SITE–RELATED WIND ANALYSIS AND ENERGY YIELD ASSESSMENT

CAUCAIA WIND FARM

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Client

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1 INTRODUCTION

1.1 Preamble

BI ENERGIA LTDA has instructed Ten Project Srl to carry out an independent assessment of site specific condition and an energy yield calculation for a proposed offshore windfarm in the North East of Brasil. The installation site is located about 5 km North Est direction from Caucaia town in the North East part of Cearà region. The aim of this work is to evaluate wind data with particular attention on wind speed, turbulence and extreme wind conditions at each WTG site installation and determine the expected energy yield.

The calculation have been focused on:

- wind data evaluation, corrections and long term correlation
- assessment of wind speed statistic for the site
- assessment of expected annual energy yields
- estimation of the expected net energy output of the w.t.g, including all relevant losses
- uncertainty assessment with the exceedance levels of the calculated energy yield
- preliminary assessment of the site classification according to IEC 61400-1 ed. 3 amendment 1 with reference to:
    - characteristic turbulence intensity calculated on the reference point at the hub height
    - estimation of the extreme wind speed at hub height
    - topographical complexity of the site

1.2 Performed activities

For this study, the following activities were performed:

- a general review and assessment of the available meteorological data material has been performed. The raw anemological data of a 60 m meteorological mast station located on the coast and different satellite data sets were analyzed and used for the estimation. The data have been assessed regarding their quality and usability for the intended purposes.
- A simulation model has been set out based on a linear model using Wasp computer program for the assessment of energy yield estimation.
- Potential source of energy losses has been assessed and deducted from the gross annual energy production (AEP).
- Uncertainties from several sources has been quantified and, considering the variability of the future wind speed, net AEP for several confidence levels has been predicted.

2 PROJECT SITE

2.1 Site survey

The area of project development is located in the North East part of Brazil in the municipality of Caucaia, few km from the city of Fortaleza which is the capital of the state of Cearà.

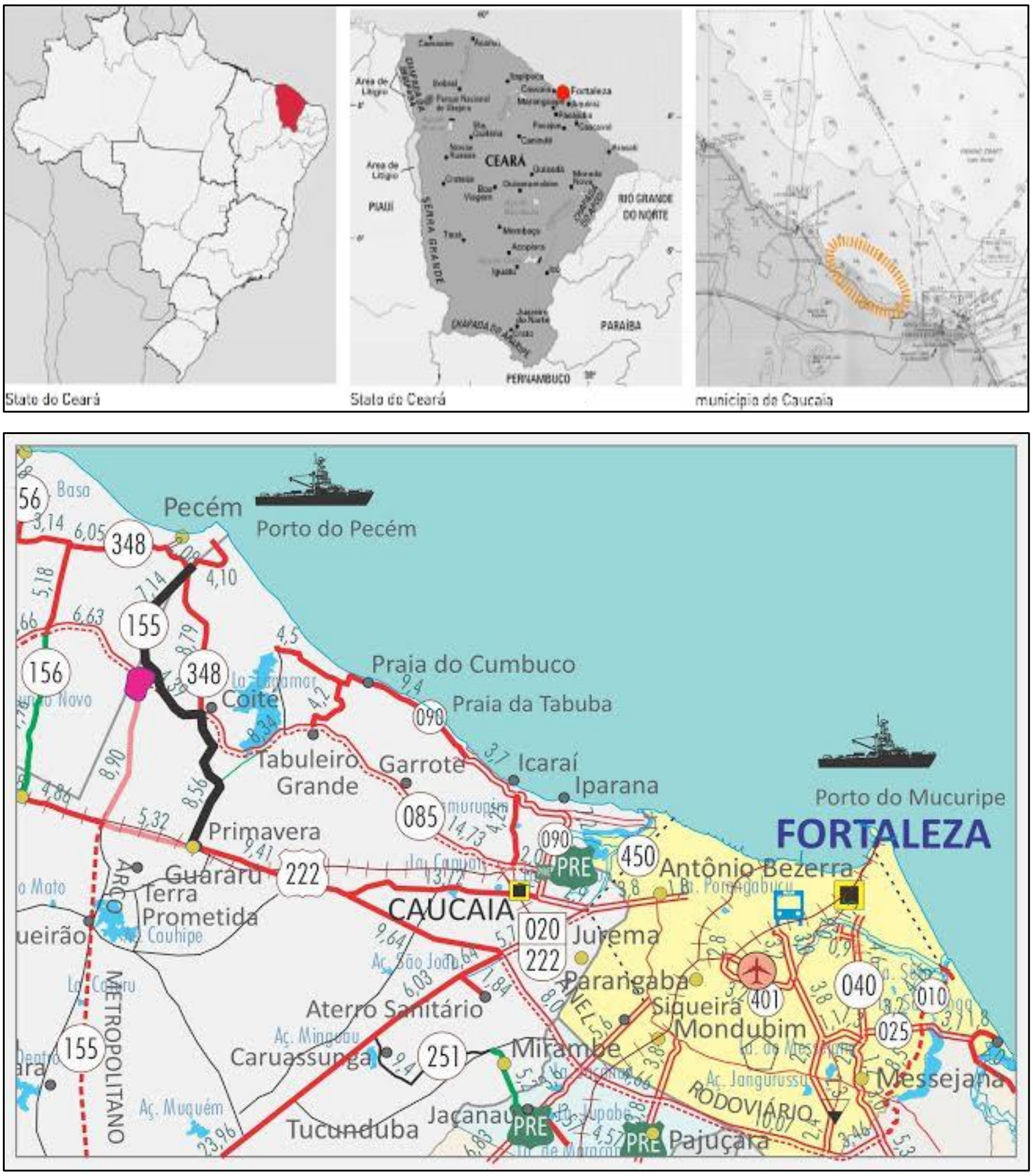


Figure 1 : Site maps of Caucaia area

The project involves the installation of 48 wind turbines with nominal power (greater or equal) to 12 MW in offshore mode, and an additional 11 wind turbines up to 3.3 MW power positioned on specific piers, near the coast in semi-offshore mode.

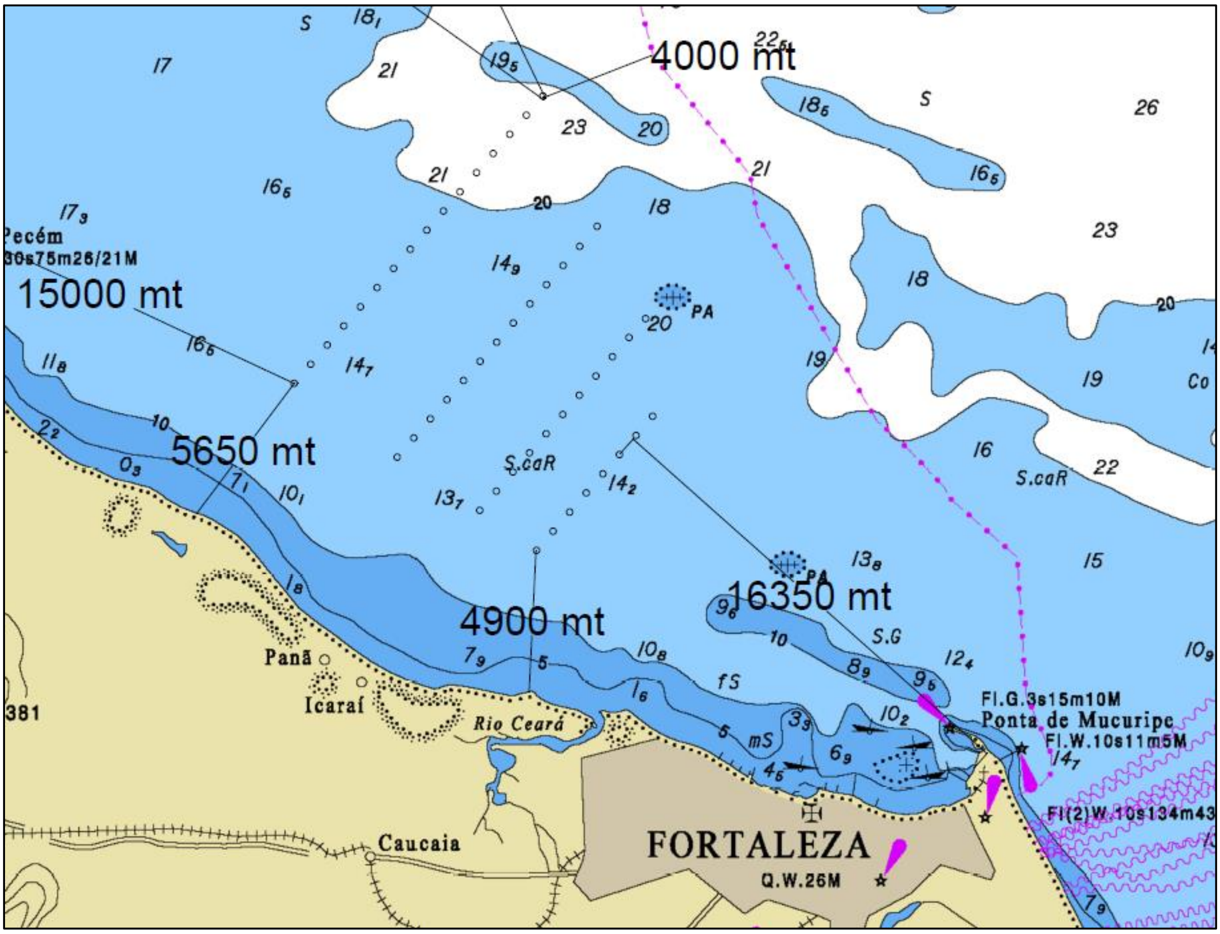


Figure 2 : Plant layout with detail of distance from the coast and bathymetry

3 METHODOLOGY

3.1 Used software

Ten Project used the following software for the investigation among several tools and programs for evaluation and correlation of the wind data:

- Wind Atlas Analysis and Application Program (WAsP), Version 12.3.16, Release A, , Risø National Laboratory, Roskilde, Denmark. [24]
- WAsP Engineering 4.00.0180 [24]
- WindPRO, version 3.3.261 2019, EMD International A/S, Denmark licence number: 7384 [23]

3.2 Numerical models

For this study the numerical approach based on WindPro / Wasp software was used, one of the main and most complete wind analysis instrument tools currently available on the market.

The Wind Atlas Analysis and Application Program (WAsP), described in detail by Mortensen et al (2003) [2], is a widely used computer program that is able to generalize a set of surface wind observations into a regionally representative set of wind statistics by modeling the wind flow across the landscape. In the analysis mode, the statistics derived from a set of long-term wind speed and direction data from a long-term reference site are used to create an Observed Wind Climate (OWC). The OWC is then extrapolated to the top of the boundary layer by fitting to a Weibull distribution and modeling the effects due to obstacles, terrain roughness and topography at the reference site. The resulting set of wind speed and direction statistics representative of the geostrophic wind over the region is known as a Wind Atlas. Applying the reverse path of the analysis process, a prediction of the wind resource at a candidate site is extrapolated down from the top of the boundary layer using the Wind Atlas data.

The input data necessary for the determination of the wind maps are [23]:

- orography of the area
- wind data (speed and direction) of at least one point in the area considered,
- "roughness" characteristics of the soil,
- obstacles

The output consists of wind atlas or a climatology of the wind in the considered area with which it is possible to elaborate a wind map of the area in question and, once the site to install the wind plant is chosen, is also capable to calculate the annual producibility of a single machine and a whole Windfarm taking into account any interference between the blades due to the trail effect and the possible presence of obstacles that can alter the wind distribution.

In detail, the WASP model is composed of a set of numerical models that have the task of correcting the anemometric measurements in order to obtain a climatology of the wind of the considered area.

These models are:

• **The model for stability:** it is based on some corrections to be made to the logarithmic profile of the wind at changing atmospheric stability conditions and requires as input the climatological averages and the average quadratic deviations of the surface heat flow. The model is derived from the law of geostrophic resistance and the wind profile is derived from an expansion of the first order of the expression of the sensible heat flux for atmospheric neutrality conditions

• **The model for the roughness change:** it is based on some corrections to be made to the wind field in the case where the ground is not homogeneous. In this case roughness lengths are assigned to the ground in such a way that the wind flow, passing between two inhomogeneous surfaces, is calculated by considerations on the surface limit state. This model plays a substantial role in the estimation of the producibility of a Windfarm as it establishes what the wind speed growth factor should be with height. It is therefore essential to rigorously reproduce the roughness characteristics of the area in question by introducing a roughness map of the area [16].

• **The model for the barrier effect:** it comes into play considering the effects of friction caused by aerodynamic resistance due to possible obstacles with variable dimensions close to the anemometer or to the wind site. In fact, it is known that near an obstacle, at distances or dimensions comparable with its height, the wind profile is disturbed. This model thus allows to "clean" the anemometric data eliminating these effects.

• **The model for orography**: like the previous two, it is used to correct the wind data from effects due to the inhomogeneities of the surrounding terrain; in this case the effects induced by the altimetric variations of the ground around the measurement station are calculated [17], [18].

The algorithm can be represented through a flow chart:

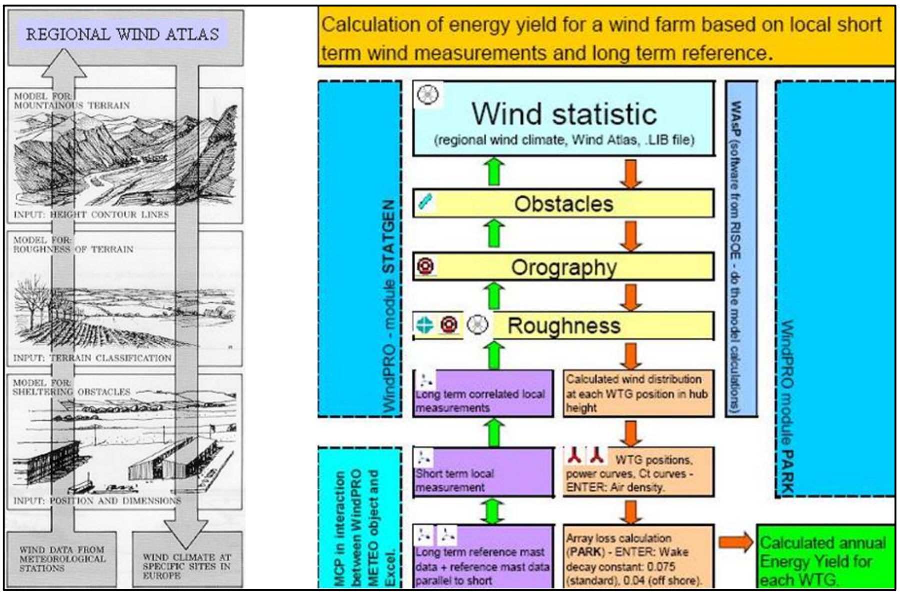


Figure 3: Wind atlas methodology flow charts both in Wasp and Wpro software

The "European Wind Atlas" [1], [9], is a calculation procedure which corrects site specific measurement data according to the influences of the topography and extrapolates these data to a general non site specific, regional wind climate (wind atlas data, "WASP lib" data). To calculate the wind climate at another site from this general wind climate, the same procedures are used in opposite way, taking into account the site-specific topography. The model is based on the physical principals of flows in atmospheric boundary layers. It takes into account following effects: the reduction of wind speed caused by vegetation and other surface roughness, shadow effects of buildings and other obstacles and changes in wind speed as well as wind direction caused by orographic effects (mountains, valleys).

For application of this model, the surrounding of the site under consideration and of the meteorological base is described in assigning roughness lengths to the surface characteristics. The positions and heights of obstacles are determined and an orographic map of the surrounding is made. Based on this site description the average wind speed and wind statistics at the site can be calculated from the regional wind climate. In detail, for a specific height the frequency distribution of the wind speed (Weibull distribution) is calculated for each of 12 wind direction sectors. With this site-specific distributions and the power curve of each single WT the average annual energy yield is calculated. To do a correct selection and assessment of the input data, considerable experience with the principles and sensitiveness of the wind atlas method is required. The meteorological base has a great influence on the result and has to be selected appropriate concerning its location and measuring period.

To calculate the energy yield of a wind farm, the annual energy yield of the single wind turbines has to be calculated as well as the energy yield losses caused by mutual shading effects. This calculations are performed on basis of the "Park Model" developed by Risø National Laboratory, Denmark. N.O. Jensen developed the used mathematical model of the wake of WTs in Risø [2].

Basic input data for this calculation are the frequency distributions of the wind speed at each turbine position of the planned wind farm, consisting of the A and k parameters of the Weibull distributions. These quantities are calculated according to the European Wind Atlas methods (see above). The model of a wake behind a wind turbine uses impulse and mass conservation to determine the wind speed behind the rotor. A linear expansion of wake is assumed. The wind speed deficit inside the wake is calculated using the thrust coefficient curve ct. The opening angle depends on the turbulence intensity and it can be calculated using empirical relations. [3]

To calculate energy yield and farm efficiency of a wind farm the installation geometry of the farm and the overlapping of the single wakes have to be taken into account. For these tasks, the Risø model uses a method of linear wake-superposition. Summarising the calculation procedure uses the following input data:

- WTs-characteristic, i.e. power curve P(v), thrust coefficient curve $c_t(v)$, hub height and diameter of the rotor
- coordinates of each WT of the wind farm
- meteorological data for the turbine positions (Weibull distribution)

The results of the wind farm calculation are the energy yield and the wind farm efficiency, for each wind turbine and for the whole farm. The total farm efficiency is the ratio of the total electrical energy of the farm (taking into account wake losses) to the sum of the energy of all single WTs assuming an undisturbed flow.

3.3 Topographical inputs

3.3.1 Orographic map

A digital map of 45 km x 45 km was obtained from SRTM [31] database of the U.S. Geological Survey.and was checked for the area surrounding the site and a good accord was found.
Shuttle Radar Topography Mission (SRTM) data obtained, was released in the 1 arc-second resolution at the end of 2014 and South America is covered [23]. According to the USGS product description, these SRTM data meet the absolute horizontal and vertical accuracies of 20 meters (circular error at 90% confidence) and 16 meters (linear error at 90% confidence), respectively.

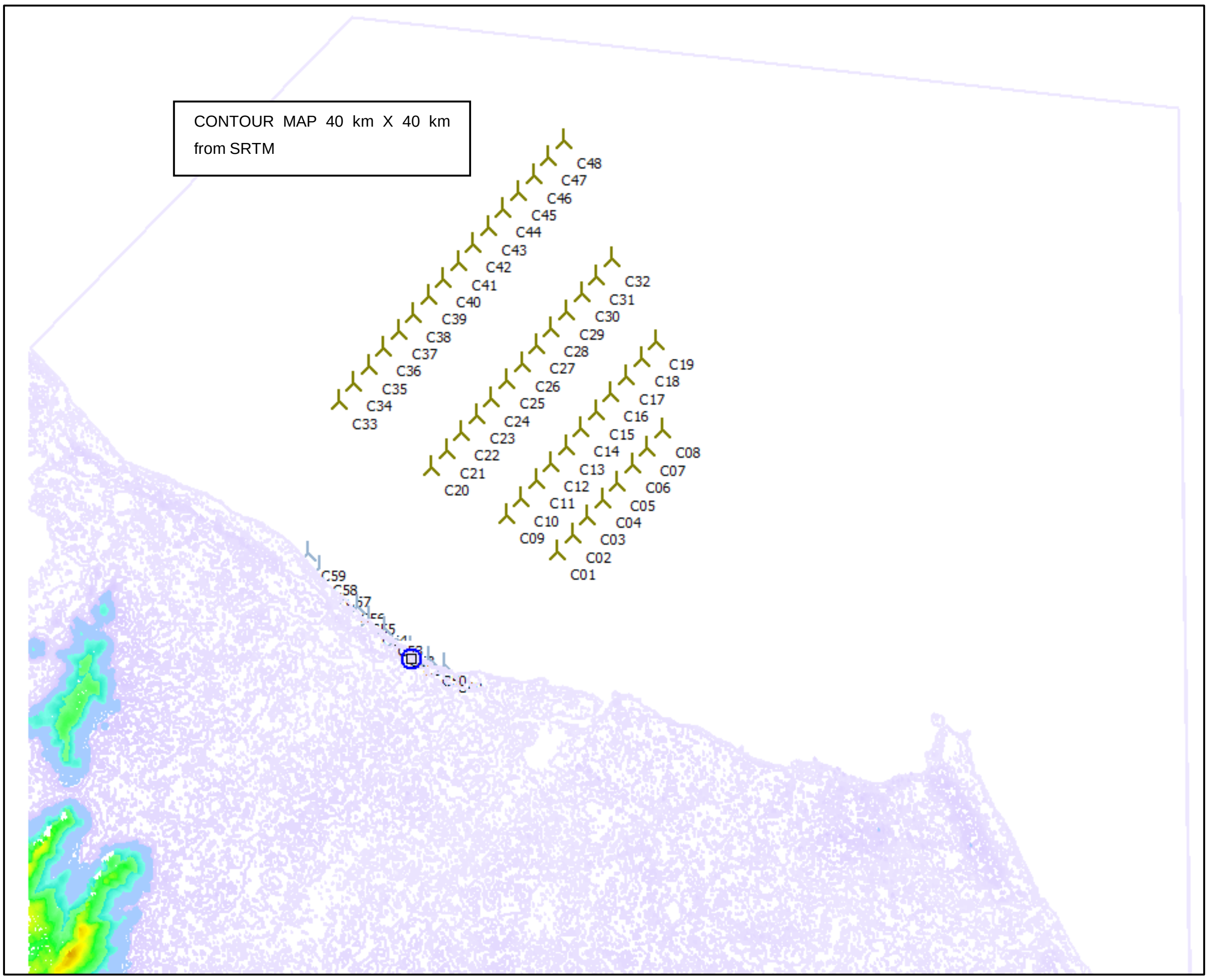


Figure 4: Characteristic of DTM file used for both simulation models, with evidence of detailed area

3.3.2 Roughness map

The land surface roughness which is determined mainly by the height and type of vegetation and buildings, has an important impact on the mean wind speed at heights of interest for wind turbines. The roughness information is based on the “GlobCover 2009” that is a global land cover dataset with a 300 m spatial resolution [32]. The dataset is developed and processed by ESA and the Université catholique de Louvain (UCL) http://due.esrin.esa.int/; the digital map was adjusted resolving the conflicts of the overlapping lines and enriched with the information derived from manual input from orto-photographic maps and site survey. It covers an area of 60x60 km within the wind park area and around the site.

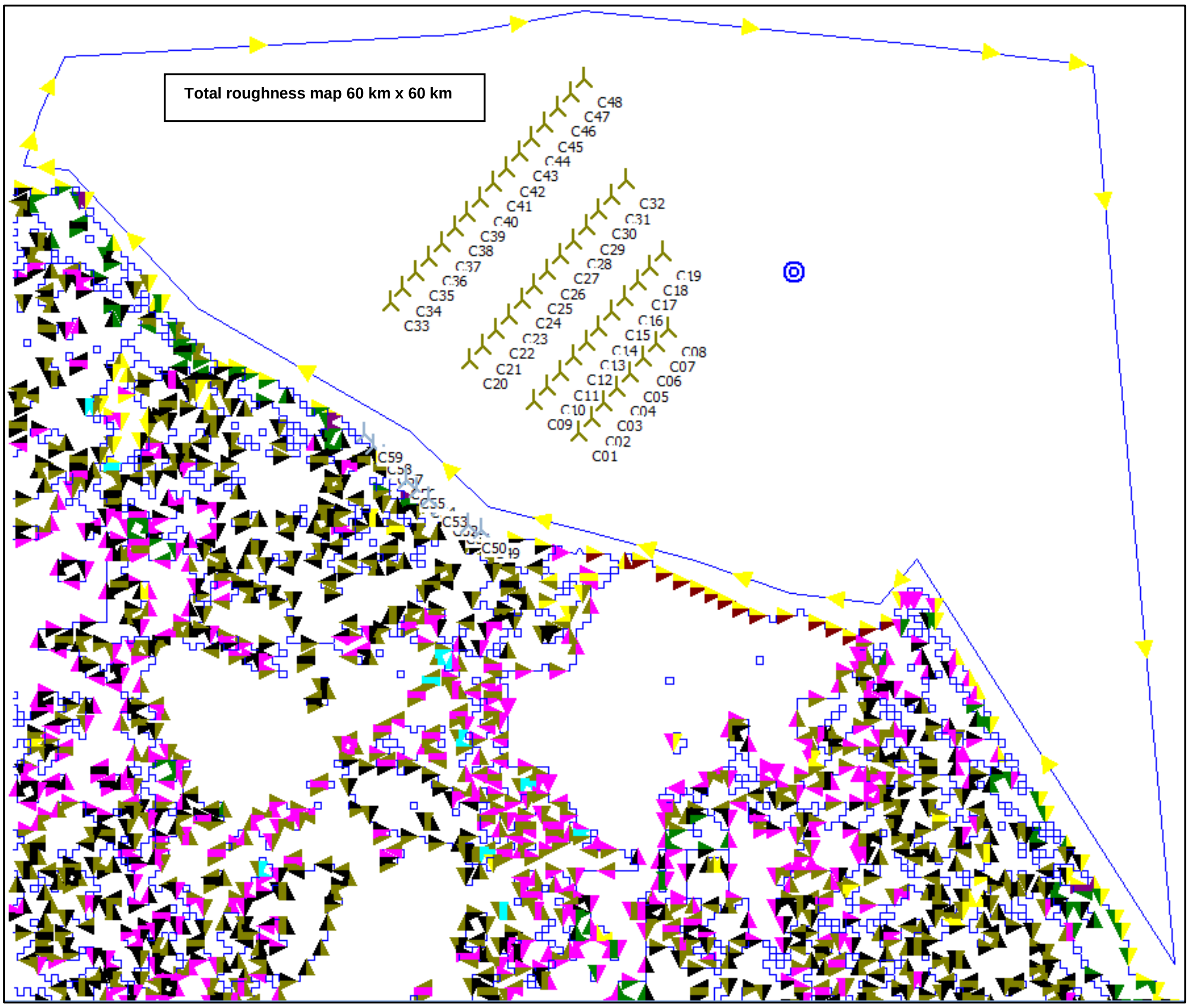


Figure 5: Roughness map used for simulation models

4 WIND DATA INPUTS

4.1 Wind data

The following table lists some information of the available met masts used for the analyzed site. The TP_2839_60 m mast, is considered as the site mast while the others are reference station found to check and stabilize wind speed on a long term period. [26], [27], [28]

Table 1: Coordinates of masts used for climate assessment of site

ID Mast	Mast detail	Height [m]	WGS84 zone 24 Est [m] [m]	WGS 84 zone 24 Nord [m]
TP_2839_60m	Tubular mast logger NGR Synphonie	60	543279	9592142
CFSR2_W38.659_S03.578	Satellite data	10	537872	9604511
ERA5_S03.512879_W038.53125	Satellite data	100, 10	552091	9611690

Table 2: Detail of measuring period of met masts used for climate assessment of site

	Height [m]	First data	Last data	Months
TP_2839	60,00m - 1	12/06/2009	17/12/2012	42,2
	40,00m - 2	03/06/2009	28/11/2012	41,9
	60,00m - 3	17/05/2010	17/12/2012	31,1
ERA5_S03.512879_W38.53125	10,00m -	01/01/2000	31/12/2018	228,1
	100,00m -	01/01/2000	31/12/2018	228,1
CFSR2_W38,659_S03.578	10,00m -	31/12/2011	30/09/2018	81

A detailed analysis of each single meteorological used mast is reported in the appendixes. Here is showed only a summary view of their main characteristics, in particular are synthesized: the mast configuration of channels, wind data availability, total average wind speed Vm, max wind speed Vmax, monthly wind speed, weibull parameters, detailed wind directional analysis.

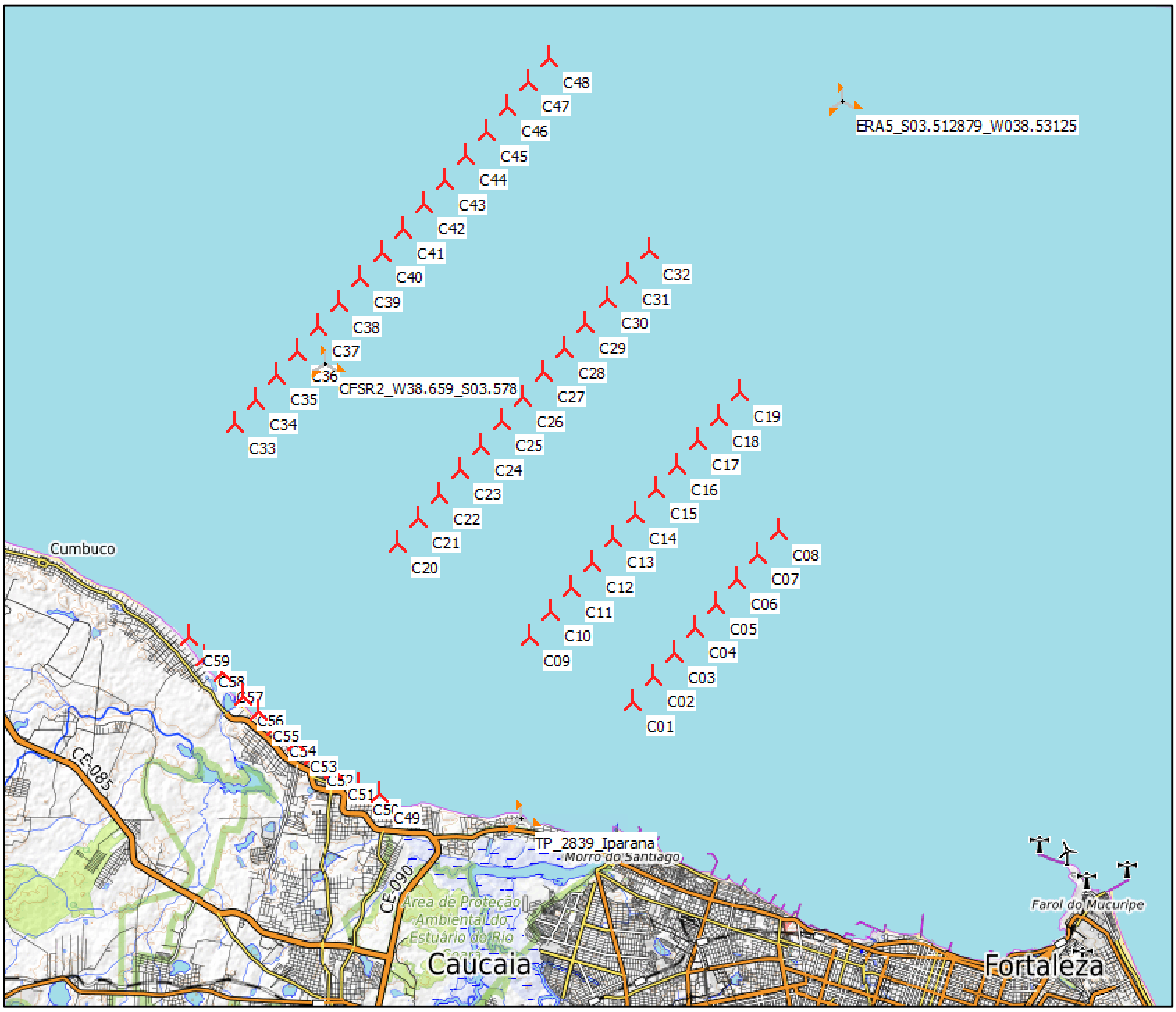


Figure 6: Locations of meteorological sources of wind data related to windfarm layout on topographic map

4.2 Site data : TP_2839_ mast_“Caucaia”

The TP_2839 mast, installed on June 2009 and dismissed on December 2012, was a 60 meters mast located near the coast. It had 3 anemometers at 60-60-40 m and 2 Vane (60-40 m). It was a lattice mast installed on the coast at about 8 m a.g.l. The closest WTG position (C01) of offshore layout is at about 5 km from the mast position while the closest wtg position of coastal windfarm is at about 4 km (C49). It was used as reference mast to estimate the requested parameters at hub height on WTG positions (after a long term correction and a vertical shear extrapolation to 90 m height).

Below a summary table of all main measuring characteristics.

Table 3: Synthesis of site mast characteristics TP_2839

	Signal	Unit	Count	Of period	Mean	Std dev	Min	Max	Weibull mean	Weibull A par	Weibull k par
60,00m - 1	Mean wind speed, all	m/s	161599	87,4%	7,60		0,4	18,5	7,65	8,46	3,8304
60,00m - 1	Wind direction, all	Degrees	161599	87,4%	123		0	356			
60,00m - 1	Turbulence intensity, enabled		151098	81,7%	0,0789	0,0687	0	0,7302			
40,00m - 2	Mean wind speed, all	m/s	133260	72,7%	6,86		0,4	18	6,91	7,7	3,3203
40,00m - 2	Wind direction, all	Degrees	133260	72,7%	126,9		4	356			
40,00m - 2	Turbulence intensity, enabled		117543	64,1%	0,1148	0,0571	0,0217	0,82			
60,00m - 3	Mean wind speed, all	m/s	124684	91,6%	7,66		0,2	16,4	7,76	8,58	3,8296
60,00m - 3	Wind direction, all	Degrees	124686	91,6%	117,5		0	356			
60,00m - 3	Turbulence intensity, enabled		114890	84,4%	0,1033	0,0532	0,0222	1,2857			
60,00m - 1 Subst	Mean wind speed, all	m/s	175204	94,1%	7,53		0,2	18,5	7,58	8,4	3,7192
60,00m - 1 Subst	Wind direction, all	Degrees	175204	94,1%	123,1		0	356			
60,00m - 1 Subst	Turbulence intensity, enabled		162547	87,3%	0,0809	0,0682	0	0,7302			

In the above table, in addition to channels 1,2,3 of 60 and 40 m, there is also reported a channel with the denomination 60.0 m Subst. These lines show the information relating to channel 1 of 60 m after a series of processing performed, where possible, to analytically recover the data lost due to partial sensor malfunctions. In detail, the following calculations have been carried out:

- Step 1: substitution from CH3 to CH1 of missing and invalid wind data pair (wind speed and direction)
- Step 2: synthesizing of wind data series from 40 to 60 m using power law applied to a detailed shear table for 12 sectors and seasonal periods [29]
- Step 3: substitution from synthesized channel to CH1 of missing and invalid wind data pair (wind speed and direction)

The obtained series of wind data results in line with the original data measured at 60 m and allows to recover 13605 strings from 10 minutes corresponding to about 3 months of data, passing the availability of valid data from 87.4% to 94.1%

The average speed of the most complete data series obtained, which has 94.1% of valid data, is equal to 7.58 m / s compared to 7.65 m / s of the original series. The series obtained is considered to be congruent and has been used for subsequent processing

The following graphs synthesize the anemological characteristics of 60 m measured values referred to 60 m 1 Subst channel.

Table 4: Shear matrix used to synthsize wind data from 40 to 60 m

Synthesized time series setup

Reference height: 40,00m - 2

Height [m]: 60,0

Create shear values based on matrix with following elements:

Height	Exclusion direction start	Exclusion direction end	Use to find sector
☐ 90,00m - LT E			○
☐ 60,00m - 1	0	0	○
☑ 60,00m - 1 Su	0	0	○
☐ 60,00m - 3	0	0	○
☑ 40,00m - 2	0	0	⦿

Shear values

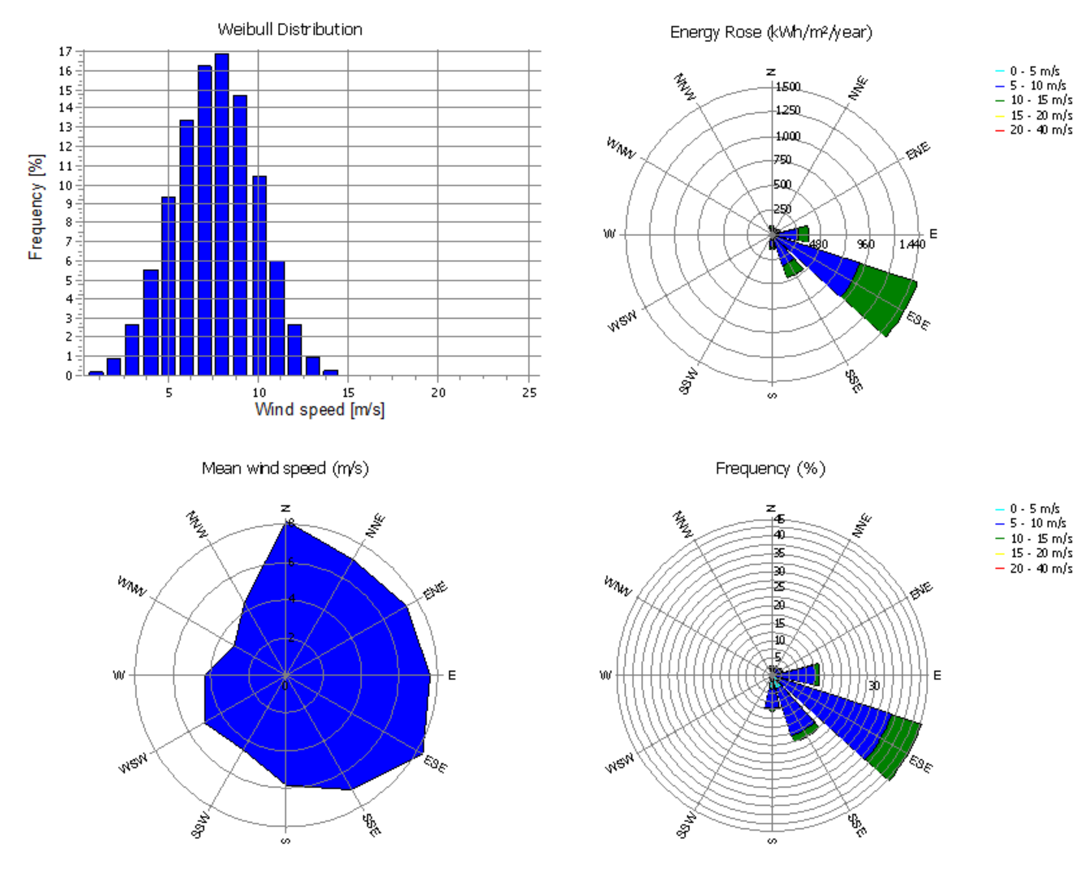
Direction: All

<0 Negative! | 0-0.1 Extreme low | 0.1-0.2 Normal, low | 0.2-0.3 | 0.3-0.4 | >0.4

Shear mean | Count

Diurnal	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Year
00-02	0,26	0,27	0,38	0,33	0,25	0,25	0,28
02-04	0,29	0,35	0,38	0,37	0,27	0,28	0,31
04-06	0,21	0,20	0,27	0,30	0,22	0,22	0,23
06-08	0,14	0,18	0,25	0,27	0,16	0,17	0,20
08-10	0,11	0,16	0,22	0,18	0,13	0,15	0,16
10-12	0,12	0,17	0,17	0,13	0,11	0,16	0,13
12-14	0,10	0,16	0,17	0,10	0,10	0,13	0,13
14-16	0,12	0,20	0,17	0,14	0,13	0,14	0,15
16-18	0,15	0,20	0,21	0,19	0,15	0,15	0,17
18-20	0,15	0,18	0,24	0,22	0,17	0,15	0,18
20-22	0,15	0,19	0,28	0,26	0,19	0,19	0,19
22-24	0,17	0,24	0,31	0,30	0,23	0,20	0,22
All	0,15	0,19	0,25	0,23	0,17	0,17	0,19

*) Value outside valid shear range #) Value below valid minimum number of samples



Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8,96	8,18	4,494	2,8
1 NNE	7,82	7,06	3,738	2,9
2 ENE	8,14	7,34	3,624	3,3
3 E	8,36	7,62	4,362	13,9
4 ESE	9,09	8,34	4,980	45,2
5 SSE	7,79	7,00	3,435	20,1
6 S	6,55	5,82	2,692	10,0
7 SSW	5,17	4,59	1,877	1,4
8 WSW	5,46	5,04	1,295	0,2
9 W	4,54	4,36	1,117	0,1
10 WNW	3,35	3,18	1,168	0,0
11 NNW	4,93	4,44	1,531	0,1
All	8,40	7,58	3,719	100,0

Figure 7: TP_2839 mast - directional graph reports for 60 m (60 m – 1 Subst) height measured frequency distribution, average wind speed and energy rose. Sector wise weibull distributions data.

4.3 Meteorological long term data

Long term correlation is recommended to reduce the uncertainty on the average wind speed at WTG hub height to improve the reliability of the energy production estimation. Several wind data set have been tested among satellite database such as Merra data, CFSR data, ERA5 data.
The available detailed data set of Merra data is related only to 1 year, additional data from other years are subject to payment, so this database was excluded from the analysis
Two data set were considered valid for the purpose and their detail are reported below.

4.3.1 CFSR2_W38.659_S03.578 wind data

CFS and CFSR DATA

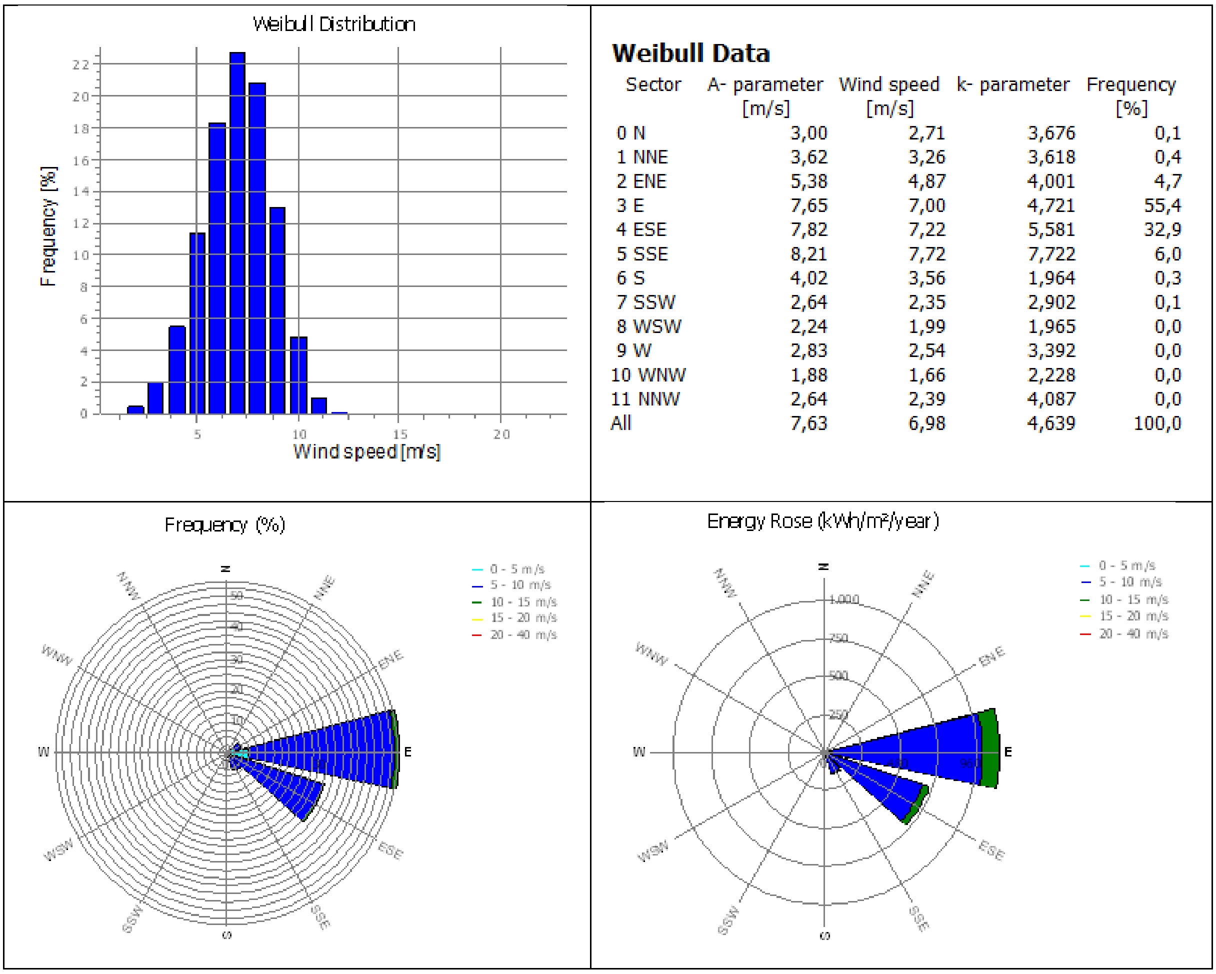
The CFSR is a third generation reanalysis product. It is a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system designed to provide the best estimate of the state of these coupled domains over this period. The CFSR includes (1) coupling of atmosphere and ocean during the generation of the 6 hour guess field, (2) an interactive sea-ice model, and (3) assimilation of satellite radiances.
All have a global coverage over land masses which is extended about 50 km into the sea near coastlines. The temporal resolution is 1 hour.
The CFSR global atmosphere resolution is ~38 km (T382) with 64 levels. The global ocean is 0.25° at the equator, extending to a global 0.5° beyond the tropics, with 40 levels. The global land surface model has 4 soil levels and the global sea ice model has 3 levels. The CFSR atmospheric model contains observed variations in carbon dioxide (CO2), together with changes in aerosols and other trace gases and solar variations. With these variable parameters, the analyzed state will include estimates of changes in the Earth system climate due to these factors

Table 5: Synthesis of site mast characteristics

Signal	Height	Unit	Count	Of period	Mean	Min	Max	Weibull mean	Weibull A par	Weibull k par
Mean wind speed	10,0m	m/s	59160	100%	6,97	0,1	11,74	6,98	7,63	4,6388
Wind direction	10,0m	Degrees	59160	100%	102,4	0,2	359,1			

Table 6: Average wind speeds of CFSR2

CFSR2_W38.659_S03.578									
10,00m - Mean wind speed [m/s]	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean**
January		7,13	6,64	6,85	7,1	5,02	6,51	6,56	6,54
February		6,36	7,14	6,29	6,2	6,54	5,56	4,28	6,06
March		6,11	6,25	5,53	5,2	5,73	5	5,14	5,57
April		6,14	5,06	5,02	5,27	6,34	5,34	4,82	5,43
May		6,77	6,09	4,97	6,63	6,08	5,43	5,73	5,96
June		6,75	6,12	6,92	6,84	6,97	6,91	7,0	6,79
July		7,85	6,65	7,54	7,81	7,78	7,15	7,18	7,42
August		8,69	8,16	8,4	8,66	8,16	8,08	7,83	8,28
September		8,5	8,65	7,96	8,38	8,44	8,98	8,42	8,48
October		8,56	8,29	8,58	8,4	8,43	8,59		8,47
November		7,1	7,96	7,42	7,34	8,19	7,64		7,61
December	5,74	7,26	7,02	7,46	7,38	7,4	7,2		7,28
mean, all data	**5,74**	**7,27**	**7,05**	**6,92**	**7,11**	**7,09**	**6,87**	**6,35**	**6,97**



Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	3,00	2,71	3,676	0,1
1 NNE	3,62	3,26	3,618	0,4
2 ENE	5,38	4,87	4,001	4,7
3 E	7,65	7,00	4,721	55,4
4 ESE	7,82	7,22	5,581	32,9
5 SSE	8,21	7,72	7,722	6,0
6 S	4,02	3,56	1,964	0,3
7 SSW	2,64	2,35	2,902	0,1
8 WSW	2,24	1,99	1,965	0,0
9 W	2,83	2,54	3,392	0,0
10 WNW	1,88	1,66	2,228	0,0
11 NNW	2,64	2,39	4,087	0,0
All	7,63	6,98	4,639	100,0

Figure 8: ERA5-measured average wind speed, directional graph reports for 100 m height measured frequency distribution, average wind speed and energy rose. Sector wise weibull distributions

4.3.2 ERA5_S03.512879_W038.53125

ERA5 is a climate reanalysis dataset developed through the Copernicus Climate Change Service (C3S) and processed/delivered by ECMWF. The dataset is intended to replace the ERA-Interim dataset from ECMWF shortly after the ERA5 dataset is complete. The ERA5 dataset has several improvements compared to ERA-Interim:

- Newer modelling system
- More observations used in the assimilation
- Higher spatial horizontal resolution (around 31 km compared to 79 km)
- Higher spatial vertical resolution

Resolution:

The model grid is a reduced gaussian grid (T620) which has a lateral resolution of 0.28125° (around 31 km). It holds hourly values. Coverage is global for land-areas and coastal regions. In windPRO, offshore coverage is expected to cover an area of approximately 300 km from the coastline.

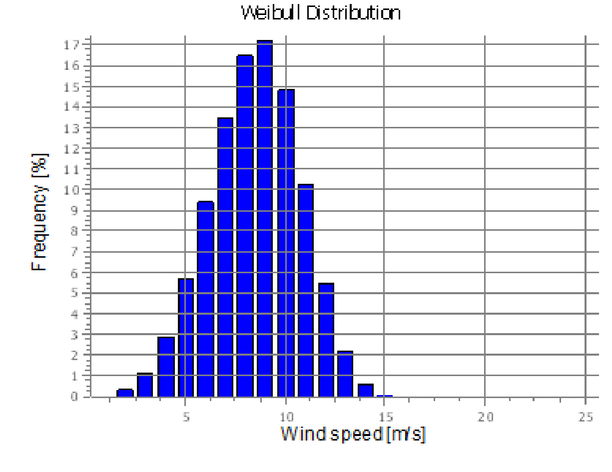
Data Evaluation:

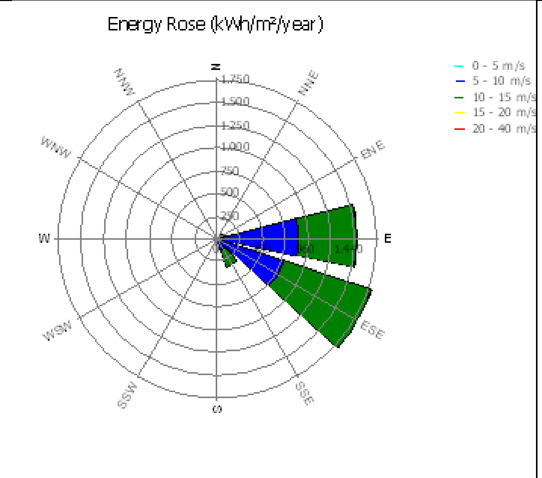
The hourly wind speeds from ERA5 data have been compared to measured wind speeds from 108 tall meteorological masts around the globe. The masts have sensor heights ranging from about 60m to 140m. Correlations have been calculated for all sites - and ERA5 data shows a significant improvement over MERRA2 – the average correlation is increased by 0.07 and the variation is also lower.

Table 7: Details of ERA5 data set

Signal	Height	Unit	Count	Of period	Mean	Min	Max	Weibull mean	Weibull A par	Weibull k par
Mean wind speed, all	100,0m	m/s	166559	100,00%	8,37	0,02	15,73	8,43	9,28	4,2167
Wind direction, all	100,0m	Degrees	166559	100,00%	104	0	359,9			
Mean wind speed, all	10,0m	m/s	166559	100,00%	7,39	0,08	13,01	7,45	8,15	4,6649
Wind direction, all	10,0m	Degrees	166559	100,00%	103,8	0	359,9			

ERA5_S03.512879_W038.53125.100,00m - Mean wind speed [m/s]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Mean
January	6,09	8,11	5,90	6,18	5,73	7,62	9,35	8,04	7,21	6,84	7,49	5,83	8,58	8,22	8,20	8,64	5,94	7,42	7,17	7,29
February	5,05	6,44	7,44	6,25	5,78	7,52	5,94	5,44	6,69	5,97	8,22	5,78	7,68	8,81	7,75	7,22	7,41	6,64	4,46	6,66
March	6,44	5,70	6,19	5,26	6,85	6,24	5,61	6,96	3,80	4,61	6,45	5,01	7,40	7,80	6,61	6,09	6,87	5,18	5,62	6,04
April	5,78	6,23	5,76	6,08	7,23	7,64	4,74	6,17	4,87	3,17	6,68	4,84	7,58	6,01	5,74	5,79	7,86	6,40	5,20	5,99
May	7,97	7,35	7,09	7,39	7,82	7,76	6,42	7,73	6,07	3,92	7,18	6,67	8,85	7,63	6,06	8,21	7,92	7,08	6,77	7,15
June	8,19	8,28	8,26	8,48	8,48	8,91	8,63	9,00	7,79	7,25	8,47	8,00	8,95	7,99	8,95	8,81	8,90	8,74	8,69	8,46
July	8,49	9,59	9,13	9,94	8,95	9,72	9,19	9,99	9,32	8,57	9,76	8,54	10,58	8,91	9,94	10,06	10,20	9,22	9,39	9,45
August	9,79	11,00	10,59	10,16	9,99	10,83	10,26	11,06	9,70	9,57	10,90	9,89	11,16	10,74	10,94	11,21	10,58	10,21	9,81	10,44
September	10,11	10,28	10,35	10,56	10,73	10,46	10,37	11,07	10,45	10,25	11,21	10,82	10,77	11,00	10,60	10,83	10,68	11,28	10,69	10,66
October	10,35	9,44	10,55	10,65	10,49	10,58	9,83	10,61	10,82	9,04	8,68	9,41	11,13	10,52	10,90	10,52	10,49	10,80	9,27	10,21
November	8,99	9,06	9,41	9,37	9,85	9,90	9,15	9,66	9,43	9,82	9,52	9,68	8,98	10,13	9,39	9,05	9,98	9,51	9,38	9,49
December	7,65	9,16	7,95	8,27	8,71	8,97	8,13	8,85	8,31	8,25	7,82	9,19	9,19	8,75	9,36	8,86	8,46	8,25	7,03	8,48
mean, all data	7,92	8,40	8,22	8,23	8,39	8,85	8,15	8,74	7,88	7,28	8,53	7,82	9,25	8,88	8,71	8,79	8,78	8,40	7,81	8,37





Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	3,72	3,32	2,955	0,3
1 NNE	4,47	4,00	3,123	1,1
2 ENE	6,38	5,75	3,615	6,1
3 E	9,09	8,32	4,742	44,2
4 ESE	9,85	9,07	5,214	40,5
5 SSE	10,17	9,51	6,941	6,8
6 S	4,63	4,18	1,509	0,2
7 SSW	2,93	2,59	2,151	0,1
8 WSW	2,56	2,27	2,022	0,1
9 W	2,79	2,54	1,396	0,1
10 WNW	3,54	3,14	2,320	0,2
11 NNW	3,67	3,25	2,195	0,2
All	9,28	8,43	4,217	100,0

Figure 9: ERA5-measured average wind speed, directional graph reports for 100 m height measured frequency distribution, average wind speed and energy rose. Sector wise weibull distributions

4.4 Wind data approach

Regarding the mast on site, all instrumentation used for measurement has been analyzed and verified; were re-imported all raw data and for each channel has been checked the matching calibration factors with received certificates. [5]
Some gaps in data to the 60 m channels have been solved by mutually replacing the two channels at the same height (CH1 60m, CH3 60m), on the basis of the fact that the two channels have shown perfect analogy of measurement. In addition, other data were recovered from the 40 m channel by using the shear power law.The new data sets have been named CH1 60 Subst.
The 60 m Ch1 data set was extrapolated to 90 m height using shear matrix of measured values 60/40.
The new 90 data set was then correlated to ERA5 long term data set to obtain a stabilized long term wind speed.

4.5 Wind shear (Measured)

The wind profile of the atmospheric boundary layer is generally logarithmic in nature and is best approximated using the log wind profile equation that accounts for surface roughness and atmospheric stability. The equation to estimate the mean wind speed (u) at height z (meters) above the ground is:

$$u_z = \frac{u_*}{\kappa}\left[\ln\left(\frac{z-d}{z_0}\right) + \psi(z, z_0, L)\right]$$

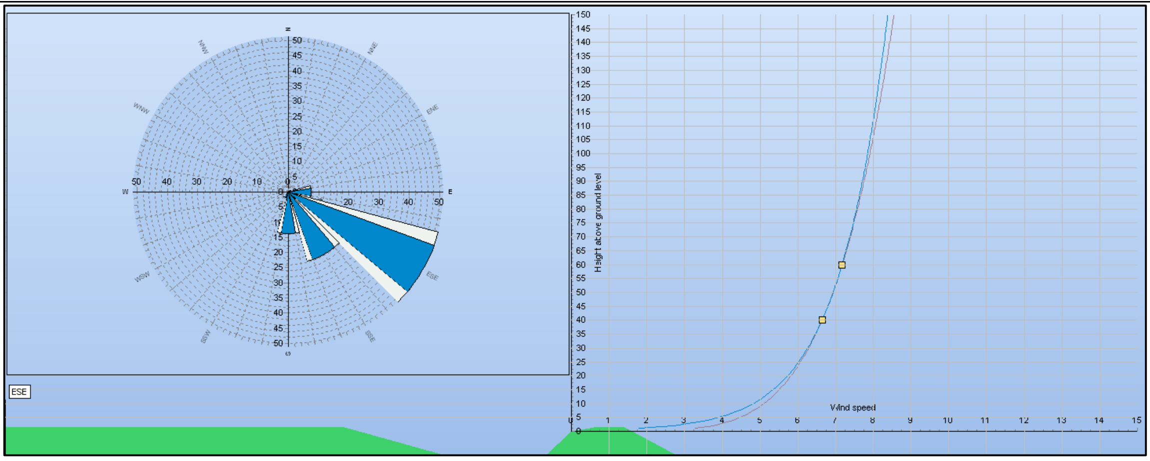
where u_* is the friction (or shear) velocity (m s-1), κ is the Von Kármán constant (~0.41), d is the zero plane displacement, z_0 is the surface roughness (in meters), and ψ is a stability term where L is the Monin-Obukhov stability parameter. Under neutral stability conditions, $z/L = 0$ and ψ drops out.
The wind profile power law relationship is often used as a substitute for the log wind profile when surface roughness or stability information is not available.
The wind profile power law relationship is:

Vz/Vzr = (Z/Zr)^α

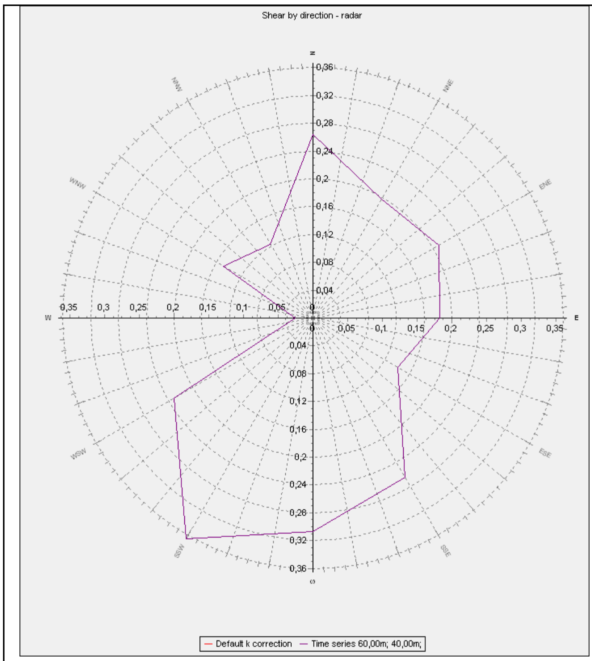
where Vz is the wind speed (in metres per second) at height Z (in meters), and Vr is the known wind speed at a reference height Zr. The exponent (α) is an empirically derived coefficient that varies dependent upon the stability of the atmosphere. For neutral stability conditions, α is approximately 1/7, or 0.143.
Wind shear is strongly depending on the reference heights, wind speed range, wind directions and seasonality. More detailed results are reported in the appendix III. The following table shows the measured wind shear basing on different sensors installed on met mast TP_2839.

Table 8: Measured wind shear at TP_2839 60m/40m both expressed as power law and log law for all direction

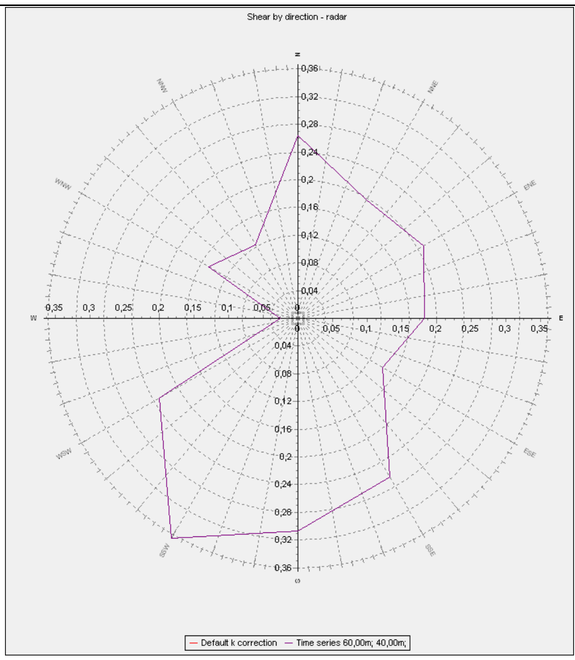
Sector	Power law exponent	Log law surface roughness length
Average	0,19	0,25
N	0,26	1,10
NNE	0,20	0,30
ENE	0,21	0,41
E	0,18	0,21
ESE	0,14	0,04
SSE	0,27	1,12
S	0,31	1,88
SSW	0,37	3,17
WSW	0,23	0,64
W	0,03	0,00
WNW	0,15	0,06
NNW	0,12	0,01



Wind rose and shear measured values graphs



Shear wind rose values



Sectorial shear values linear graph

Direction: All

<0	Negative!	0.2-0.3	Normal, high
0-0.1	Extreme low	0.3-0.4	Very high
0.1-0.2	Normal, low	>0.4	Extreme high

Shear mean | Count

Diurnal	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Year
00-02	0,26	0,27	0,40	0,33	0,24	0,25	0,28
02-04	0,29	0,35	0,39	0,37	0,27	0,28	0,31
04-06	0,21	0,20	0,28	0,30	0,23	0,22	0,23
06-08	0,14	0,18	0,25	0,27	0,16	0,17	0,20
08-10	0,11	0,16	0,23	0,18	0,13	0,15	0,16
10-12	0,12	0,17	0,17	0,13	0,11	0,16	0,13
12-14	0,10	0,16	0,17	0,10	0,10	0,13	0,13
14-16	0,12	0,20	0,17	0,14	0,13	0,14	0,15
16-18	0,15	0,20	0,22	0,19	0,15	0,15	0,17
18-20	0,15	0,18	0,25	0,22	0,17	0,15	0,18
20-22	0,15	0,19	0,28	0,26	0,19	0,19	0,19
22-24	0,17	0,24	0,31	0,30	0,22	0,20	0,22
All	0,15	0,19	0,25	0,23	0,17	0,17	0,19

Shear matrix with detail of sasonal anddiurnal values

Figure 10: Wind shear graphic representation and detail

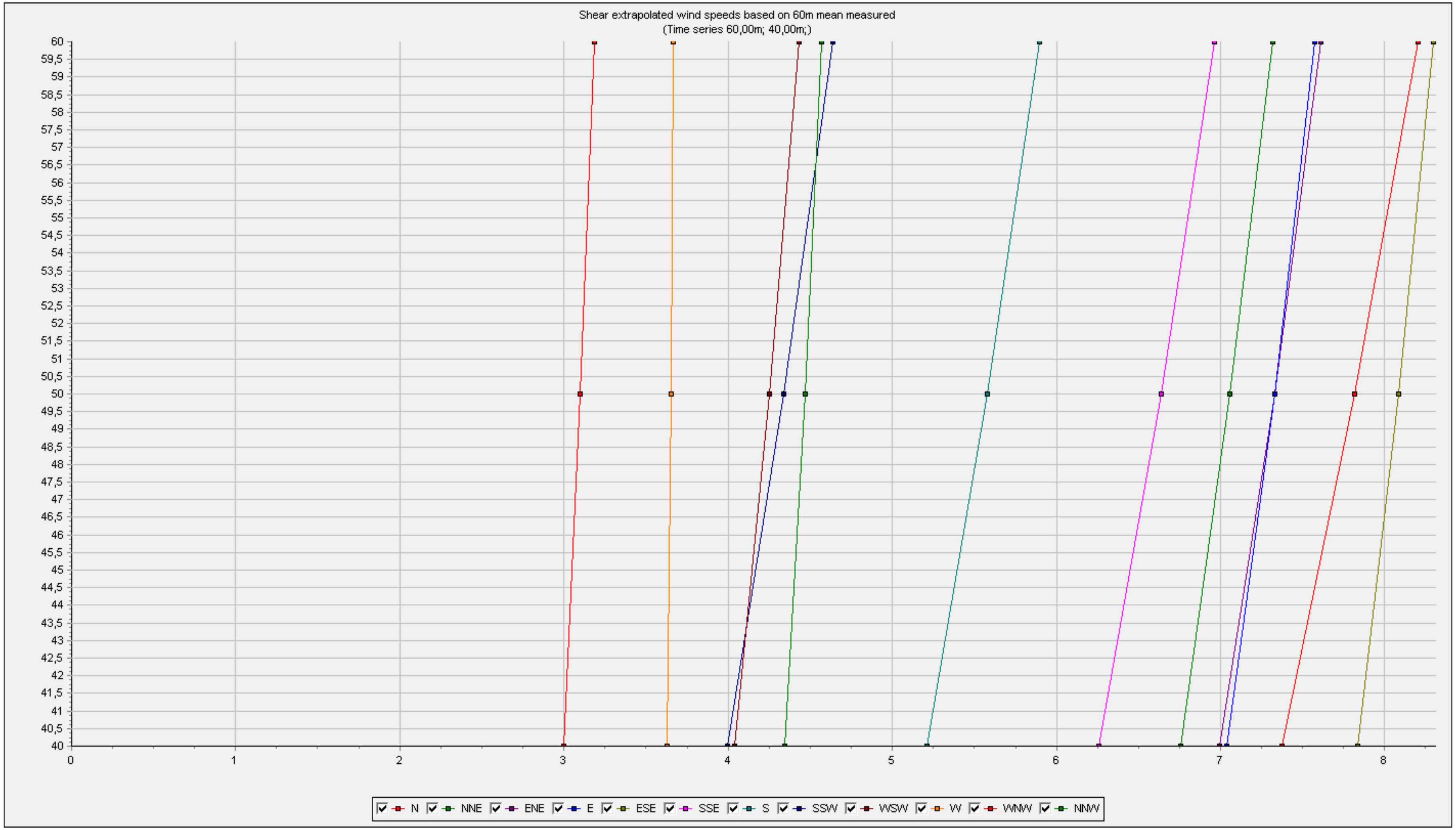


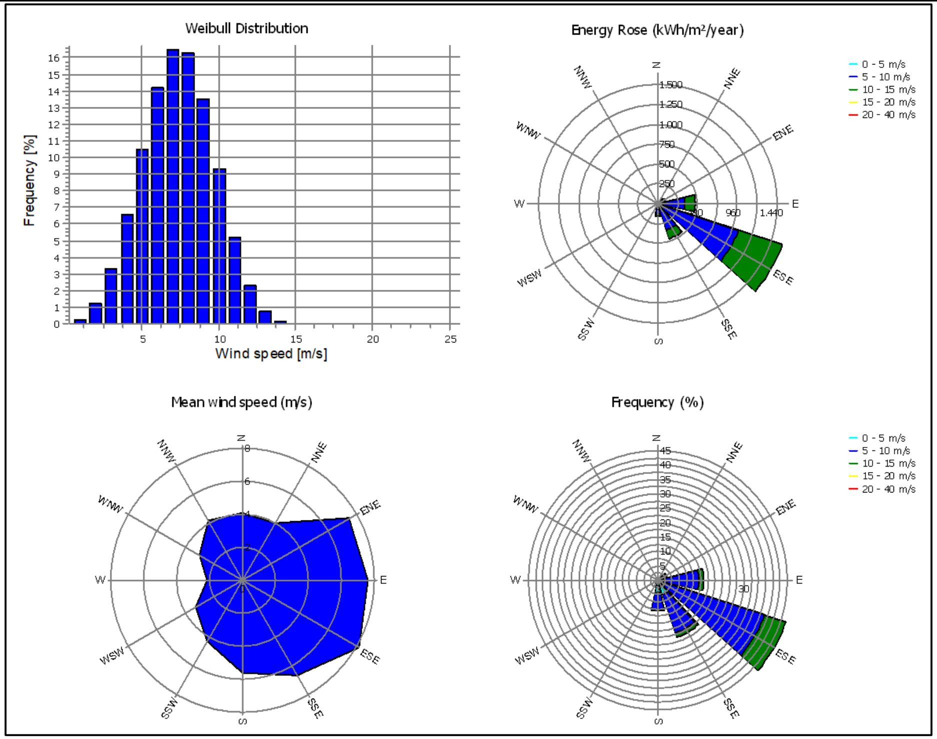
Figure 11: Extrapolated sector wise wind shear representation

The measured wind profile is the main parameter used to calibrate the software simulation.

As anticipated, the shear values measured for heights 60/40 were used to extrapolate a series of data at a height of 90 m from the ground [29], this procedure is generally performed in order to prevent the simulation software from performing excessive overestimates due to vertical extrapolation. It should be emphasized that the position of the measurement station is on the coast line, in a point very close to the net change in roughness, while 48 wt are at sea over 5 km from the coast. Although there is not the problem of orographic complexity, the case is in any case not a simple model since the difference of the physical quantities of the heat flux strongly influences the wind phenomenon. The methodology is based on the assumption that the wind shear between 60/40 is similar or higher than the one that exists between the heights of 40 and 60 m, so the assumption is precautionary. It was preferred not to go beyond 90 m because beyond a certain height the real shear decreases significantly and the intake could generate overestimation effects.

On the basis of the shear matrix shown in the previous figures, the data set at 90 m has been extrapolated whose anemological characteristics are shown on the next page.

	Signal	Unit	Count	Of period	Mean	Std dev	Min	Max	Weibull mean	Weibull A par	Weibull k par
90,00m - F Synth	Mean wind speed, all	m/s	175204	94,1%	8,15		0,2	23,4	8,18	9,04	3,869
90,00m - F Synth	Wind direction, all	Degrees	175204	94,1%	123,1		0	356			
90,00m - F Synth	Turbulence intensity, enabled		162472	87,3%	0,0741	0,062	0	0,6763			



Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	10,01	9,12	4,370	2,8
1 NNE	8,54	7,71	3,744	2,9
2 ENE	8,82	7,94	3,545	3,3
3 E	9,00	8,19	4,290	13,9
4 ESE	9,60	8,83	5,167	45,2
5 SSE	8,63	7,78	3,624	20,1
6 S	7,36	6,55	2,755	10,0
7 SSW	5,72	5,08	1,813	1,4
8 WSW	5,83	5,41	1,274	0,2
9 W	4,85	4,78	1,040	0,1
10 WNW	3,49	3,30	1,168	0,0
11 NNW	5,17	4,65	1,536	0,1
All	9,04	8,18	3,869	100,0

Figure 12: TP_2839 -measured average wind speed, directional graph reports for 90 m synthetized height : frequency distribution, average wind speed and energy rose. Sector wise weibull distributions

4.6 Wind data correlation

The data sets recorded on the proposed wind farm area are valid only for a relatively short period. For a long-term determination of wind speed and energy yield the long-term measurement should cover a period of at least 10 years, otherwise the results are influenced by seasonal and year-to-year wind variations. Even a medium period of a few years is generally not independent of year-to-year variations..Usually measurement data for a period of several months or years are available for the wind farm site. With long-term wind data of a suitable meteorological measurement station in the same region, the measured data of the site can be extrapolated to long-term data [19],[20].

For the extrapolation the simultaneously measured time series data of the site and the meteorological station are compared and evaluated to test whether the wind speed and the wind direction measurements of the two stations correlate i.e. whether a relation exists between them. If short-term and long-term time series do not show suitable correlation behaviour, the long-term extrapolation is carried out based on mean values of the wind speed. To assure that this long-term conversion is permitted, most of the wind directions, wind speed classes and thermal stability situations should be included in the short time measurements [4].

In order to perform a time series correlation between the measurement data of a reference station and a target station (located at the wind farm site), the time series of the measured wind data are compared. The relationships of wind speeds and wind directions between them are determined for the common, overlapping measuring period. Afterwards, the correlation parameters obtained by this method are applied on the long-time time-series of the reference station in order to calculate an artificial long-time time-series for the target station.

To determine the wind speed relationship a polynomial regression is applied on the wind speed data for certain wind direction sectors. This procedure, which is described in the following, is called advanced Measure-Correlate-Predict-algorithm (MCP).[7]; For this procedure, the wind direction sectors taken into account are variable and optimised regarding a good correlation. Starting with a first assumption, the determined wind speed relationships for all sectors are optimised regarding a good result, which is a minimal deviation of the wind speed distribution measured at the site and the wind speed distribution obtained by the MCP-method.. The parameters of this function are optimised regarding minimal deviations of wind direction distributions, also. Hence the comparison of the wind speed and wind direction distributions measured at the target site and those obtained by the MCP-method both during the overlapping period can be interpreted as self-consistency test of the correlation procedure and its parameters.

The application of the correlation parameters results in the expected wind distribution at the target site during the reference period. This is often referred as extrapolated wind distribution at the target site, which will be the base for the further wind resource assessment.

In our case study the data set extrapolated to 90 m is however only representative of the station's measurement period of about 3.5 years; according to the sector procedures, the next step was to correlate the site station with a long-term station in order to eliminate the seasonal component that could affect the limited measurement period.

The correlations between site mast TP_2839 and described long term series were tested satisfactory results as regards the correlation factors. ERA5 and CFSR data set showed similar trend, but the ERA5 data set was chosen as long term reference because of the longer period of available wind data.

In order to perform a time series correlation between the measurement data of a reference station and the station located at the wind farm site, the time series of the measured wind data were compared. The relationships of wind speeds and wind directions between them were determined for the common, overlapping measuring period.

To determine the wind speed relationship a statistical linear regression was applied on the wind speed data for certain wind direction sectors. This procedure is called advanced Measure-Correlate-Predict algorithm (MCP).

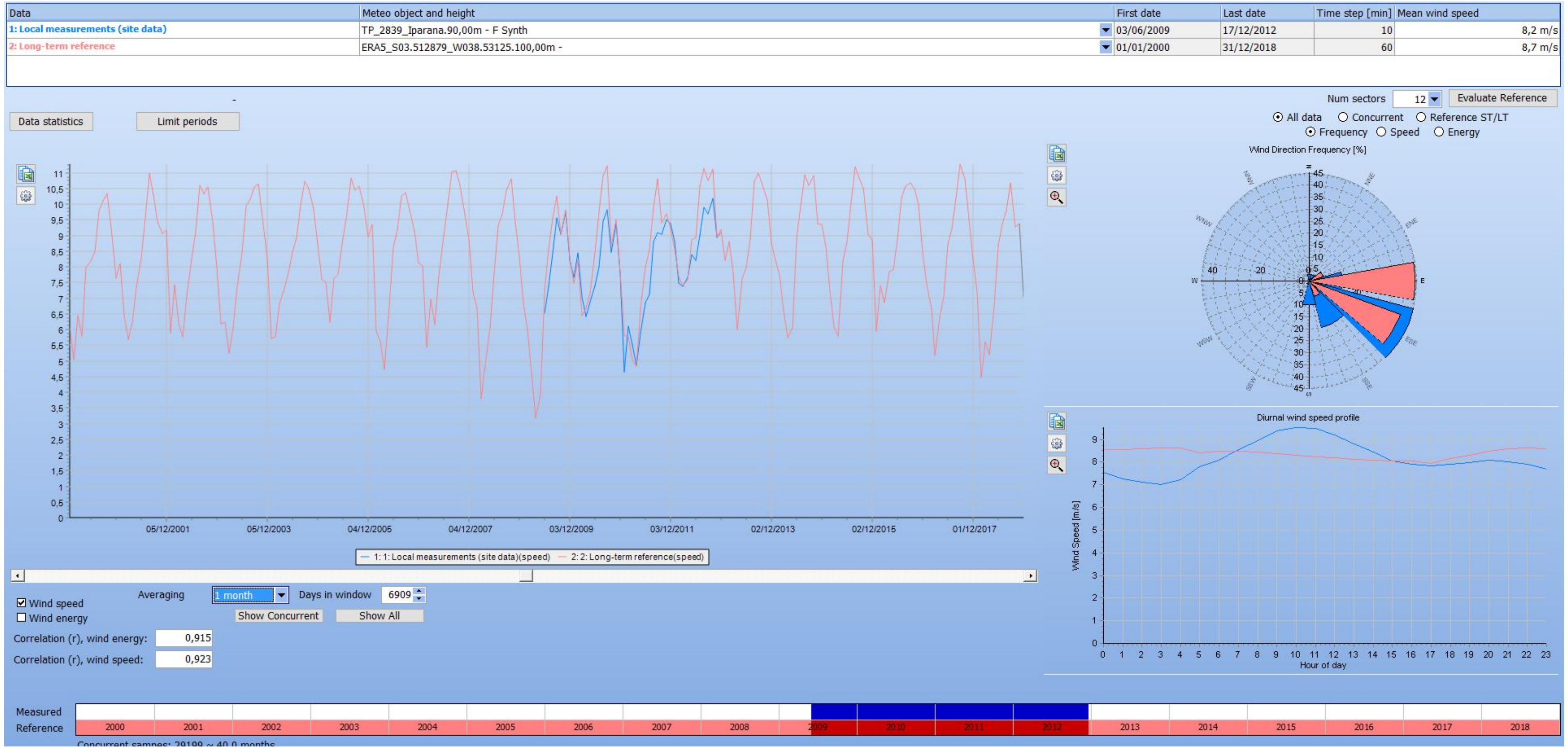


Figure 13: MCP details

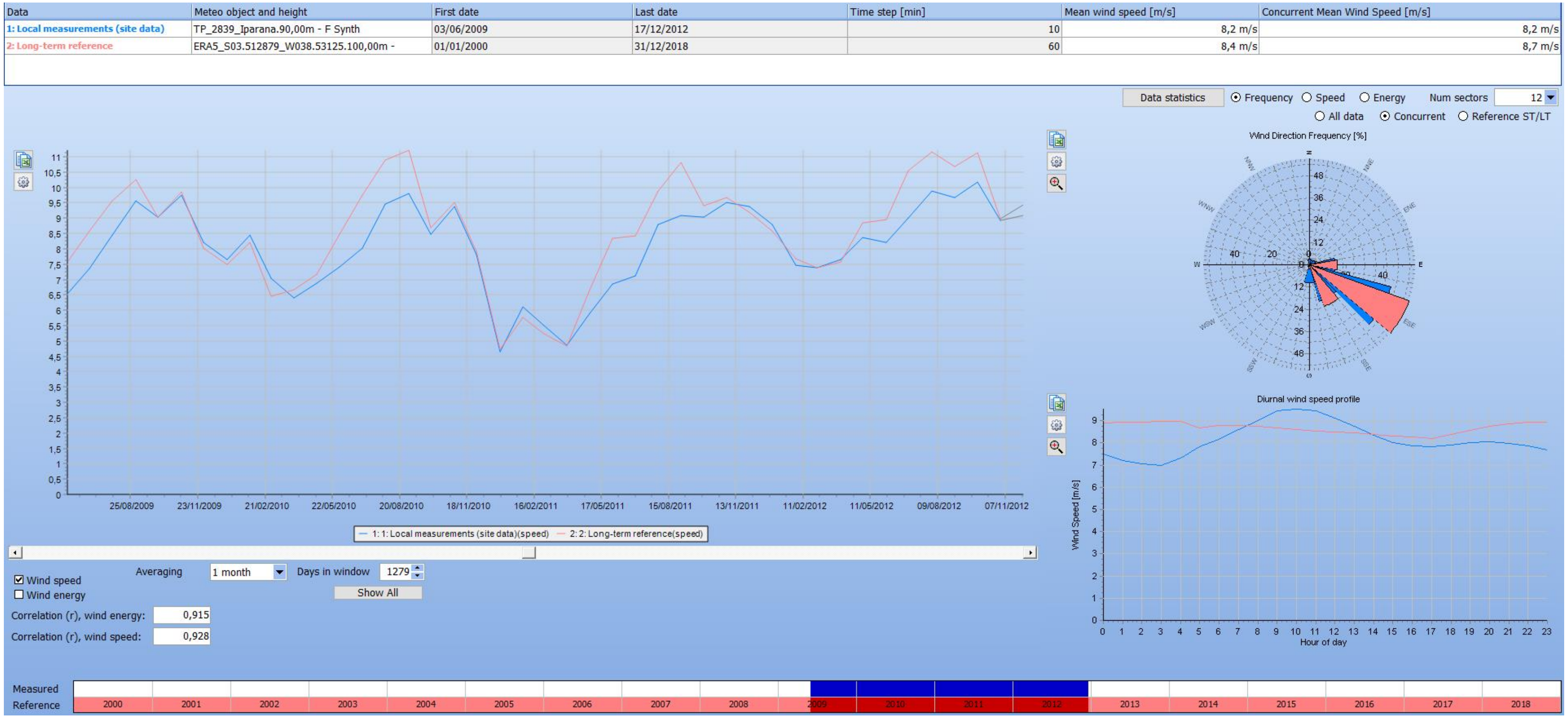
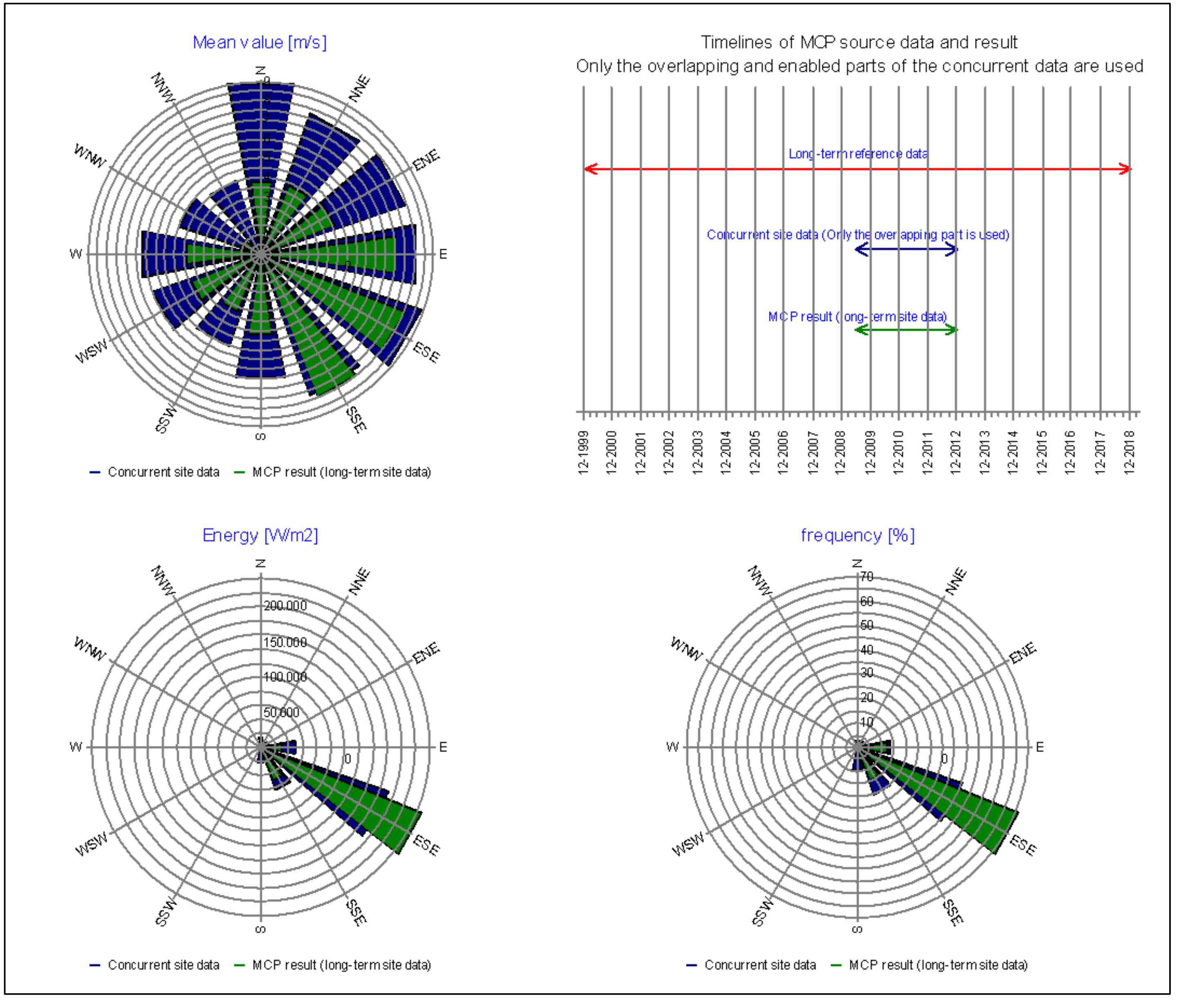


Figure 14: MCP details



Mean value [m/s]
N
NNE
ENE
E
ESE
SSE
S
SSW
WSW
W
WNW
NNW
Concurrent site data
MCP result (long-term site data)
Timelines of MCP source data and result
Only the overlapping and enabled parts of the concurrent data are used
Long-term reference data
Concurrent site data (Only the overlapping part is used)
MCP result (long-term site data)
12-1999
12-2000
12-2001
12-2002
12-2003
12-2004
12-2005
12-2006
12-2007
12-2008
12-2009
12-2010
12-2011
12-2012
12-2013
12-2014
12-2015
12-2016
12-2017
12-2018
Energy [W/m2]
200.000
150.000
100.000
50.000
0
frequency [%]
70
60
50
40
30
20
10
0

MCP - Main report Regression MCP

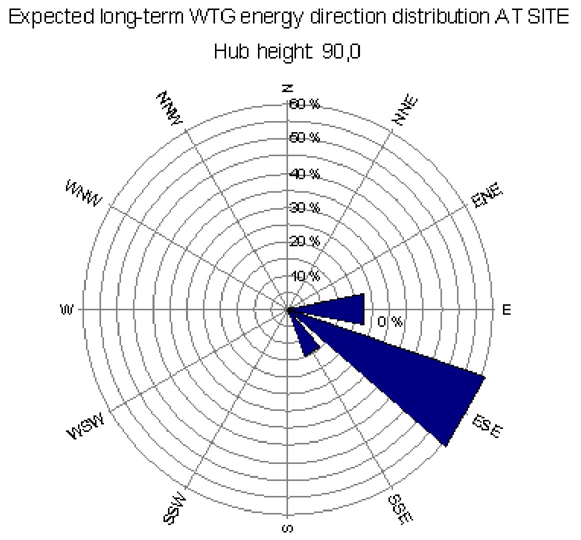
1: Local measurements (site data)	TP_2839_Iparana
Height	90,00 m
Period	03/06/2009 to 17/12/2012 3,5 years
Mean wind speed	8,18 m/s
Filters used	(Averaging)
2: Long-term reference	ERA5_S03.512879_W038.53125
Height	100,00 m
Period	01/01/2000 to 31/12/2018 19,0 years
Mean wind speed	8,43 m/s
Filters used	Not Filtered

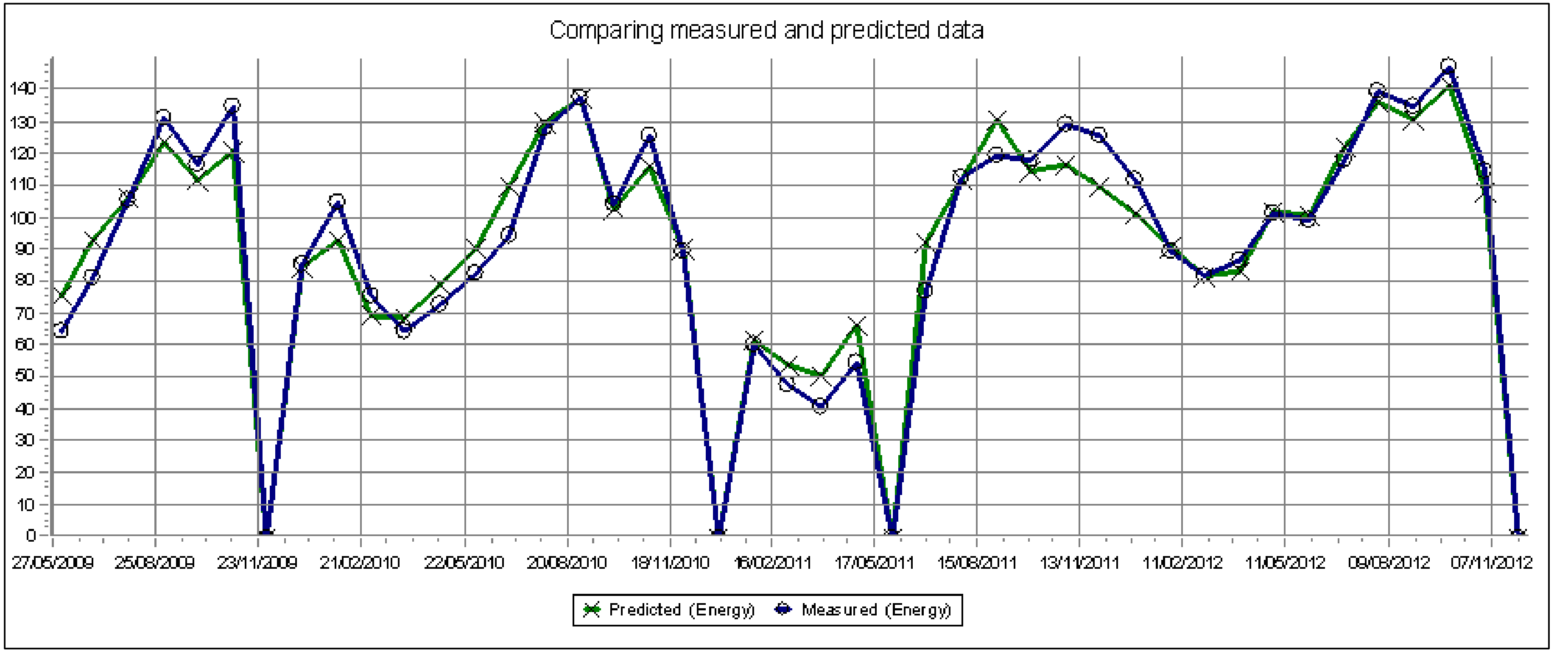
Calculation setup

Method	Find transfer function for each sector
Number of sectors	12
Skip angle differences larger than	360,00
Skip wind speeds less than	2,00
Regression model (wind speed)	Linear (1st order polynomial)
Regression model (wind direction)	Constant (0th order polynomial)
Wind speed model - use residual resampling	Advanced Gaussian: Mean and std.dev. conditioned on wind speed modelled as polynominals (Of order: 1)
Wind direction model - use residual resampling	No model

Results

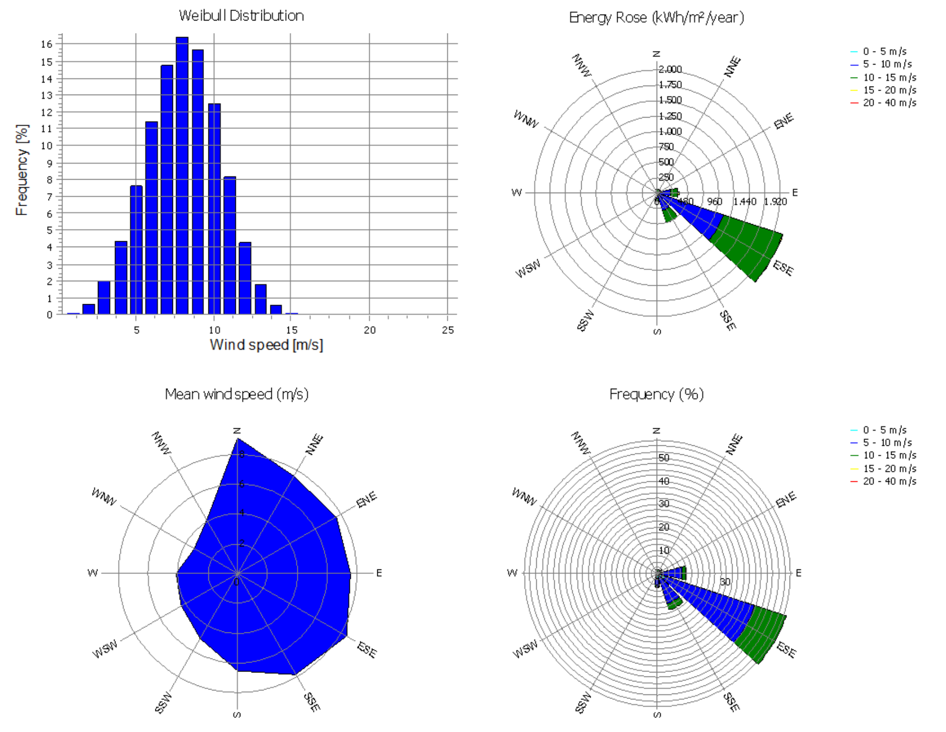
Measure height a.g.l.	90,0 m
Mean wind in measure height	7,86 m/s
Key height a.g.l.	90,0 m
Mean wind in key height	7,93 m/s
Wind energy	59,8
WTG energy	92,2
r - wind speed	0,4278
s - wind speed	2,0095 m/s
r - wind index	0,9625
s - wind index	6,5525 %
Time of calculation	24/06/2019 11:40





	Signal	Weibull mean measured period [m/s]	Weibull mean long term MCP ERA5 [m/s]	Ks historical correction factor	Overprediction measured period
90,0m	**Mean wind speed**	8,18	8,03	0,9817	1,87%

	Signal	Unit	Count	Of period	Mean	Std dev	Min	Max	Weibull mean	Weibull A par	Weibull k par
90,00m - LT ERA5	Mean wind speed, all	m/s	312564	31,3%	7,99		0	23,4	8,03	8,88	3,8279
90,00m - LT ERA5	Wind direction, all	Degrees	312564	31,3%	121,4		0	356			
90,00m - LT ERA5	Turbulence intensity, enabled		162472	16,3%	0,0741	0,062	0	0,6763			



Weibull Data

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	9,96	9,07	4,346	1,6
1 NNE	8,36	7,52	3,506	1,7
2 ENE	8,50	7,61	3,215	2,0
3 E	8,33	7,50	3,607	12,4
4 ESE	9,25	8,44	4,514	58,6
5 SSE	8,60	7,77	3,732	16,6
6 S	7,31	6,50	2,722	5,8
7 SSW	5,63	5,00	1,830	0,8
8 WSW	4,63	4,37	1,191	0,2
9 W	4,39	4,07	1,275	0,2
10 WNW	3,54	3,33	1,204	0,0
11 NNW	4,65	4,16	1,625	0,1
All	8,88	8,03	3,828	100,0

	Signal	Weibull mean measured period [m/s]	Weibull mean long term MCP ERA5 [m/s]	Ks historical correction factor	Overprediction measured period
90,0m	Mean wind speed	8,18	8,03	0,9817	1,87%

Figure 15: TP_2839 –long term average wind speed, directional graph reports for 90 m height : frequency distribution, average wind speed and energy rose. Sector wise weibull distributions

4.7 Wind statistic input for simulation

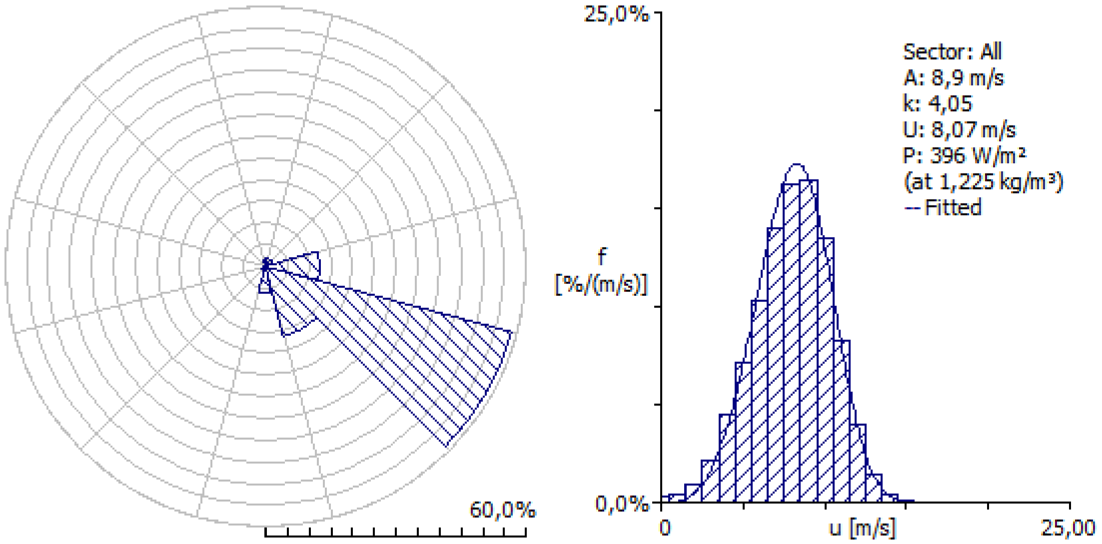
Based on the whole procedure described, the following is the detail of the statistic of long-term representative wind (19 years) used for the simulations, obtained using the measurements of the TP_2839 station in the period of 3.5 years from June 2009 to December 2012 correlated with the ERA5 mesoscale data set (19 years from January 2000 to December 2018).

The correlation methodology showed that the 3.5-year measurement period is slightly above the historical long-term average, in detail the long-term correction consists of a 1.87% reduction in the average speed with a correction factor ks equal to 0.9817.

4.7.1.1 TP_2839_LT_ERA5 90m' Input simulation - Summary

The anemometer is located at co-ordinates -3,69°N -38,61°E Height 90 m

Parameter	Measured	Emergent	Discrepancy
MeanWindSpeed	8,03	8,03	0.0 %
Mean power density	397,5	396	0.4 %



4.7.1.2 Wind

-	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
A [m/s]	10,0	8,4	8,5	8,3	9,2	8,6	7,3	5,6	4,6	4,4	3,5	4,6
k	4,36	3,49	3,21	3,62	4,51	3,72	2,72	1,83	1,19	1,28	1,20	1,62
U [m/s]	9,08	7,52	7,61	7,51	8,44	7,76	6,50	5,00	4,37	4,07	3,33	4,16
P [W/m²]	549	339	365	332	437	363	250	161	206	147	90	107
f [%]	1,6	1,7	2,0	12,4	58,6	16,6	5,8	0,8	0,2	0,2	0,0	0,1

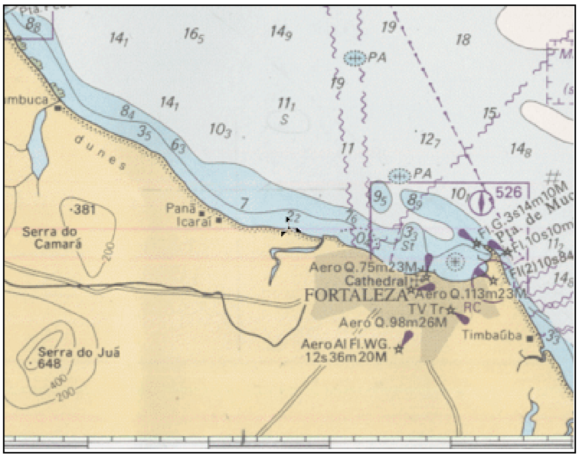
4.7.1.3 Histogram bins

U [m/s]	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	All
0,5	1	7	5	2	1	1	3	9	17	100	79	49	2
1,5	3	12	11	6	2	3	7	25	59	117	145	76	4
2,5	7	23	24	13	5	10	20	70	129	140	204	136	9
3,5	7	46	49	28	12	24	57	136	164	161	204	179	22
4,5	13	86	86	55	26	56	121	192	232	140	105	185	45
5,5	32	99	93	92	51	89	156	207	131	107	99	125	71
6,5	54	94	98	137	89	119	151	130	67	69	72	60	103
7,5	115	120	121	163	137	149	140	73	23	40	13	49	140
8,5	165	146	121	156	172	165	119	41	18	27	13	49	162
9,5	158	150	121	141	185	151	95	31	15	8	26	65	164
10,5	155	106	112	109	156	113	63	37	18	23	7	11	134
11,5	128	61	86	62	97	69	38	20	25	21	13	5	83
12,5	109	31	47	27	46	32	19	15	44	11	13	5	40
13,5	43	14	21	7	16	13	7	8	52	15	0	5	14
14,5	10	2	3	1	4	4	2	5	4	19	0	0	4
15,5	1	2	0	0	1	1	1	1	1	2	0	0	1
16,5	0	0	0	0	0	0	0	0	0	0	7	0	0
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0

Wind statistics - Overview

File: \\192.168.1.5\Med-Tp\WPROjects\ESTERO\BRASILE\CAUCAIA\BR TP_2839_Iparana - LT ERA5 90 WP -60+50+5.wws

Name
TP_2839_Iparana - LT ERA5 90 WP -60+50+5
Source
USER
Country
Brazil
Site coordinates
UTM WGS84 S Zone: 24 East: 543.279 North: 9.592.142
WAsP version
WAsP 11 Version 11.06.0028
Interval used
01/01/2000 - 31/12/2018



Scale 1:500.000

Mean wind speed [m/s]

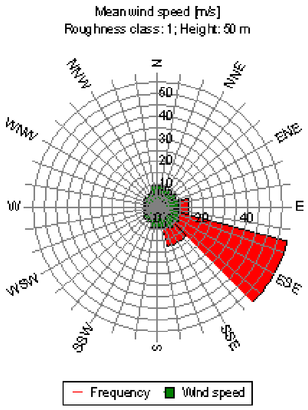
Height [m]	0 0,00 m	1 0,03 m	2 0,10 m	3 0,40 m	4 1,50 m
10,0	7,0	4,7	4,1	3,2	2,1
25,0	7,6	5,7	5,1	4,2	3,2
50,0	8,2	6,6	6,0	5,1	4,1
100,0	8,8	7,9	7,2	6,3	5,2
200,0	9,5	9,8	8,9	7,8	6,6

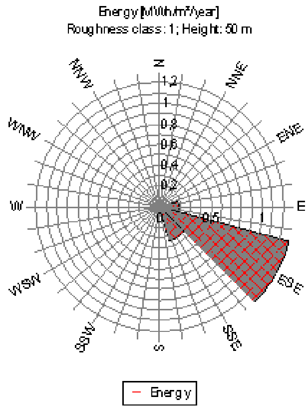
(Roughness class/Length)

Wind energy [kWh/m²/year]

Height [m]	0 0,00 m	1 0,03 m	2 0,10 m	3 0,40 m	4 1,50 m
10,0	2.377	787	507	238	68
25,0	3.082	1.326	940	540	235
50,0	3.757	2.013	1.494	942	493
100,0	4.651	3.319	2.500	1.654	965
200,0	5.872	6.128	4.608	3.110	1.918

(Roughness class/Length)





WTG energy [kWh/m²/year]

Normal rated WTG (0.45 kW/m2)

Height [m]	0 0,00 m	1 0,03 m	2 0,10 m	3 0,40 m	4 1,50 m
10,0	1.075	388	213	56	3
25,0	1.274	669	483	246	58
50,0	1.435	961	758	499	222
100,0	1.608	1.363	1.142	846	530
200,0	1.797	1.860	1.634	1.319	955

High wind rated WTG (0.55 kW/m2)

Height [m]	0 0,00 m	1 0,03 m	2 0,10 m	3 0,40 m	4 1,50 m
10,0	1.154	394	206	50	2
25,0	1.405	692	495	242	51
50,0	1.603	1.022	788	511	216
100,0	1.806	1.516	1.238	890	544
200,0	2.032	2.108	1.837	1.461	1.016

Low wind rated WTG (0.35 kW/m2)

Height [m]	0 0,00 m	1 0,03 m	2 0,10 m	3 0,40 m	4 1,50 m
10,0	985	388	236	66	3
25,0	1.153	631	470	265	68
50,0	1.278	886	708	484	244
100,0	1.382	1.228	1.042	785	510
200,0	1.547	1.610	1.398	1.191	881

(Roughness class/Length)

4.8 Turbulence

The expression “Wind Turbulence” denotes the stochastic variations in the velocity from 10 min average. The wind turbulence depends on the surrounding topography, the surface roughness, the stability of the different atmospheric layers and the general weather conditions. Turbulence is generated mainly from two causes:

- friction with the earth’s surface where flow disturbances are caused by topographical features as hills, obstacles and mountains.
- thermal effects which can cause vertically motion of air masses due to variations of temperature, and hence of the density of the air.

Often these two effects are interconnected as when an air mass flows over a mountain range and is forced up into cooler regions where it is no longer in thermal equilibrium with its surroundings. Turbulence is clearly a complex process and cannot be represented simply in terms of deterministic equations. The standard deviation of wind speed fluctuations is a known key parameter for both extreme and fatigue loading and their action must be taken into account to ensure sufficient structural sustainability of the wind turbines exposed to “wind farm flow”.

4.8.1 Ambient turbulence intensity

The ambient Turbulence (I) is determined as a ratio of wind speed standard deviation (σ) to the mean wind speed evaluated in the same 10 min interval.

$$I = \frac{\sigma}{V_{mean}}$$

The following two table show the turbulence intensity and the standard deviation for all wind direction sector and all wind speed bin at 61m a.g.l. The last row (“Sector mean”) gives the mean values per wind direction sector for all wind speed bin. The red value in the lower right corner is total mean value. The turbulence values and the standard deviation are calculated for all measured data without filters.
According to the WTGS classification referring to the standard IEC 61400-1, edition 3, a wind turbine has to be designed to withstand the turbulence intensity (I_{ref}) of 16 % (class A), 14 % (class B) or 12 % (class C). The turbulence intensity I_{ref} according is defined as the expected value of hub height turbulence intensity at a ten-minute average wind speed of 15 m/s.
The following figure shows the bin-wise turbulence intensity measured at mast (61 m height) in comparison to the turbulence classes of IEC61400-1, edition 3. [14]

<u>A detailed measured turbulence analysis for each wind speed bin and for each sector is described in the mast report.</u>

Table 9: Numerical bin wise turbulence intensity measured

Bin	Mean	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
Mean	0,08	0,11	0,12	0,1	0,09	0,06	0,1	0,09	0,06	0,07	0,08	0,08	0,08
0	0,21					0,21							
1	0,11							0,11					
2	0,12					0,09		0,15					
3	0,09				0,07	0,11	0,1	0,13	0,08	0,05			
4	0,09	0,14	0,11	0,1	0,1	0,11	0,1	0,06	0,05	0,09	0,13	0,07	0,12
5	0,1	0,15	0,13	0,1	0,1	0,1	0,11	0,07	0,04	0,04	0,08	0,1	0,1
6	0,09	0,15	0,14	0,1	0,09	0,08	0,11	0,09	0,05	0,06	0,18	0,1	0,11
7	0,09	0,14	0,13	0,09	0,09	0,07	0,1	0,1	0,07	0,11			0,07
8	0,08	0,12	0,12	0,09	0,09	0,06	0,11	0,11	0,09	0,1			0,07
9	0,07	0,1	0,12	0,09	0,09	0,05	0,11	0,11	0,11	0,1	0,08	0,05	0,05
10	0,07	0,09	0,11	0,1	0,09	0,05	0,1	0,12	0,1	0,06	0,06		0,06
11	0,07	0,07	0,09	0,1	0,09	0,05	0,1	0,12	0,08	0,06	0,06	0,13	0,11
12	0,07	0,06	0,08	0,11	0,09	0,06	0,1	0,13	0,08	0,06	0,05		0,08
13	0,08	0,06	0,09	0,14	0,09	0,06	0,11	0,12	0,14	0,07			
14	0,07	0,06	0,06	0,06	0,06	0,06	0,11	0,07	0,09	0,05			
15	0,08	0,04			0,13	0,06	0,09	0,06				0,04	
16	0,13		0,04	0,22	0,1	0,19	0,16						
17	0					0							
18													
19	0					0							
20													

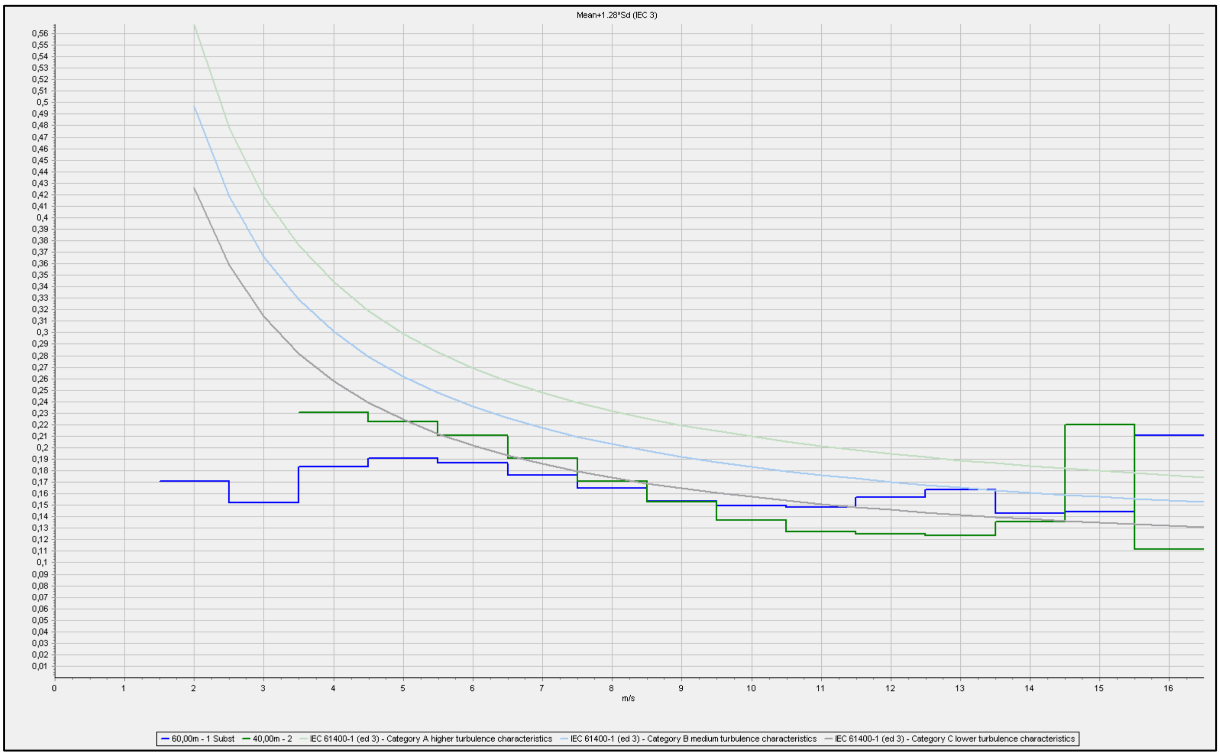


Figure 16: Graphic representation of bin-wise turbulence intensity measured at mast (60 m height) in comparison to the turbulence classes of IEC61400-1 ed. 3

5 SITE ASSESSMENT

5.1 Wasp modelling

Using all described input data of orography, roughness and wind data a WPRO/Wasp model was set out. The default vertical wind profile in the applied calculation model WAsP is optimized for the usage in the middle or northern Europe. The heat flux parameter at the regarded site differs from northern Europe conditions. The two parameters available for changing the stability treatment in WAsP are identified as RMS heat flux and offset heat flux [8]; [30]. According to recommended literature values the followings parameters were set initially:

"Offset heat flux over land" = 60 W/m^2 (Default -40 W/m^2)

"RMS heat flux over land" = 50 W/m^2 (Default 100 W/m^2)

"RMS heat flux over water" = 5 W/m^2 (Default 30 W/m^2)

Using these recommended parameters resulted in a poor adaptation of the measured shear and a strong overestimation of the resource in the offshore area verified by cross-comparison with the ERA5 data at 100 m

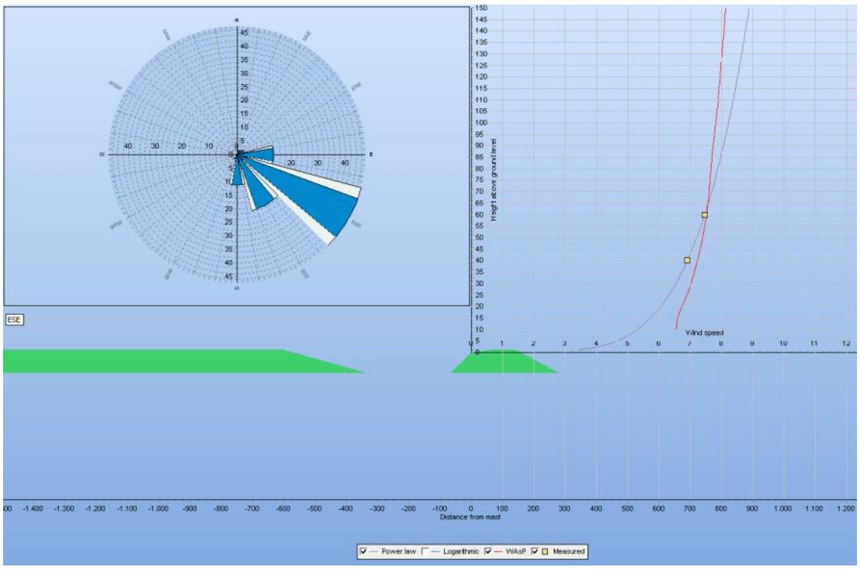


Figure 17: Adaption of wasp shear profile using rcomended heat flux parameters

Table 10: Cross prediction values with heat flux recomended settings

Cross prediction values using recomended HF 60;50;5					**Predicted values by predictor**			
Predicted at	**Mast Description**	**Height ID**	**Height [m]**	**Measured wind speed [m/s]**	**A [m/s]**	**B [m/s]**	**A [%]**	**B [%]**
A	ERA5_S03.512879_W038.53125	100,00m -	100	8,43	8,43	8,79	-0,1	4,3
B	TP_2839_Iparana	90,00m - LT ERA5	90	7,88	7,80	7,94	-0,9	0,8

Although not always recommendable, due to caution in the estimate it was preferred to adapt the profile of the wasp modeling to the one measured, a good result was obtained leaving the recommended parameters and changing only the offset value of the heat flux in detail

"Offset heat flux over land" = -60 W/m^2 (Default -40 W/m^2)

"RMS heat flux over land" = 50 W/m^2 (Default 100 W/m^2)

"RMS heat flux over water" = 5 W/m^2 (Default 30 W/m^2)

Using the parameters described, a good adaptation of the profile and good values of self and cross prediction were obtained

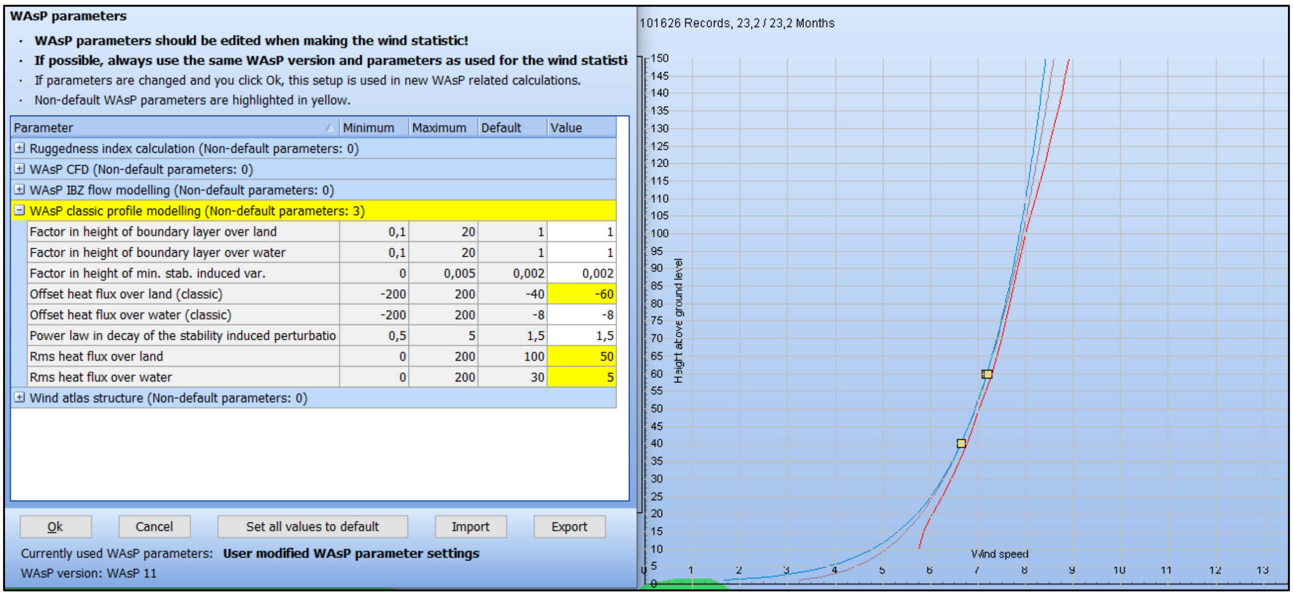


Figure 18: Adaption of wasp shear profile using modified heat flux parameters

Table 11: Cross prediction values with heat flux modified settings

Cross prediction values using modified HF -60;50;5					**Predicted values by predictor**			
Predicted at	**Mast Description**	**Height ID**	**Height [m]**	**Measured wind speed [m/s]**	**A [m/s]**	**B [m/s]**	**A [%]**	**B [%]**
A	ERA5_S03.512879_W038.53125	100,00 m -	100	8,43	8,43	8,46	-0,1	0,4
B	TP_2839_Iparana	90,00m - LT ERA5	90	7,88	7,90	7,87	0,3	-0,1

A good self-prediction values were obtained for the site mast with a maximum overprediction of 0,4 %

5.2 Technical data of wind turbine

To date most of the offshore plants are located in areas characterized by a high wind speed (for example the northern seas, the Baltic Sea) with high gust values and wind distributions requiring robust structural characteristics and power curves eligible for such schemes.
The anemological regime of the Brazilian area of Caucaia has very peculiar features, as it is characterized by a high average speed (8.5 m / s at 100 m) but by a statistical distribution corresponding to a Weibull with super form factor at 3.5, practically a Gaussian. The expected extreme values are very low (<25 m / s), the flow is very regular characterized by low turbulence.
The power curves suitable for exploiting this wind speed are those with a large rotor size and a generator set to work on the Gaussian centered regimes. The wind turbines designed for low wind speeds can be installed and they ca guarantee a capacity factor of over 50%.
For the Caucaia project it has been imagined to install rotor machines up to 250 m and power up to 12 MW to take account of the rapid development of technology.
No one of the most recent offshore wind turbine power curves have been made available by suppliers.
MHI -Vestas supplied the power curves but with the condition of not divulging the technical details, for this reason in the case of the Vestas only the results of the final productions are shown
In all others offshore cases, unofficial theoretical power curves were used, extrapolated using WindPro software based on pitch technology standards for an assigned rotor and power. The method is very cautious and is based on “simplified HP – curves” which assume that all WTGs performs quite similar. Only specific power loading (kW/M^2) and single/dual speed or stall/pitch decides the calculated values.
It has been decided to perform some estimates with power curves of onshore wind turbine models that have the appropriate characteristics to highlight the productive capacity of the Brazilian offshore resource with wind turbines with the right technical characteristics .
In the tables below are synthesized the main characteristic of chosen wind turbine for the windfarm.

Table12: Types of wind turbine generators simulated for the project for the different scenarios

Turbine Type	N° WTG	Type	Total Power [MW]	Hub Height a.g.l. [m]
48*Siemens SG 6.0-170 + 11*Siemens SWT-2.3-101	59	Onshore	313,300	[110-80]
48*VESTAS V162-5.6 + 11*VESTAS V110-2.0	59	Onshore	290,800	[110-95]
48*Siemens SG 8.0-154 + 11*Siemens SWT-2.3-101	59	**Offshore**	409,300	[110-80]
48*VESTAS V164-10.0 + 11*VESTAS V110-2.0	59	**Offshore**	502,000	[110-95]
48*VESTAS V174-9.5 + 11*VESTAS V110-2.0	59	**Offshore**	478,000	[110-95]
48*GE WIND 220 12 MW + 11*GE 116-2.0	59	**Offshore**	598,000	[150-90]

Overview | Features

A trusted choice from day one, built on the proven 9 MW platform and Vestas technology lineage with minimal design changes

Configured for worldwide application and engineered for IEC T

9.5 MW rated power, with an optimal rotor to generator ratio

Rotor diameter of 174 metres

85 m blades with an optimised, load minimising design profile

Each blade weighs 35 tonnes, same as the V164-9.5 MW blade

Swept area of 23,779 m2, more than double the area of the London Eye

The nacelle is 21 m long, 9 m wide and 9 m high, weighing approximately 390 tonnes

Approximate hub height of 110 m

Approximate tip height of 197 m

One turbine can power 9,000 UK homes

V174-9.5 MW™

- Largest commercially proven rotor size – 174 meters
- Engineered for IEC class T
- Based on the proven, trusted and bankable V164 turbine platform
- Aerodynamically efficient, upgraded blade profile
- Swept area of 23,779 m2, more than double the area of the London Eye

Overview | Features

The V164-10.0 MW™ incorporates a stronger gearbox, some minor mechanical upgrades, and a small design change to enhance air flow and increase cooling in the converter. The upgrades ensure that this gentle giant can run at full power, at a site with wind speeds of 10 metres per second, for 25 years.

- Flanged connected drive train with easy-access key-components
- Main bearings, coupling, gearbox and generator is possible to lift out separately for service
- Permanent magnet generator
- Full scale converter 50/60 Hz at 66 kV nominal voltage
- Nacelle dimensions: 9.3 m x 20.7 m x 8.8 m (H x L x W)
- Rotor diameter: 164 m
- Swept area: 21,124 m2
- Helihoist platform available

V164-10.0 MW™

- The world's first commercial double digit offshore wind turbine
- Built on the proven and trusted 9 MW Platform
- Ready for installation from 2021

SG 6.0-170

SIEMENS Gamesa
RENEWABLE ENERGY

Technical Specifications

Rotor
Type .... 3-bladed, horizontal axis
Position .... Upwind
Diameter............................ 170 m
Swept area .... 22,698 m²
Power regulation .... Pitch & torque regulation with variable speed
Rotor tilt............................ 6 degrees

Blade
Type .... Self-supporting
Blade length .... 83 m
Max chord .... 4.5 m
Aerodynamic profile .... Siemens Gamesa proprietary airfoils
Material .... GRE (Glassfiber Reinforced Epoxy) – CRP (Carbon Reinforced Plastic)
Surface gloss .... Semi-gloss, < 30 / ISO2813
Surface color .... Light grey, RAL 7035 or White, RAL 9018

Aerodynamic Brake
Type .... Full span pitching
Activation.......................... Active, hydraulic

Load-Supporting Parts
Hub.................................... Nodular cast iron
Main shaft.......................... Forged steel
Nacelle bed frame .... Nodular cast iron

Mechanical Brake
Type .... Hydraulic disc brake
Position .... Gearbox rear end

Nacelle Cover
Type .... Totally enclosed
Surface gloss .... Semi-gloss, <30 / ISO2813
Color.................................. Light Grey, RAL 7035 or White, RAL 9018

Generator
Type.................................. Asynchronous, DFIG

Grid Terminals (LV)
Baseline nominal power . 6.0 MW
Voltage .... 690 V
Frequency.......................... 50 Hz or 60 Hz

Yaw System
Type.................................. Active
Yaw bearing...................... Externally geared
Yaw drive.......................... Electric gear motors
Yaw brake......................... Active friction brake

Controller
Type .... Siemens Integrated Control System (SICS)
SCADA system .... SGRE SCADA System

Tower
Type .... Tubular steel / Hybrid

Hub height .... 100m to 165 m, site-specific

Corrosion protection ...... Painted
Surface gloss .... Semi-gloss, <30 / ISO-2813
Color .... Light grey, RAL 7035 or White, RAL 9018

Operational Data
Cut-in wind speed .... 3 m/s
Rated wind speed .... 10.0 m/s (steady wind without turbulence, as defined by IEC61400-1)
Cut-out wind speed .... 25 m/s
Restart wind speed......... 22 m/s

Weight
Modular approach............ All modules weight lower than 80 t for transport

V162-5.6 MW 50/60 Hz

Generator	
Type	Permanent Magnet Synchronous generator
Rated Power [P_N]	Up to 5850 kW (depending on turbine variant)
Frequency range [f_N]	0-138 Hz
Voltage, Stator [U_{NS}]	3 x 800 V (at rated speed)
Number of Poles	36
Winding Type	Form with Vacuum Pressurized Impregnation
Winding Connection	Star
Operational speed range	0-460 rpm
Overspeed Limit (2 minutes)	TBD
Temperature Sensors, Stator	PT100 sensors placed in the stator hot spots.
Insulation Class	H
Enclosure	IP54

Rotor	V150	V162
Diameter	150 m	162 m
Swept Area	17671 m²	20611 m²
Speed, Dynamic Operation Range	4.9 - 12.6 rpm	4.3 -12.1 rpm
Rotational Direction	Clockwise (front view)	
Orientation	Upwind	
Tilt	6°	
Hub Coning	6°	
No. of Blades	3	
Aerodynamic Brakes	Full feathering	

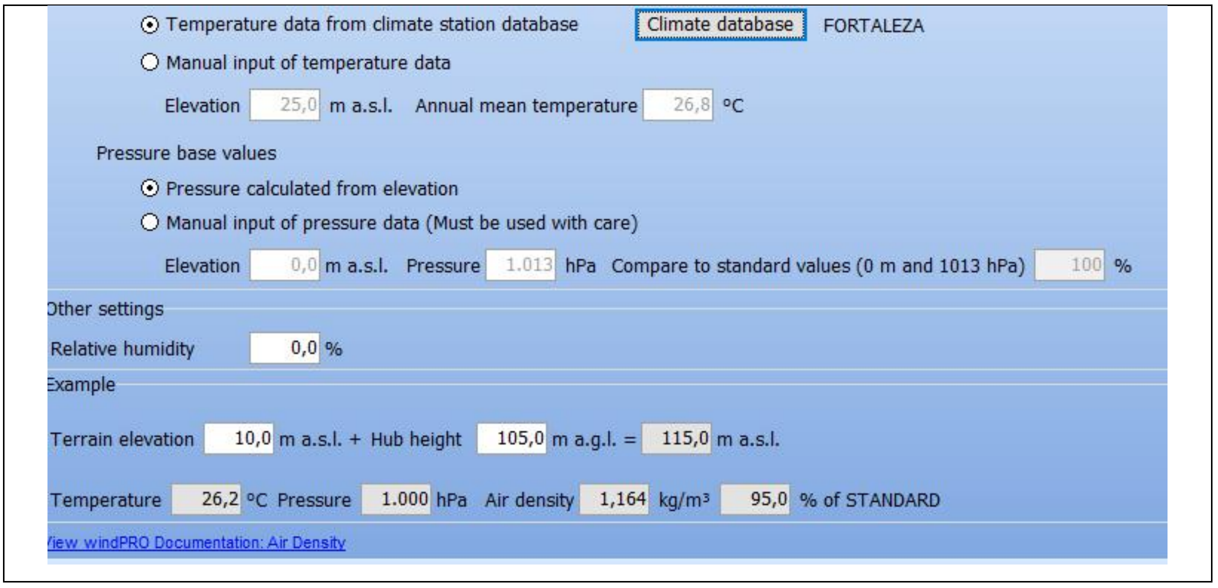
Blades	V150	V162
Blade Length	73.65 m	79.35 m
Maximum Chord	4.2 m	4.3 m
Chord at 90% blade radius	1.4 m	1.57 m
Type Description	Structural airfoil shell	
Material	Fibreglass reinforced epoxy, carbon fibres and Solid Metal Tip (SMT)	
Blade Connection	Steel roots inserted	
Airfoils	High-lift profile	

Haliade-X Specifications

Rated Power	12 MW
Rotor Diameter	220m
Blade Length	107m
Rotor Swept Area	38,000m²
Total Height	260m

5.3 Power curve analysis

The power curve describes the electric power output from a specific WTG versus the wind speed at hub height. The power curve is typically provided from the WTG supplier. The official power curve supplied is typically measured by a certificated society by installing wind monitoring equipment close to a WTG, and measuring the coincident values in detailed standard condition for the normalized air density of 1,225. kg/m³. The power curve was adapted to the air density condition of site location at hub height. The calculation of air density at the sites was based on the long term temperature measurements of Fortaleza climate database taking into account the altitude of the site.



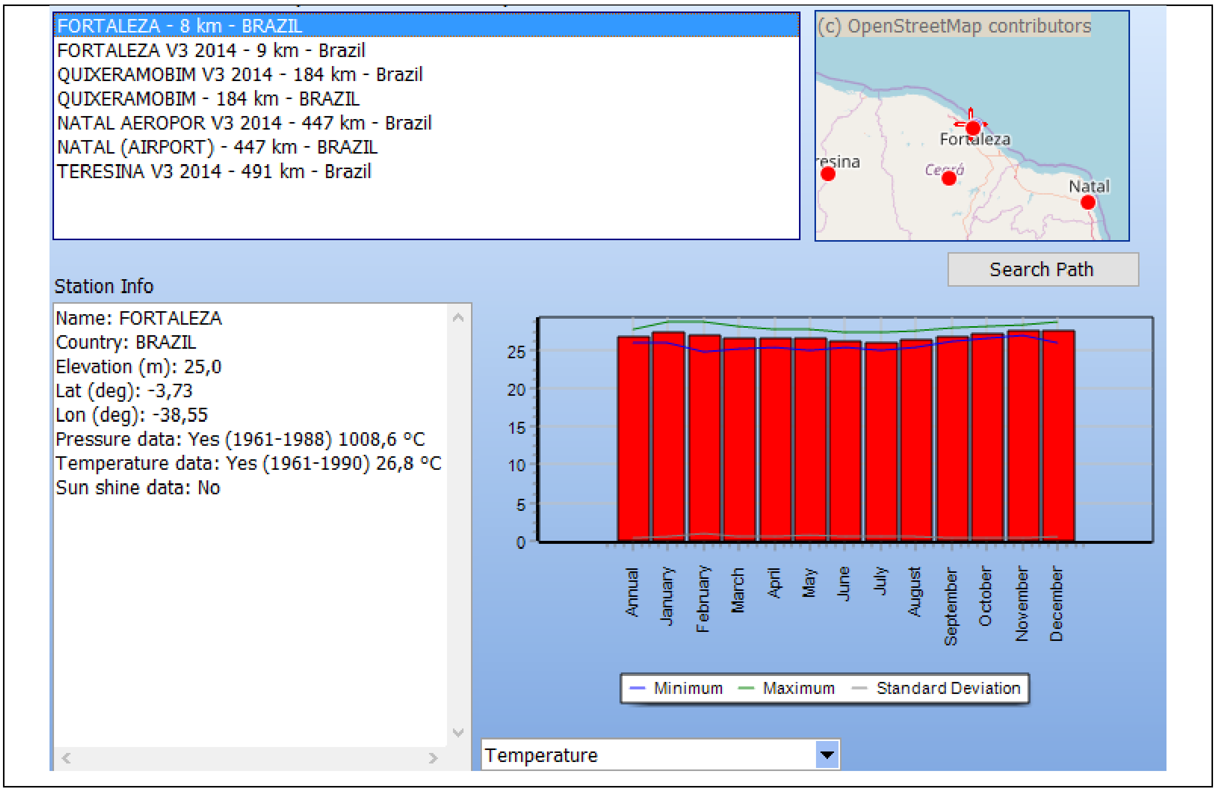


Figure 19: Characteristics of Fortaleza weather station used for improving pressure estimation on site

Site air density was based on the closest available data from the climate database of WindPRO that is given below. The evaluated average air density at calculation height is 1,164 kg/m^3

So, this value was used to calculate the energy yield, air density on WTG position taking into account the altitude and hub height, calculated by standard air density, using the following equation:

$$\rho_1 V_1^3 = \rho_2 V_2^3 \; ; \quad V_2 = \left(\frac{\rho_1}{\rho_2} \right)^{1/3} V_1$$

Calculation: SG 170 6 MW**WTG:** 26 - Siemens SG 6.0-170 6000 170.0 !O!, Hub height: 122,5 m

Name: Mode Std.
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m²
08/09/2017	USER	03/05/2017	08/05/2019	27,0	Pitch	User defined	Variable	0,26

Power Curve Rev. 0.
Siemens Wind Power and its affiliates reserve the right to change the above specifications without prior notice.

HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.225	16.735	21.905	26.405	30.135	33.074
Siemens SG 6.0-170 6000 170.0 !O! Mode Std.	[MWh]	11.459	17.007	22.177	26.648	30.335	33.239
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

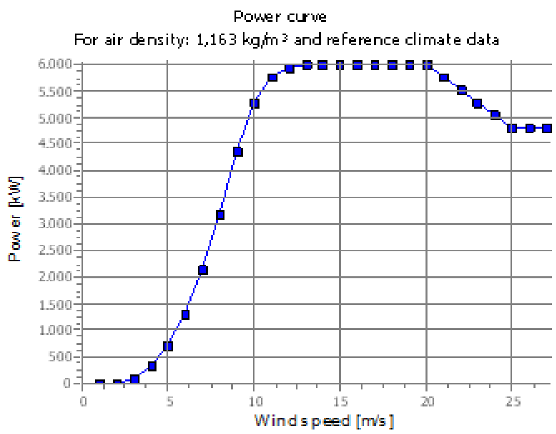
Original data, Air density: 1,225 kg/m³

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	94,0	0,25	3,0	0,91
3,5	184,0	0,31	3,5	0,86
4,0	334,0	0,38	4,0	0,84
4,5	538,0	0,42	4,5	0,83
5,0	764,0	0,44	5,0	0,82
5,5	1.047,0	0,45	5,5	0,82
6,0	1.383,0	0,46	6,0	0,82
6,5	1.779,0	0,47	6,5	0,82
7,0	2.238,0	0,47	7,0	0,82
7,5	2.763,0	0,47	7,5	0,82
8,0	3.348,0	0,47	8,0	0,81
8,5	3.969,0	0,46	8,5	0,79
9,0	4.570,0	0,45	9,0	0,74
9,5	5.083,0	0,43	9,5	0,68
10,0	5.464,0	0,39	10,0	0,60
10,5	5.712,0	0,35	10,5	0,52
11,0	5.855,0	0,32	11,0	0,45
11,5	5.931,0	0,28	11,5	0,39
12,0	5.969,0	0,25	12,0	0,33
12,5	5.986,0	0,22	12,5	0,29
13,0	5.994,0	0,20	13,0	0,26
13,5	5.997,0	0,18	13,5	0,23
14,0	5.999,0	0,16	14,0	0,20
14,5	5.999,0	0,14	14,5	0,18
15,0	6.000,0	0,13	15,0	0,16
15,5	6.000,0	0,12	15,5	0,15
16,0	6.000,0	0,11	16,0	0,13
16,5	6.000,0	0,10	16,5	0,12
17,0	6.000,0	0,09	17,0	0,11
17,5	6.000,0	0,08	17,5	0,10
18,0	6.000,0	0,07	18,0	0,10
18,5	6.000,0	0,07	18,5	0,09
19,0	6.000,0	0,06	19,0	0,08
19,5	6.000,0	0,06	19,5	0,08
20,0	6.000,0	0,05	20,0	0,07
20,5	5.880,0	0,05	20,5	0,06
21,0	5.760,0	0,04	21,0	0,06
21,5	5.640,0	0,04	21,5	0,05
22,0	5.520,0	0,04	22,0	0,05
22,5	5.400,0	0,03	22,5	0,04
23,0	5.280,0	0,03	23,0	0,04
23,5	5.160,0	0,03	23,5	0,04
24,0	5.040,0	0,03	24,0	0,04
24,5	4.920,0	0,02	24,5	0,03
25,0	4.800,0	0,02	25,0	0,03

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,163 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc.Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50- 1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50- 2,50	0,0	0,0	0,0
3,0	84,4	0,24	2,50- 3,50	17,9	17,9	0,1
4,0	312,7	0,37	3,50- 4,50	109,2	127,1	0,4
5,0	722,1	0,44	4,50- 5,50	379,8	506,8	1,6
6,0	1.311,4	0,46	5,50- 6,50	992,6	1.499,4	4,8
7,0	2.123,8	0,47	6,50- 7,50	2.122,5	3.621,9	11,5
8,0	3.180,4	0,47	7,50- 8,50	3.777,4	7.399,4	23,6
9,0	4.362,1	0,45	8,50- 9,50	5.452,9	12.852,3	41,0
10,0	5.296,0	0,40	9,50-10,50	6.171,6	19.023,9	60,6
11,0	5.772,9	0,33	10,50-11,50	5.425,0	24.448,8	77,9
12,0	5.941,5	0,26	11,50-12,50	3.736,2	28.185,0	89,8
13,0	5.987,4	0,21	12,50-13,50	2.018,2	30.203,2	96,2
14,0	5.997,2	0,17	13,50-14,50	841,8	31.045,0	98,9
15,0	5.999,0	0,13	14,50-15,50	264,6	31.309,6	99,8
16,0	6.000,0	0,11	15,50-16,50	61,0	31.370,6	100,0
17,0	6.000,0	0,09	16,50-17,50	10,0	31.380,6	100,0
18,0	6.000,0	0,08	17,50-18,50	1,1	31.381,7	100,0
19,0	6.000,0	0,07	18,50-19,50	0,1	31.381,8	100,0
20,0	6.000,0	0,06	19,50-20,50	0,0	31.381,8	100,0
21,0	5.760,0	0,05	20,50-21,50	0,0	31.381,8	100,0
22,0	5.520,0	0,04	21,50-22,50	0,0	31.381,8	100,0
23,0	5.280,0	0,03	22,50-23,50	0,0	31.381,8	100,0
24,0	5.040,0	0,03	23,50-24,50	0,0	31.381,8	100,0
25,0	4.800,0	0,02	24,50-25,50	0,0	31.381,8	100,0
26,0	4.800,0	0,02	25,50-26,50	0,0	31.381,8	100,0
27,0	4.800,0	0,02	26,50-27,50	0,0	31.381,8	100,0



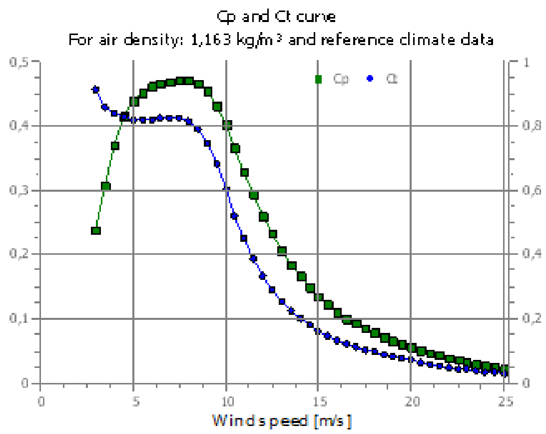


Figure 20: Power curve details of SG 170 6 MW

Calculation: Vestas V162 5.6**WTG:** 26 - VESTAS V162-5.6 5600 162.0 !O!, Hub height: 125,0 m

Name: Level 0 - Calculated - Power Curves, Mode 0 - 24-10-2018
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m²
24/10/2018	USER	10/08/2017	14/01/2019	24,0	Pitch	User defined	Variable	0,27

Document no.: 0079-5337 V00
Date: 2018-10-24
Document owner: Platform Management
Type: T05 - General Description

HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	10.249	15.343	20.152	24.357	27.855	30.619
VESTAS V162-5.6 5600 162.0 !O! Level 0 - Calculated - Power Curves, Mode 0 - 24-10-2018	[MWh]	10.446	15.650	20.507	24.652	27.934	30.319
Check value	[%]	-2	-2	-2	-1	0	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

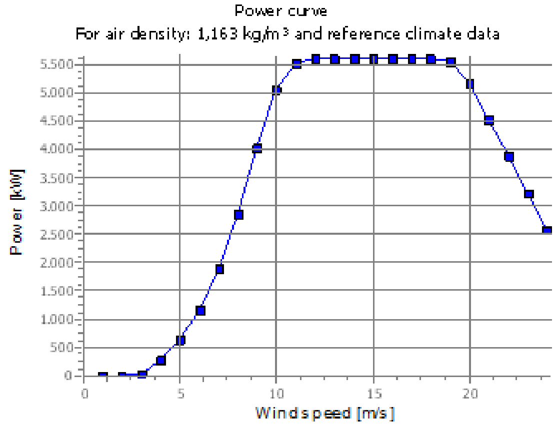
Original data, Air density: 1,225 kg/m³

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	52,0	0,15	3,0	0,92
3,5	166,0	0,31	3,5	0,88
4,0	304,0	0,38	4,0	0,85
4,5	470,0	0,41	4,5	0,83
5,0	672,0	0,43	5,0	0,83
5,5	922,0	0,44	5,5	0,83
6,0	1.224,0	0,45	6,0	0,82
6,5	1.579,0	0,46	6,5	0,82
7,0	1.996,0	0,46	7,0	0,81
7,5	2.472,0	0,46	7,5	0,81
8,0	3.012,0	0,47	8,0	0,80
8,5	3.614,0	0,47	8,5	0,79
9,0	4.245,0	0,46	9,0	0,76
9,5	4.813,0	0,44	9,5	0,70
10,0	5.238,0	0,41	10,0	0,62
10,5	5.472,0	0,37	10,5	0,53
11,0	5.574,0	0,33	11,0	0,45
11,5	5.597,0	0,29	11,5	0,38
12,0	5.600,0	0,26	12,0	0,33
12,5	5.600,0	0,23	12,5	0,29
13,0	5.600,0	0,20	13,0	0,25
13,5	5.600,0	0,18	13,5	0,22
14,0	5.600,0	0,16	14,0	0,20
14,5	5.600,0	0,15	14,5	0,18
15,0	5.600,0	0,13	15,0	0,16
15,5	5.600,0	0,12	15,5	0,15
16,0	5.600,0	0,11	16,0	0,13
16,5	5.600,0	0,10	16,5	0,12
17,0	5.600,0	0,09	17,0	0,11
17,5	5.600,0	0,08	17,5	0,10
18,0	5.600,0	0,08	18,0	0,09
18,5	5.600,0	0,07	18,5	0,09
19,0	5.558,0	0,06	19,0	0,08
19,5	5.409,0	0,06	19,5	0,07
20,0	5.147,0	0,05	20,0	0,06
20,5	4.831,0	0,04	20,5	0,06
21,0	4.514,0	0,04	21,0	0,05
21,5	4.195,0	0,03	21,5	0,04
22,0	3.870,0	0,03	22,0	0,04
22,5	3.559,0	0,02	22,5	0,03
23,0	3.225,0	0,02	23,0	0,03
23,5	2.899,0	0,02	23,5	0,03
24,0	2.584,0	0,01	24,0	0,02

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,163 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc.Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50- 1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50- 2,50	0,0	0,0	0,0
3,0	39,8	0,12	2,50- 3,50	15,6	15,6	0,1
4,0	284,3	0,37	3,50- 4,50	96,6	112,2	0,4
5,0	636,0	0,42	4,50- 5,50	333,3	445,6	1,5
6,0	1.159,3	0,45	5,50- 6,50	873,0	1.318,6	4,5
7,0	1.891,8	0,46	6,50- 7,50	1.881,7	3.200,2	10,9
8,0	2.856,6	0,47	7,50- 8,50	3.394,3	6.594,6	22,4
9,0	4.025,7	0,46	8,50- 9,50	5.042,2	11.636,8	39,5
10,0	5.049,8	0,42	9,50-10,50	5.874,2	17.511,0	59,5
11,0	5.515,2	0,35	10,50-11,50	5.222,8	22.733,8	77,3
12,0	5.597,8	0,27	11,50-12,50	3.591,9	26.325,7	89,5
13,0	5.600,0	0,21	12,50-13,50	1.945,3	28.271,0	96,1
14,0	5.600,0	0,17	13,50-14,50	820,9	29.092,0	98,9
15,0	5.600,0	0,14	14,50-15,50	262,4	29.354,4	99,8
16,0	5.600,0	0,11	15,50-16,50	61,8	29.416,2	100,0
17,0	5.600,0	0,10	16,50-17,50	10,4	29.426,5	100,0
18,0	5.600,0	0,08	17,50-18,50	1,2	29.427,7	100,0
19,0	5.558,0	0,07	18,50-19,50	0,1	29.427,8	100,0
20,0	5.147,0	0,05	19,50-20,50	0,0	29.427,8	100,0
21,0	4.514,0	0,04	20,50-21,50	0,0	29.427,8	100,0
22,0	3.870,0	0,03	21,50-22,50	0,0	29.427,8	100,0
23,0	3.225,0	0,02	22,50-23,50	0,0	29.427,8	100,0
24,0	2.584,0	0,02	23,50-24,50	0,0	29.427,8	100,0



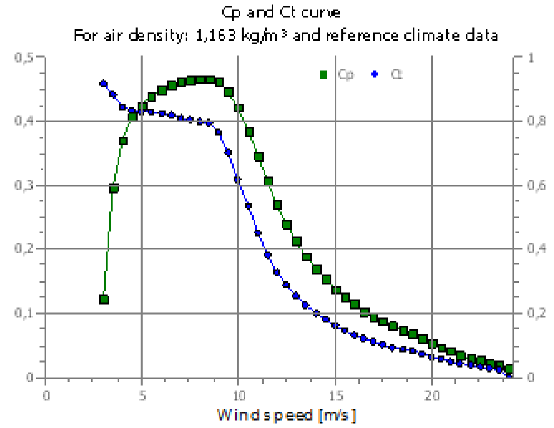


Figure 21: Power curve details of Vestas V162 5.6 MW

GE WIND ENERGY GE 2.0-116 2000 116.0 !O! Level 0 - Calculated - Normal Operation - 2011[MWh]	4.769	6.806	8.580	10.037	11.190	12.054
Check value [%]	1	0	0	0	0	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

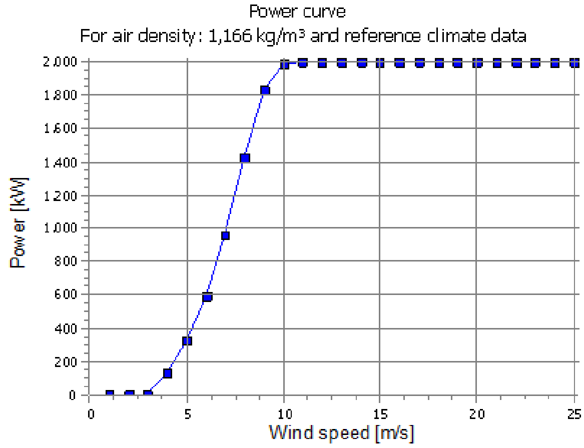
Original data, Air density: 1,225 kg/m³

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	0,0	0,00	3,0	1,55
3,5	62,0	0,22	3,5	0,95
4,0	139,0	0,34	4,0	0,89
4,5	231,0	0,39	4,5	0,88
5,0	341,0	0,42	5,0	0,88
5,5	473,0	0,44	5,5	0,86
6,0	627,0	0,45	6,0	0,85
6,5	804,0	0,45	6,5	0,84
7,0	1.008,0	0,45	7,0	0,84
7,5	1.241,0	0,45	7,5	0,84
8,0	1.500,0	0,45	8,0	0,83
8,5	1.731,0	0,44	8,5	0,77
9,0	1.879,0	0,40	9,0	0,67
9,5	1.988,0	0,36	9,5	0,56
10,0	2.000,0	0,31	10,0	0,47
10,5	2.000,0	0,27	10,5	0,40
11,0	2.000,0	0,23	11,0	0,34
11,5	2.000,0	0,20	11,5	0,29
12,0	2.000,0	0,18	12,0	0,26
12,5	2.000,0	0,16	12,5	0,22
13,0	2.000,0	0,14	13,0	0,20
13,5	2.000,0	0,13	13,5	0,18
14,0	2.000,0	0,11	14,0	0,16
14,5	2.000,0	0,10	14,5	0,14
15,0	2.000,0	0,09	15,0	0,13
15,5	2.000,0	0,08	15,5	0,12
16,0	2.000,0	0,08	16,0	0,11
16,5	2.000,0	0,07	16,5	0,10
17,0	2.000,0	0,06	17,0	0,09
17,5	2.000,0	0,06	17,5	0,08
18,0	2.000,0	0,05	18,0	0,08
18,5	2.000,0	0,05	18,5	0,07
19,0	2.000,0	0,05	19,0	0,07
19,5	2.000,0	0,04	19,5	0,06
20,0	2.000,0	0,04	20,0	0,06
20,5	2.000,0	0,04	20,5	0,06
21,0	2.000,0	0,03	21,0	0,05
21,5	2.000,0	0,03	21,5	0,05
22,0	2.000,0	0,03	22,0	0,05
22,5	2.000,0	0,03	22,5	0,04
23,0	2.000,0	0,03	23,0	0,04
23,5	2.000,0	0,02	23,5	0,04
24,0	2.000,0	0,02	24,0	0,04
24,5	2.000,0	0,02	24,5	0,04
25,0	2.000,0	0,02	25,0	0,03

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,166 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc.Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50- 1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50- 2,50	0,0	0,0	0,0
3,0	0,0	0,00	2,50- 3,50	10,0	10,0	0,1
4,0	128,7	0,33	3,50- 4,50	82,0	92,0	1,1
5,0	322,6	0,42	4,50- 5,50	299,6	391,5	4,5
6,0	596,0	0,45	5,50- 6,50	730,0	1.121,5	13,0
7,0	960,2	0,45	6,50- 7,50	1.337,8	2.459,3	28,5
8,0	1.430,0	0,45	7,50- 8,50	1.860,2	4.319,5	50,0
9,0	1.830,7	0,41	8,50- 9,50	1.851,7	6.171,2	71,5
10,0	1.995,0	0,32	9,50-10,50	1.287,8	7.458,9	86,4
11,0	2.000,0	0,24	10,50-11,50	670,4	8.129,4	94,2
12,0	2.000,0	0,19	11,50-12,50	299,3	8.428,7	97,6
13,0	2.000,0	0,15	12,50-13,50	127,2	8.555,9	99,1
14,0	2.000,0	0,12	13,50-14,50	51,4	8.607,3	99,7
15,0	2.000,0	0,10	14,50-15,50	18,2	8.625,5	99,9
16,0	2.000,0	0,08	15,50-16,50	5,3	8.630,8	100,0
17,0	2.000,0	0,07	16,50-17,50	1,2	8.632,1	100,0
18,0	2.000,0	0,06	17,50-18,50	0,2	8.632,3	100,0
19,0	2.000,0	0,05	18,50-19,50	0,1	8.632,4	100,0
20,0	2.000,0	0,04	19,50-20,50	0,0	8.632,4	100,0
21,0	2.000,0	0,04	20,50-21,50	0,0	8.632,4	100,0
22,0	2.000,0	0,03	21,50-22,50	0,0	8.632,4	100,0
23,0	2.000,0	0,03	22,50-23,50	0,0	8.632,4	100,0
24,0	2.000,0	0,02	23,50-24,50	0,0	8.632,4	100,0
25,0	2.000,0	0,02	24,50-25,50	0,0	8.632,4	100,0



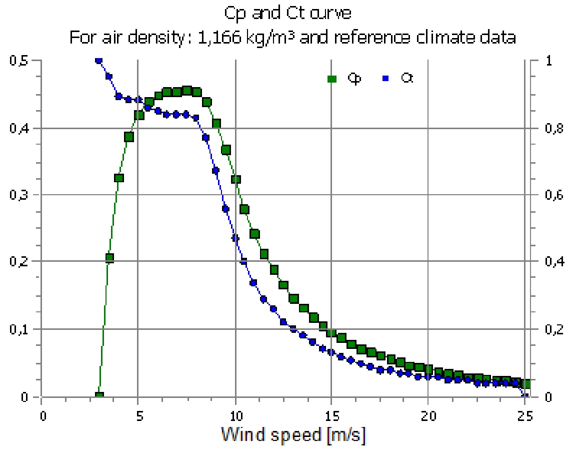


Figure 22: Power curve details of GE 116 2 MW

5.4 Windfarm layout and location

The planned windfarm are well positioned with respect to the prevailing directions, and it is confirmed by low value of calculated wake loss; the layer was optimized to reduce the wake losses and the wake decay, so the distance between the rows orthogonal to wind is increasing with the number of rows and start with a minimum value of about 3,2 km , until about 5,5 km for the last rows.
In the table below are reported WGS 84 coordinates of WT positions, while in the table below are represented the horizontal distances among wind turbines.

Table 13: Distance matrix of wind turbine

Label	WGS 84 Zone 24 East [m]	WGS 84 Zone 24 North [m]	Z [m]	Nearest WTG [m]	Horizontal distance [m]
C01	543747	9597143	0	C02	880
C02	544323	9597808	0	C01	880
C03	544900	9598473	0	C02	880
C04	545476	9599139	0	C05	878
C05	546052	9599801	0	C04	878
C06	546628	9600469	0	C07	878
C07	547203	9601133	0	C06	878
C08	547780	9601799	0	C07	881
C09	541778	9598534	0	C10	880
C10	542354	9599199	0	C09	880
C11	542930	9599865	0	C12	880
C12	543506	9600530	0	C13	878
C13	544083	9601192	0	C12	878
C14	544659	9601860	0	C15	881
C15	545234	9602528	0	C14	881
C16	545810	9603196	0	C15	882
C17	546385	9603865	0	C18	882
C18	546961	9604533	0	C19	872
C19	547534	9605190	0	C18	872
C20	538910	9600380	0	C21	880
C21	539487	9601045	0	C22	879
C22	540062	9601710	0	C21	879
C23	540639	9602376	0	C24	880
C24	541215	9603041	0	C25	880
C25	541791	9603706	0	C26	880
C26	542367	9604371	0	C27	880
C27	542943	9605036	0	C28	876
C28	543512	9605702	0	C27	876
C29	544096	9606367	0	C30	880
C30	544672	9607032	0	C31	880

Label	WGS 84 Zone 24 East [m]	WGS 84 Zone 24 North [m]	Z [m]	Nearest WTG [m]	Horizontal distance [m]
C31	545248	9607697	0	C30	880
C32	545851	9608394	0	C31	922
C33	535331	9602939	0	C34	881
C34	535907	9603605	0	C35	880
C35	536484	9604270	0	C36	880
C36	537060	9604935	0	C37	880
C37	537636	9605600	0	C38	880
C38	538212	9606265	0	C37	880
C39	538788	9606931	0	C40	880
C40	539364	9607596	0	C41	879
C41	539940	9608260	0	C40	879
C42	540516	9608925	0	C41	880
C43	541092	9609591	0	C44	880
C44	541668	9610256	0	C45	880
C45	542244	9610921	0	C44	880
C46	542821	9611586	0	C47	879
C47	543396	9612251	0	C46	879
C48	543972	9612916	0	C47	880
C49	539387	9592831	0	C50	627
C50	538799	9593049	0	C49	627
C51	538116	9593470	0	C52	667
C52	537557	9593834	0	C53	616
C53	537075	9594218	0	C52	616
C54	536508	9594629	0	C55	623
C55	536054	9595055	0	C56	593
C56	535631	9595470	0	C55	593
C57	535082	9596128	0	C58	665
C58	534574	9596557	0	C57	665
C59	534169	9597104	0	C58	681

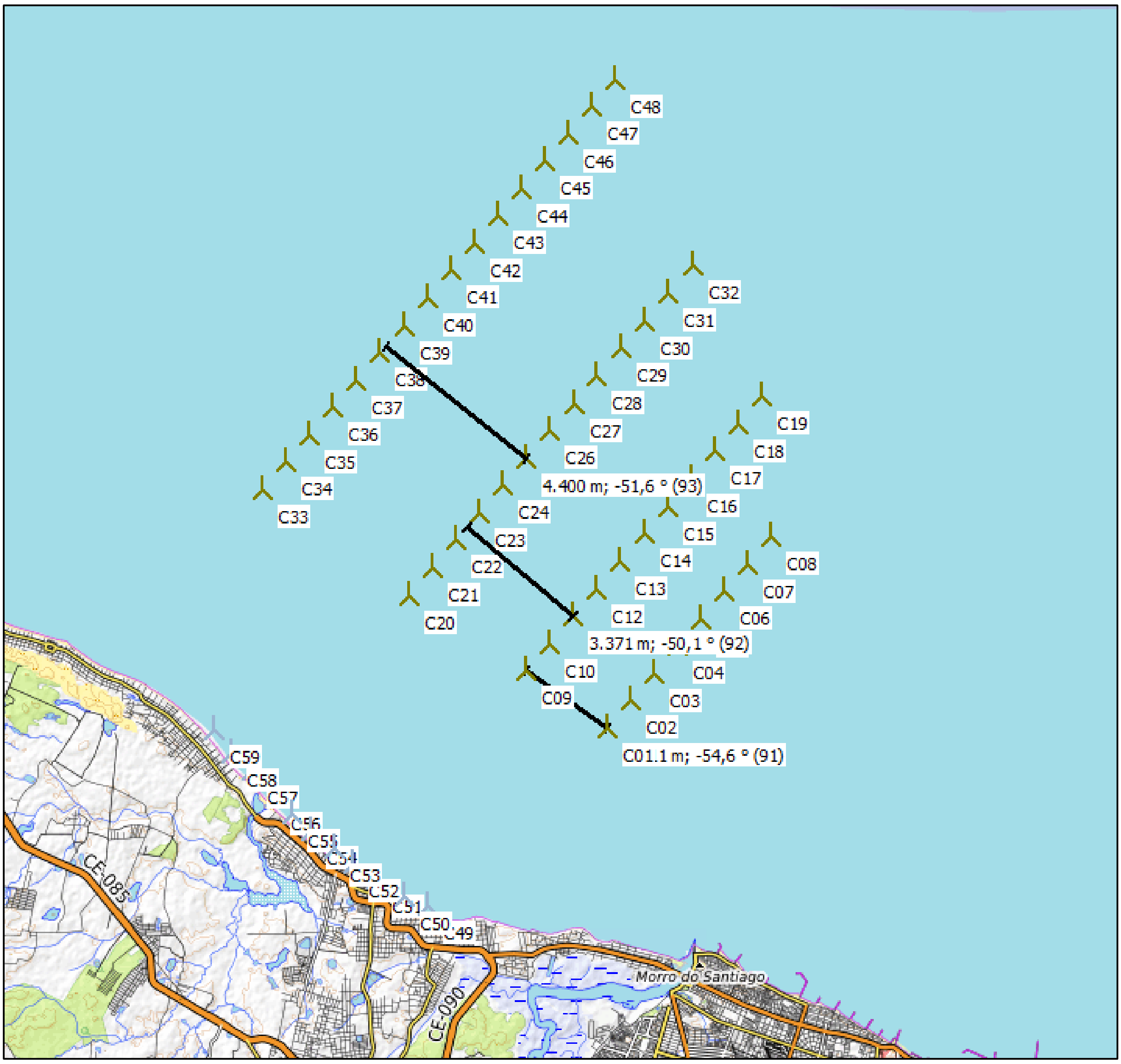


Figure 23: Graphical evidence of layout design and distances. For each WT is drown with a green line an ellipse with a major axis set to 7 D oriented in wind prevailing direction. The minor axis is equal to 3D

6 ENERGY YIELD ESTIMATION

6.1 Results

Waiting for official power curves of most recent WEC developed for offshore purpose the following wtg model were teste for the windfarm layout:

48 * Siemens SG 6.0-170 +11 * SWT-2.3-101-2.300

48 * Vestas V162-5.6 + 11 * VESTAS V110-2.0

48 * Siemens SG 8.0-154 + 11 * SWT-2.3-101-2.300

48 * Vestas V164-10.0 + 11 * VESTAS V110-2.0

48 * Vestas V174-9.5 + 11 * VESTAS V110-2.0

48 * GE Wind GE 220 12 MW + 11 * GE Wind 116 -2.0 MW

The following model parameters were applies

- **WAKE MODEL : N.O. Jensen (RISO/EMD Park 2018)**
- **WAKE DECAY COSTANT : DTU default offshore WDC = 0.06**

The predicted average wind speed at hub height for Caucaia windfarm is calculated in about 8,5 m/s for at 120 m a.g.l. with a wind statistic distributions which assure a reliable and good energy production even taking into account about 8.5 % of technical losses.

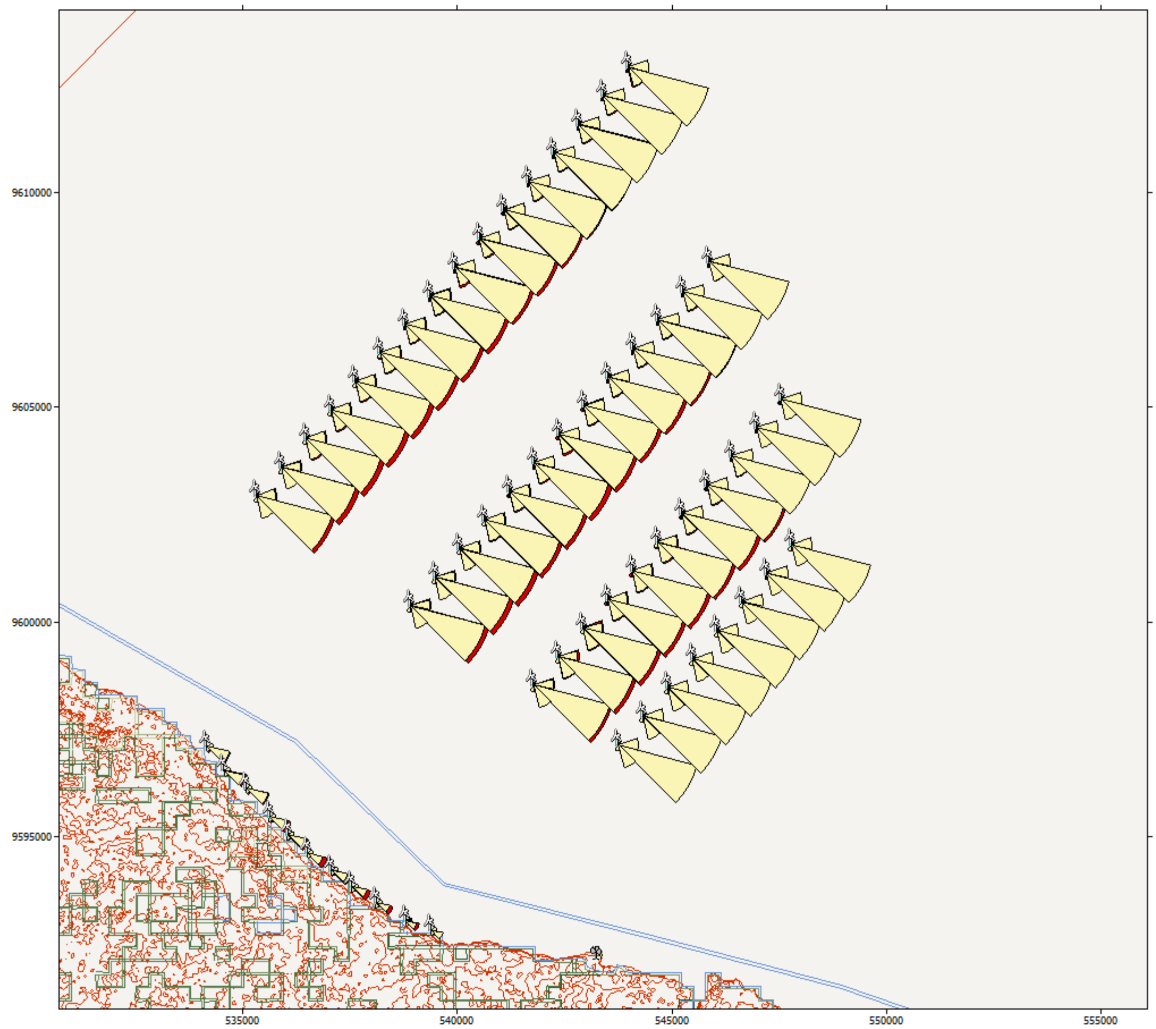
On the basis of specified power curve and described methodology, the energy output was calculated and the results are reported below.

Table14: Main projects parameters

WINDFARM	Caucaia
N° WTG	48 WT OFFSHORE + 11 WT ONSHORE (COASTAL)

Table 15: Synthesis of all AEP estimated values

Turbine Type	N° WTG	Type	Total Power [MW]	Hub Height a.g.l. [m]	Total gross AEP [GWh]	Total AEP net of wake loss [GWh]	Total AEP net of all technical losses [GWh]	Mean wake loss [%]	FLEOH MWh/MW	Capacity Factor [%]
48*Siemens SG 6.0-170 + 11*Siemens SWT-2.3-101	59	Onshore	313,300	[110-80]	1712,984	1644,071	1504,325	4,89	4802	54,8%
48*VESTAS V162-5.6 + 11*VESTAS V110-2.0	59	Onshore	290,800	[110-95]	1609,384	1547,341	1415,817	4,50	4869	55,5%
48*Siemens SG 8.0-154 + 11*Siemens SWT-2.3-101	59	**Offshore**	409,300	[110-80]	1361,148	1285,242	1175,996	6,15	2873	32,8%
48*VESTAS V164-10.0 + 11*VESTAS V110-2.0	59	**Offshore**	502,000	[110-95]	1977,866	1863,093	1704,730	6,25	3396	38,7%
48*VESTAS V174-9.5 + 11*VESTAS V110-2.0	59	**Offshore**	478,000	[110-95]	2144,708	2029,655	1857,134	5,89	3885	44,3%
48*GE WIND 220 12 MW + 11*GE 116-2.0	59	**Offshore**	598,000	[150-90]	3201,767	3022,584	2765,664	6,27	4625	52,8%



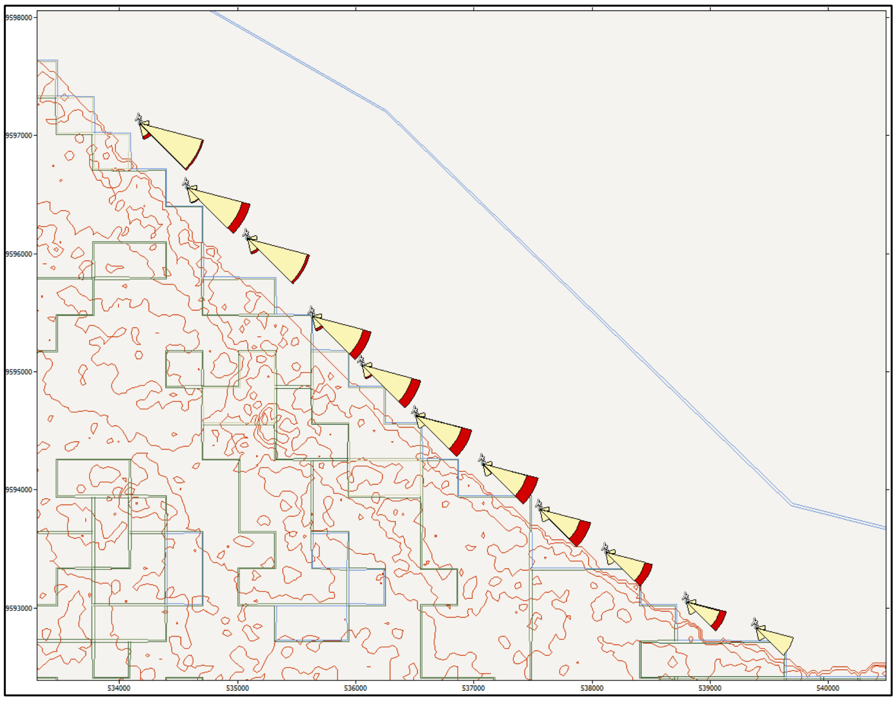


Figure 24: Graphical evidence of layout wake loss (Wasp 12)

6.2 Estimated losses

The calculated energy yields are based on the power curves, the wake shading effects and the calculated wind conditions and do not take into account reductions due to the limited availability of wind turbines, electrical losses etc. The determined discount values for these effects were estimated by project specific calculations or assumed according to experience.
The following effects can be regarded as relevant reduction of the energy output:

- Electrical losses of wiring and the interconnecting station depend on the project specific design of the grid connection and the involved components. For this study the presented values are based on estimation, but they could be calculated by receiving detailed input
- The availability is an estimated average availability during normal operation, and it assumed to be lightly higher of standard agreed contractual conditions for a wind farm because of particular innovative technology ipothized for the site. It should be considered that the losses depend strongly on the strategy of the control system of the wind turbine and the availability is often lower for the first months of operation.
- Planned maintenance is usually not included in the non-availability level. Details to the maintenance should be determined in the contracts. The influence is estimated to be quite limited (80 hours with mean wind speed), under the assumption that a good maintenance concept is existing.
- The grid availability at the site is considered to be high (grid downtime of 50 hours with mean wind speed). This is a general assumption without consideration of site specific properties.
- If wind turbines have to be temporarily taken from the grid or if turbines are running in a power limited operation mode due to administrative orders, this has to be considered separately. Discounts for such effects have not been taken into account.
- Over the lifetime of the wind turbines it can be expected that the rotor blades do not keep their ideal aerodynamic profile. This is due to dirt, insects, salt, sand, and aging of the rotor blade material, a small loss for rotor blade degradation is assumed.

Potential source of energy losses has been assessed and deducted from the gross AEP they are estimated on empirical known values and are reported below.

Table 16: Detail of estimated technical losses

Technical Losses		
Specificy	**Input**	**Loss value [%]**
Availability		0
Turbine availability	Warrenty	3
Balance of plant (BOP)	Assumption	0,8
Grid Availability	Assumption	0,5
Other availability	Assumption	0,1
Performance Losses		0
High wind hysteresis	Assumption	0,1
Windy flow variability	Assumption	0
Performance Losses/Other (Icing/blade degradation)	Assumption	0
Electric losses		
Electric leakage losses		3,5
Facility consumption		0,1
Enviromental Losses		
Performance degradation not due to icing	Assumption	0
Shutdown due to icing, lightning, hail, etc.	Assumption	0,1
High and low temperature	Assumption	0,1
Site access and other force majeure events	Assumption	0,1
Tree growth or felling	Assumption	0
Curtailment		
Wind sector management	Assunzione	0
Grid curtailment and ramp-rate	Assunzione	0
Power purchase agreement curtailment	Assunzione	0
Noise	Calcolato	0
Flickering	Calcolato	0
Birds/Bats	Assunzione	0
Other loss	Assunzione	0,1
Totale perdite tecniche	**Calcolato**	**8,5**

6.3 Detailed results, net AEP

In the following table are presented definitive assessed results discounted of all technical losses, based on analysed data.

Table 17:Assessed definitive results for Siemens SG 6.0 170 / 2.3 101

	TENPROJECT			MED Misure Elaborazione Dati	SIEMENS GAMESA SG 170 6 MW E SG 113 2,3 MW							
	ID WTG	UTM WGS84 Long. Est [m]	UTM WGS 84 Lat. Nord [m]	WEC Model	Power [KW]	Hub Height a.g.l. [m]	Gross AEP [GWh]	AEP net of wake loss[GWh]	Wake Loss [%]	Net AEP [GWh]	Vm [m/s]	Fleoh [MWh/MW]
OFFSHORE	C01	543747	9597143	Siemens SG 6.0-170-6.000	6000	110	33,466	33,232	0,70	30,407	8,84	5068
	C02	544323	9597808	Siemens SG 6.0-170-6.000	6000	110	33,496	33,243	0,76	30,417	8,85	5070
	C03	544900	9598473	Siemens SG 6.0-170-6.000	6000	110	33,532	33,279	0,75	30,451	8,85	5075
	C04	545476	9599139	Siemens SG 6.0-170-6.000	6000	110	33,536	33,287	0,74	30,458	8,86	5076
	C05	546052	9599801	Siemens SG 6.0-170-6.000	6000	110	33,523	33,288	0,70	30,459	8,86	5076
	C06	546628	9600469	Siemens SG 6.0-170-6.000	6000	110	33,522	33,305	0,65	30,474	8,86	5079
	C07	547203	9601133	Siemens SG 6.0-170-6.000	6000	110	33,519	33,341	0,53	30,507	8,86	5085
	C08	547780	9601799	Siemens SG 6.0-170-6.000	6000	110	33,524	33,468	0,17	30,623	8,86	5104
	C09	541778	9598534	Siemens SG 6.0-170-6.000	6000	110	33,455	31,973	4,43	29,255	8,84	4876
	C10	542354	9599199	Siemens SG 6.0-170-6.000	6000	110	33,489	31,821	4,98	29,116	8,85	4853
	C11	542930	9599865	Siemens SG 6.0-170-6.000	6000	110	33,514	31,748	5,27	29,049	8,85	4842
	C12	543506	9600530	Siemens SG 6.0-170-6.000	6000	110	33,523	31,732	5,34	29,035	8,86	4839
	C13	544083	9601192	Siemens SG 6.0-170-6.000	6000	110	33,533	31,766	5,27	29,065	8,86	4844
	C14	544659	9601860	Siemens SG 6.0-170-6.000	6000	110	33,505	31,841	4,97	29,134	8,85	4856
	C15	545234	9602528	Siemens SG 6.0-170-6.000	6000	110	33,522	32,024	4,47	29,302	8,86	4884
	C16	545810	9603196	Siemens SG 6.0-170-6.000	6000	110	33,531	32,423	3,31	29,667	8,86	4944
	C17	546385	9603865	Siemens SG 6.0-170-6.000	6000	110	33,524	32,997	1,57	30,192	8,86	5032
	C18	546961	9604533	Siemens SG 6.0-170-6.000	6000	110	33,518	33,183	1,00	30,363	8,86	5060
	C19	547534	9605190	Siemens SG 6.0-170-6.000	6000	110	33,513	33,393	0,36	30,554	8,86	5092
	C20	538910	9600380	Siemens SG 6.0-170-6.000	6000	110	33,422	31,805	4,84	29,102	8,84	4850
	C21	539487	9601045	Siemens SG 6.0-170-6.000	6000	110	33,479	31,616	5,56	28,929	8,85	4821
	C22	540062	9601710	Siemens SG 6.0-170-6.000	6000	110	33,492	31,535	5,84	28,854	8,85	4809
	C23	540639	9602376	Siemens SG 6.0-170-6.000	6000	110	33,502	31,491	6,00	28,814	8,85	4802
	C24	541215	9603041	Siemens SG 6.0-170-6.000	6000	110	33,505	31,487	6,02	28,810	8,85	4802
	C25	541791	9603706	Siemens SG 6.0-170-6.000	6000	110	33,514	31,515	5,96	28,836	8,86	4806
	C26	542367	9604371	Siemens SG 6.0-170-6.000	6000	110	33,498	31,617	5,61	28,930	8,85	4822
	C27	542943	9605036	Siemens SG 6.0-170-6.000	6000	110	33,501	31,795	5,09	29,093	8,85	4849
	C28	543512	9605702	Siemens SG 6.0-170-6.000	6000	110	33,509	32,013	4,47	29,291	8,86	4882
	C29	544096	9606367	Siemens SG 6.0-170-6.000	6000	110	33,512	32,228	3,83	29,489	8,86	4915
	C30	544672	9607032	Siemens SG 6.0-170-6.000	6000	110	33,503	32,534	2,89	29,769	8,85	4961
	C31	545248	9607697	Siemens SG 6.0-170-6.000	6000	110	33,507	32,929	1,73	30,130	8,86	5022
	C32	545851	9608394	Siemens SG 6.0-170-6.000	6000	110	33,504	33,211	0,87	30,388	8,86	5065
	C33	535331	9602939	Siemens SG 6.0-170-6.000	6000	110	33,398	31,804	4,77	29,101	8,83	4850
	C34	535907	9603605	Siemens SG 6.0-170-6.000	6000	110	33,433	31,634	5,38	28,945	8,84	4824
	C35	536484	9604270	Siemens SG 6.0-170-6.000	6000	110	33,451	31,562	5,65	28,879	8,84	4813
	C36	537060	9604935	Siemens SG 6.0-170-6.000	6000	110	33,479	31,544	5,78	28,863	8,85	4810
	C37	537636	9605600	Siemens SG 6.0-170-6.000	6000	110	33,481	31,544	5,79	28,862	8,85	4810
	C38	538212	9606265	Siemens SG 6.0-170-6.000	6000	110	33,485	31,573	5,71	28,890	8,85	4815
	C39	538788	9606931	Siemens SG 6.0-170-6.000	6000	110	33,495	31,633	5,56	28,944	8,85	4824
	C40	539364	9607596	Siemens SG 6.0-170-6.000	6000	110	33,491	31,704	5,34	29,009	8,85	4835
	C41	539940	9608260	Siemens SG 6.0-170-6.000	6000	110	33,491	31,829	4,96	29,124	8,85	4854
	C42	540516	9608925	Siemens SG 6.0-170-6.000	6000	110	33,491	31,985	4,50	29,267	8,85	4878
	C43	541092	9609591	Siemens SG 6.0-170-6.000	6000	110	33,491	32,148	4,01	29,415	8,85	4903
	C44	541668	9610256	Siemens SG 6.0-170-6.000	6000	110	33,493	32,347	3,42	29,597	8,85	4933
	C45	542244	9610921	Siemens SG 6.0-170-6.000	6000	110	33,488	32,620	2,59	29,847	8,85	4975
	C46	542821	9611586	Siemens SG 6.0-170-6.000	6000	110	33,489	32,870	1,85	30,076	8,85	5013
	C47	543396	9612251	Siemens SG 6.0-170-6.000	6000	110	33,487	33,034	1,35	30,226	8,85	5038
	C48	543972	9612916	Siemens SG 6.0-170-6.000	6000	107	33,486	33,228	0,77	30,404	8,85	5067
	MEAN VALUES								3,586	29,550		4925
	TOTAL				288.000		1607,821	1550,179		1418,413		
ONSHORE	C49	539387	9592831	Siemens SWT-2.3-101-2.300	2300	80	7,790	7,766	0,31	7,105	6,96	3089
	C50	538799	9593049	Siemens SWT-2.3-101-2.300	2300	80	8,083	7,244	10,38	6,629	7,06	2882
	C51	538116	9593470	Siemens SWT-2.3-101-2.300	2300	80	8,639	7,661	11,32	7,010	7,25	3048
	C52	537557	9593834	Siemens SWT-2.3-101-2.300	2300	80	9,207	7,918	14,00	7,245	7,46	3150
	C53	537075	9594218	Siemens SWT-2.3-101-2.300	2300	80	9,584	8,131	15,16	7,440	7,60	3235
	C54	536508	9594629	Siemens SWT-2.3-101-2.300	2300	80	9,752	8,379	14,08	7,666	7,66	3333
	C55	536054	9595055	Siemens SWT-2.3-101-2.300	2300	80	10,032	8,691	13,36	7,952	7,77	3458
	C56	535631	9595470	Siemens SWT-2.3-101-2.300	2300	80	10,169	8,878	12,69	8,123	7,82	3532
	C57	535082	9596128	Siemens SWT-2.3-101-2.300	2300	80	10,539	9,840	6,63	9,004	7,97	3915
	C58	534574	9596557	Siemens SWT-2.3-101-2.300	2300	80	10,583	9,351	11,64	8,557	7,98	3720
	C59	534169	9597104	Siemens SWT-2.3-101-2.300	2300	80	10,785	10,033	6,98	9,180	8,07	3991
	MEAN VALUES								10,596	7,810		3396
	TOTAL				25.300		105,163	93,892		85,911		
ALL WT	MEAN VALUES								4,893			4802
	TOTAL				313.300		1.712,984	1.644,071		1.504,325		

Table 18: Assessed definitive results for Vestas V162 5.6 /V110 2.0

				MED Misure Elaborazione Dati	VESTAS V162 5,6 MW H 105 E V110 2,0 MW							
	ID WTG	UTM WGS84 Long. Est [m]	UTM WGS 84 Lat. Nord [m]	WEC Model	Power [KW]	Hub Height a.g.l. [m]	Gross AEP [GWh]	AEP net of wake loss[GWh]	Wake Loss [%]	Net AEP [GWh]	Vm [m/s]	Fleoh [MWh/MW]
OFFSHORE	C01	543747	9597143	VESTAS V162-5.6-5.600	5600	105	31,065	30,858	0,67	28,235	8,82	5042
	C02	544323	9597808	VESTAS V162-5.6-5.600	5600	105	31,101	30,877	0,72	28,252	8,82	5045
	C03	544900	9598473	VESTAS V162-5.6-5.600	5600	105	31,136	30,912	0,72	28,284	8,83	5051
	C04	545476	9599139	VESTAS V162-5.6-5.600	5600	105	31,145	30,925	0,71	28,296	8,83	5053
	C05	546052	9599801	VESTAS V162-5.6-5.600	5600	105	31,134	30,926	0,67	28,298	8,83	5053
	C06	546628	9600469	VESTAS V162-5.6-5.600	5600	105	31,133	30,941	0,62	28,311	8,83	5056
	C07	547203	9601133	VESTAS V162-5.6-5.600	5600	105	31,132	30,974	0,51	28,341	8,83	5061
	C08	547780	9601799	VESTAS V162-5.6-5.600	5600	105	31,138	31,089	0,16	28,446	8,84	5080
	C09	541778	9598534	VESTAS V162-5.6-5.600	5600	105	31,062	29,732	4,28	27,205	8,82	4858
	C10	542354	9599199	VESTAS V162-5.6-5.600	5600	105	31,094	29,598	4,81	27,082	8,82	4836
	C11	542930	9599865	VESTAS V162-5.6-5.600	5600	105	31,124	29,540	5,09	27,029	8,83	4827
	C12	543506	9600530	VESTAS V162-5.6-5.600	5600	105	31,135	29,529	5,16	27,019	8,83	4825
	C13	544083	9601192	VESTAS V162-5.6-5.600	5600	105	31,144	29,560	5,08	27,048	8,84	4830
	C14	544659	9601860	VESTAS V162-5.6-5.600	5600	105	31,120	29,628	4,80	27,110	8,83	4841
	C15	545234	9602528	VESTAS V162-5.6-5.600	5600	105	31,136	29,793	4,31	27,261	8,83	4868
	C16	545810	9603196	VESTAS V162-5.6-5.600	5600	105	31,147	30,154	3,19	27,591	8,84	4927
	C17	546385	9603865	VESTAS V162-5.6-5.600	5600	105	31,141	30,673	1,50	28,066	8,84	5012
	C18	546961	9604533	VESTAS V162-5.6-5.600	5600	105	31,136	30,839	0,95	28,218	8,84	5039
	C19	547534	9605190	VESTAS V162-5.6-5.600	5600	105	31,132	31,027	0,34	28,389	8,84	5070
	C20	538910	9600380	VESTAS V162-5.6-5.600	5600	105	31,031	29,586	4,66	27,071	8,81	4834
	C21	539487	9601045	VESTAS V162-5.6-5.600	5600	105	31,088	29,424	5,35	26,923	8,82	4808
	C22	540062	9601710	VESTAS V162-5.6-5.600	5600	105	31,106	29,358	5,62	26,862	8,83	4797
	C23	540639	9602376	VESTAS V162-5.6-5.600	5600	105	31,117	29,320	5,77	26,828	8,83	4791
	C24	541215	9603041	VESTAS V162-5.6-5.600	5600	105	31,118	29,317	5,79	26,825	8,83	4790
	C25	541791	9603706	VESTAS V162-5.6-5.600	5600	105	31,128	29,344	5,73	26,850	8,83	4795
	C26	542367	9604371	VESTAS V162-5.6-5.600	5600	105	31,114	29,436	5,39	26,934	8,83	4810
	C27	542943	9605036	VESTAS V162-5.6-5.600	5600	105	31,118	29,597	4,89	27,081	8,83	4836
	C28	543512	9605702	VESTAS V162-5.6-5.600	5600	105	31,127	29,793	4,29	27,261	8,83	4868
	C29	544096	9606367	VESTAS V162-5.6-5.600	5600	105	31,130	29,986	3,67	27,437	8,84	4900
	C30	544672	9607032	VESTAS V162-5.6-5.600	5600	105	31,123	30,262	2,77	27,689	8,83	4945
	C31	545248	9607697	VESTAS V162-5.6-5.600	5600	105	31,127	30,615	1,64	28,013	8,83	5002
	C32	545851	9608394	VESTAS V162-5.6-5.600	5600	105	31,124	30,866	0,83	28,242	8,83	5043
	C33	535331	9602939	VESTAS V162-5.6-5.600	5600	105	31,014	29,595	4,58	27,079	8,81	4836
	C34	535907	9603605	VESTAS V162-5.6-5.600	5600	105	31,049	29,448	5,16	26,945	8,82	4812
	C35	536484	9604270	VESTAS V162-5.6-5.600	5600	105	31,069	29,387	5,41	26,889	8,82	4802
	C36	537060	9604935	VESTAS V162-5.6-5.600	5600	105	31,094	29,373	5,53	26,876	8,83	4799
	C37	537636	9605600	VESTAS V162-5.6-5.600	5600	105	31,097	29,374	5,54	26,878	8,83	4800
	C38	538212	9606265	VESTAS V162-5.6-5.600	5600	105	31,103	29,403	5,47	26,904	8,83	4804
	C39	538788	9606931	VESTAS V162-5.6-5.600	5600	105	31,114	29,458	5,32	26,954	8,83	4813
	C40	539364	9607596	VESTAS V162-5.6-5.600	5600	105	31,110	29,522	5,11	27,013	8,83	4824
	C41	539940	9608260	VESTAS V162-5.6-5.600	5600	105	31,111	29,634	4,75	27,115	8,83	4842
	C42	540516	9608925	VESTAS V162-5.6-5.600	5600	105	31,111	29,773	4,30	27,243	8,83	4865
	C43	541092	9609591	VESTAS V162-5.6-5.600	5600	105	31,112	29,918	3,84	27,375	8,83	4888
	C44	541668	9610256	VESTAS V162-5.6-5.600	5600	105	31,114	30,095	3,28	27,537	8,83	4917
	C45	542244	9610921	VESTAS V162-5.6-5.600	5600	105	31,110	30,341	2,47	27,762	8,83	4958
	C46	542821	9611586	VESTAS V162-5.6-5.600	5600	105	31,111	30,564	1,76	27,966	8,83	4994
	C47	543396	9612251	VESTAS V162-5.6-5.600	5600	105	31,110	30,710	1,29	28,100	8,83	5018
	C48	543972	9612916	VESTAS V162-5.6-5.600	5600	105	31,110	30,883	0,73	28,258	8,83	5046
	MEAN VALUES								**3,442**	**27,487**		**4908**
	TOTAL				**268.800**		**1493,348**	**1441,957**		**1319,391**		
ONSHORE	C49	539387	9592831	VESTAS V110-2.0-2.000	2000	95	9,140	9,120	0,22	8,344	7,21	4172
	C50	538799	9593049	VESTAS V110-2.0-2.000	2000	95	9,409	8,565	8,97	7,837	7,32	3918
	C51	538116	9593470	VESTAS V110-2.0-2.000	2000	95	9,830	8,885	9,62	8,130	7,49	4065
	C52	537557	9593834	VESTAS V110-2.0-2.000	2000	95	10,313	9,086	11,89	8,314	7,69	4157
	C53	537075	9594218	VESTAS V110-2.0-2.000	2000	95	10,591	9,248	12,68	8,462	7,82	4231
	C54	536508	9594629	VESTAS V110-2.0-2.000	2000	95	10,724	9,429	12,07	8,628	7,88	4314
	C55	536054	9595055	VESTAS V110-2.0-2.000	2000	95	10,912	9,656	11,51	8,835	7,98	4418
	C56	535631	9595470	VESTAS V110-2.0-2.000	2000	95	11,025	9,790	11,20	8,958	8,03	4479
	C57	535082	9596128	VESTAS V110-2.0-2.000	2000	95	11,300	10,623	5,99	9,720	8,17	4860
	C58	534574	9596557	VESTAS V110-2.0-2.000	2000	95	11,319	10,240	9,54	9,369	8,18	4685
	C59	534169	9597104	VESTAS V110-2.0-2.000	2000	95	11,473	10,743	6,36	9,830	8,27	4915
	MEAN VALUES								**9,097**	**8,766**		**4383**
	TOTAL				**22.000**		**116,036**	**105,384**		**96,427**		
ALL WT	**MEAN VALUES**								**4,496**			**4869**
	TOTAL				**290.800**		**1.609,384**	**1.547,341**		**1.415,817**		

Table 19: Assessed definitive results for Siemens SG 8.0 154 / 2.3 101

				MED Misure Elaborazione Dati	SIEMENS GAMESA SG 154 8 MW E SG 113 2,3 MW							
	ID WTG	UTM WGS84 Long. Est [m]	UTM WGS 84 Lat. Nord [m]	WEC Model	Power [KW]	Hub Height a.g.l. [m]	Gross AEP [GWh]	AEP net of wake loss[GWh]	Wake Loss [%]	Net AEP [GWh]	Vm [m/s]	Fleoh [MWh/MW]
OFFSHORE	C01	543747	9597143	Siemens Gamesa 8.0-154	8000	110	26,061	25,865	0,75	23,666	8,84	2958
	C02	544323	9597808	Siemens Gamesa 8.0-154	8000	110	26,110	25,899	0,81	23,697	8,85	2962
	C03	544900	9598473	Siemens Gamesa 8.0-154	8000	110	26,174	25,964	0,80	23,757	8,85	2970
	C04	545476	9599139	Siemens Gamesa 8.0-154	8000	110	26,190	25,983	0,79	23,774	8,86	2972
	C05	546052	9599801	Siemens Gamesa 8.0-154	8000	110	26,176	25,978	0,75	23,770	8,86	2971
	C06	546628	9600469	Siemens Gamesa 8.0-154	8000	110	26,183	25,998	0,71	23,788	8,86	2974
	C07	547203	9601133	Siemens Gamesa 8.0-154	8000	110	26,189	26,033	0,60	23,820	8,86	2978
	C08	547780	9601799	Siemens Gamesa 8.0-154	8000	110	26,200	26,151	0,19	23,928	8,86	2991
	C09	541778	9598534	Siemens Gamesa 8.0-154	8000	110	26,085	24,366	6,59	22,295	8,84	2787
	C10	542354	9599199	Siemens Gamesa 8.0-154	8000	110	26,126	24,214	7,32	22,155	8,85	2769
	C11	542930	9599865	Siemens Gamesa 8.0-154	8000	110	26,171	24,153	7,71	22,100	8,85	2763
	C12	543506	9600530	Siemens Gamesa 8.0-154	8000	110	26,184	24,144	7,79	22,092	8,86	2762
	C13	544083	9601192	Siemens Gamesa 8.0-154	8000	110	26,201	24,189	7,68	22,133	8,86	2767
	C14	544659	9601860	Siemens Gamesa 8.0-154	8000	110	26,160	24,268	7,23	22,205	8,85	2776
	C15	545234	9602528	Siemens Gamesa 8.0-154	8000	110	26,195	24,487	6,52	22,405	8,86	2801
	C16	545810	9603196	Siemens Gamesa 8.0-154	8000	110	26,214	24,980	4,71	22,856	8,86	2857
	C17	546385	9603865	Siemens Gamesa 8.0-154	8000	110	26,207	25,700	1,93	23,516	8,86	2939
	C18	546961	9604533	Siemens Gamesa 8.0-154	8000	110	26,204	25,896	1,18	23,695	8,86	2962
	C19	547534	9605190	Siemens Gamesa 8.0-154	8000	110	26,199	26,098	0,39	23,879	8,86	2985
	C20	538910	9600380	Siemens Gamesa 8.0-154	8000	110	26,057	24,203	7,12	22,146	8,84	2768
	C21	539487	9601045	Siemens Gamesa 8.0-154	8000	110	26,135	23,986	8,22	21,947	8,85	2743
	C22	540062	9601710	Siemens Gamesa 8.0-154	8000	110	26,163	23,911	8,61	21,878	8,85	2735
	C23	540639	9602376	Siemens Gamesa 8.0-154	8000	110	26,176	23,865	8,83	21,836	8,85	2730
	C24	541215	9603041	Siemens Gamesa 8.0-154	8000	110	26,176	23,861	8,84	21,833	8,85	2729
	C25	541791	9603706	Siemens Gamesa 8.0-154	8000	110	26,194	23,902	8,75	21,871	8,86	2734
	C26	542367	9604371	Siemens Gamesa 8.0-154	8000	110	26,173	24,020	8,23	21,978	8,85	2747
	C27	542943	9605036	Siemens Gamesa 8.0-154	8000	110	26,180	24,239	7,41	22,179	8,85	2772
	C28	543512	9605702	Siemens Gamesa 8.0-154	8000	110	26,194	24,489	6,51	22,407	8,86	2801
	C29	544096	9606367	Siemens Gamesa 8.0-154	8000	110	26,200	24,742	5,56	22,639	8,86	2830
	C30	544672	9607032	Siemens Gamesa 8.0-154	8000	110	26,190	25,126	4,06	22,990	8,85	2874
	C31	545248	9607697	Siemens Gamesa 8.0-154	8000	110	26,198	25,611	2,24	23,434	8,86	2929
	C32	545851	9608394	Siemens Gamesa 8.0-154	8000	110	26,194	25,908	1,09	23,706	8,86	2963
	C33	535331	9602939	Siemens Gamesa 8.0-154	8000	110	26,043	24,217	7,01	22,158	8,83	2770
	C34	535907	9603605	Siemens Gamesa 8.0-154	8000	110	26,092	24,020	7,94	21,978	8,84	2747
	C35	536484	9604270	Siemens Gamesa 8.0-154	8000	110	26,116	23,943	8,32	21,908	8,84	2738
	C36	537060	9604935	Siemens Gamesa 8.0-154	8000	110	26,153	23,929	8,51	21,895	8,85	2737
	C37	537636	9605600	Siemens Gamesa 8.0-154	8000	110	26,158	23,935	8,50	21,901	8,85	2738
	C38	538212	9606265	Siemens Gamesa 8.0-154	8000	110	26,164	23,974	8,37	21,936	8,85	2742
	C39	538788	9606931	Siemens Gamesa 8.0-154	8000	110	26,185	24,053	8,14	22,008	8,85	2751
	C40	539364	9607596	Siemens Gamesa 8.0-154	8000	110	26,177	24,135	7,80	22,084	8,85	2760
	C41	539940	9608260	Siemens Gamesa 8.0-154	8000	110	26,177	24,282	7,24	22,218	8,85	2777
	C42	540516	9608925	Siemens Gamesa 8.0-154	8000	110	26,179	24,474	6,51	22,393	8,85	2799
	C43	541092	9609591	Siemens Gamesa 8.0-154	8000	110	26,179	24,668	5,77	22,572	8,85	2821
	C44	541668	9610256	Siemens Gamesa 8.0-154	8000	110	26,183	24,909	4,87	22,792	8,85	2849
	C45	542244	9610921	Siemens Gamesa 8.0-154	8000	110	26,179	25,257	3,52	23,110	8,85	2889
	C46	542821	9611586	Siemens Gamesa 8.0-154	8000	110	26,181	25,566	2,35	23,393	8,85	2924
	C47	543396	9612251	Siemens Gamesa 8.0-154	8000	110	26,178	25,744	1,66	23,556	8,85	2944
	C48	543972	9612916	Siemens Gamesa 8.0-154	8000	110	26,180	25,933	0,94	23,729	8,85	2966
	MEAN VALUES								**5,154**	**22,708**		**2839**
	TOTAL				**384.000**		**1255,986**	**1191,265**		**1090,008**		
ONSHORE	C49	539387	9592831	Siemens SWT-2.3-101	2300	80	7,790	7,770	0,26	7,110	6,96	3091
	C50	538799	9593049	Siemens SWT-2.3-101	2300	80	8,083	7,249	10,32	6,633	7,06	2884
	C51	538116	9593470	Siemens SWT-2.3-101	2300	80	8,639	7,666	11,26	7,014	7,25	3050
	C52	537557	9593834	Siemens SWT-2.3-101	2300	80	9,207	7,923	13,94	7,250	7,46	3152
	C53	537075	9594218	Siemens SWT-2.3-101	2300	80	9,584	8,137	15,10	7,445	7,60	3237
	C54	536508	9594629	Siemens SWT-2.3-101	2300	80	9,752	8,385	14,02	7,672	7,66	3336
	C55	536054	9595055	Siemens SWT-2.3-101	2300	80	10,032	8,698	13,29	7,959	7,77	3460
	C56	535631	9595470	Siemens SWT-2.3-101	2300	80	10,169	8,886	12,61	8,131	7,82	3535
	C57	535082	9596128	Siemens SWT-2.3-101	2300	80	10,539	9,850	6,53	9,013	7,97	3919
	C58	534574	9596557	Siemens SWT-2.3-101	2300	80	10,583	9,364	11,52	8,568	7,98	3725
	C59	534169	9597104	Siemens SWT-2.3-101	2300	80	10,785	10,048	6,83	9,194	8,07	3997
	MEAN VALUES								**10,518**	**7,817**		**3399**
	TOTAL				**25.300**		**105,163**	**93,976**		**85,988**		
ALL WT	**MEAN VALUES**								**6,154**			**2873**
	TOTAL				**409.300**		**1.361,148**	**1.285,242**		**1.175,996**		

Table 20: Assessed definitive results for Vestas V164 10.0 MW / V110 2.0 MW

				MED Misure Elaborazione Dati		48*VESTAS V164 10 MW e 11*V110 2MW						
	ID WTG	UTM WGS84 Long. Est [m]	UTM WGS 84 Lat. Nord [m]	WEC Model	Power [KW]	Hub Height a.g.l. [m]	Gross AEP [GWh]	AEP net of wake loss[GWh]	Wake Loss [%]	Net AEP [GWh]	Vm [m/s]	Feoh [MWh/MW]
OFFSHORE	C01	543747	9597143	VESTAS V164-10.0	10000	110	38,669	38,343	0,84	35,083	8,84	3508
	C02	544323	9597808	VESTAS V164-10.0	10000	110	38,730	38,378	0,91	35,116	8,85	3512
	C03	544900	9598473	VESTAS V164-10.0	10000	110	38,808	38,457	0,90	35,189	8,85	3519
	C04	545476	9599139	VESTAS V164-10.0	10000	110	38,826	38,480	0,89	35,209	8,86	3521
	C05	546052	9599801	VESTAS V164-10.0	10000	110	38,806	38,477	0,85	35,206	8,86	3521
	C06	546628	9600469	VESTAS V164-10.0	10000	110	38,814	38,505	0,80	35,232	8,86	3523
	C07	547203	9601133	VESTAS V164-10.0	10000	110	38,819	38,558	0,67	35,280	8,86	3528
	C08	547780	9601799	VESTAS V164-10.0	10000	110	38,832	38,750	0,21	35,457	8,86	3546
	C09	541778	9598534	VESTAS V164-10.0	10000	110	38,691	35,942	7,11	32,887	8,84	3289
	C10	542354	9599199	VESTAS V164-10.0	10000	110	38,744	35,680	7,91	32,647	8,85	3265
	C11	542930	9599865	VESTAS V164-10.0	10000	110	38,799	35,566	8,33	32,543	8,85	3254
	C12	543506	9600530	VESTAS V164-10.0	10000	110	38,815	35,545	8,42	32,524	8,86	3252
	C13	544083	9601192	VESTAS V164-10.0	10000	110	38,836	35,611	8,31	32,584	8,86	3258
	C14	544659	9601860	VESTAS V164-10.0	10000	110	38,784	35,750	7,82	32,711	8,85	3271
	C15	545234	9602528	VESTAS V164-10.0	10000	110	38,826	36,086	7,05	33,019	8,86	3302
	C16	545810	9603196	VESTAS V164-10.0	10000	110	38,849	36,863	5,11	33,730	8,86	3373
	C17	546385	9603865	VESTAS V164-10.0	10000	110	38,840	38,009	2,14	34,778	8,86	3478
	C18	546961	9604533	VESTAS V164-10.0	10000	110	38,834	38,324	1,31	35,067	8,86	3507
	C19	547534	9605190	VESTAS V164-10.0	10000	110	38,828	38,658	0,44	35,372	8,86	3537
	C20	538910	9600380	VESTAS V164-10.0	10000	110	38,651	35,686	7,67	32,652	8,84	3265
	C21	539487	9601045	VESTAS V164-10.0	10000	110	38,750	35,310	8,88	32,308	8,85	3231
	C22	540062	9601710	VESTAS V164-10.0	10000	110	38,783	35,175	9,30	32,185	8,85	3219
	C23	540639	9602376	VESTAS V164-10.0	10000	110	38,801	35,096	9,55	32,113	8,85	3211
	C24	541215	9603041	VESTAS V164-10.0	10000	110	38,801	35,088	9,57	32,106	8,85	3211
	C25	541791	9603706	VESTAS V164-10.0	10000	110	38,823	35,147	9,47	32,160	8,86	3216
	C26	542367	9604371	VESTAS V164-10.0	10000	110	38,796	35,340	8,91	32,336	8,85	3234
	C27	542943	9605036	VESTAS V164-10.0	10000	110	38,803	35,687	8,03	32,654	8,85	3265
	C28	543512	9605702	VESTAS V164-10.0	10000	110	38,821	36,084	7,05	33,017	8,86	3302
	C29	544096	9606367	VESTAS V164-10.0	10000	110	38,828	36,489	6,03	33,387	8,86	3339
	C30	544672	9607032	VESTAS V164-10.0	10000	110	38,815	37,098	4,42	33,945	8,85	3394
	C31	545248	9607697	VESTAS V164-10.0	10000	110	38,824	37,865	2,47	34,646	8,86	3465
	C32	545851	9608394	VESTAS V164-10.0	10000	110	38,819	38,351	1,20	35,091	8,86	3509
	C33	535331	9602939	VESTAS V164-10.0	10000	110	38,628	35,710	7,56	32,674	8,83	3267
	C34	535907	9603605	VESTAS V164-10.0	10000	110	38,690	35,371	8,58	32,365	8,84	3236
	C35	536484	9604270	VESTAS V164-10.0	10000	110	38,722	35,235	9,00	32,240	8,84	3224
	C36	537060	9604935	VESTAS V164-10.0	10000	110	38,769	35,198	9,21	32,206	8,85	3221
	C37	537636	9605600	VESTAS V164-10.0	10000	110	38,775	35,203	9,21	32,210	8,85	3221
	C38	538212	9606265	VESTAS V164-10.0	10000	110	38,782	35,262	9,08	32,265	8,85	3226
	C39	538788	9606931	VESTAS V164-10.0	10000	110	38,808	35,379	8,83	32,372	8,85	3237
	C40	539364	9607596	VESTAS V164-10.0	10000	110	38,798	35,515	8,46	32,496	8,85	3250
	C41	539940	9608260	VESTAS V164-10.0	10000	110	38,797	35,749	7,85	32,711	8,85	3271
	C42	540516	9608925	VESTAS V164-10.0	10000	110	38,799	36,054	7,08	32,989	8,85	3299
	C43	541092	9609591	VESTAS V164-10.0	10000	110	38,799	36,367	6,27	33,276	8,85	3328
	C44	541668	9610256	VESTAS V164-10.0	10000	110	38,804	36,751	5,29	33,627	8,85	3363
	C45	542244	9610921	VESTAS V164-10.0	10000	110	38,798	37,305	3,85	34,134	8,85	3413
	C46	542821	9611586	VESTAS V164-10.0	10000	110	38,801	37,793	2,60	34,581	8,85	3458
	C47	543396	9612251	VESTAS V164-10.0	10000	110	38,797	38,082	1,85	34,845	8,85	3484
	C48	543972	9612916	VESTAS V164-10.0	10000	110	38,799	38,392	1,05	35,129	8,85	3513
	MEAN VALUES								**5,591**	**33,507**		**3351**
	TOTAL				**480.000**		**1861,830**	**1757,762**		**1608,352**		
ONSHORE	C49	539387	9592831	VESTAS V110-2.0	2000	95	9,140	9,117	0,25	8,342	7,21	4171
	C50	538799	9593049	VESTAS V110-2.0	2000	95	9,409	8,562	9,00	7,834	7,32	3917
	C51	538116	9593470	VESTAS V110-2.0	2000	95	9,830	8,882	9,65	8,127	7,49	4063
	C52	537557	9593834	VESTAS V110-2.0	2000	95	10,313	9,083	11,92	8,311	7,69	4156
	C53	537075	9594218	VESTAS V110-2.0	2000	95	10,591	9,244	12,71	8,459	7,82	4229
	C54	536508	9594629	VESTAS V110-2.0	2000	95	10,724	9,425	12,11	8,624	7,88	4312
	C55	536054	9595055	VESTAS V110-2.0	2000	95	10,912	9,651	11,55	8,831	7,98	4416
	C56	535631	9595470	VESTAS V110-2.0	2000	95	11,025	9,785	11,25	8,953	8,03	4477
	C57	535082	9596128	VESTAS V110-2.0	2000	95	11,300	10,617	6,05	9,715	8,17	4857
	C58	534574	9596557	VESTAS V110-2.0	2000	95	11,319	10,232	9,61	9,362	8,18	4681
	C59	534169	9597104	VESTAS V110-2.0	2000	95	11,473	10,732	6,46	9,820	8,27	4910
	MEAN VALUES								**9,141**	**8,762**		**4381**
	TOTAL				**22.000**		**116,036**	**105,332**		**96,378**		
ALL WT	**MEAN VALUES**								**6,253**			**3396**
	TOTAL				**502.000**		**1.977,866**	**1.863,093**		**1.704,730**		

Table 21: Assessed definitive results for Vestas V174 9.5 MW / V110 2.0 MW

				MED Misure Elaborazione Dati		**48*VESTAS V174 9,5 MW e 11*V110 2MW**						
	ID WTG	**UTM WGS84 Long. Est [m]**	**UTM WGS 84 Lat. Nord [m]**	**WEC Model**	**Power [KW]**	**Hub Height a.g.l. [m]**	**Gross AEP [GWh]**	**AEP net of wake loss[GWh]**	**Wake Loss [%]**	**Net AEP [GWh]**	**Vm [m/s]**	**Fleoh [MWh/MW]**
OFFSHORE	C01	543747	9597143	VESTAS V174-9.5	9500	110	42,166	41,814	0,83	38,260	8,84	4027
	C02	544323	9597808	VESTAS V174-9.5	9500	110	42,223	41,845	0,90	38,288	8,85	4030
	C03	544900	9598473	VESTAS V174-9.5	9500	110	42,296	41,920	0,89	38,356	8,85	4038
	C04	545476	9599139	VESTAS V174-9.5	9500	110	42,310	41,939	0,88	38,374	8,86	4039
	C05	546052	9599801	VESTAS V174-9.5	9500	110	42,289	41,937	0,83	38,372	8,86	4039
	C06	546628	9600469	VESTAS V174-9.5	9500	110	42,294	41,966	0,78	38,398	8,86	4042
	C07	547203	9601133	VESTAS V174-9.5	9500	110	42,296	42,023	0,65	38,451	8,86	4047
	C08	547780	9601799	VESTAS V174-9.5	9500	110	42,307	42,223	0,20	38,634	8,86	4067
	C09	541778	9598534	VESTAS V174-9.5	9500	110	42,177	39,452	6,46	36,099	8,84	3800
	C10	542354	9599199	VESTAS V174-9.5	9500	110	42,230	39,187	7,21	35,856	8,85	3774
	C11	542930	9599865	VESTAS V174-9.5	9500	110	42,281	39,068	7,60	35,747	8,85	3763
	C12	543506	9600530	VESTAS V174-9.5	9500	110	42,296	39,046	7,68	35,727	8,86	3761
	C13	544083	9601192	VESTAS V174-9.5	9500	110	42,316	39,110	7,58	35,786	8,86	3767
	C14	544659	9601860	VESTAS V174-9.5	9500	110	42,264	39,249	7,13	35,913	8,85	3780
	C15	545234	9602528	VESTAS V174-9.5	9500	110	42,302	39,584	6,43	36,219	8,86	3813
	C16	545810	9603196	VESTAS V174-9.5	9500	110	42,323	40,343	4,68	36,914	8,86	3886
	C17	546385	9603865	VESTAS V174-9.5	9500	110	42,313	41,458	2,02	37,934	8,86	3993
	C18	546961	9604533	VESTAS V174-9.5	9500	110	42,307	41,779	1,25	38,227	8,86	4024
	C19	547534	9605190	VESTAS V174-9.5	9500	110	42,300	42,120	0,42	38,540	8,86	4057
	C20	538910	9600380	VESTAS V174-9.5	9500	110	42,132	39,164	7,04	35,835	8,84	3772
	C21	539487	9601045	VESTAS V174-9.5	9500	110	42,230	38,795	8,14	35,497	8,85	3737
	C22	540062	9601710	VESTAS V174-9.5	9500	110	42,260	38,656	8,53	35,370	8,85	3723
	C23	540639	9602376	VESTAS V174-9.5	9500	110	42,276	38,577	8,75	35,298	8,85	3716
	C24	541215	9603041	VESTAS V174-9.5	9500	110	42,278	38,570	8,77	35,291	8,85	3715
	C25	541791	9603706	VESTAS V174-9.5	9500	110	42,297	38,627	8,68	35,344	8,86	3720
	C26	542367	9604371	VESTAS V174-9.5	9500	110	42,270	38,821	8,16	35,522	8,85	3739
	C27	542943	9605036	VESTAS V174-9.5	9500	110	42,277	39,162	7,37	35,834	8,85	3772
	C28	543512	9605702	VESTAS V174-9.5	9500	110	42,293	39,563	6,45	36,200	8,86	3811
	C29	544096	9606367	VESTAS V174-9.5	9500	110	42,300	39,964	5,52	36,567	8,86	3849
	C30	544672	9607032	VESTAS V174-9.5	9500	110	42,286	40,560	4,08	37,113	8,85	3907
	C31	545248	9607697	VESTAS V174-9.5	9500	110	42,294	41,315	2,32	37,803	8,86	3979
	C32	545851	9608394	VESTAS V174-9.5	9500	110	42,289	41,807	1,14	38,253	8,86	4027
	C33	535331	9602939	VESTAS V174-9.5	9500	110	42,104	39,168	6,97	35,839	8,83	3773
	C34	535907	9603605	VESTAS V174-9.5	9500	110	42,164	38,834	7,90	35,533	8,84	3740
	C35	536484	9604270	VESTAS V174-9.5	9500	110	42,195	38,696	8,29	35,407	8,84	3727
	C36	537060	9604935	VESTAS V174-9.5	9500	110	42,243	38,660	8,48	35,374	8,85	3724
	C37	537636	9605600	VESTAS V174-9.5	9500	110	42,247	38,664	8,48	35,378	8,85	3724
	C38	538212	9606265	VESTAS V174-9.5	9500	110	42,254	38,724	8,36	35,432	8,85	3730
	C39	538788	9606931	VESTAS V174-9.5	9500	110	42,277	38,839	8,13	35,538	8,85	3741
	C40	539364	9607596	VESTAS V174-9.5	9500	110	42,268	38,975	7,79	35,662	8,85	3754
	C41	539940	9608260	VESTAS V174-9.5	9500	110	42,267	39,215	7,22	35,881	8,85	3777
	C42	540516	9608925	VESTAS V174-9.5	9500	110	42,269	39,519	6,51	36,160	8,85	3806
	C43	541092	9609591	VESTAS V174-9.5	9500	110	42,269	39,831	5,77	36,446	8,85	3836
	C44	541668	9610256	VESTAS V174-9.5	9500	110	42,274	40,214	4,87	36,796	8,85	3873
	C45	542244	9610921	VESTAS V174-9.5	9500	110	42,267	40,752	3,58	37,288	8,85	3925
	C46	542821	9611586	VESTAS V174-9.5	9500	110	42,269	41,234	2,45	37,729	8,85	3971
	C47	543396	9612251	VESTAS V174-9.5	9500	110	42,266	41,525	1,75	37,996	8,85	4000
	C48	543972	9612916	VESTAS V174-9.5	9500	110	42,267	41,845	1,00	38,288	8,85	4030
	MEAN VALUES								**5,144**	**36,683**		**3861**
	TOTAL				**456.000**		**2028,672**	**1924,340**		**1760,771**		
ONSHORE	C49	539387	9592831	VESTAS V110-2.0	2000	95	9,140	9,116	0,26	8,341	7,21	4171
	C50	538799	9593049	VESTAS V110-2.0	2000	95	9,409	8,561	9,01	7,833	7,32	3917
	C51	538116	9593470	VESTAS V110-2.0	2000	95	9,830	8,881	9,66	8,126	7,49	4063
	C52	537557	9593834	VESTAS V110-2.0	2000	95	10,313	9,082	11,93	8,310	7,69	4155
	C53	537075	9594218	VESTAS V110-2.0	2000	95	10,591	9,243	12,73	8,458	7,82	4229
	C54	536508	9594629	VESTAS V110-2.0	2000	95	10,724	9,424	12,12	8,623	7,88	4312
	C55	536054	9595055	VESTAS V110-2.0	2000	95	10,912	9,650	11,57	8,830	7,98	4415
	C56	535631	9595470	VESTAS V110-2.0	2000	95	11,025	9,783	11,26	8,952	8,03	4476
	C57	535082	9596128	VESTAS V110-2.0	2000	95	11,300	10,615	6,07	9,713	8,17	4856
	C58	534574	9596557	VESTAS V110-2.0	2000	95	11,319	10,230	9,63	9,360	8,18	4680
	C59	534169	9597104	VESTAS V110-2.0	2000	95	11,473	10,729	6,48	9,817	8,27	4909
	MEAN VALUES								**9,155**	**8,760**		**4380**
	TOTAL				**22.000**		**116,036**	**105,315**		**96,363**		
ALL WT	**MEAN VALUES**								**5,892**			**3885**
	TOTAL				**478.000**		**2.144,708**	**2.029,655**		**1.857,134**		

Table 22: Assessed definitive results for GE WIND 220 12 MW / GE 116 2.0 MW

				MED Misure Elaborazione Dati	48*GE 220 - 12 MW + 11* GE 116 -2.0							
	ID WTG	UTM WGS84 Long. Est [m]	UTM WGS 84 Lat. Nord [m]	WEC Model	Power [KW]	Hub Height a.g.l. [m]	Gross AEP [GWh]	AEP net of wake loss[GWh]	Wake Loss [%]	Net AEP [GWh]	Vm [m/s]	Fleoh [MWh/MW]
OFFSHORE	C01	543747	9597143	GE WIND HALIADE X 12-220	12000	150	64,634	64,012	0,96	58,571	9,15	4881
	C02	544323	9597808	GE WIND HALIADE X 12-220	12000	150	64,566	63,899	1,03	58,468	9,15	4872
	C03	544900	9598473	GE WIND HALIADE X 12-220	12000	150	64,548	63,884	1,03	58,454	9,15	4871
	C04	545476	9599139	GE WIND HALIADE X 12-220	12000	150	64,474	63,823	1,01	58,398	9,14	4867
	C05	546052	9599801	GE WIND HALIADE X 12-220	12000	150	64,395	63,780	0,96	58,358	9,13	4863
	C06	546628	9600469	GE WIND HALIADE X 12-220	12000	150	64,331	63,765	0,88	58,345	9,13	4862
	C07	547203	9601133	GE WIND HALIADE X 12-220	12000	150	64,278	63,819	0,71	58,395	9,13	4866
	C08	547780	9601799	GE WIND HALIADE X 12-220	12000	150	64,250	64,107	0,22	58,658	9,12	4888
	C09	541778	9598534	GE WIND HALIADE X 12-220	12000	150	64,493	60,270	6,55	55,147	9,14	4596
	C10	542354	9599199	GE WIND HALIADE X 12-220	12000	150	64,476	59,747	7,33	54,669	9,14	4556
	C11	542930	9599865	GE WIND HALIADE X 12-220	12000	150	64,462	59,461	7,76	54,407	9,14	4534
	C12	543506	9600530	GE WIND HALIADE X 12-220	12000	150	64,411	59,340	7,87	54,296	9,14	4525
	C13	544083	9601192	GE WIND HALIADE X 12-220	12000	150	64,374	59,369	7,77	54,323	9,13	4527
	C14	544659	9601860	GE WIND HALIADE X 12-220	12000	150	64,273	59,574	7,31	54,510	9,12	4543
	C15	545234	9602528	GE WIND HALIADE X 12-220	12000	150	64,262	60,037	6,57	54,934	9,12	4578
	C16	545810	9603196	GE WIND HALIADE X 12-220	12000	150	64,248	61,138	4,84	55,941	9,12	4662
	C17	546385	9603865	GE WIND HALIADE X 12-220	12000	150	64,211	62,784	2,22	57,448	9,12	4787
	C18	546961	9604533	GE WIND HALIADE X 12-220	12000	150	64,175	63,282	1,39	57,903	9,12	4825
	C19	547534	9605190	GE WIND HALIADE X 12-220	12000	150	64,146	63,825	0,50	58,400	9,12	4867
	C20	538910	9600380	GE WIND HALIADE X 12-220	12000	150	64,326	59,598	7,35	54,532	9,13	4544
	C21	539487	9601045	GE WIND HALIADE X 12-220	12000	150	64,381	58,918	8,49	53,910	9,13	4492
	C22	540062	9601710	GE WIND HALIADE X 12-220	12000	150	64,355	58,619	8,91	53,637	9,13	4470
	C23	540639	9602376	GE WIND HALIADE X 12-220	12000	150	64,325	58,431	9,16	53,464	9,13	4455
	C24	541215	9603041	GE WIND HALIADE X 12-220	12000	150	64,278	58,363	9,20	53,402	9,13	4450
	C25	541791	9603706	GE WIND HALIADE X 12-220	12000	150	64,263	58,413	9,10	53,448	9,12	4454
	C26	542367	9604371	GE WIND HALIADE X 12-220	12000	150	64,191	58,693	8,57	53,704	9,12	4475
	C27	542943	9605036	GE WIND HALIADE X 12-220	12000	150	64,171	59,203	7,74	54,171	9,12	4514
	C28	543512	9605702	GE WIND HALIADE X 12-220	12000	150	64,160	59,816	6,77	54,732	9,12	4561
	C29	544096	9606367	GE WIND HALIADE X 12-220	12000	150	64,149	60,437	5,79	55,300	9,12	4608
	C30	544672	9607032	GE WIND HALIADE X 12-220	12000	150	64,115	61,327	4,35	56,114	9,11	4676
	C31	545248	9607697	GE WIND HALIADE X 12-220	12000	150	64,108	62,471	2,55	57,161	9,11	4763
	C32	545851	9608394	GE WIND HALIADE X 12-220	12000	150	64,088	63,264	1,29	57,886	9,11	4824
	C33	535331	9602939	GE WIND HALIADE X 12-220	12000	150	64,180	59,436	7,39	54,384	9,12	4532
	C34	535907	9603605	GE WIND HALIADE X 12-220	12000	150	64,200	58,825	8,37	53,825	9,12	4485
	C35	536484	9604270	GE WIND HALIADE X 12-220	12000	150	64,196	58,540	8,81	53,564	9,12	4464
	C36	537060	9604935	GE WIND HALIADE X 12-220	12000	150	64,213	58,425	9,01	53,459	9,12	4455
	C37	537636	9605600	GE WIND HALIADE X 12-220	12000	150	64,184	58,390	9,03	53,427	9,12	4452
	C38	538212	9606265	GE WIND HALIADE X 12-220	12000	150	64,159	58,445	8,91	53,477	9,12	4456
	C39	538788	9606931	GE WIND HALIADE X 12-220	12000	150	64,155	58,590	8,67	53,610	9,12	4467
	C40	539364	9607596	GE WIND HALIADE X 12-220	12000	150	64,124	58,796	8,31	53,798	9,11	4483
	C41	539940	9608260	GE WIND HALIADE X 12-220	12000	150	64,102	59,163	7,70	54,134	9,11	4511
	C42	540516	9608925	GE WIND HALIADE X 12-220	12000	150	64,086	59,645	6,93	54,575	9,11	4548
	C43	541092	9609591	GE WIND HALIADE X 12-220	12000	150	64,073	60,141	6,14	55,029	9,11	4586
	C44	541668	9610256	GE WIND HALIADE X 12-220	12000	150	64,064	60,724	5,21	55,563	9,11	4630
	C45	542244	9610921	GE WIND HALIADE X 12-220	12000	150	64,040	61,537	3,91	56,306	9,11	4692
	C46	542821	9611586	GE WIND HALIADE X 12-220	12000	150	64,033	62,278	2,74	56,984	9,11	4749
	C47	543396	9612251	GE WIND HALIADE X 12-220	12000	150	64,020	62,750	1,98	57,416	9,10	4785
	C48	543972	9612916	GE WIND HALIADE X 12-220	12000	150	64,009	63,272	1,15	57,894	9,10	4824
	MEAN VALUES								**5,427**	**55,594**		**4633**
	TOTAL				**576.000**		**3083,754**	**2916,427**		**2668,531**		
ONSHORE	C49	539387	9592831	GE WIND ENERGY 2.0-116	2000	90	9,297	9,265	0,34	8,478	7,13	4239
	C50	538799	9593049	GE WIND ENERGY 2.0-116	2000	90	9,568	8,634	9,77	7,900	7,24	3950
	C51	538116	9593470	GE WIND ENERGY 2.0-116	2000	90	10,000	8,945	10,54	8,185	7,41	4093
	C52	537557	9593834	GE WIND ENERGY 2.0-116	2000	90	10,491	9,133	12,95	8,356	7,62	4178
	C53	537075	9594218	GE WIND ENERGY 2.0-116	2000	90	10,773	9,297	13,70	8,506	7,75	4253
	C54	536508	9594629	GE WIND ENERGY 2.0-116	2000	90	10,903	9,481	13,05	8,675	7,81	4337
	C55	536054	9595055	GE WIND ENERGY 2.0-116	2000	90	11,104	9,713	12,52	8,888	7,91	4444
	C56	535631	9595470	GE WIND ENERGY 2.0-116	2000	90	11,216	9,848	12,20	9,011	7,96	4506
	C57	535082	9596128	GE WIND ENERGY 2.0-116	2000	90	11,491	10,721	6,70	9,810	8,10	4905
	C58	534574	9596557	GE WIND ENERGY 2.0-116	2000	90	11,509	10,300	10,50	9,425	8,12	4712
	C59	534169	9597104	GE WIND ENERGY 2.0-116	2000	90	11,661	10,819	7,22	9,899	8,20	4950
	MEAN VALUES								**9,953**	**8,830**		**4415**
	TOTAL				**22.000**		**118,013**	**106,157**		**97,133**		
ALL WT	**MEAN VALUES**								**6,271**			**4625**
	TOTAL				**598.000**		**3.201,767**	**3.022,584**		**2.765,664**		

6.4 Analysis of uncertainties

Essential part of the assessment of wind resource and energy output of a wind farm is a detailed uncertainty analysis. Within such an analysis the uncertainty of different steps of the assessment are determined and combined taking into account their dependencies. in order to derive the overall uncertainty on the long-term annual energy output [25]. This uncertainty on the energy output is given as standard uncertainty. The uncertainties associated with the meteorological wind data have been assessed and are following presented. The uncertainty of the projected wind conditions derives from different sources: The uncertainty of the measurement is due to the quality of the measurement set-up and the measurement data. Uncertainty of the wind speed measurement is a combination of several uncertainty components. Usually the most important ones are the mounting effects on the anemometers and the uncertainty of the anemometer calibration [12]. Uncertainty analyses for the wind resource measurement at the site TP_2839 is done according IEC 61400-12-1 [12] according to the following equation:

$$\mathrm{u}_{\mathrm{V,i}} = \sqrt{\left(u_{V1,i}^2 + u_{V2,i}^2 + u_{V3,i}^2 + u_{dV,i}^2\right)}$$

where:

- $u_{V1,i}$ = uncertainty of the anemometer calibration in,.wind speed bin i;
- $u_{V2,i}$ = uncertainty due to operational characteristics of the anemometer in wind speed bin i;
  $u_{V3,i}$ = uncertainty of flow distortion due to mounting effects in wind speed bin i;
- $u_{dV,i}$ = uncertainty in the data acquisition system for the wind speed bin i.

Used anemometers are only partially calibrated by an independent institute. The calibration has not been carried according to MEASNET standard [12]. General uncertainty of anemometer calibration according to MEASNET standard is estimated to be 0.1 m/s [12], 0.2 m/s are applied here. According to IEC 61400-12-1 the uncertainty due to operational characteristic of anemometers is estimated to be 0.5 % of the wind speed [12]. For the used anemometer at the measurement mast TP_2839, which are not first class anemometer. the uncertainty due to operational characteristics is estimated to be 1.0% of the wind speed.

The complete measurement system including mast; dimensions and directions of the booms and mounting of sensors is not designed following the requirements of IEC 61400-12-1 [12]. Uncertainty due to mounting of the anemometer is estimated to be 1.5% of the wind speed for all boom mounted anemometers and 0.5 for top mounted anemometers. Uncertainty of the data acquisition system is indicated as 0.1 % of the wind speed according to the manufacturer.

The uncertainty of the long-term scaling comprises the uncertainty of the calculated wind conditions for long term period, and it is calculated by software basing on the Klintø method. [33] (Klintø, April 2015). This method considers four main parameters as uncertainty contributors to the overall estimate. These parameters are weighted based on their contribution to the long-term correction. The contributors are: The wind index in concurrent period; the correlation factor between short and long-term dataset; The inter-annual variability of the long-term dataset and the number of concurrent years between measurements and long-term series.

The calculated uncertainty in vertical extrapolation from the measurement height to the hub height as well as uncertainty of the horizontal extrapolation of the wind conditions between measurement mast and the wind turbines are associated with the used orographic correction model and the roughness model. This uncertainty is relatively high due to the position of met mast

The 1 and 10 years uncertainties shows how much the wind resource varies from year to year in the specific region. Basing on long term series chosen ERA5, the calculated value is **5.9%** on wind speed. The variability entered is used for the 1-year calculated uncertainty, the 10y variability uncertainty is the σ_{1y}/sqrt(10)on wind speed. It is important to be aware of that the variability tells about the fluctuations within few years, not the very long term variations .

With energy uncertainties, which are assumed to be stochastical and independent, an overall wind speed uncertainty is calculated for each wind turbine site. The wind speed uncertainty is converted into wind energy uncertainty by a calculated sensitivity of the energy yield in regards to the wind speed. The value of that sensitivity is stronlgy depending from WT power curve [4], [11],and it is 1.6 for GE WIND solution and 2.0 for Vestas V174+Vestas V110. That means e.g. that a variation of 10 % in wind speed leads to a variation of 20 % in energy yield. It is different for other configurations or wind turbine types.

The technical characteristics of the chosen wind energy converters at the site (e.g. the power curve) are regarded to be a subject of the contract with the manufacturer. However, a standard uncertainty associated with the WT-data is assumed set to 5% basing on a standard guarantee of supplier, in this specific case a 8% value is assumed due to the fact that official power curves are not available. [author assumption]

The uncertainty evaluation was made only for the two solution of GE WIND and Vestas V174 + V110 because considered the most suitable for site anemology

Table 23: Detail of uncertainty evaluation for Vestas V174 9.5 MW + V110 2 MW

Uncertainty evaluation		
(**Stvty**: [%AEP] / %[m/s])		**2,0**
Parameter	**Unc.Wind Speed [%]**	**Unc.Energy [%]**
Wind measurement/Wind data	2,5	5
Long term correction	2,98	5,96
Year-to-year variability	5,9	11,8
10 Year variability	1,87	3,73
Future climate	1	2
Other wind related	1	2
Wind model	0	0
Vertical extrapolation	2,5	5,0
Horizontal extrapolation	2,5	5
Other wind model related	1,8	3,6
Power conversion	0	0
Power curve uncertainty	4,0	8,0
Metering uncertainty	2,5	5
Other AEP related uncertainties	1	2
Total uncertainty 1 year	**9,54**	**19,1**
Total uncertainty 10 year	**7,72**	**15,4**

Table 24: Detail of uncertainty evaluation for GE WIND 220 12 MW e GE 116 2 MW

Uncertainty evaluation		
(**Stvty**: [%AEP] / %[m/s])		**1,6**
Parameter	**Unc.Wind Speed [%]**	**Unc.Energy [%]**
Wind measurement/Wind data	2,5	4
Long term correction	2,98	4,77
Year-to-year variability	5,8	9,3
10 Year variability	1,83	2,93
Future climate	1	1,6
Other wind related	1	1,6
Wind model	0	0
Vertical extrapolation	2,5	4,0
Horizontal extrapolation	2,5	4
Other wind model related	1,8	2,88
Power conversion	0	0
Power curve uncertainty	5,0	8,0
Metering uncertainty	2,5	4
Other AEP related uncertainties	1	1,6
Total uncertainty 1 year	**9,94**	**15,9**
Total uncertainty 10 year	**8,28**	**13,2**

The next tables presents the levels of energy yield that are exceeded with a given probability basing on a Gaussian process. Values from this table may be the basis for an economic assessment of the project, and in this sense, systematic losses have to be taken into account by subtracting them from the calculated energy yield.

Table 25:Exceedance levels of net energy yield based on a 1 year and 10 years of future wind conditions for Vestas V174 9.5 MW scenario

Exceedance probability		P50	P75	P90
1 Year	[MWh]	1.857.134	1.619.783	1.406.160
	FLEOH [MWh/MW]	3885	3389	2942
10 Years	[MWh]	1.857.134	1.663.915	1.490.012
	FLEOH [MWh/MW]	3885	3481	3117

Table 26:Exceedance levels of net energy yield based on a 1 year and 10 years of future wind conditions for GE 220 12 MW e GE 116 2.0 MW scenario

Exceedance probability		P50	P75	P90
1 Year	[MWh]	2.765.664	2.469.054	2.202.095
	FLEOH [MWh/MW]	4625	4129	3682
10 Years	[MWh]	2.765.664	2.518.668	2.296.363
	FLEOH [MWh/MW]	4625	4212	3840

7 SITE IEC CLASSIFICATION

The International Electrotechnical Commission (IEC) standards establishes the design requirements. IEC 61400-1 [13], [14], [15] specifies design classes with associated extreme wind speeds and turbulence intensities. Turbulence models and other environmental conditions such as topographical complexity are also specified. Next figure presents the basic parameters for wind turbine classification.

Wind turbine class		I	II	III	S
V_{ave}	(m/s)	10	8,5	7,5	Values specified by the designer
V_{ref}	(m/s)	50	42,5	37,5	
	Tropical (m/s) $V_{ref,T}$	57	57	57	
A+	I_{ref} (-)	0,18			
A	I_{ref} (-)	0,16			
B	I_{ref} (-)	0,14			
C	I_{ref} (-)	0,12			

The parameter values apply at hub height and

- V_{ave} is the annual average wind speed;
- V_{ref} is the reference wind speed average over 10 min;
- $V_{ref,T}$ is the reference wind speed average over 10 min applicable for areas subject to tropical cyclones;
- A+ designates the category for very high turbulence characteristics;
- A designates the category for higher turbulence characteristics;
- B designates the category for medium turbulence characteristics;
- C designates the category for lower turbulence characteristics; and
- I_{ref} is a reference value of the turbulence intensity (see 6.3.2.3).

From [24] IEC 61400-1 ed. 4 (2019): "Table 1 – Basic parameters for wind turbine classes".

Figure 25: basic parameters for WTG classes

Where: **Vref** is the reference wind speed with a recurrence period of 50 years; it is the basic extreme parameter used for defining wind turbine classes (a turbine designed for a WTGS class with a reference wind speed V_{ref}, is designed to withstand climates for which the extreme 10 min average wind speed with a recurrence period of 50 years is lower than or equal to V_{ref})

A designates the category for higher turbulence characteristics;

B designates the category for medium turbulence characteristics;

C designates the category for lower turbulence characteristics;

Iref is the characteristic value of the turbulence intensity at 15 m/s; Iref is here defined as the mean value.

The assessments of structural integrity by reference to wind data are described in the IEC 61400-1 section 11.9. Referring to the last version of IEC 61400_1 third edition amendment 1, the following variables must be checked:

Wind shear : It must be positive and less than 0.2.

Wind inflow angle : Flow inclination must be less than 8° (in absolute value).

Extreme wind speed: The site estimate of extreme 10 minute average wind speed at hub height with a recurrence period of 50 years shall be less than V_{ref}, value defined in the IEC standards.

Criterion for the probability density: The site value of the probability density function of wind speed at the hub height V_{hub} shall be less than the design probability density function at all values of V_{hub} between the wind speeds 0.2 V_{ref} and 0.4 V_{ref}.

Criterion for sigma1: The ambient turbulence standard deviation σ and the standard deviation $σ_σ$ must be estimated at V_{hub} between V_{in} and V_{out}.

V_{in} is the cut-in wind speed and V_{out} is the cut-out wind speed.

In case the wake effect the test is true if

The IEC ed. 4 wind climate checks are split into a list of checks for fatigue loads and a list for ultimate loads. The below list of five checks, a) to e), represent fatigue loads or "normal climate", were also in

IEC ed. 3. a) Wind Distribution b) Effective turbulence c) Flow Inclination d) Wind Shear e) Air Density

$$\sigma_1 \geq I_{eff}.V_{hub} + 1.28\,\widehat{\sigma_\sigma}$$

Where according to the IEC standard (Edition 3), for the normal turbulence model, we have:

$$\sigma_1 = I_{ref}\,(0.75\,V_{hub} + 5.6)$$

Criterion for the turbulence : The effective turbulence intensity must be lower than

$$I_{eff} < \frac{I_{ref}\,(5.6 + 0.75V_{hub})}{V_{hub}}$$

All these tests were performed with a single detailed form for each wind turbine generator.

In the image below are synthetized the results of a preliminary IEC compliance calculation based on site measured values.

Main result

		Check Design Load Case:
Main IEC checks		
Terrain complexity	OK	
Fatigue/Normal conditions		
Effective turbulence	OK	
Wind distribution	**Critical**	DLC1.2* (+DLC3.1,DLC4.1,DLC6.4)
Flow inclination	OK	
Wind shear	*Caution*	
Air density	OK	
Ultimate/Extreme conditions		
Extreme wind	OK	
Ambient 90% turbulence [NTM]	OK	
Ambient extreme turbulence [ETM]	OK	
Max centre-wake 90% turbulence [ETM]	OK	
Other IEC checks & analysis		
Seismic hazard	OK	
Lightning rate	OK	

**) DLC1.2 is implemented in LOAD RESPONSE. DLCs 3.1,4.1,6.4 are less significant.*

Result details

			WTG class	Method	Quality	WTG Mean	Max WTG	Min WTG	WTGs OK	WTGs Caution	WTGs Critica
Main IEC checks											
Terrain complexity	ic	[-]		Active DEM		0,00	0,00	0,00	59	*0*	**0**
Fatigue/Normal conditions											
Effective turbulence	σeff(u)*	[-]	IIIA	Mast	A+-	-	-	-	59	*0*	**0**
Wind distribution	pdf(u)*	[-]	IIIA	Mast Weibull shear	B	-	-	-	0	*0*	**59**
Flow inclination	φmax	[°]		Terrain fit	C	0,2	2,2	0,0	59	*0*	**0**
Wind shear	α	[-]		Mast	C	0,20	0,20	0,20	0	*59*	**0**
Air density	ρ	[kg/m³]		GHCN	C	1,162	1,165	1,161	59	*0*	**0**
Ultimate/Extreme conditions											
Extreme wind	u50y	[m/s]	IIIA	AM	A+C	19,4	19,7	18,3	59	*0*	**0**
Ambient 90% turbulence [NTM]		[-]	IIIA	Mast	A+-	-	-	-	0	*0*	**0**
Ambient extreme turbulence [ETM]		[-]	IIIA	Mast	A+-	-	-	-	0	*0*	**0**
Max centre-wake 90% turbulence [ETM]		[-]	IIIA	Mast	A+-	-	-	-	0	*0*	**0**
Other IEC checks & analysis											
Seismic hazard	PGA	[m/s²]		GSHAP map		0,5	-	-			
Lightning rate		[flashes/year/km²]		NASA GHCC		0,7	-	-			

* Parameter checked for a range of windspeeds (u), a single summary value is not possible.

Figure 26: Main results of IEC assessment

7.1 Site turbulence

In order to determine the turbulence intensity at hub height on WTG site, Wind Pro site compliance module wasused with the employ of wasp engineering algorithm .

The corrected directional turbulence at the result point Icorp(dir) is computed according to:

DELTA_I(dir) = Imes(dir) – Icalcm(dir)

*Icorp(dir) = Icalcp(dir) + DELTA_I(dir) * Cm(dir) / Cp(dir)*

The corrected directional turbulence at the result point Icorp(dir) is computed according to:

- Imes(dir) is the measured directional turbulent intensity on the reference point.
- Icalcm(dir) is the computed directional turbulent intensity on the reference point.
- Icalcp(dir) is the computed directional turbulent intensity on the result point.

- Cm(dir) is the computed directional speed-up factor on the reference point.
- Cp(dir) is the computed directional speed-up factor on the result point.

All turbulence analysis are based on IEC 61400-1 Ed 3 Amendment 1, in the following table only summary results of sigma parameters recommended in the IEC 61400 ed.3 Am. 1 are reported for the worst wt:

All turbulence analysis are based on IEC 61400-1 Ed 3 Amendment 1, **A detailed turbulence analysis is reported in appendix I for each wtg**, in the following table only summary results of following parameters recommended in the IEC 61400 ed.3 Am. 1 are reported:

Mean effective turbulence intensity :It gives the mean effective turbulence intensity for allwind speeds and is calculated among all the directions. All turbulence intensity values available were computed by taking into account values associated with a wind speed over 4 m/s.

Mean representative turbulence intensity for strong winds: it gives the mean representative turbulence intensity for strong wind speeds (greater than 10 m/s) and is calculated among all the directions.

As effective turbulence is intended ambient turbulence which shall include adequate representation of the effect on loading of ambient turbulence and turbulent wake effects [10]. For the estimation of effective turbulence Frandsen [3] model is used.

Mean effective turbulence intensity for strong winds: It gives the mean effective turbulence intensity for strong wind speeds (greater than 10 m/s) and is calculated among all the directions.

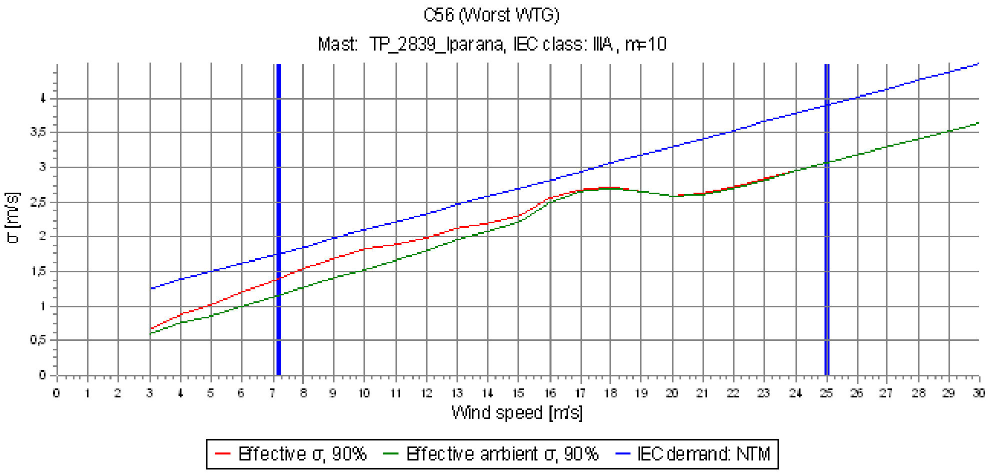
Mean effective turbulence intensity: It gives the mean effective turbulence intensity for all wind speeds and is calculated among all the directions.

IEC limits

"Normal turbulence model" (σ) for each wind speed bin in m/s

IEC class	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]
IIIA	1,86	1,98	2,10	2,22	2,34	2,46	2,58	2,70	2,82	2,94	3,06	3,18	3,30	3,42	3,54	3,66	3,78	3,90	4,02	4,14

Results (Graphics)



Results (Table)

Effective turbulence, P90 (σeff(u)) for each wind speed bin in m/s

WTG	Class	Mast	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
			[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]	[m/s]
C01	IIIA	A	1,26	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,58	2,61	2,71	2,82	2,94	3,09	3,21	3,30
C02	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,71	2,83	2,94	3,08	3,20	3,30
C03	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,71	2,83	2,95	3,07	3,19	3,30
C04	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,72	2,83	2,95	3,07	3,19	3,30
C05	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,72	2,83	2,95	3,07	3,18	3,30
C06	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,72	2,83	2,95	3,07	3,18	3,30
C07	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,72	2,83	2,95	3,07	3,18	3,30
C08	IIIA	A	1,27	1,39	1,51	1,65	1,79	1,96	2,06	2,20	2,49	2,65	2,70	2,65	2,59	2,62	2,72	2,83	2,95	3,07	3,18	3,30

Figure 27: Summary results about turbulence sigma parameter for worst wtg

Eliminated subtitle

7.2 Vref

The reference wind speed V_{ref} , or the extreme wind speed with a return period of 50 years, is an important parameter in the site class analysis and often is the discriminant to select the suitable turbine model, because directly associated to the nominal design loads of wind turbine. A good investigation of this parameter needs of an extreme analysis based on a GEV/Gumbel distribution [22]. Since this approach takes into account only one max speed value per epoch (1 year), the data set from which the epochal extremes are drawn must be long: Cook (1985) suggests at least 20 years of data for reliable results (20 extremes), and states that the method should not be employed with fewer than 10 years. For the wind energy applications this long data set is often not available and the application of Gumbel method can result in an unreliable V_{ref} estimation. Since the storms tend to occur in families or clusters and the second strongest extreme value in one year may be considerably larger than the strongest in another year, the epochal extreme analysis ignores important information.

An alternative approach for extreme analysis is the “Peak Over Threshold method” (P.O.T) that leads to an appropriate ensemble obtained as independent storms above a minimum threshold value.

The P.O.T method takes into account all independent and identically distributed extreme speeds exceeding a specific threshold value. The extreme samples can be analyzed with Gumbel or other types of extreme distributions (i.e. modified Gumbel) [21].

This approach is implemented as a tool of WINDPRO computer program and requires a suitable combination of both threshold and minimum separation time between events to select only the independent samples. This two parameter can have a very large impact on the V_{ref} estimation and they are selected from an iterative process. The extreme data set can be selected from both real wind speed and squared wind speed.

According to Cook (1985), a better estimate of the extreme wind probability is obtained by fitting a Gumbel distribution to extreme values of squared wind speed, just because the cumulative probability distribution function of squared wind speed is closer to exponential than the distribution of real wind speed, and it converges much more rapidly to the Gumbel distribution. Therefore, using this method to predict extreme values of squared wind speeds, more reliable estimates can be obtained from a given number of observations. Here are presented the result of Vref calculation according to:

WINDPRO – Gumbel distribution: a V_{ref} values has been calculated fitting the Gumbel distribution on two extreme ensemble selected applying the Peak over threshold method (P.O.T) and independent storm method (I.S) to the measured wind speed. This is carried out with Extreme Wind Speed Estimator tool of WINDPRO software at 61-m measuring height on mast position and extrapolated to hub height of planned turbine. The following table shows the Vref Value on TP_2839 Mast position at 60 m a.g.l. calculated using WINDPRO EWSE tool (Extreme Wind Speed Estimator).

The following image shows the selected samples used to estimate the Vref using the WINDPRO EWSE tool.

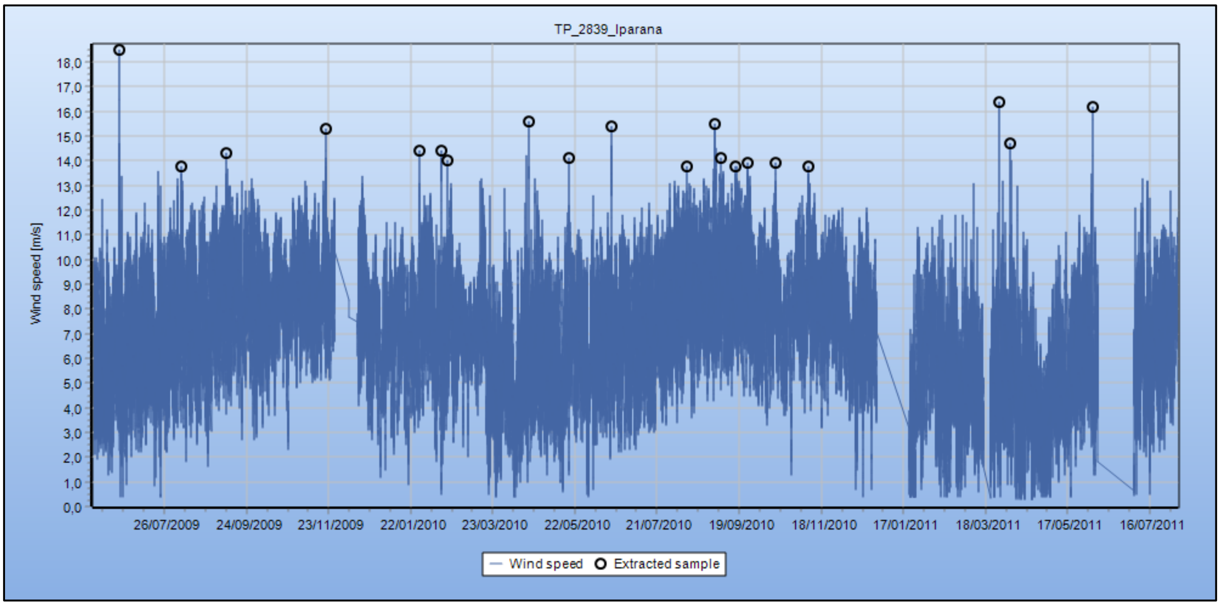


Figure 28: Selected samples to estimate the Vref with WINDPRO EWSE tool

The following picture shows the Vref results on TP_2839 at 60 m a.g.l. using WINDPRO EWSE tool on quadratic wind speed.

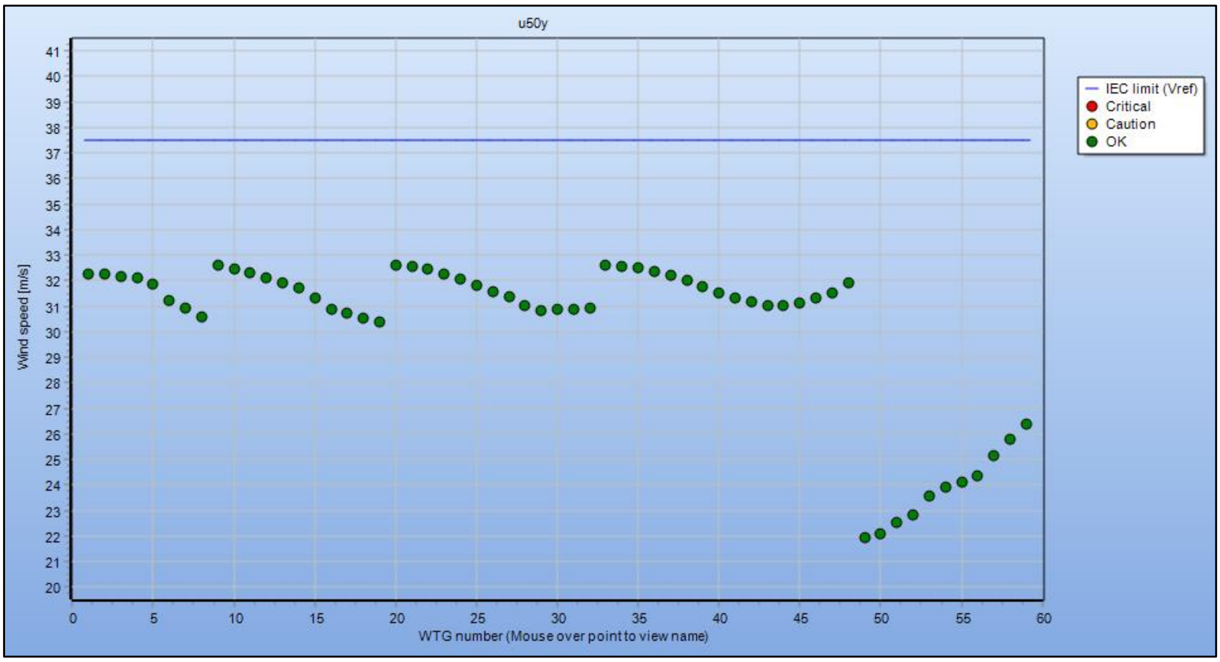


Figure 29: Vref estimation with WINDPRO EWSE tool using the quadratic wind speed on TP_2839 at 60 m a.g.l.

For a given stability condition (here neutral), the impact of the topography is independent from the wind speed level. As a result, the topographical effects on mean wind speed and direction can be evaluated by comparing the computed wind to a reference wind, defined as the wind speed we would have in reference conditions. The reference conditions are defined as: 10 m height, flat terrain, homogeneous roughness length of 5 cm (open rural terrain). Then, at any location, is defined a directional speed-up factor as the ratio of the computed wind speed *V* and the reference wind speed Vref. If C_i is the speed up factor at one location, for a reference wind direction sector i. In addition, is defined the 3-sec gust coefficient **G** in any given point of the site as the average value of the ratio of the maximum instantaneous wind speed during a period of 10 min, divided by the 10-min mean wind speed. It can be computed as a function of turbulence intensity I with:

$$G = 1 + 2.84 * I$$

Where *I* is the turbulent intensity computed for each direction.

Since the position and height of measuring mast do not coincide with position and hub height of WT an extrapolation process of the V_{ref} value was needed.

The calculated 50-yr value of the 10-min mean wind speed at the measurement point is used to calculate at any result point the 50-yr 10-min mean wind speed and 3-sec gust speed by:

$$V_{50mean} = (C/C_0)_{max} V_{50mean\ mes}$$

$$V_{50gust} = (GC/C_0)_{max} V_{50mean\ mes}$$

Where we call C_0 and G_0 the directional speed-up factor and gust coefficient at the measurement point. In the extreme wind analysis, the direction of the extreme wind speed is not known. Therefore, it would be safer to consider that the extreme wind speed can occur from any directions. However, for some directions, C_0 can be very low. As a consequence, the calculated extreme wind speed can be overestimated because the direction for which C/C_0 is maximal may be a direction where strong winds are rare. This is why can be ignored the directions which have a low speed-up coefficient.
For the extreme definitive results sectors 30, 60, 90, 120, 180 were ignored basing on tabled measured extreme values.

7.3 Shear IEC compliance

The **wind shear** has been determined over the rotor plane, the shear exponent **α** has been calculated from WIND PRO software with IEC compliance module according to IEC 61400-1 third edition amendment 1 2010.The wind shear exponent for each wind turbine position is presented in the following table.
According to the IEC 61400-1, the maximum allowable wind shear is 0.20 (α. exponent.)
All WT position are within the prescribed limits

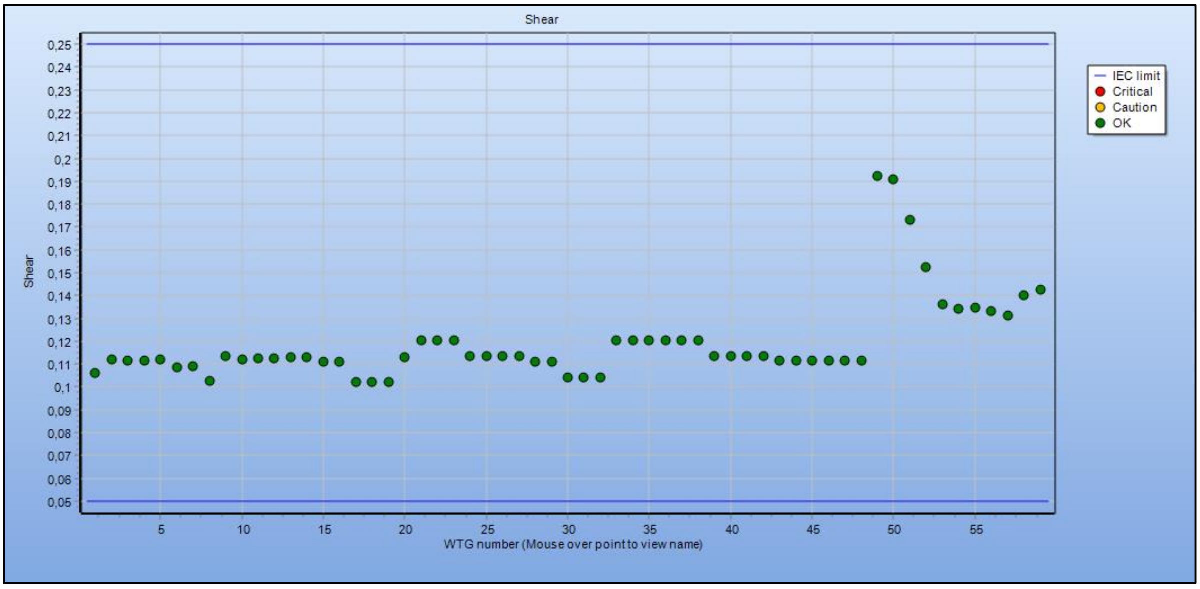


Figure 30: Calculated shear parameters

7.4 Wind distribution compliance

According to the last recommendation of IEC [24] the wind distribution check evaluates the frequency of occurrence at different wind speeds for each WTG by comparing them to the frequency of occurrence assumed in the IEC design limit. The IEC design limit for the Wind distribution check is a Weibull distribution with a shape factor of k=2. The mean wind speed is defined as 20% of the basic design parameter V_{ref} which is 10m/s, 8.5m/s and 7.5m/s for the wind speed classes I, II and III, respectively. A range of wind speeds ranging from 20% to 40% of V_{ref} must be checked, i.e. from the mean wind speed to twice the mean wind speed of each WTG class.

In the IEC standard, it is required that the wind distribution estimated for each WTG is long-term representative. Hence, an evaluation of the long-term level and possibly a long-term correction is required.

This parameter seems to be the only one that may require further investigation as regards the conditions of machine installability. The effect of this requirement is on fatigue loads and the conditions expressed are still to be considered overcome by using engineering devices suggested by the supplier.

Design standard: IEC61400-1 ed. 4 (2019)

Result: Critical

Check setup

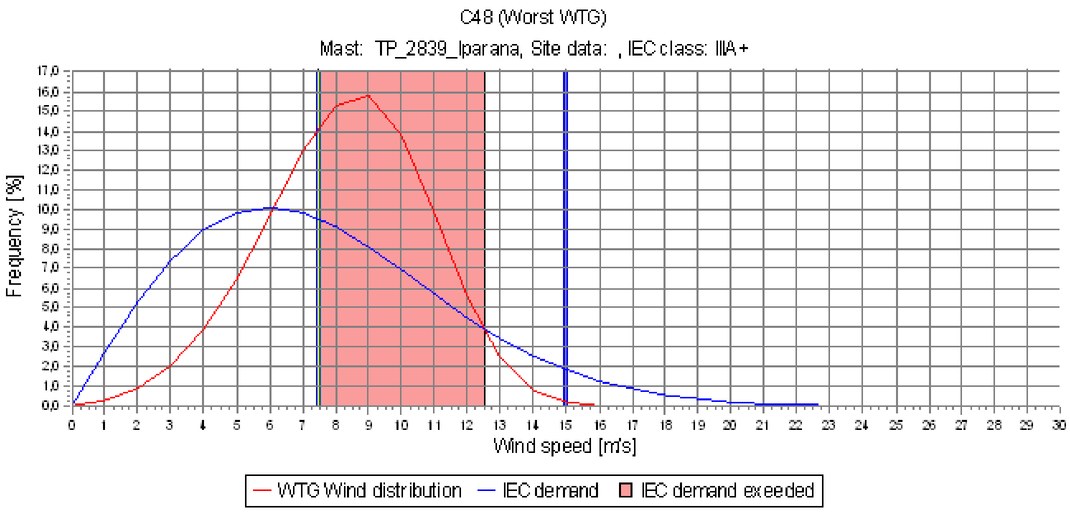
Method used	Mast Weibull shear	(quality: B)
Method details	Mast sector Weibulls and sector shears (mast shear required)	
Methods available	Mast Weibull shear	(quality: B)
	Mast direct	(quality: C)
User comment	DLC1.2* (+DLC3.1,DLC4.1,DLC6.4)	

IEC limits

Max frequency for each wind speed bin [m/s]

IEC class	8	9	10	11	12	13	14	15
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
IIIA+	9,1	8,1	6,9	5,7	4,5	3,4	2,5	1,8

Results (Graphics)



Results (Table)

WTG	Class	Mast	8	9	10	11	12	13	14	15
			Frequency for each wind speed bin [m/s]							
			[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
C01	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C02	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C03	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C04	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C05	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C06	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C07	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C08	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C09	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2
C10	IIIA+	A	**15,3**	**15,8**	**13,8**	**9,8**	**5,6**	2,4	0,8	0,2

Figure 31: Wind distribution verification range according to IEC 61400

8 Conclusions and recommendations

The predicted average wind speed at hub height is about **8,8 m/s at about 120 m** a.s.l.with a wind statistic distributions which assure a reliable and good energy production with all wind turbine models tested, even taking into account about 8.5 % of technical losses.

Regarding IEC compliance, a warning should be considered with reference wind distribution which can lead to fatigue loads.

Basing on these considerations following the recommendations below might lower the uncertainties of the energy yield calculation and possible further evaluations:

- It should be considered to install additional measurement systems at the site with larger height in order to decrease the uncertainty.
- a lidar campaign is recommended to clarify all vertical extrapolation uncertainties.

9 References

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APPENDIX 1 : TP_2839_Site mast report

The measurement station identified with ID TP_2839 is a lattice measurement station installed on 03/06/2009 in the municipality of Caucaia in the Iparana locality.

The station was installed near the coast at the following geographical coordinates

Table 27: Coordinates of met mast station

Geografic coordinates			
Latitude	3º 41' 23,4"S - 9592142 S	Fuse	24
Longitude	38º 36' 36,8"W - 543279 E	Altitude: m a.s.l.	8 m

Figure 32: Met mast position on ortophoto

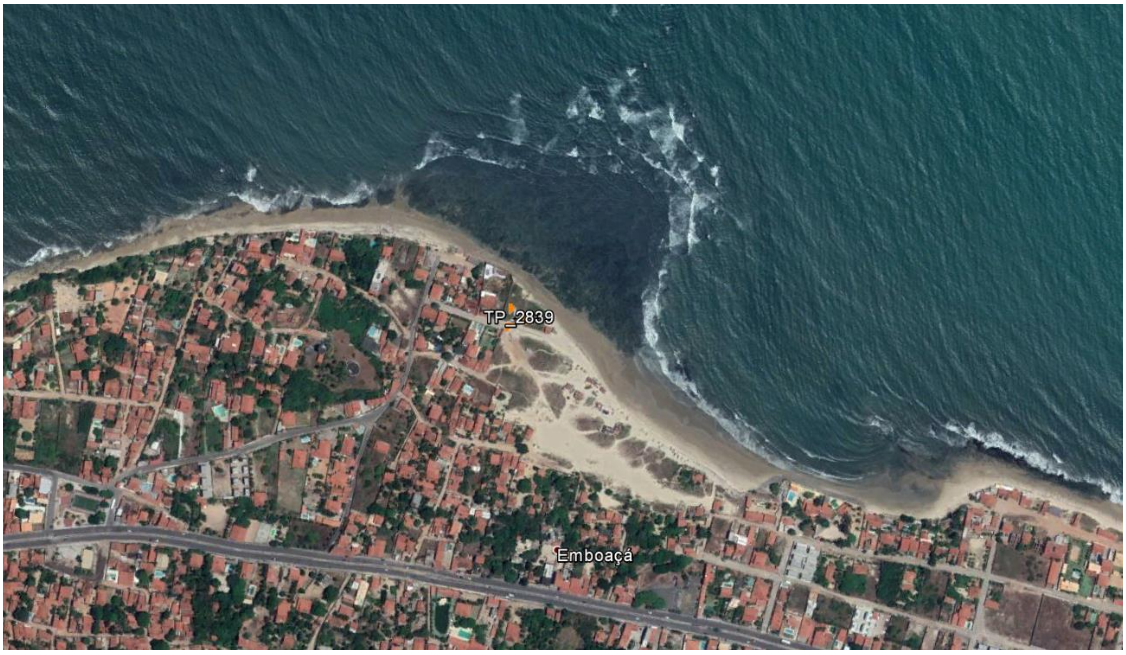


Figure 33: Met mast position on ortophoto

GIERRET S.R.L. via Alcide de Gasperi n°44, 82018 S.Giorgio del Sannio (BN)					
SCHEDA SITO EOLICO					
Numero di sito 2839			PIN:		
Nome del sito	IPARANA		Nome del progetto:		
Ubicazione sito	CAUCAIA –		Brasile		
Incarico di installazione firma:		Data di installazione	03/06/2009		
Tipo NRG symphonie n° 309012833					
	anemometro 1	**anemometro 2**		**banderuola 1**	**banderuola 2**
Altezza di monitoraggio	**60m**	**40 m**		**60m**	**40 m**
Principale o ridondante	Principale	Ridondante		Principale	Ridondante
Orientamento di installazione (Gradi - Magnetico)	180° da nord	180° da nord		0° nord	0° nord
Lunghezza supporto	1,5 mt	1,5 mt		1,5 mt	1,5 mt
Orientamento supporto	180° da nord	180° da nord		0° nord	0° nord
Certificato di calibrazione-numero	**62864**	127		139	142
Offset	0,37	0,35		0	0
Unità di misura	m/s	m/s		deg	deg
Fattore di scala	0,761	0,765		0,351	0,351
N. canale del data logger	**1**	**2**		**7**	**8**
LUNGHEZZA CAVI		**100m 3*0,50**		**100m 3*0,50**	
CAVO GIALLO-VERDE PER MESSA A TERRA				**100m**	

Figure 34: Met mast installation report

SCHEDA SITO - Mast n° 2839

Numero di sito			
Data Istallazione	***03/06/2009***		
Aggiornato al			
Coordinate Geografiche			
Lat	3º 41' 23,4"S - 9592142 S	*Fuso*	24
Long	38º 36' 36,8"W - 543279 E	*Altitudine m s.l.m.*	8 m
Luogo Installazione			
Regione	Ceará - Brasil		
Comune	Caucaia		
Provincia			
Località	Iparana		
Dati Catastali			
Proprietario: Arnaldo Amadori		**Foglio**	**Particella**
Tel.			
Descrizione Sito			
Posicionada à beira-mar de Iparana, com boas rajadas de vent, pois não há construções			
Torre di misura			
Tipo	Reticular	*Altezza*	60 m
Materiale	Ferro - Galvanizado	*Produttore*	J. Antenas
Configurazione torre di misura			
Altezza di misura	*Orientamento Booms in gradi rispetto al Nord*	*Lunghezza Booms*	Ultima configurazione Serial Number sensori
60 m Anemometro	180º SUL	1,5 m	62864
60 m Anemometro	0º NORTE	1,5 m	20177
40 m Anemometro	180º SUL	1,5 m	127
60 m Banderuola	0º NORTE	1,5 m	139
40 m Banderuola	0º NORTE	1,5 m	142
Data Logger			
Tipo	NRG Symphony	*S.N.*	309012833

Figure 35: TP_2839 mast maintenance sheet1

SCHEDA SITO - Mast TP_2839- Iparana							
Sensori di misura							
Altezza	***Serial Numb.***	***Tipo***	***Calibrazione***		***Slope [m/s]***	***Offset [m/s]***	***Periodo di misura***
60	62864	NRG #40C Anemom.	☑	Otech	0,761	0,37	
60	20177	NRG #40C Anemom.	☑	Svend	0,772	0,24	
40	127	NRG #40C Anemom.	☑		0,765	0,35	
60	139	NRG 200P Wind Vane	☑		0,351	0	
40	142	NRG 200P Wind Vane	☑		0,351	0	
Storico Data Logger							
Tipo		***Serial Numb.***					***Periodo di misura***
NRG Symphony		309012839					3-6-09 a 7-09-12
NRG Symphony		408005364					7-9-12 a 17-12-12

Figure 36: TP_2839 mast maintenance sheet2

Mast 001 - Vista da NORD	Mast 001 - Vista da SUD

Mast 001 - Vista da EST	Mast 001 - Vista da OVEST

Figure 37: TP_2839 pictures

Figure 38

A general review and assessment of the available meteorological data material has been performed. The data have been assessed regarding their quality and usability for the intended purposes. The used data have been checked for detectable measuring, recording or conversion errors and inconsistencies. The following table shows the ricalibration parameters used.

Table 28: Channel configuration of logger and recalibration parameters

Channel	Height (m)	Instrument	Model	SN	Orient.	Start date	End date	Slope in Logger	Offset in Logger	Slope Desired	Offset Desired	Slope correction	Offset correction
-	4	Logger	NRG Symphony	309012839	-	03/06/2009	07/09/2012	-	-	-	-	-	-
-	4	Logger	NRG Symphony	408005364	-	07/09/2012	17/12/2012	-	-	-	-	-	-
C1	100	Anemometer	NRG #40C Anemom.	62864	270°	03/06/2009	07/09/2012	0,761	0,37	0,761	0,37	1,000	0,000
C2	100	Anemometer	NRG #40C Anemom.		90°	03/06/2009	17/12/2012	0,765	0,35	0,765	0,35	1,000	0,000
C3	80	Anemometer	NRG #40C Anemom.	20177	270°	03/06/2009	07/09/2012	0,772	0,24	0,772	0,24	1,000	0,000
C1	100	Anemometer	NRG #40C Anemom.	62864	270°	07/09/2012	17/12/2012	0,765	0,35	0,761	0,37	0,9948	0,0218
C3	80	Anemometer	NRG #40C Anemom.	20177	270°	07/09/2012	17/12/2012	0,765	0,35	0,772	0,24	1,0092	-0,1132
A1	98	Wind Vane	NRG 200P	-	270°	11/06/2018	today	0,351	0	0,351	0	1,0000	0,0000
A2	58	Wind Vane	NRG 200P	-	270°	11/06/2018	today	0,351	0	0,351	0	1,0000	0,0000
A3	10	Temp Sensor	NRG 110S	-	-	30/12/2013	today	0,351	0	0,351	0	1,0000	0,0000

The completeness of the data has been checked and some data gaps has been filled by following steps:

1. substitution from CH3 to CH1 of missing and invalid wind data pair (wind speed and direction)
2. synthesizing of wind data series from 40 to 60 m using power law apllied to a detailed shear table for 12 sectors and seasonal periods
3. step substitution from synthesized channel to CH1 of missing and invalid wind data pair (wind speed and direction)

Meteo data report TP_2839

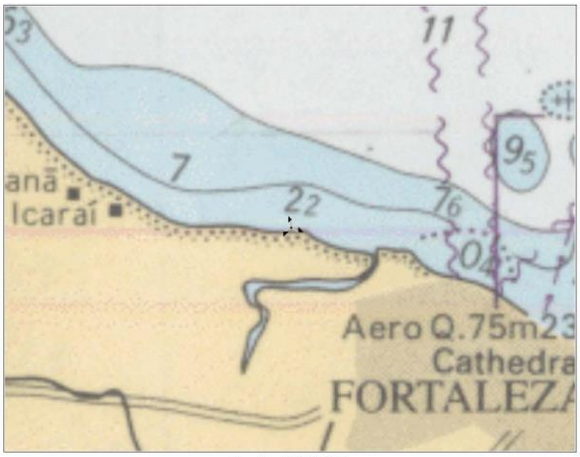
Meteo data report - Main results

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Mast position: UTM WGS84 S Zone: 24 East: 543.279 North: 9.592.142

Measurement heights and wind speeds (in this report)
Disabled data not included in overview table below

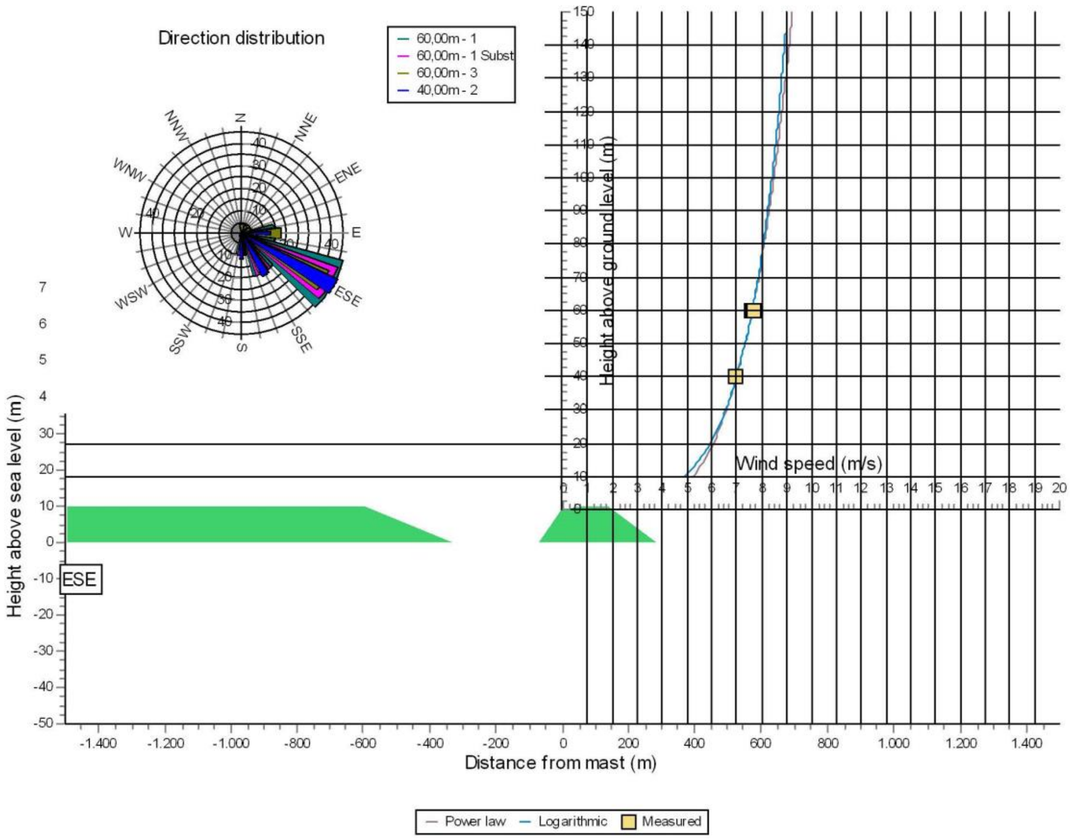
ID	Height [m]	Data recovery [%]	Records	U_max [m/s]	U_mean *) [m/s]
60,00m - 1	60,00	87,4	161599	18,5	7,6
60,00m - 1 Subst#)	60,00	94,1	175204	18,5	7,5
60,00m - 3	60,00	91,6	124684	16,4	7,7
40,00m - 2	40,00	72,7	133260	18,0	6,9



Scale: 200.000

**) U_mean is simple arithmetic average*
#) Chosen as fixed height in profile graph

Mean wind profile for all concurrent data and terrain profile for the most frequent sector of height: 60,00m - 1: ESE (left side)

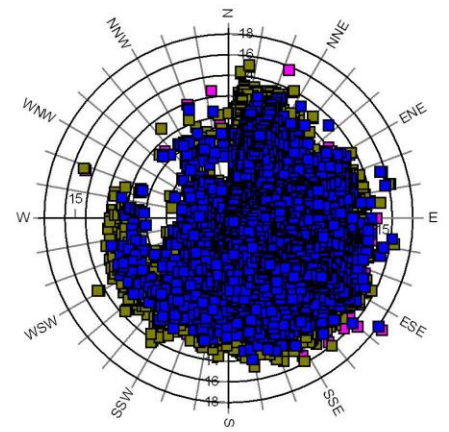


Profile characteristics for best curve fit through all data (Note: Values are only fully valid in flat terrain)

Shear exponent	0,2094	(Power law profile)
Roughness length	0,4118 m class 3,02	(Equivalent roughness for logarithmic profile)

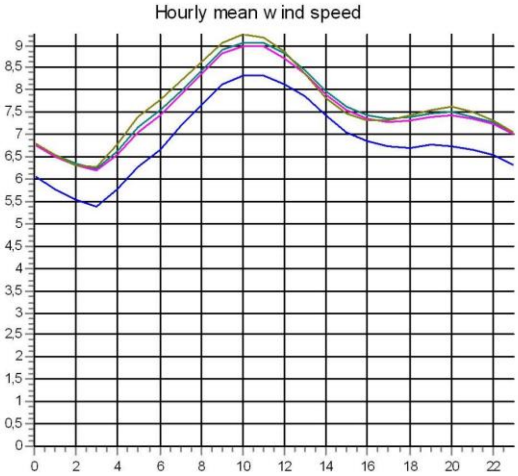
Meteo data report - Main results

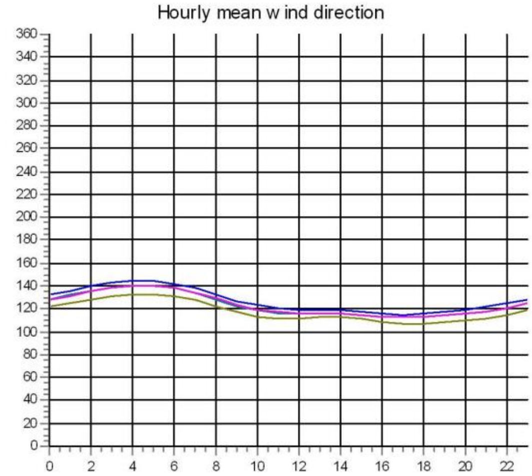
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

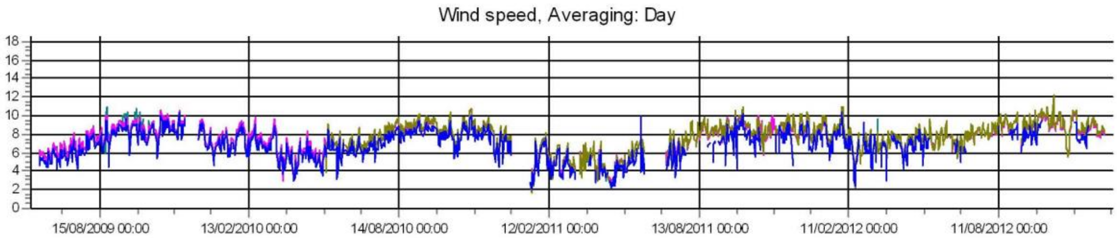


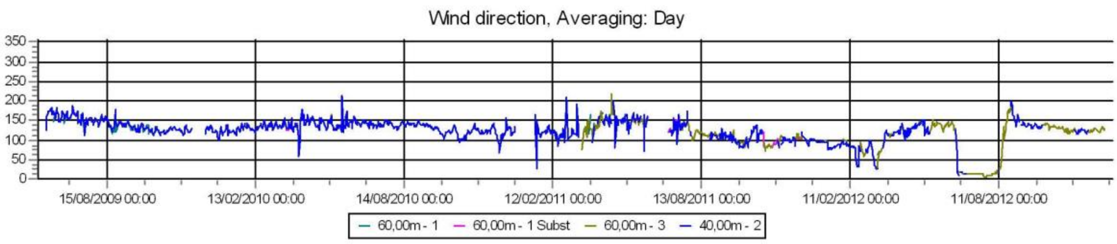
Statistics

	Signal	Unit	Count	Of period [%]	Mean	Weibull mean	Weibull A	Weibull k
60,00m - 1	Mean wind speed, all	m/s	161599	100,0	7,60	7,65	8,46	3,83
60,00m - 1	Wind direction, all	Degrees	161599	100,0	122,99			
60,00m - 1	Turbulence intensity, all		161599	100,0	0,16			
60,00m - 1	Turbulence intensity, enabled		151098	93,5	0,08			
60,00m - 1 Subst	Mean wind speed, all	m/s	175204	100,0	7,53	7,58	8,40	3,72
60,00m - 1 Subst	Wind direction, all	Degrees	175204	100,0	123,12			
60,00m - 1 Subst	Turbulence intensity, all		175204	100,0	0,16			
60,00m - 1 Subst	Turbulence intensity, enabled		162547	92,8	0,08			
60,00m - 3	Mean wind speed, all	m/s	124684	100,0	7,66	7,76	8,58	3,83
60,00m - 3	Wind direction, all	Degrees	124686	100,0	117,51			
60,00m - 3	Turbulence intensity, all		124684	100,0	0,11			
60,00m - 3	Turbulence intensity, enabled		114890	92,1	0,10			
40,00m - 2	Mean wind speed, all	m/s	133260	100,0	6,86	6,91	7,70	3,32
40,00m - 2	Wind direction, all	Degrees	133260	100,0	126,94			
40,00m - 2	Turbulence intensity, all		133260	100,0	0,12			
40,00m - 2	Turbulence intensity, enabled		117543	88,2	0,11			









Meteo data report - Import filters, files and heights

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Import filter: I1

Files/Folders

\\192.168.1.5\Med-Tp\ARCHIVIO ANEMOMETRI TEN PROJECT\ESTERO\BRASILE\CAUCAIA_IPARANA\Iparana Old Logger (2839).txt

Time zone for measurements: Same as in the project properties: (UTC-03:00) Brasilia
Line with header: 141
Header field separator: "Tab"
First line with data: 142
Data field separator: "Tab"

Column	Channel	Type	Sub type	Unit	Height	Name
1		Time stamp	Date&Time	d/m/y h:m:s		
2	1	Wind speed	Mean	m/s	60,00 m	CH1Avg
3	1	Wind speed	StdDev	m/s	60,00 m	CH1SD
4	1	Wind speed	Max	m/s	60,00 m	CH1Max
5	1	Wind speed	Min	m/s	60,00 m	CH1Min
6	2	Wind speed	Mean	m/s	40,00 m	CH2Avg
7	2	Wind speed	StdDev	m/s	40,00 m	CH2SD
8	2	Wind speed	Max	m/s	40,00 m	CH2Max
9	2	Wind speed	Min	m/s	40,00 m	CH2Min
10	3	Wind speed	Mean	m/s	60,00 m	CH3Avg
11	3	Wind speed	StdDev	m/s	60,00 m	CH3SD
12	3	Wind speed	Max	m/s	60,00 m	CH3Max
13	3	Wind speed	Min	m/s	60,00 m	CH3Min
26	7	Wind direction	Mean	Degrees	60,00 m	CH7Avg
27	7	Wind direction	StdDev	Degrees	60,00 m	CH7SD
28	7	Wind direction	Max	Degrees	60,00 m	CH7Max
29	7	Wind direction	Min	Degrees	60,00 m	CH7Min
30	8	Wind direction	Mean	Degrees	40,00 m	CH8Avg
31	8	Wind direction	StdDev	Degrees	40,00 m	CH8SD
32	8	Wind direction	Max	Degrees	40,00 m	CH8Max
33	8	Wind direction	Min	Degrees	40,00 m	CH8Min

Import filter: I2

Files/Folders

\\192.168.1.5\Med-Tp\ARCHIVIO ANEMOMETRI TEN PROJECT\ESTERO\BRASILE\CAUCAIA_IPARANA\Iparana New Logger (5364).csv

Time zone for measurements: Same as in the project properties: (UTC-03:00) Brasilia
Line with header: 171
Header field separator: "; (Semicolon)"
First line with data: 172
Data field separator: "; (Semicolon)"

Column	Channel	Type	Sub type	Unit	Height	Name	Scale	Offset
1		Time stamp	Date&Time	dd/mm/yyyy hh:mm			1,0000	0,0000
2	1	Wind speed	Mean	m/s	60,00 m	CH1Avg	0,9948	0,0218
3	1	Wind speed	StdDev	m/s	60,00 m	CH1SD	1,0000	0,0000
4	1	Wind speed	Max	m/s	60,00 m	CH1Max	0,9948	0,0218
5	1	Wind speed	Min	m/s	60,00 m	CH1Min	0,9948	0,0218
6	2	Wind speed	Mean	m/s	40,00 m	CH2Avg	1,0000	0,0000
7	2	Wind speed	StdDev	m/s	40,00 m	CH2SD	1,0000	0,0000
8	2	Wind speed	Max	m/s	40,00 m	CH2Max	1,0000	0,0000
9	2	Wind speed	Min	m/s	40,00 m	CH2Min	1,0000	0,0000
10	3	Wind speed	Mean	m/s	60,00 m	CH3Avg	1,0091	-0,1132
11	3	Wind speed	StdDev	m/s	60,00 m	CH3SD	1,0000	0,0000
12	3	Wind speed	Max	m/s	60,00 m	CH3Max	1,0091	-0,1132
13	3	Wind speed	Min	m/s	60,00 m	CH3Min	1,0091	-0,1132
26	7	Wind direction	Mean	Degrees	60,00 m	CH7Avg	1,0000	0,0000
27	7	Wind direction	StdDev	Degrees	60,00 m	CH7SD	1,0000	0,0000
28	7	Wind direction	Max	Degrees	60,00 m	CH7Max	1,0000	0,0000
29	7	Wind direction	Min	Degrees	60,00 m	CH7Min	1,0000	0,0000
30	8	Wind direction	Mean	Degrees	40,00 m	CH8Avg	1,0000	0,0000
31	8	Wind direction	StdDev	Degrees	40,00 m	CH8SD	1,0000	0,0000
32	8	Wind direction	Max	Degrees	40,00 m	CH8Max	1,0000	0,0000
33	8	Wind direction	Min	Degrees	40,00 m	CH8Min	1,0000	0,0000

Meteo data report - Missing data wind speed and direction - calendar view

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1**

- some records missing, disabled, erroneous, or out of range current day
- all records missing, disabled, erroneous, or out of range current day

Month/Year	%	Total	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jun/2009	2,8	**74**												0	0	0	0	0	0	0	0	0	0	0	23	0	27	24	0	0	0	0	
Jul/2009	4,5	**203**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	112	61	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2009	16,7	**744**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121	85	109	99	94	111	105	20	0	0	0
Sep/2009	19,2	**829**	0	0	0	0	0	0	0	0	0	0	30	62	83	74	52	47	69	100	47	46	0	0	0	0	0	14	53	41	68	43	
Oct/2009	33,8	**1510**	19	94	95	96	92	103	144	90	144	144	144	144	85	79	10	12	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
Nov/2009	8,5	**366**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	144	144		
Dec/2009	43,7	**1949**	144	144	144	144	144	144	142	144	144	144	144	144	144	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2010	0,6	**28**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2010	8,1	**360**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	144	144		
Jan/2011	66,3	**2958**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	78	0	0	0	0	0	0	0	0	0	0
Feb/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2011	22,2	**991**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	144	144	144	144	53	0	0	0	0	0	0	98	75	118	
Apr/2011	61,9	**2676**	144	86	75	121	144	144	144	144	91	144	144	144	15	113	144	144	144	144	144	144	83	76	0	0	0	0	0	0	0	0	
May/2011	5,7	**255**	0	0	0	0	0	0	0	0	33	10	144	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2011	72,2	**3120**	0	0	0	0	0	0	0	96	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144		
Jul/2011	11,3	**504**	144	144	144	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2012	39,6	**1653**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	144	144	144	144	144	144	144	144	144	144	144			
Mar/2012	49,6	**2214**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2012	3,1	**138**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	42
Aug/2012	21,2	**947**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	144	144	144	144	144	144		
Sep/2012	22,1	**956**	144	144	144	144	144	144	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0														
Total	**12,2**	**22475**																															

Meteo data report - Missing data wind speed and direction - calendar view

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst**

- some records missing, disabled, erroneous, or out of range current day
- all records missing, disabled, erroneous, or out of range current day

Month/Year	%	Total	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jun/2009	0,0	**0**			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2009	8,5	**366**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	144	144		
Dec/2009	43,7	**1949**	144	144	144	144	144	144	142	144	144	144	144	144	144	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2010	8,1	**360**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	144	144		
Jan/2011	66,3	**2958**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	78	0	0	0	0	0	0	0	0	0	0
Feb/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2011	15,7	**700**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	144	144	144	144	53	0	0	0	0	0	0	0	0	0	0
Apr/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2011	72,2	**3120**	0	0	0	0	0	0	0	96	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144		
Jul/2011	11,3	**504**	144	144	144	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Mar/2012	0,1	**6**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2012	3,1	**138**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	42
Aug/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2012	10,5	**452**	0	0	0	72	144	144	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0														
Total	**5,7**	**10553**																															

Meteo data report - Missing data wind speed and direction - calendar view

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 3**

- some records missing, disabled, erroneous, or out of range current day
- all records missing, disabled, erroneous, or out of range current day

Month/Year	%	Total	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
May/2010	0,0	**0**																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2010	8,1	**360**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	144	144	
Jan/2011	66,3	**2958**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	78	0	0	0	0	0	0	0	0	0	0
Feb/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2011	15,7	**702**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	144	144	144	144	55	0	0	0	0	0	0	0	0	0	0
Apr/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2011	72,2	**3120**	0	0	0	0	0	0	0	96	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144		
Jul/2011	31,7	**1414**	144	144	144	144	34	0	0	0	0	0	0	0	0	74	113	144	144	144	144	41	0	0	0	0	0	0	0	0	0	0	0
Aug/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2011	3,6	**156**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	100	22	18	0	0	0	0	0	0	0	
Oct/2011	18,1	**808**	0	0	43	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	96	132	144	131	54	0	0
Nov/2011	19,8	**855**	0	0	0	0	0	31	0	82	144	144	144	144	144	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2011	2,8	**125**	0	0	0	0	0	0	0	0	0	44	15	54	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Mar/2012	0,1	**6**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2012	3,1	**138**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	42
Aug/2012	0,7	**30**	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2012	10,5	**452**	0	0	0	72	144	144	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2012	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0														
Total	**8,2**	**11124**																															

Meteo data report - Missing data wind speed and direction - calendar view

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **40,00m - 2**

- some records missing, disabled, erroneous, or out of range current day
- all records missing, disabled, erroneous, or out of range current day

Month/Year	%	Total	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jun/2009	0,0	**0**			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2009	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2009	8,5	**366**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	144	144		
Dec/2009	43,7	**1949**	144	144	144	144	144	144	142	144	144	144	144	144	144	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2010	2,2	**100**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	83	0	0	0	0	0	0
Apr/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2010	1,4	**63**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	61
Jun/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Jul/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov/2010	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dec/2010	8,1	**360**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	144	144	
Jan/2011	66,3	**2958**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	78	0	0	0	0	0	0	0	0	0	0
Feb/2011	0,0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Mar/2011	48,1	**2145**	0	0	0	0	0	0	0	0	0	0	0	0	0	58	0	71	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
Apr/2011	43,4	**1877**	144	86	0	33	144	144	144	144	41	125	144	144	144	43	0	0	0	0	0	0	0	0	0	61	144	144	48	0	0	0	
May/2011	10,4	**465**	3	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	27	0	0	69	58	61	80	
Jun/2011	82,9	**3583**	144	144	98	0	0	0	77	96	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144		
Jul/2011	41,5	**1853**	144	144	144	144	33	0	0	0	0	94	102	0	0	74	99	0	0	0	0	94	99	0	0	0	114	0	143	144	144	78	59
Aug/2011	87,4	**3902**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	132	144	144	144	144	144	144	144	128	0	37	25	144	144	124	0
Sep/2011	38,6	**1667**	0	78	144	144	57	0	76	107	81	0	71	113	0	0	134	94	37	133	61	0	0	0	0	58	0	47	0	119	53	60	
Oct/2011	32,8	**1466**	67	52	0	0	67	0	0	70	48	46	0	0	0	0	119	0	0	0	0	0	0	0	86	120	96	132	144	131	144	144	
Nov/2011	57,8	**2499**	144	144	144	144	144	144	144	144	144	144	144	144	144	22	72	144	144	142	103	0	0	0	0	0	0	0	0	0	0	0	
Dec/2011	29,1	**1301**	0	0	0	0	115	144	144	144	144	144	144	144	82	0	0	0	0	0	0	0	0	0	0	0	42	0	54	0	0	0	0
Jan/2012	9,0	**402**	0	0	0	0	0	0	0	0	0	123	144	90	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb/2012	31,5	**1314**	0	0	112	144	77	117	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	144	144	144	144	144	47		
Mar/2012	26,6	**1189**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	144	144	144	144	144	103	0	0	0	0	0	0	44	144	144	
Apr/2012	6,0	**260**	144	53	0	0	0	0	0	0	0	0	0	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
May/2012	45,9	**2050**	0	0	0	0	35	0	0	0	0	0	111	59	0	0	0	0	117	144	144	144	144	144	144	144	144	144	144	144	144	144	
Jun/2012	78,3	**3384**	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	39	0	0	64	106	144	144	97	15	144	144	39	0	
Jul/2012	92,9	**4149**	0	117	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
Aug/2012	73,3	**3272**	144	144	144	144	144	144	144	144	144	93	20	144	144	144	144	144	144	144	144	144	144	144	144	75	24	36	0	0	0	0	0
Sep/2012	10,5	**452**	0	0	0	72	144	144	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Oct/2012	90,5	**4042**	0	10	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
Nov/2012	41,6	**1639**	144	144	144	144	144	144	144	144	144	144	144	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total	**26,6**	**48707**																															

Meteo data report - Table of missing data

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1**

23/06/2009 16:00:00 - 23/06/2009 20:00:00 No data
25/06/2009 05:40:00 - 25/06/2009 10:20:00 No data
26/06/2009 03:30:00 - 26/06/2009 07:40:00 No data
17/07/2009 18:50:00 - 18/07/2009 03:30:00 No data
18/07/2009 08:40:00 - 19/07/2009 10:10:00 No data
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24/08/2009 05:20:00 - 24/08/2009 22:00:00 No data
25/08/2009 01:50:00 - 25/08/2009 14:20:00 No data
25/08/2009 20:30:00 - 26/08/2009 03:00:00 No data
26/08/2009 08:20:00 - 27/08/2009 17:30:00 No data
28/08/2009 05:20:00 - 28/08/2009 08:50:00 No data
11/09/2009 04:10:00 - 11/09/2009 07:20:00 No data
11/09/2009 20:30:00 - 11/09/2009 22:40:00 No data
12/09/2009 00:30:00 - 12/09/2009 08:00:00 No data
12/09/2009 20:50:00 - 13/09/2009 07:10:00 No data
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18/09/2009 15:40:00 - 19/09/2009 07:10:00 No data
19/09/2009 23:10:00 - 20/09/2009 07:40:00 No data
26/09/2009 21:30:00 - 27/09/2009 08:50:00 No data
28/09/2009 03:50:00 - 28/09/2009 07:20:00 No data
28/09/2009 20:20:00 - 29/09/2009 08:30:00 No data
29/09/2009 21:00:00 - 30/09/2009 07:10:00 No data
01/10/2009 20:40:00 - 02/10/2009 08:00:00 No data
02/10/2009 16:10:00 - 03/10/2009 07:40:00 No data
03/10/2009 15:40:00 - 04/10/2009 07:20:00 No data
04/10/2009 15:10:00 - 05/10/2009 06:50:00 No data
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14/10/2009 16:40:00 - 15/10/2009 01:10:00 No data
15/10/2009 23:20:00 - 16/10/2009 02:00:00 No data
20/10/2009 13:50:00 - 20/10/2009 16:30:00 No data
27/11/2009 10:50:00 - 07/12/2009 17:40:00 No data
07/12/2009 17:50:00 - 14/12/2009 13:10:00 No data
17/05/2010 07:40:00 - 17/05/2010 12:30:00 No data
28/12/2010 11:50:00 - 21/01/2011 13:00:00 No data
16/03/2011 12:00:00 - 21/03/2011 08:50:00 No data
28/03/2011 07:30:00 - 29/03/2011 12:30:00 No data
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02/04/2011 15:40:00 - 02/04/2011 19:40:00 No data
03/04/2011 11:20:00 - 04/04/2011 14:40:00 No data
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09/04/2011 15:30:00 - 13/04/2011 02:30:00 No data
14/04/2011 05:00:00 - 21/04/2011 13:50:00 No data
22/04/2011 02:00:00 - 22/04/2011 14:50:00 No data
09/05/2011 08:20:00 - 09/05/2011 14:00:00 No data
10/05/2011 22:10:00 - 12/05/2011 11:20:00 No data
08/06/2011 07:50:00 - 04/07/2011 12:00:00 No data
17/02/2012 12:20:00 - 16/03/2012 09:00:00 No data
30/07/2012 07:50:00 - 31/07/2012 07:00:00 No data
24/08/2012 10:00:00 - 07/09/2012 15:20:00 No data

Height: **60,00m - 1 Subst**

27/11/2009 10:50:00 - 07/12/2009 17:40:00 No data
07/12/2009 17:50:00 - 14/12/2009 13:10:00 No data
28/12/2010 11:50:00 - 21/01/2011 13:00:00 No data
16/03/2011 12:00:00 - 21/03/2011 08:50:00 No data
08/06/2011 07:50:00 - 04/07/2011 12:00:00 No data
16/03/2012 07:50:00 - 16/03/2012 09:00:00 No data
30/07/2012 07:50:00 - 31/07/2012 07:00:00 No data
04/09/2012 11:50:00 - 07/09/2012 15:20:00 No data

Meteo data report - Table of missing data

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 3**

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16/03/2011 12:00:00 - 21/03/2011 08:50:00 No data
08/06/2011 07:50:00 - 05/07/2011 05:40:00 No data
14/07/2011 11:30:00 - 15/07/2011 16:30:00 No data
15/07/2011 21:30:00 - 20/07/2011 06:50:00 No data
17/09/2011 16:30:00 - 17/09/2011 19:20:00 No data
21/09/2011 07:10:00 - 22/09/2011 03:40:00 No data
23/09/2011 06:20:00 - 23/09/2011 09:30:00 No data
03/10/2011 16:40:00 - 04/10/2011 14:40:00 No data
24/10/2011 03:50:00 - 25/10/2011 16:00:00 No data
26/10/2011 01:50:00 - 28/10/2011 17:20:00 No data
28/10/2011 19:20:00 - 29/10/2011 09:00:00 No data
06/11/2011 14:50:00 - 06/11/2011 20:10:00 No data
08/11/2011 10:10:00 - 14/11/2011 03:40:00 No data
10/12/2011 16:30:00 - 11/12/2011 02:30:00 No data
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12/12/2011 15:10:00 - 12/12/2011 16:50:00 No data
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10/08/2012 04:50:00 - 10/08/2012 06:00:00 No data
10/08/2012 06:00:00 - 10/08/2012 10:10:00 No data
04/09/2012 11:50:00 - 07/09/2012 15:20:00 No data
21/03/2011 08:50:00 - 21/03/2011 09:00:00 Missing Turbulence intensity

Height: **40,00m - 2**

27/11/2009 10:50:00 - 07/12/2009 17:40:00 No data
07/12/2009 17:50:00 - 14/12/2009 13:10:00 No data
24/03/2010 21:00:00 - 25/03/2010 13:50:00 No data
30/05/2010 23:30:00 - 31/05/2010 10:10:00 No data
28/12/2010 11:50:00 - 21/01/2011 13:00:00 No data
14/03/2011 10:00:00 - 14/03/2011 19:50:00 No data
16/03/2011 12:00:00 - 02/04/2011 10:30:00 No data
02/04/2011 15:40:00 - 02/04/2011 19:40:00 No data
04/04/2011 18:20:00 - 09/04/2011 06:50:00 No data
10/04/2011 03:00:00 - 14/04/2011 07:10:00 No data
24/04/2011 13:40:00 - 27/04/2011 08:00:00 No data
01/05/2011 23:20:00 - 02/05/2011 20:20:00 No data
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08/06/2011 07:50:00 - 05/07/2011 05:30:00 No data
10/07/2011 08:10:00 - 11/07/2011 17:00:00 No data
14/07/2011 11:30:00 - 15/07/2011 16:30:00 No data
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25/07/2011 02:50:00 - 25/07/2011 22:00:00 No data
27/07/2011 00:00:00 - 30/07/2011 13:00:00 No data
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11/09/2011 12:00:00 - 12/09/2011 18:50:00 No data
15/09/2011 01:30:00 - 16/09/2011 15:40:00 No data
17/09/2011 02:40:00 - 17/09/2011 09:00:00 No data
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24/09/2011 04:50:00 - 24/09/2011 14:40:00 No data
26/09/2011 02:00:00 - 26/09/2011 10:00:00 No data
28/09/2011 04:00:00 - 29/09/2011 08:50:00 No data

To be continued on next page...

Meteo data report - Table of missing data

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

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01/10/2011 02:30:00 - 01/10/2011 13:50:00 No data
02/10/2011 03:20:00 - 02/10/2011 12:10:00 No data
05/10/2011 02:00:00 - 05/10/2011 13:20:00 No data
08/10/2011 01:20:00 - 08/10/2011 13:10:00 No data
09/10/2011 02:30:00 - 09/10/2011 10:40:00 No data
10/10/2011 03:30:00 - 10/10/2011 11:20:00 No data
15/10/2011 01:20:00 - 15/10/2011 21:20:00 No data
23/10/2011 04:20:00 - 23/10/2011 18:50:00 No data
24/10/2011 03:50:00 - 25/10/2011 16:00:00 No data
26/10/2011 01:50:00 - 28/10/2011 17:20:00 No data
28/10/2011 19:20:00 - 14/11/2011 03:40:00 No data
15/11/2011 11:50:00 - 18/11/2011 01:20:00 No data
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28/03/2012 16:30:00 - 02/04/2012 08:50:00 No data
12/04/2012 07:50:00 - 12/04/2012 18:30:00 No data
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22/06/2012 06:10:00 - 25/06/2012 16:10:00 No data
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02/07/2012 04:20:00 - 10/08/2012 15:30:00 No data
11/08/2012 20:30:00 - 24/08/2012 12:30:00 No data
25/08/2012 19:50:00 - 26/08/2012 06:00:00 No data
04/09/2012 11:50:00 - 07/09/2012 15:20:00 No data
02/10/2012 22:10:00 - 12/11/2012 09:10:00 No data

Meteo data report - Monthly wind speeds

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Monthly wind speeds

60,00m - 1

Month	2009	2010	2011	2012	Mean	Mean of month
January		7,20	4,35	8,27	7,25	6,61
February		7,91	5,73	7,97	7,08	7,20
March		6,52	5,07	6,95	6,14	6,18
April		5,91	3,55	7,13	6,04	5,53
May		6,26	5,27	7,65	6,42	6,39
June	5,98	6,72	6,17	7,34	6,73	6,55
July	6,72	7,35	6,53	8,08	7,19	7,17
August	7,75	8,69	8,15	8,92	8,37	8,38
September	8,98	9,12	8,53	8,86	8,87	8,87
October	8,71	7,95	8,51	9,46	8,65	8,66
November	9,11	8,79	8,65	8,36	8,71	8,73
December	7,66	7,27	8,54	8,50	7,99	7,99
mean, all data	7,88	7,47	7,03	8,14	7,45	
mean of months	7,84	7,47	6,59	8,12		7,36

Monthly wind speeds

60,00m - 1 Subst

Month	2009	2010	2011	2012	Mean	Mean of month
January		7,20	4,35	8,27	7,25	6,61
February		7,91	5,73	7,00	6,88	6,88
March		6,52	5,12	6,85	6,22	6,16
April		5,91	4,49	7,13	5,84	5,84
May		6,29	5,29	7,65	6,41	6,41
June	5,88	6,72	6,17	7,34	6,63	6,53
July	6,67	7,35	6,53	8,08	7,17	7,16
August	7,73	8,69	8,15	8,97	8,38	8,38
September	8,89	9,12	8,53	8,96	8,87	8,88
October	8,49	7,95	8,51	9,46	8,60	8,60
November	9,11	8,79	8,65	8,36	8,71	8,73
December	7,66	7,27	8,54	8,50	7,99	7,99
mean, all data	7,78	7,47	6,89	8,03	7,41	
mean of months	7,78	7,48	6,67	8,05		7,35

Monthly wind speeds

60,00m - 3

Month	2010	2011	2012	Mean	Mean of month
January		4,22	8,38	7,33	6,30
February		5,65	7,06	6,37	6,36
March		5,01	6,86	6,01	5,93
April		4,43	7,14	5,79	5,79
May	6,93	5,21	7,68	6,54	6,61
June	6,69	6,13	7,39	6,94	6,74
July	7,40	6,73	8,16	7,50	7,43
August	8,82	8,30	9,06	8,73	8,73
September	9,24	8,70	9,11	9,01	9,02
October	8,03	8,52	9,65	8,75	8,73
November	8,89	8,73	8,53	8,72	8,72
December	7,40	8,74	8,73	8,24	8,29
mean, all data	8,00	6,86	8,12	7,49	
mean of months	7,92	6,70	8,15		7,39

Meteo data report - Monthly wind speeds

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Monthly wind speeds

40,00m - 2

Month	2009	2010	2011	2012	Mean	Mean of month
January		6,83	4,08	7,61	6,73	6,17
February		7,41	5,33	6,56	6,42	6,43
March		6,17	4,53	6,26	5,83	5,65
April		5,45	3,89	6,70	5,57	5,35
May		5,79	4,58	7,16	5,64	5,84
June	5,32	6,15	5,13	6,39	5,78	5,75
July	6,04	6,71	5,52	6,54	6,19	6,20
August	7,22	8,04	6,71	8,26	7,65	7,56
September	8,45	8,49	7,70	8,03	8,22	8,17
October	8,02	7,55	7,85	9,24	7,83	8,17
November	8,73	8,30	7,96	7,63	8,26	8,16
December	7,33	6,86	7,73		7,27	7,31
mean, all data	7,30	6,98	5,93	7,20	6,78	
mean of months	7,30	6,98	5,92	7,31		6,73

Meteo data report - Frequency distribution (TAB file data)

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Frequency distribution (TAB file data)

60,00m - 1

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			7,60	8,20	7,32	7,61	7,58	8,30	6,96	5,90	4,64	4,43	3,67	3,18	4,57
0		0,49	163	3	9	24	10	28	17	24	13	12	15	6	2
1	0,50	1,49	560	7	25	40	68	109	112	88	46	24	23	9	9
2	1,50	2,49	1560	19	35	51	119	326	425	350	147	44	19	12	13
3	2,50	3,49	4329	26	120	161	342	669	1345	1268	297	58	18	16	9
4	3,50	4,49	8942	67	230	255	1039	1484	2783	2525	472	51	9	9	18
5	4,50	5,49	12993	199	289	356	1956	3158	3834	2732	422	31	4	5	7
6	5,50	6,49	18166	467	422	324	3256	6278	4814	2411	173	13	3	2	3
7	6,50	7,49	25074	871	631	488	4001	11420	5382	2154	113	8	0	0	6
8	7,50	8,49	28737	988	731	620	4303	15084	5179	1732	88	4	0	0	8
9	8,50	9,49	27425	896	495	671	4185	15954	4081	1072	57	4	0	3	7
10	9,50	10,49	19360	683	316	625	2750	11865	2528	560	22	6	3	0	2
11	10,50	11,49	9891	433	181	319	1166	6364	1154	237	13	9	13	1	1
12	11,50	12,49	3374	140	78	108	299	2166	496	49	13	21	3	0	1
13	12,50	13,49	827	16	13	11	36	562	164	24	0	1	0	0	0
14	13,50	14,49	171	1	1	1	8	115	43	0	1	1	0	0	0
15	14,50	15,49	20	1	0	0	3	12	3	0	0	0	0	1	0
16	15,50	16,49	5	0	0	1	2	1	1	0	0	0	0	0	0
17	16,50	17,49	1	0	0	0	0	1	0	0	0	0	0	0	0
18	17,50	18,49	0	0	0	0	0	0	0	0	0	0	0	0	0
19	18,50	19,49	1	0	0	0	0	1	0	0	0	0	0	0	0
20	19,50	20,49	0	0	0	0	0	0	0	0	0	0	0	0	0
21	20,50	21,49	0	0	0	0	0	0	0	0	0	0	0	0	0
22	21,50	22,49	0	0	0	0	0	0	0	0	0	0	0	0	0
23	22,50	23,49	0	0	0	0	0	0	0	0	0	0	0	0	0
24	23,50	24,49	0	0	0	0	0	0	0	0	0	0	0	0	0
25	24,50	25,49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25,50	26,49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26,50	27,49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27,50	28,49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28,50	29,49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29,50	30,49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30,50	31,49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31,50	32,49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32,50	33,49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33,50	34,49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34,50	35,49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35,50	36,49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36,50	37,49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37,50	38,49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38,50	39,49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39,50	40,49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40,50		0	0	0	0	0	0	0	0	0	0	0	0	0

Meteo data report - Frequency distribution (TAB file data)

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Frequency distribution (TAB file data)

60,00m - 1 Subst

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			7,53	8,20	6,85	7,18	7,54	8,29	6,95	5,89	4,79	5,45	4,70	3,10	4,62
0		0,49	245	5	38	27	29	32	22	37	19	13	15	6	2
1	0,50	1,49	710	8	63	53	78	125	143	106	57	31	26	11	9
2	1,50	2,49	1906	21	110	91	142	359	493	417	174	53	19	13	14
3	2,50	3,49	5112	26	202	256	395	733	1499	1526	372	59	18	16	10
4	3,50	4,49	10439	67	459	467	1102	1561	3091	2965	637	54	9	9	18
5	4,50	5,49	14683	199	527	633	2021	3327	4224	3185	520	31	4	5	7
6	5,50	6,49	19928	467	601	640	3350	6619	5261	2747	222	13	3	2	3
7	6,50	7,49	26928	871	814	834	4155	11919	5779	2397	143	10	0	0	6
8	7,50	8,49	30549	988	907	841	4403	15807	5551	1932	105	7	0	0	8
9	8,50	9,49	29028	902	620	787	4283	16732	4381	1208	83	15	5	3	9
10	9,50	10,49	20493	683	372	701	2783	12431	2779	664	47	17	14	0	2
11	10,50	11,49	10488	433	194	342	1172	6658	1295	305	36	32	19	1	1
12	11,50	12,49	3593	142	79	114	301	2257	543	85	27	40	4	0	1
13	12,50	13,49	884	17	15	14	38	583	181	30	3	3	0	0	0
14	13,50	14,49	186	1	1	1	9	119	49	3	2	1	0	0	0
15	14,50	15,49	23	1	0	0	4	12	4	1	0	0	0	1	0
16	15,50	16,49	7	0	1	1	3	1	1	0	0	0	0	0	0
17	16,50	17,49	1	0	0	0	0	1	0	0	0	0	0	0	0
18	17,50	18,49	0	0	0	0	0	0	0	0	0	0	0	0	0
19	18,50	19,49	1	0	0	0	0	1	0	0	0	0	0	0	0
20	19,50	20,49	0	0	0	0	0	0	0	0	0	0	0	0	0
21	20,50	21,49	0	0	0	0	0	0	0	0	0	0	0	0	0
22	21,50	22,49	0	0	0	0	0	0	0	0	0	0	0	0	0
23	22,50	23,49	0	0	0	0	0	0	0	0	0	0	0	0	0
24	23,50	24,49	0	0	0	0	0	0	0	0	0	0	0	0	0
25	24,50	25,49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25,50	26,49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26,50	27,49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27,50	28,49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28,50	29,49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29,50	30,49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30,50	31,49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31,50	32,49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32,50	33,49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33,50	34,49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34,50	35,49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35,50	36,49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36,50	37,49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37,50	38,49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38,50	39,49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39,50	40,49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40,50		0	0	0	0	0	0	0	0	0	0	0	0	0

Meteo data report - Mean turbulence

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Mean turbulence

60,00m - 1

Bin	Start	End	Mean	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			0,08	0,11	0,12	0,09	0,09	0,06	0,10	0,09	0,05	0,06	0,09	0,08	0,08
0		0,49													
1	0,50	1,49													
2	1,50	2,49													
3	2,50	3,49													
4	3,50	4,49	0,08	0,14	0,10	0,07	0,10	0,11	0,10	0,05	0,04	0,10	0,13	0,07	0,12
5	4,50	5,49	0,09	0,15	0,12	0,08	0,10	0,10	0,10	0,06	0,04	0,04	0,08	0,10	0,10
6	5,50	6,49	0,09	0,15	0,14	0,08	0,09	0,08	0,10	0,08	0,04	0,06	0,18	0,10	0,11
7	6,50	7,49	0,08	0,14	0,14	0,08	0,09	0,06	0,10	0,09	0,06	0,10			0,07
8	7,50	8,49	0,08	0,12	0,13	0,09	0,09	0,06	0,10	0,11	0,09	0,06			0,07
9	8,50	9,49	0,07	0,10	0,12	0,09	0,09	0,05	0,11	0,12	0,12	0,09		0,05	0,05
10	9,50	10,49	0,07	0,09	0,11	0,10	0,09	0,05	0,10	0,12	0,12	0,07	0,06		0,06
11	10,50	11,49	0,07	0,07	0,09	0,10	0,09	0,05	0,10	0,13	0,09	0,05	0,06	0,13	0,11
12	11,50	12,49	0,07	0,06	0,08	0,11	0,09	0,06	0,10	0,14	0,07	0,05	0,05		0,08
13	12,50	13,49	0,08	0,06	0,08	0,14	0,09	0,06	0,11	0,12		0,07			
14	13,50	14,49	0,07	0,06	0,06	0,06	0,05	0,06	0,11		0,06	0,05			
15	14,50	15,49	0,08	0,04			0,14	0,06	0,09					0,04	
16	15,50	16,49	0,15			0,22	0,08	0,19	0,16						
17	16,50	17,49	0,00					0,00							
18	17,50	18,49													
19	18,50	19,49	0,00					0,00							
20	19,50	20,49													
21	20,50	21,49													

Meteo data report - Mean turbulence

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Mean turbulence

60,00m - 1 Subst

Bin	Start	End	Mean	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			0,08	0,11	0,12	0,10	0,09	0,06	0,10	0,09	0,06	0,07	0,08	0,08	0,08
0		0,49	0,21					0,21							
1	0,50	1,49	0,11							0,11					
2	1,50	2,49	0,12					0,09		0,15					
3	2,50	3,49	0,09				0,07	0,11	0,10	0,13	0,08	0,05			
4	3,50	4,49	0,09	0,14	0,11	0,10	0,10	0,11	0,10	0,06	0,05	0,09	0,13	0,07	0,12
5	4,50	5,49	0,10	0,15	0,13	0,10	0,10	0,10	0,11	0,07	0,04	0,04	0,08	0,10	0,10
6	5,50	6,49	0,09	0,15	0,14	0,10	0,09	0,08	0,11	0,09	0,05	0,06	0,18	0,10	0,11
7	6,50	7,49	0,09	0,14	0,13	0,09	0,09	0,07	0,10	0,10	0,07	0,11			0,07
8	7,50	8,49	0,08	0,12	0,12	0,09	0,09	0,06	0,11	0,11	0,09	0,10			0,07
9	8,50	9,49	0,07	0,10	0,12	0,09	0,09	0,05	0,11	0,11	0,11	0,10	0,08	0,05	0,05
10	9,50	10,49	0,07	0,09	0,11	0,10	0,09	0,05	0,10	0,12	0,10	0,06	0,06		0,06
11	10,50	11,49	0,07	0,07	0,09	0,10	0,09	0,05	0,10	0,12	0,08	0,06	0,06	0,13	0,11
12	11,50	12,49	0,07	0,06	0,08	0,11	0,09	0,06	0,10	0,13	0,08	0,06	0,05		0,08
13	12,50	13,49	0,08	0,06	0,09	0,14	0,09	0,06	0,11	0,12	0,14	0,07			
14	13,50	14,49	0,07	0,06	0,06	0,06	0,06	0,06	0,11	0,07	0,09	0,05			
15	14,50	15,49	0,08	0,04			0,13	0,06	0,09	0,06				0,04	
16	15,50	16,49	0,13		0,04	0,22	0,10	0,19	0,16						
17	16,50	17,49	0,00					0,00							
18	17,50	18,49													
19	18,50	19,49	0,00					0,00							
20	19,50	20,49													
21	20,50	21,49													

Meteo data report - Mean turbulence

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Mean turbulence

40,00m - 2

Bin	Start	End	Mean	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			0,11	0,14	0,15	0,12	0,10	0,09	0,16	0,16	0,13	0,08	0,10	0,09	0,10
0		0,49													
1	0,50	1,49													
2	1,50	2,49													
3	2,50	3,49													
4	3,50	4,49	0,14	0,25	0,19	0,16	0,13	0,15	0,15	0,13	0,11	0,08	0,10	0,09	0,13
5	4,50	5,49	0,15	0,17	0,19	0,14	0,12	0,13	0,16	0,16	0,14	0,07	0,18	0,10	0,10
6	5,50	6,49	0,14	0,17	0,17	0,15	0,11	0,11	0,17	0,18	0,17	0,08	0,23	0,14	0,13
7	6,50	7,49	0,12	0,15	0,14	0,13	0,10	0,10	0,16	0,17	0,17	0,14			0,13
8	7,50	8,49	0,10	0,12	0,11	0,11	0,10	0,09	0,16	0,17	0,16	0,13	0,09		0,07
9	8,50	9,49	0,10	0,13	0,10	0,11	0,09	0,08	0,15	0,16	0,11	0,08	0,07	0,05	0,09
10	9,50	10,49	0,09	0,10	0,09	0,09	0,09	0,08	0,15	0,15	0,09	0,07	0,07		
11	10,50	11,49	0,08	0,10	0,08	0,09	0,08	0,07	0,14	0,14	0,11	0,08	0,08		0,12
12	11,50	12,49	0,08	0,05	0,06	0,08	0,08	0,07	0,14	0,13	0,13	0,08	0,08		
13	12,50	13,49	0,08		0,09	0,10	0,10	0,07	0,13	0,08					
14	13,50	14,49	0,09				0,07	0,09	0,11	0,07					
15	14,50	15,49	0,13			0,20	0,15	0,07	0,16						
16	15,50	16,49	0,09				0,08	0,11							
17	16,50	17,49													
18	17,50	18,49	0,08					0,08							
19	18,50	19,49													
20	19,50	20,49													
21	20,50	21,49													

Meteo data report - Standard deviation on turbulence

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Standard deviation on turbulence

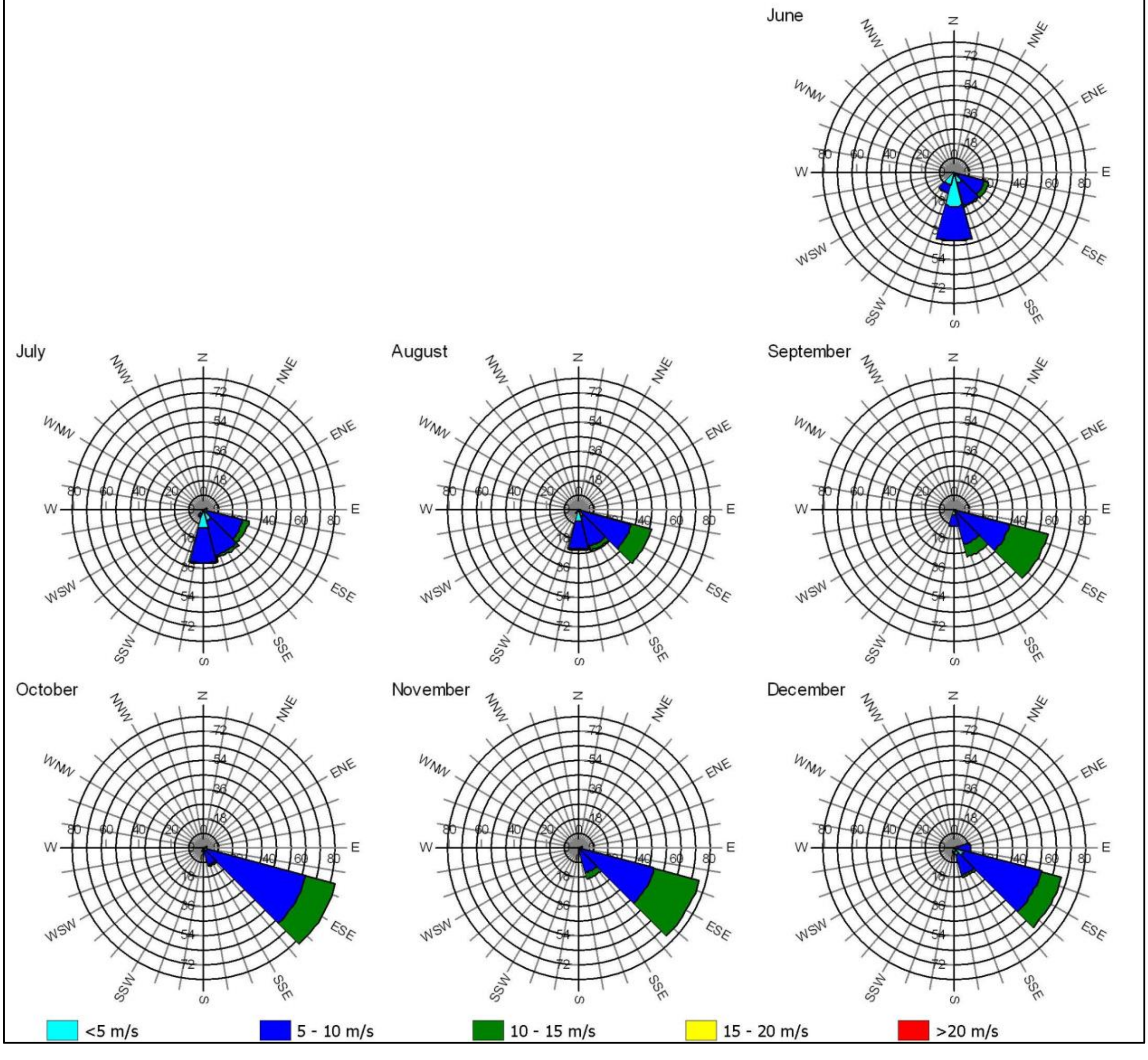
60,00m - 1 Subst

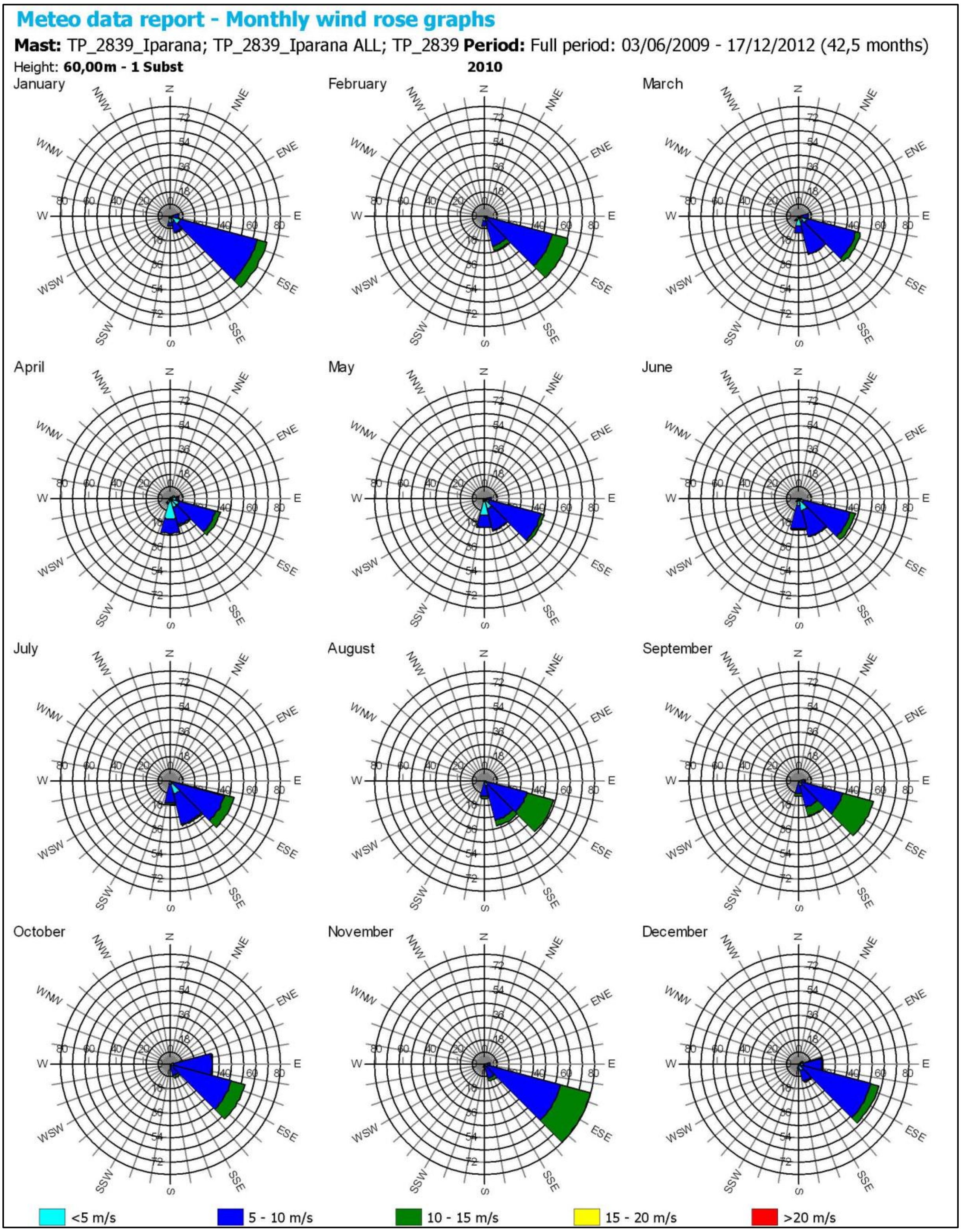
Bin	Start	End	Mean	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			0,0682	0,0539	0,0547	0,0644	0,0638	0,0580	0,0776	0,0792	0,0692	0,0561	0,0425	0,0338	0,0332
0		0,49													
1	0,50	1,49													
2	1,50	2,49	0,0429												
3	2,50	3,49	0,0459					0,0202	0,0648	0,0557	0,0304				
4	3,50	4,49	0,0747	0,0440	0,0455	0,0645	0,0699	0,0807	0,0776	0,0642	0,0601	0,1199	0,0503	0,0371	0,0306
5	4,50	5,49	0,0741	0,0507	0,0566	0,0595	0,0634	0,0746	0,0754	0,0759	0,0660	0,0452	0,0314	0,0196	0,0349
6	5,50	6,49	0,0731	0,0437	0,0508	0,0565	0,0610	0,0684	0,0793	0,0834	0,0720	0,0541	0,0686	0,0236	0,0204
7	6,50	7,49	0,0706	0,0487	0,0519	0,0543	0,0643	0,0610	0,0801	0,0832	0,0810	0,0427			0,0365
8	7,50	8,49	0,0657	0,0512	0,0553	0,0542	0,0592	0,0547	0,0777	0,0790	0,0697	0,0523			0,0137
9	8,50	9,49	0,0625	0,0516	0,0509	0,0654	0,0612	0,0494	0,0767	0,0736	0,0672	0,0321	0,0119	0,0062	0,0097
10	9,50	10,49	0,0628	0,0448	0,0527	0,0716	0,0664	0,0523	0,0756	0,0665	0,0563	0,0203	0,0086		0,0178
11	10,50	11,49	0,0632	0,0361	0,0554	0,0914	0,0772	0,0513	0,0756	0,0541	0,0396	0,0234	0,0136		
12	11,50	12,49	0,0664	0,0342	0,0613	0,0930	0,0831	0,0584	0,0754	0,0386	0,0310	0,0187	0,0097		
13	12,50	13,49	0,0661	0,0265	0,0476	0,1149	0,0758	0,0581	0,0720	0,0498	0,0587	0,0057			
14	13,50	14,49	0,0537				0,0822	0,0514	0,0440	0,0086	0,0532				
15	14,50	15,49	0,0516				0,0780	0,0392	0,0406						
16	15,50	16,49	0,0634				0,0241								
17	16,50	17,49													
18	17,50	18,49													
19	18,50	19,49													
20	19,50	20,49													
21	20,50	21,49													

Meteo data report - Monthly wind rose graphs

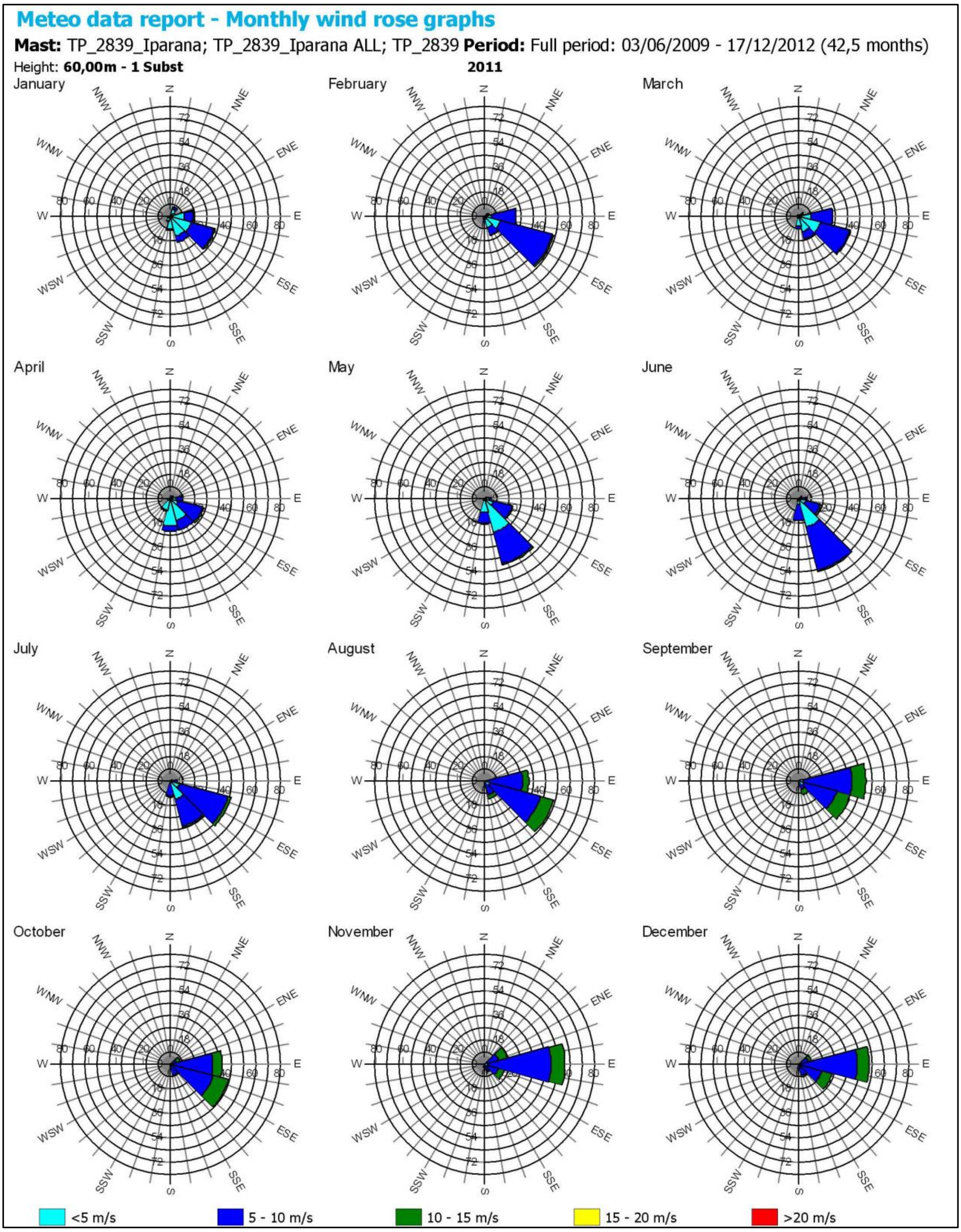
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst** **2009**





Meteo data report - Monthly wind rose graphs
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 Period: Full period: 03/06/2009 - 17/12/2012 (42,5 months)
Height: 60,00m - 1 Subst
2010
January
February
March
April
May
June
July
August
September
October
November
December
N
NNE
ENE
E
ESE
SSE
S
SSW
WSW
W
WNW
NNW
<5 m/s
5 - 10 m/s
10 - 15 m/s
15 - 20 m/s
>20 m/s

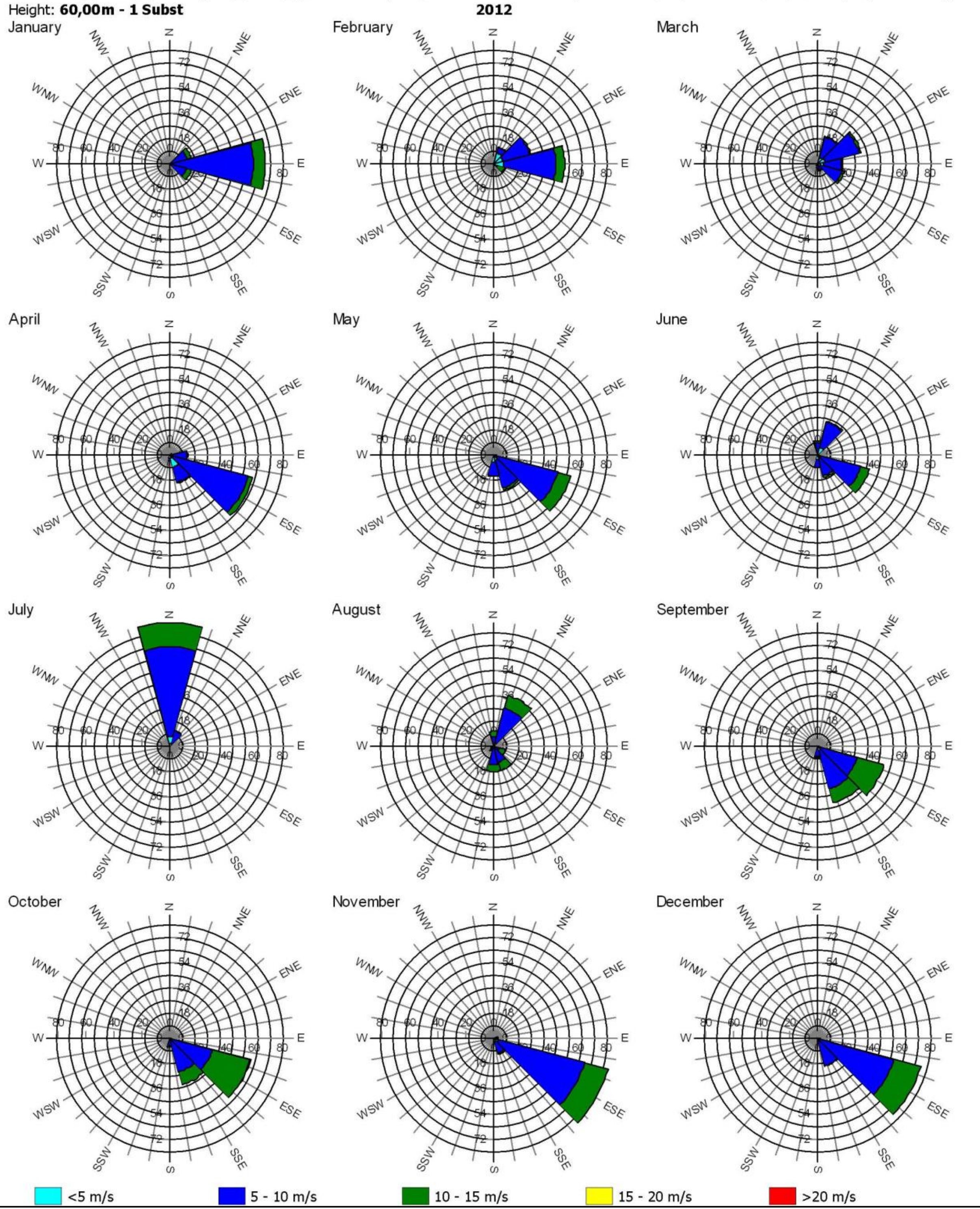


Meteo data report - Monthly wind rose graphs
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 Period: Full period: 03/06/2009 - 17/12/2012 (42,5 months)
Height: 60,00m - 1 Subst
2011
January
February
March
April
May
June
July
August
September
October
November
December
N
NNE
ENE
E
ESE
SSE
S
SSW
WSW
W
WNW
NNW
<5 m/s
5 - 10 m/s
10 - 15 m/s
15 - 20 m/s
>20 m/s

Meteo data report - Monthly wind rose graphs

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst** **2012**

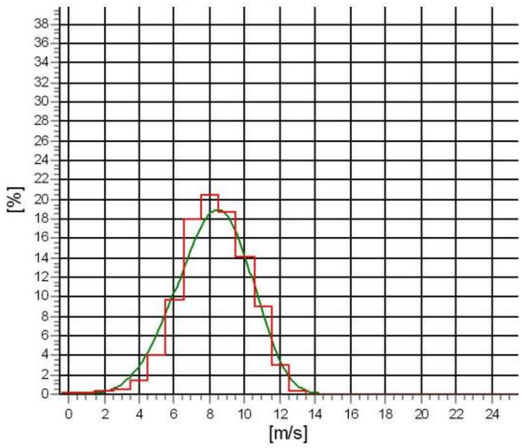


Meteo data report - Sector wise histogram/weibull graphs

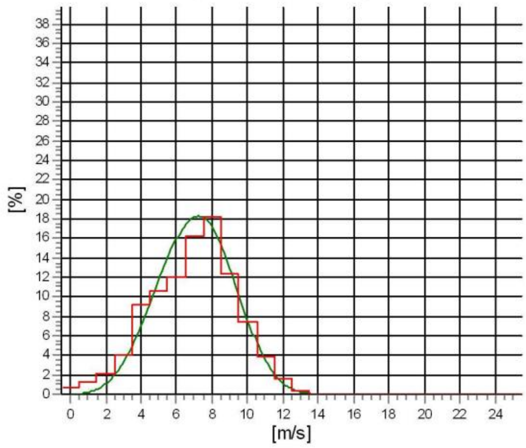
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst**

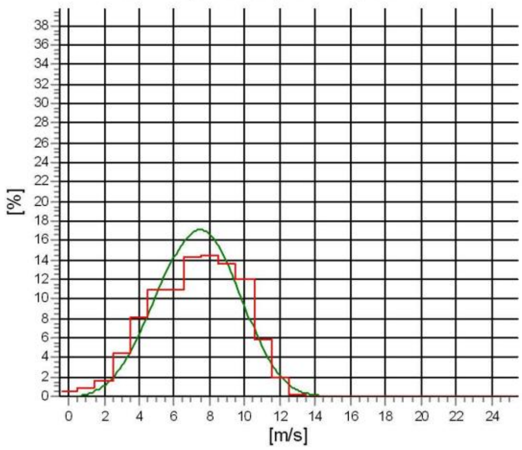
N A: 9,0 m/s k: 4,49 Vm: 8,2 m/s



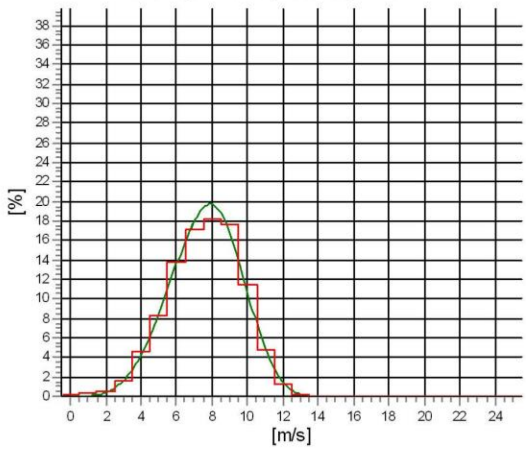
NNE A: 7,8 m/s k: 3,74 Vm: 7,1 m/s



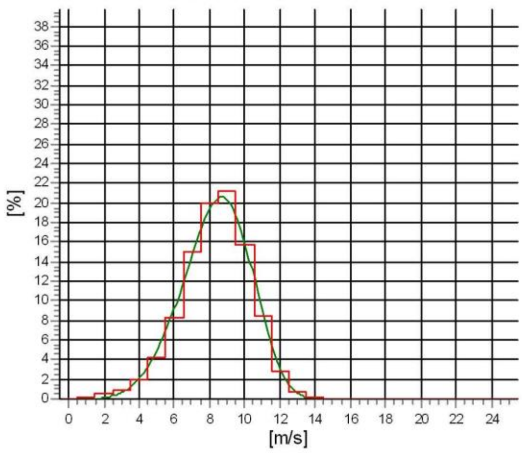
ENE A: 8,1 m/s k: 3,62 Vm: 7,3 m/s



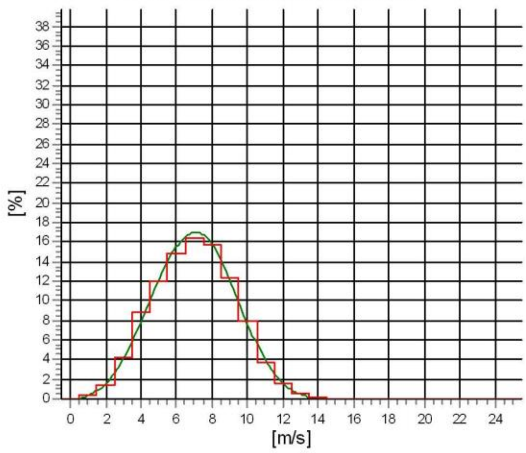
E A: 8,4 m/s k: 4,36 Vm: 7,6 m/s



ESE A: 9,1 m/s k: 4,98 Vm: 8,3 m/s



SSE A: 7,8 m/s k: 3,43 Vm: 7,0 m/s

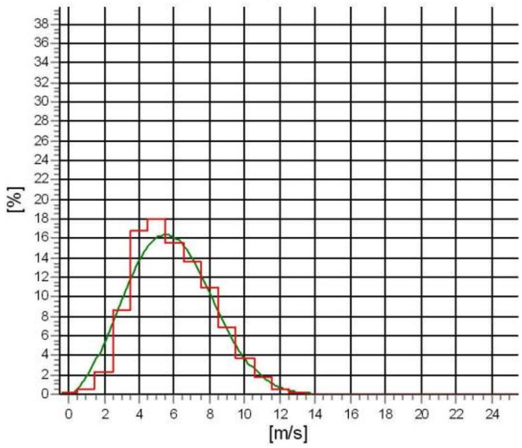


Meteo data report - Sector wise histogram/weibull graphs

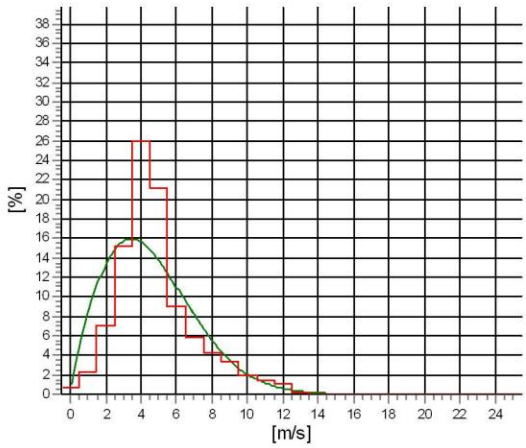
Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst**

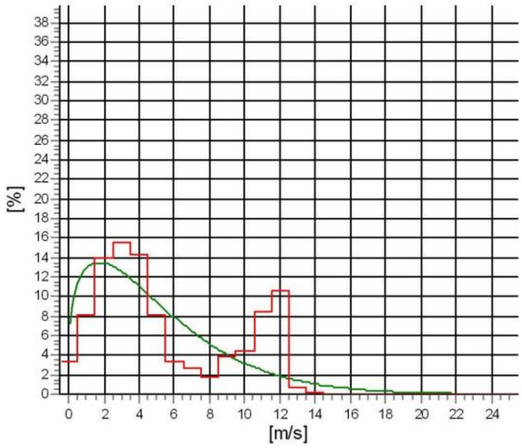
S A: 6,5 m/s k: 2,69 Vm: 5,8 m/s



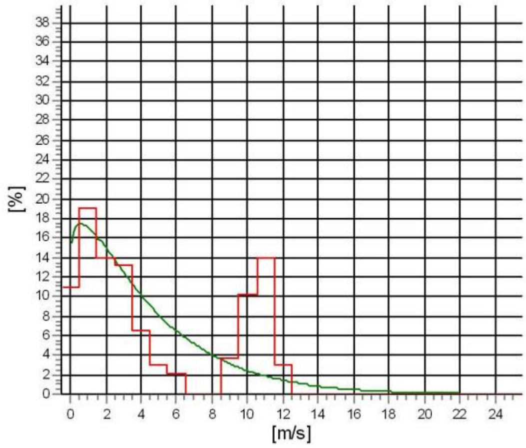
SSW A: 5,2 m/s k: 1,88 Vm: 4,6 m/s



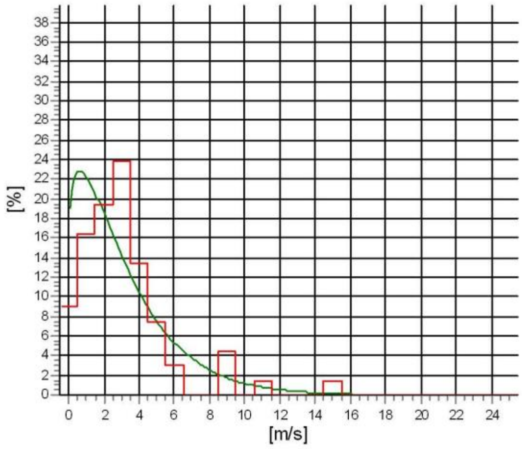
WSW A: 5,5 m/s k: 1,29 Vm: 5,0 m/s



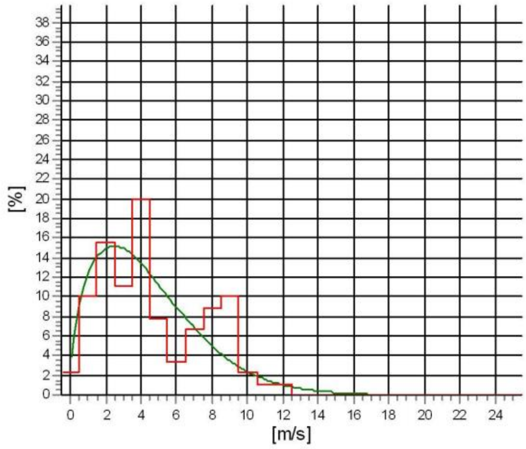
W A: 4,5 m/s k: 1,12 Vm: 4,4 m/s



WNW A: 3,4 m/s k: 1,17 Vm: 3,2 m/s



NNW A: 4,9 m/s k: 1,53 Vm: 4,4 m/s



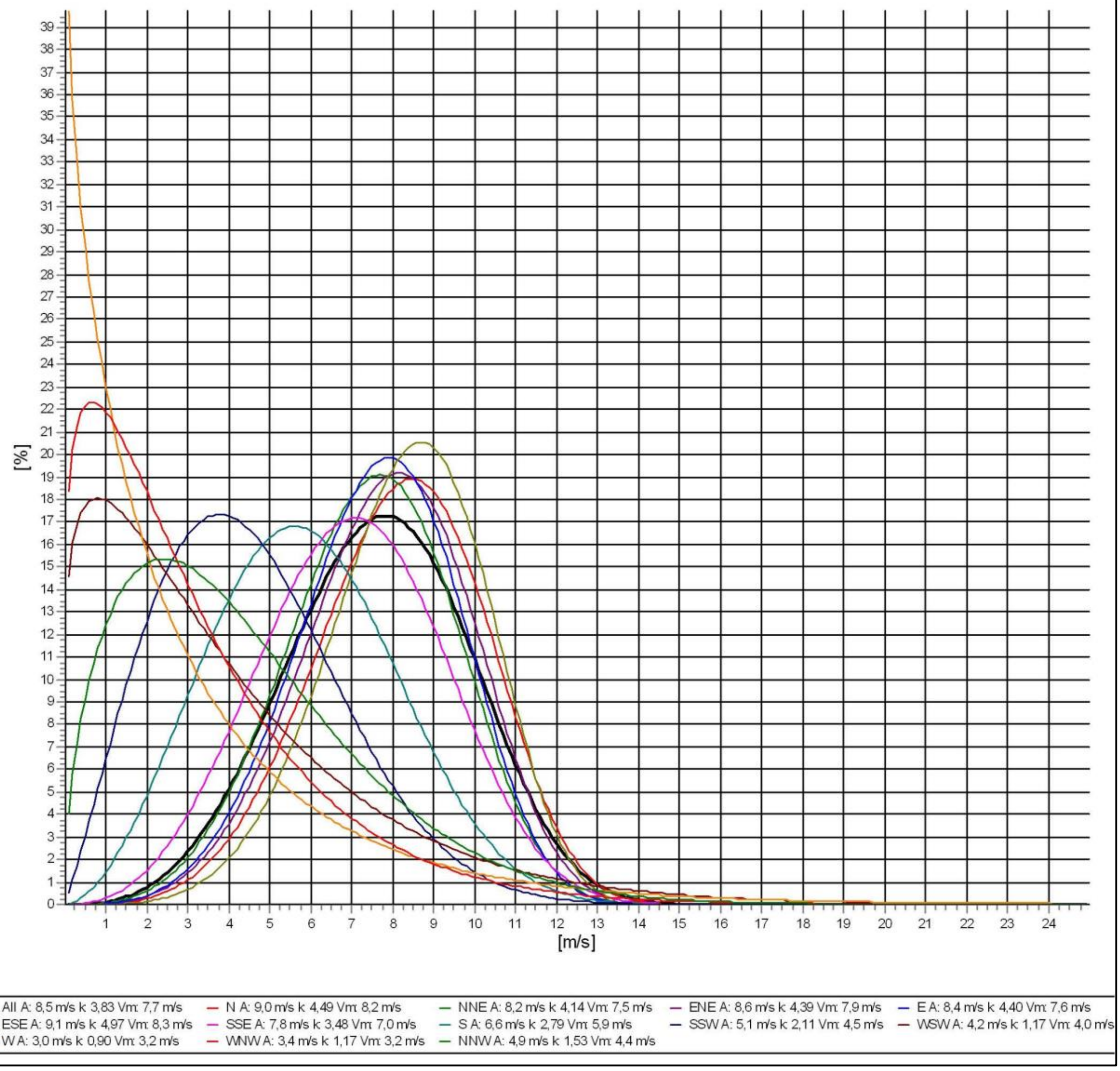
Meteo data report - Weibull data overview

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8,96	4,486	2,98	8,18
1-NNE	8,23	4,137	2,21	7,47
2-ENE	8,65	4,388	2,51	7,88
3-E	8,39	4,403	14,57	7,65
4-ESE	9,09	4,972	46,78	8,35
5-SSE	7,81	3,484	20,03	7,02
6-S	6,58	2,793	9,42	5,86
7-SSW	5,13	2,113	1,16	4,55
8-WSW	4,24	1,167	0,18	4,02
9-W	3,03	0,903	0,07	3,18
10-WNW	3,42	1,173	0,04	3,24
11-NNW	4,88	1,526	0,05	4,39
Mean	**8,46**	**3,830**	**100,00**	**7,65**



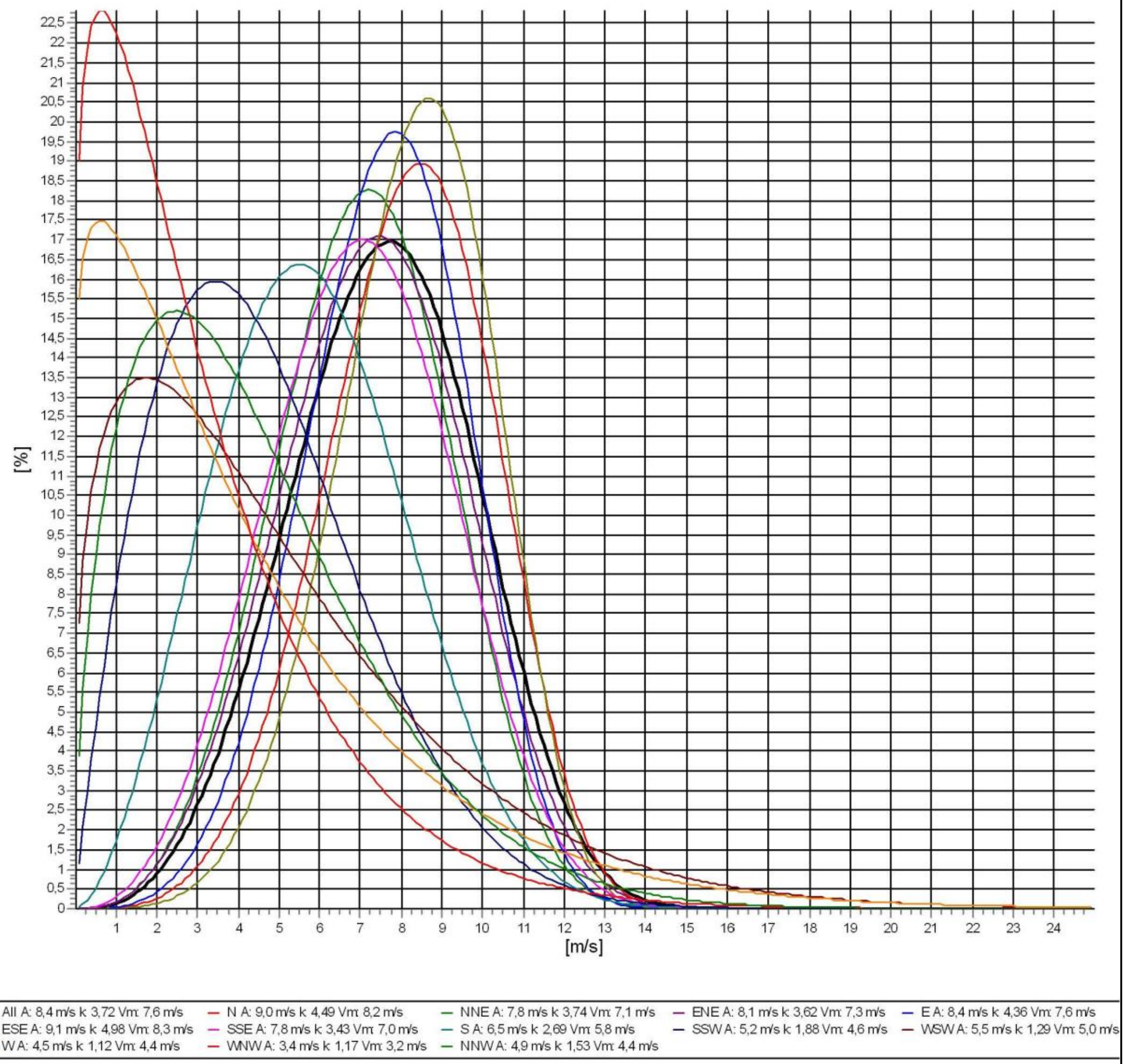
Meteo data report - Weibull data overview

Mast: TP_2839_Iparana; TP_2839_Iparana ALL; TP_2839 **Period:** Full period: 03/06/2009 - 17/12/2012 (42,5 months)

Height: **60,00m - 1 Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8,96	4,494	2,76	8,18
1-NNE	7,82	3,738	2,86	7,06
2-ENE	8,14	3,624	3,31	7,34
3-E	8,36	4,362	13,85	7,62
4-ESE	9,09	4,980	45,25	8,34
5-SSE	7,79	3,435	20,15	7,00
6-S	6,55	2,692	10,05	5,82
7-SSW	5,17	1,877	1,40	4,59
8-WSW	5,46	1,295	0,22	5,04
9-W	4,54	1,117	0,08	4,36
10-WNW	3,35	1,168	0,04	3,18
11-NNW	4,93	1,531	0,05	4,44
Mean	**8,40**	**3,719**	**100,00**	**7,58**



APPENDIX 2 : Wind resource maps

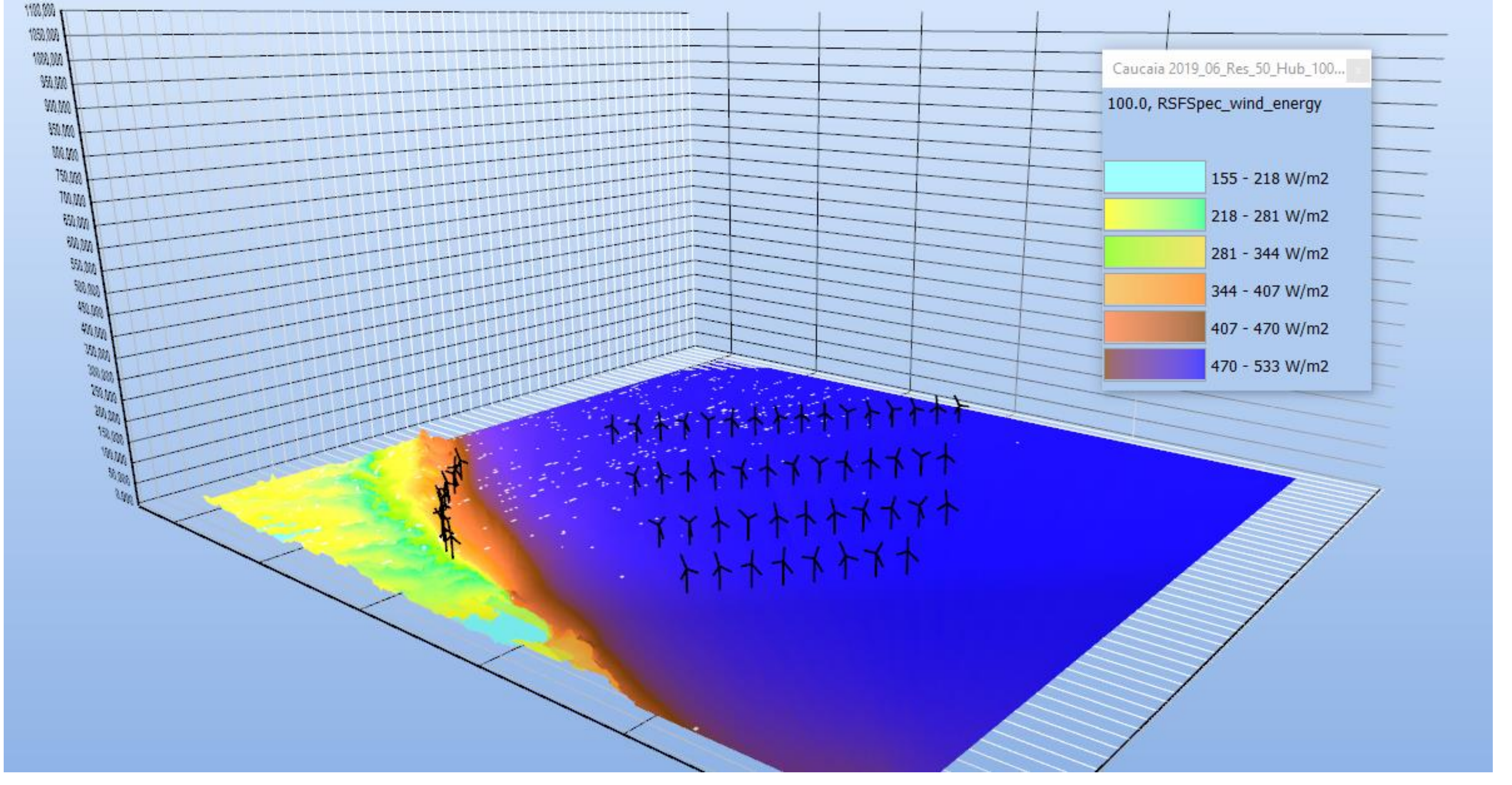


Figure 39: Wind resource map – specific wind energy W/m^2

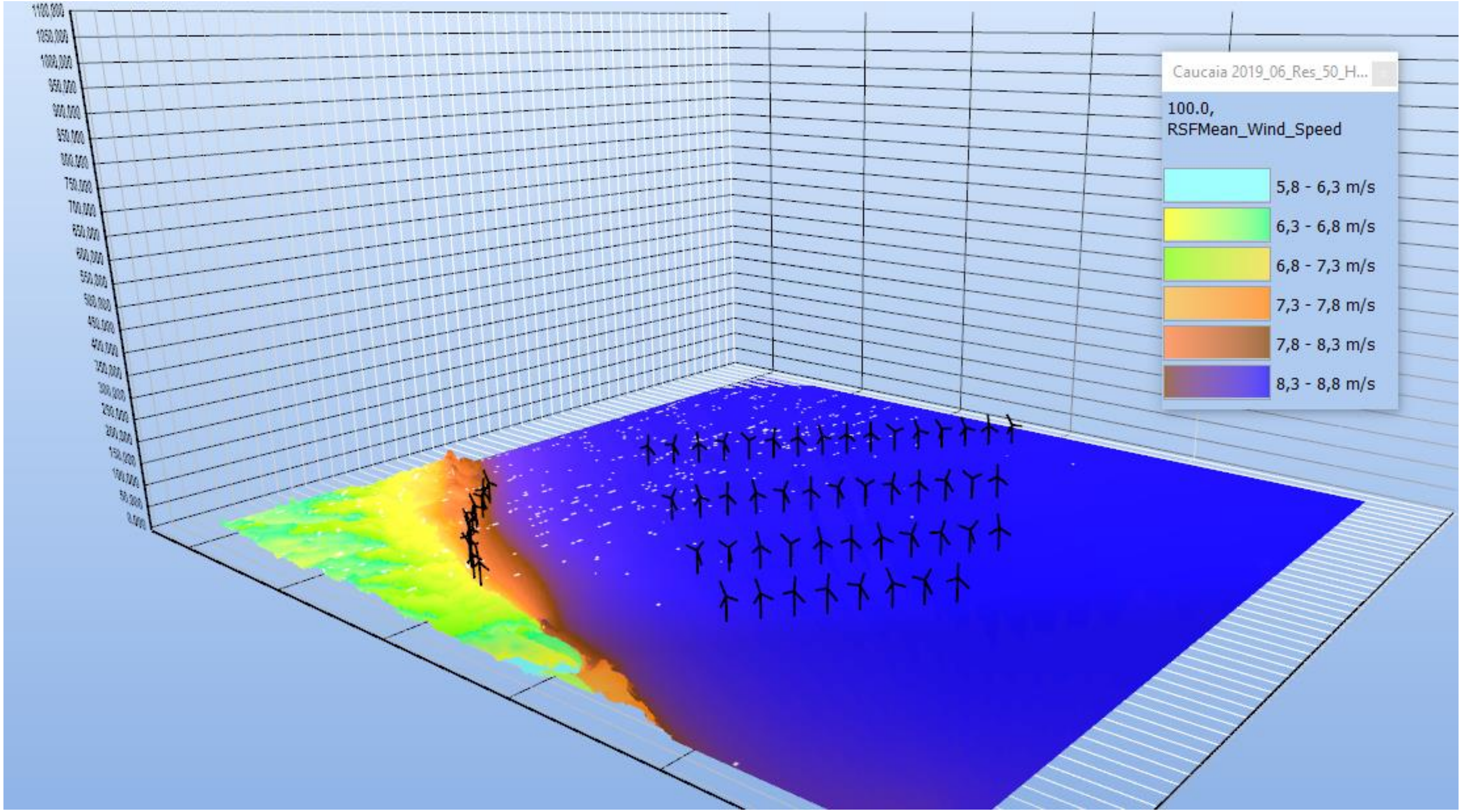


Figure 40: Wind resource map – wind speed [m/s] at 100 m a.s.l.

APPENDIX 3 : Glossary

Annual average
Mean value of a set of measured data of sufficient size and duration to serve as an estimate of the expected value of the quantity. The averaging time interval should be a whole number of years to average out non-stationary effects such as seasonality.
Annual average wind speed
V_{ave}: Wind speed averaged according to the definition of annual average.
Annual energy production
AEP: Estimate of the total energy production of a wind turbine during a one-year period by applying the measured power curve to different reference wind speed frequency distributions at hub height, assuming 100 % availability.
Brake (wind turbines)
Device capable of reducing the rotor speed or stopping rotation.
Control system (wind turbines)
Subsystem that receives information about the condition of the wind turbine and/or its environment, and adjusts the wind turbine in order to maintain it within its operating limits.
Cut-in wind speed (V_{in})
Lowest wind speed at hub height at which the wind turbine starts to produce useable power.
Cut-out wind speed (V_{out})
Maximum wind speed at hub height at which the wind turbine is designed to produce useable power.
Data set
Collection of data that was sampled over a continuous period.
Design limits
Maximum or minimum values used in a design
Design situation
Possible mode of wind turbine operation (for example power production, parking etc.)
Distance constant
Indication of the response time of an anemometer, defined as the length of air that must pass the instrument for it to indicate 63 % of the final value for a step input in wind speed.
Downwind
In the direction of the main wind vector.
Electrical power network
Particular installations, substations, lines or cables for the transmission and distribution of electricity.
Emergency shutdown (wind turbines)
Rapid shutdown of the wind turbine triggered by a protection function or by manual intervention.
Environmental conditions
Characteristics of the environment (wind, altitude, temperature, humidity, etc.) which may affect the wind turbine behavior.
Extrapolated power curve
Extension of the measured power curve by estimating power output from the maximum measured wind speed to cut-out wind speed.
Extreme wind speed
Value of the highest wind speed, averaged over *t* s, with an annual probability of exceedance of 1/*N* ("recurrence period": *N* years)
External conditions (wind turbines)

Factors affecting the operation of wind turbine, including the wind regime, other climatic factors (snow, ice, etc.).

Fall-safe
Design property of an item, which prevents its failures from resulting in critical faults.
Flow distortion
Change in air flow caused by obstacles, topographical variations, or other wind turbines that results in a deviation of the measured wind speed from the free stream wind speed and in a significant uncertainty.
Gust
Temporary change in the wind speed, which may be characterized by its rise-time, its amplitude and its

duration.
Horizontal axis wind turbine (HAWT)
Wind turbine whose rotor axis is parallel to the wind flow.
Hub
Fixture for attaching the blades or blade assembly to the rotor shaft.
Hub height (wind turbines)
Height of the centre of the swept area of the wind turbine rotor above the ground at the tower. NOTE: For a vertical axis wind turbine the hub height is the height of the equator plane.
Idling (wind turbines)
Condition of a wind turbine generator that is rotating slowly and not producing power.
Limit state
State of a structure and the loads acting upon it beyond which the structure no longer satisfies the design requirements (see ISO 2394).
Mean wind speed
Statistical mean of the instantaneous value of the wind speed averaged over a given time period which can vary from a few seconds to many years.
Measurement period
Period during which a statistically significant database has been collected for the power performance test.
Measurement sector
A sector of wind directions from which data are selected for the measured power curve.
Method of bins
Data reduction procedure that groups test data for a certain parameter into wind speed intervals (bins) NOTE: For each bin, the number of data sets or samples and their sum are recorded, and the average parameter value within each bin is calculated.
Nacelle
Housing which contains the drive-train and other elements on top of a horizontal axis wind turbine tower.
Net active electric power
Measure of the wind turbine electric power output that is delivered to the electrical power network.
Network connection point (wind turbines)
Cable terminals of a single wind turbine or, for a wind power station, the connection point to the electrical bus of the site power collection system.
Network loss
Loss of network for period exceeding any ride through provision in the turbine control system.
Normal shutdown (wind turbines)
Shutdown in which all stages are under the control of the control system.
Obstacles
Things that blocks the wind and creates distortion of the flow, such as buildings and trees.
Pitch angle
Angle between the chord line at a defined blade radial location (usually 100 % of the blade
Radius) and the rotor plane of rotation.
Power coefficient
Ratio of the net electric power output of a wind turbine to the power available in the free stream wind over the rotor swept area.
Power output
Power delivered by a device in a specific form and for a specific purpose. NOTE: (wind turbines) the electric power delivered by a wind turbine.
Power performance
Measure of the capability of a wind turbine to produce electric power and energy.
Protection functions (wind turbine)
Functions of the control and protection system, which ensure that a wind turbine remains within the design limits.
Uncertainty in measurement
Parameter, associated with the result of a measurement, which characterizes the dispersion of the values that could reasonably be attributed to the measurand.
Unscheduled maintenance
Maintenance carried out, not in accordance with an established time schedule, but after reception of an indication regarding the state of an item.

Upwind
In the direction opposite to the main wind vector.
Vertical axis wind turbine
Wind turbine whose rotor axis is vertical.
Weibull distribution
Probability distribution function.
Wind shear
Variation of wind speed across a plane perpendicular to the wind direction.
Wind shear exponent
Also commonly known as power law exponent.
Wind speed
At a specified point in space it is the speed of motion of a minute amount of air surrounding the specified point. NOTE: It is also the magnitude of the local wind velocity (vector)
Wind turbine electrical system
All electrical equipment internal to the wind turbine, up to and including the wind turbine terminals, including equipment for earthing, bonding and communications. Conductors local to the wind turbine, which are intended to provide an earth termination network specifically for the wind turbine, are included.
Wind turbine generator system (wind turbine)
System which converts kinetic energy in the wind into electrical energy.
Wind turbine site
The location of an individual wind turbine either alone or within a wind farm.
Wind turbine terminals
Point or points identified by the wind turbine supplier at which the wind turbine may be connected to the power collection system. This includes connection for the purposes of transferring energy and communications.
Wind turbine terminals
Point or points identified by the wind turbine supplier at which the wind turbine may be connected to the power collection system. This includes connection for the purposes of transferring energy and communications.
Wind velocity
Vector pointing in the direction of motion of a minute amount of air surrounding the point of consideration, the magnitude of the vector being equal to the speed of motion of this air "parcel" (i.e. the local wind speed)
Rated power
Quantity of power assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment. NOTE: Maximum continuous electrical power output which a wind turbine is designed to achieve under normal operating conditions.
Rated wind speed
Minimum wind speed at hub height at which a wind turbine's rated power is achieved in the case of steady wind without turbulence.
Reference wind speed V_{ref}
Basic parameter for wind speed used for defining wind turbine classes. Other design related climatic parameters are derived from the reference wind speed and other basic wind turbine class parameters.
NOTE: A turbine designed for a wind turbine class with a reference wind speed V_{ref}, is designed to withstand climates for which the extreme 10 min average wind speed with a recurrence period of 50 years at turbine hub height is lower than or equal to V_{ref}.
Rotationally sampled wind velocity
Wind velocity experienced at a fixed point of the rotating wind turbine rotor
NOTE: The turbulence spectrum of a rotationally sampled wind velocity is distinctly different from the normal turbulence spectrum. While rotating, the blade cuts through a wind flow that varies in space. Therefore, the resulting turbulence spectrum will contain sizeable amounts of variance at the frequency of rotation and harmonics of the same.
Rotor speed (wind turbines)
Rotational speed of a wind turbine rotor about its axis.
Roughness length
z_0 : Extrapolated height at which the mean wind speed becomes zero if the vertical wind profile is assumed to have a logarithmic variation with height.
Scheduled maintenance

Preventive maintenance carried out in accordance with an established time schedule.

Site data

Environmental, seismic, soil and electrical network data for the wind turbine site. Wind data shall be the statistics of 10 min samples unless otherwise stated.

Standard uncertainty

Uncertainty of the result of a measurement expressed as a standard deviation.

Standstill

Condition of a wind turbine that is stopped.

Support structure (wind turbines)

Part of a wind turbine comprising the tower and foundation.

Survival wind speed

Popular name for the maximum wind speed that a construction is designed to withstand. NOTE: In this standard, the expression is not used. Design conditions instead refer to extreme wind speed.

Swept area

Projected area perpendicular to the wind direction that a rotor will describe during one complete rotation.

Test site

Location of the wind turbine under test and its surroundings.

Turbulence intensity

Ratio of the wind speed standard deviation to the mean wind speed, determined from the same set of measured data samples of wind speed, and taken over a specified period of time.

Turbulence scale parameter

Wavelength where the non-dimensional, longitudinal power spectral density is equal to 0,05

Turbulence standard deviation

Standard deviation of the longitudinal component of the turbulent wind velocity at hub height.

Ultimate limit state

Limit states which generally correspond to maximum load carrying capacity.

Yawing

Rotation of the rotor axis about a vertical axis (for horizontal axis wind turbines only)