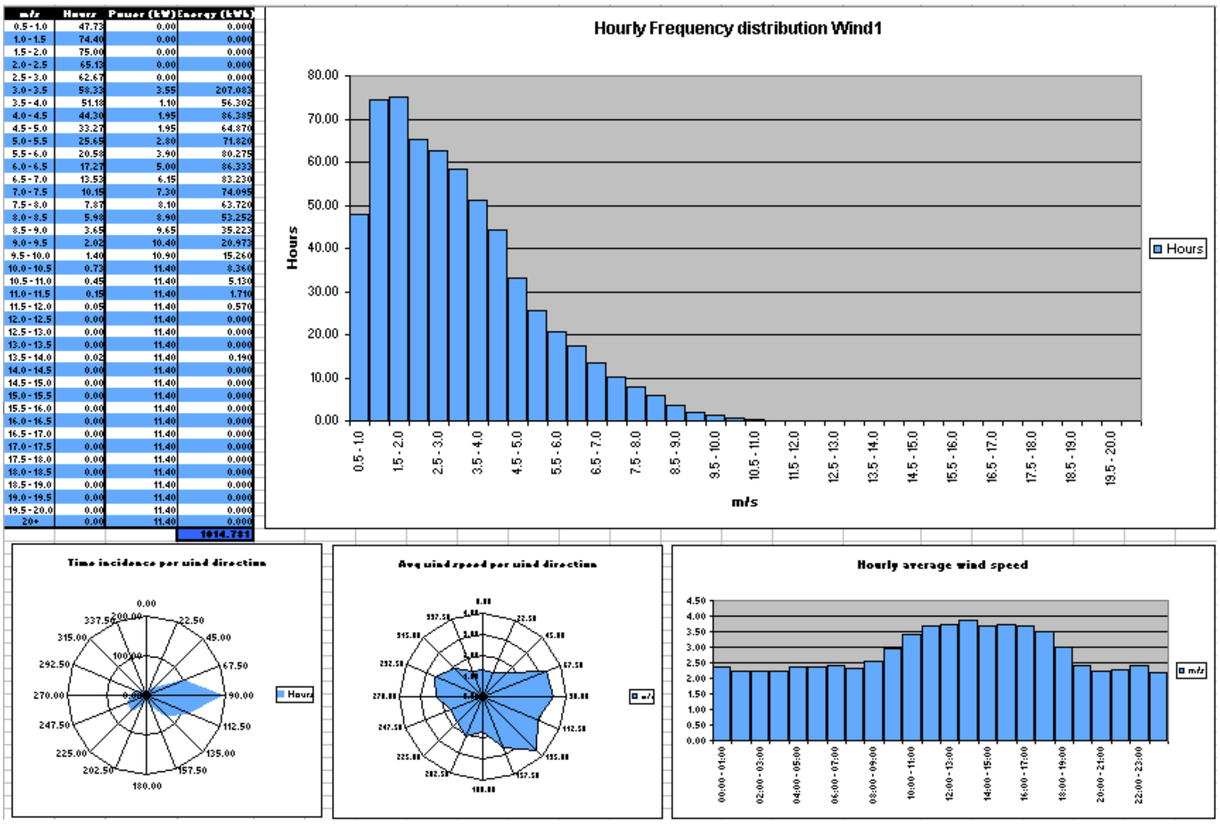
7.0 WIND LOGGING

7.1 DATA RECORDING

The basis of wind energy prognosis is the relative frequency distribution of wind speed.

- Rayleigh and Weibull Functions are used when only a few wind details are known about the site, like the average wind speed.
- Classifying measurement data, this procedure is used in order to get the measured data into a form which is general and reduced to the necessary facts. Data needs to be recorded at intervals of one minute or ten minutes for higher heights >20 meters)
- Data will be recorded over at least one year, so that seasonal fluctuations are taken into consideration. Furthermore, the data of a single year has to be compared with long-term data, because wind speeds over a single year can differ by up to 20% from the long-term average. Estimating energy with just a few months can result in big miscalculations, economic losses and frustrated customers.

If the measurement data has been recorded with sufficient resolution and accuracy and corrected as described, very good prognosis results will be obtained. For that purpose the average frequencies of the single wind speed classes will be multiplied with corresponding power values of the wind energy converter and then added. The result is the average output of the station, which – when multiplied with the number of hours is a year – gives you the annual power output in kWh.



m/s	Hours	Power (kW)	Energy (kWh)
0.5 - 1.0	47.73	0.00	0.000
1.0 - 1.5	74.40	0.00	0.000
1.5 - 2.0	75.00	0.00	0.000
2.0 - 2.5	65.13	0.00	0.000
2.5 - 3.0	62.67	0.00	0.000
3.0 - 3.5	58.33	3.55	207.083
3.5 - 4.0	51.18	1.10	56.302
4.0 - 4.5	44.30	1.95	86.385
4.5 - 5.0	33.27	1.95	64.870
5.0 - 5.5	25.65	2.80	71.820
5.5 - 6.0	20.58	3.90	80.275
6.0 - 6.5	17.27	5.00	86.333
6.5 - 7.0	13.53	6.15	83.230
7.0 - 7.5	10.15	7.30	74.095
7.5 - 8.0	7.87	8.10	63.720
8.0 - 8.5	5.98	8.90	53.252
8.5 - 9.0	3.65	9.65	35.223
9.0 - 9.5	2.02	10.40	20.973
9.5 - 10.0	1.40	10.90	15.260
10.0 - 10.5	0.73	11.40	8.360
10.5 - 11.0	0.45	11.40	5.130
11.0 - 11.5	0.15	11.40	1.710
11.5 - 12.0	0.05	11.40	0.570
12.0 - 12.5	0.00	11.40	0.000
12.5 - 13.0	0.00	11.40	0.000
13.0 - 13.5	0.00	11.40	0.000
13.5 - 14.0	0.02	11.40	0.190
14.0 - 14.5	0.00	11.40	0.000
14.5 - 15.0	0.00	11.40	0.000
15.0 - 15.5	0.00	11.40	0.000
15.5 - 16.0	0.00	11.40	0.000
16.0 - 16.5	0.00	11.40	0.000
16.5 - 17.0	0.00	11.40	0.000
17.0 - 17.5	0.00	11.40	0.000
17.5 - 18.0	0.00	11.40	0.000
18.0 - 18.5	0.00	11.40	0.000
18.5 - 19.0	0.00	11.40	0.000
19.0 - 19.5	0.00	11.40	0.000
19.5 - 20.0	0.00	11.40	0.000
20+	0.00	11.40	0.000
			1014.781

Fig.9

7.2 WIND ROSE

The recording of the wind direction at the site is very important so the wind turbines are positioned correctly avoiding shading effects. Furthermore, exact directional datasets are needed to crate streaming patters to determinate wind turbulences.

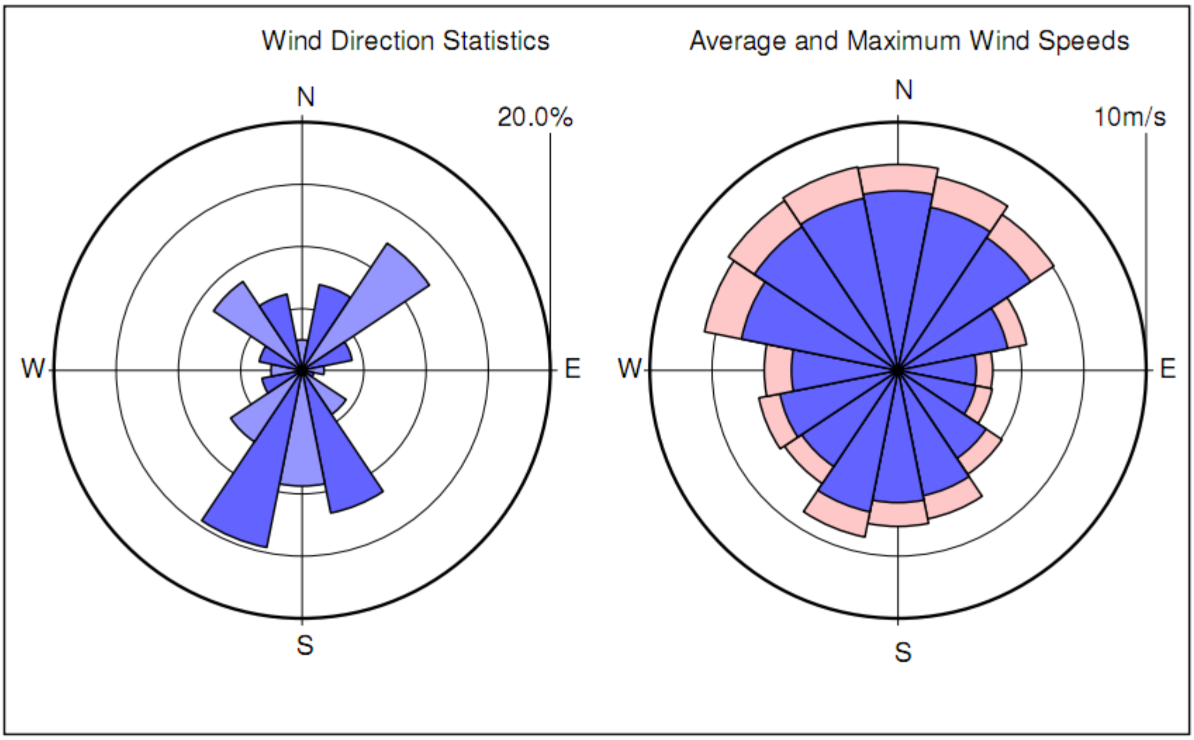


Fig.10

7.3 WIND DATA LOGGER

Good measurement systems will carry out extensive statistical pre-evaluations in addition to the time series of all measured data that will be registered. At regular intervals of 1 minute the average and extreme reading as well as the standard deviation will be calculated and stored for different anemometers connecting to the wind logging equipment.
With this type of wind logger[3] you can precisely have any wind information condition at any certain time:

- A more detailed evaluation is possible, for example the judgement of turbulence or elaboration of statistics for certain periods
- The data can be useful for other applications apart from wind energy prognosis.
- Better look into details and graphs as some vital information may be lost, in particular wrong measurements, caused by sensor faults, lighting or freezing can hardly be identified and eliminated.
- Logging time series at 1 minute intervals with average, maximum and calculated standard deviation wind speed allows for turbulence observation.

7.4 WIND DATA RESULTS

With all the time series results, it is possible to generate wind statistics like the chart below, where it can clearly be observed most frequent wind speeds. This is much more important that an annual or monthly average wind speed.

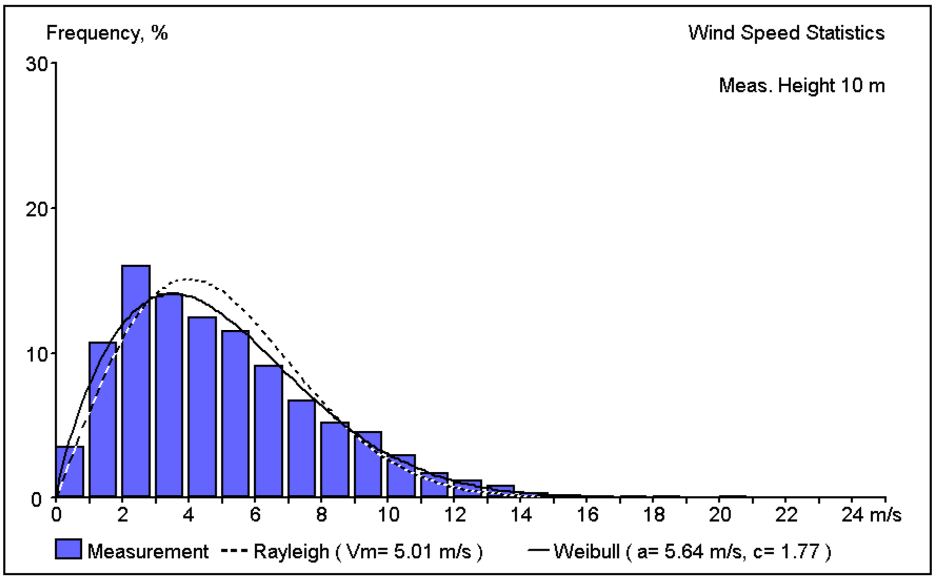


Fig.11

[3] LeWL: Wind logger, www.logicenergy.com

With the data above, calculating energy availability on a site is very simple. This is done by multiplying the number of hours at different wind speeds times the power curve of the wind turbine being proposed.

Fig. 12 shows a similar graph with statistical results. For example, about 50% of the time, this particular wind turbine will be working at its 30-40% maximum rated power.

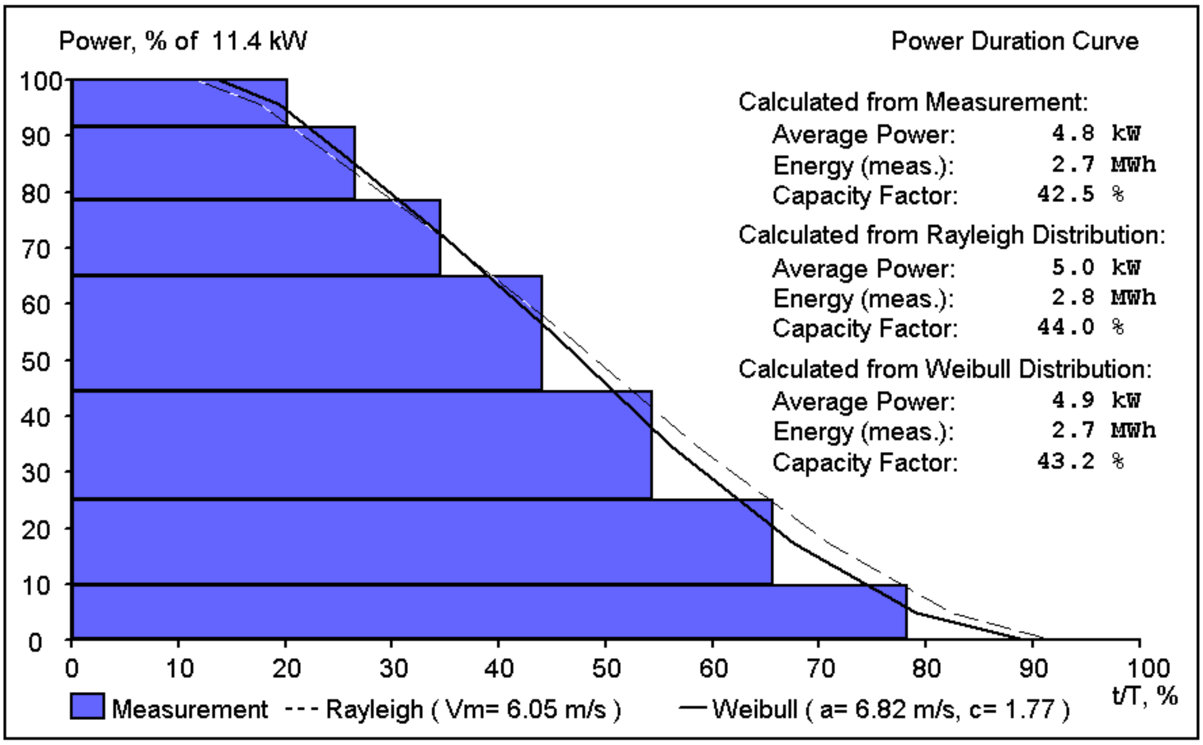


Fig. 12