

WIND MEASUREMENT AND ASSESSMENT

for the

Wind Park

KOLLSNES

Norway

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References:

- Wind data measured on site
- Various topographical maps
- Google Earth
- Wind Correlation with long term reference data from meteorological stations at Hellisoy and Bergen Flesland.
- WAsP and European Wind Atlas by Risø National Laboratory in Denmark

1. Preface:

This report is a Wind Assessment for a proposed wind power project to be established at Kollsnes on the western coast of Norway, 30km Northwest of Bergen.

Kollsnes wind project



The purpose of this report is to form an overview of the estimated long term wind resource based on the ongoing wind measurement campaign on the site and related to long-term references.

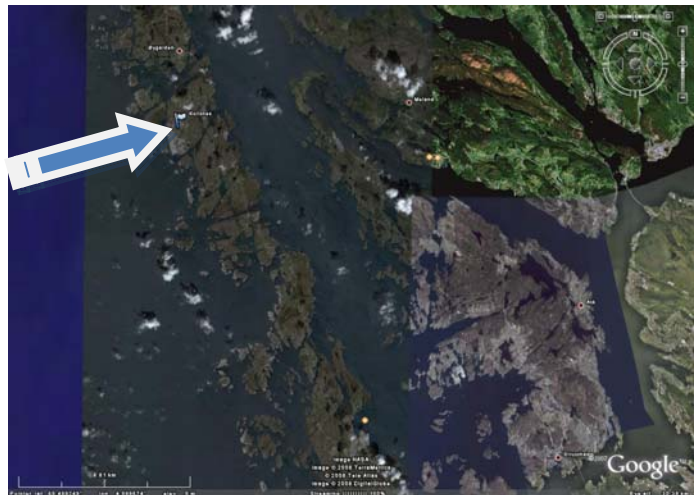
2. General Description of the site:

The site is located on rocky islands directly at the sea shore of western coast. The site, which is elevated approximately 20 to 40 meters above sea level, is a part of the row of connected islands running North-Northwest along the Norwegian west coastline.

The site is regular in shape running approx. 2 km East west and 3 km north south.

The centre of the site is found at the position 60°33' North and 4°51' East.

The site is flat and open surfaced of solid rock.



3. The Wind Regime

The on-site meteorological equipment has until writing this report been recording wind speed 13 months from February 2nd 2007 and is still ongoing. The data up to March 4th are used as basis reference for this report.

As long-term references data, used for correlation, we use the dataset from a meteorological station in Hellisoj Fedje (*Station: #52535 (60°45'02''N 04°42'41''E) Altitude above sea level: 19m*) having a total period from August 2004 up to present. As cross reference for verification of the data we uses the Bergen Flesland (*VMO Station: #1311 (60°17'N 5°14'E) Altitude above sea level: 50m*) with data for an 8-year period and full overlap with the measured period.

The two reference wind data is presented in Annex 3.

The on-site wind speeds have been measured in 10 minutes average at the height of 50m (two positions), 48,4m, 30m and 10m. There is a 100% data recovery for this period. The measured average wind speed at:

- 50m levels is 7,45m/s,
- 48,4m level is 7,4m/s,
- 30m is 6,4 and
- 10m level is 5,3m/s.

The position of the mast is presented in Annex 4.

A detailed wind report is presented in Annex 1.

The correlation between the long term stations recordings and on-site station at 50m level is presented in Annex 2.

The details of the meteorological monitoring equipment are presented in Annex 4.

Measure Correlate Predict (MCP) procedure:

Due to inter annual variations it is important to know how the wind speed during the measuring period, deviate from the long term average. A correlation based on simultaneous recordings between the long term references and the on-site measurements has been carried out to perform the adjustments.

The correlation report which has been prepared by WindPRO's MCP programme using the linear regression method indicates total and sector wise correlation. For all sectors the correlation returns a formula stating that the wind in Kollsnes is different than for the reference records, however, as the nominal values of the long term reference values are not of interest, only the deviation of the measured period correlated to the long term history is used to predict the future wind speed, assuming that the future will show same pattern as the historical data.

Basis for the long term wind is the average of the two MCP results.

The long term wind speed at Kollsnes is predicted to <u>7,6 m/s</u> at 50m level

Due to the surface roughness, the wind speed will increase with the height above ground level following the formula $U_2 = U_1 * (h_2/h_1)^{exp}$; where U_2 is the wind speed at hub height, U_1 is the wind speed at 50m height, h_2 is the hub height (80m), h_1 is measure height (50m). The exponent is a value following the surface roughness and is calculated to 0,15 based on the assessment of general roughness length surrounding the site of 0,03 (corresponding to Roughness Cl. 1,0).

$$U_2 = 7,6 * \left(\frac{80}{50} \right)^{0,15} = \underline{8,2 \text{ m/s}}$$

Following the assumptions and lifted to hub height the average long-term annual wind speed is calculated to 8,2m/s at the location of the meteorological station. At the individual wind turbine locations the wind speed can vary due to topographical and wake influences.

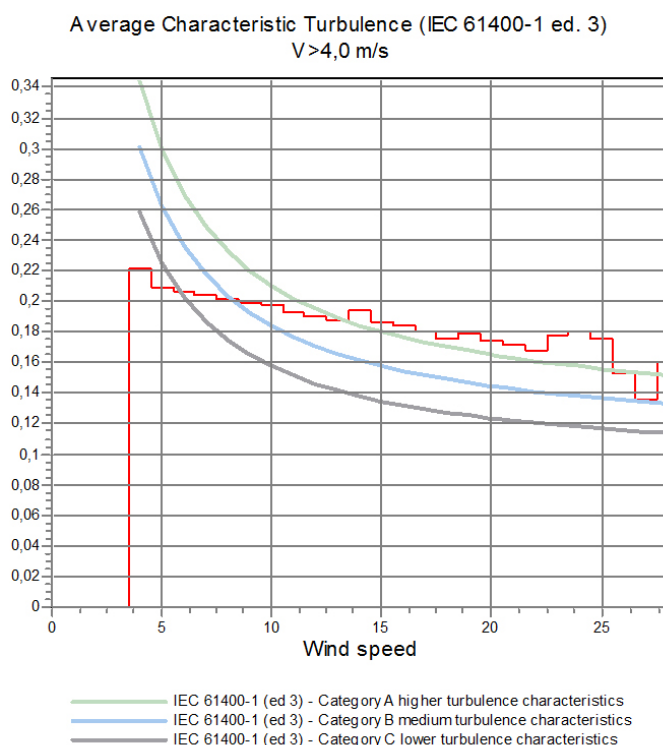
Due to the relatively flat terrain of the site and the surrounding areas no separation of the flow would be expected.

The long term wind speed at Kollsnes is predicted to 8,2 m/s at 80m level

4. Turbulence Analysis

Due to the proximity to the ocean and flat smooth surface of the site and its surroundings the surface created turbulence is low. The total measured turbulence is according to the IEC 61400-1 (ed3) for categories with lower turbulence characteristics below 16% for wind speeds exceeding 10m/s.

See left side table. The total sector wise turbulence is presented in Appendix 1.



5. Extreme Wind Analysis

The estimated 10minutes extreme wind speed is reported as the expected maximum in the return period. The statistical uncertainty is calculated using a bootstrap resampling technique, and these uncertainty estimates are taken as the expected mean plus one and two standard deviations respectively (also the CV (CV=coefficient of variation) is shown).

Estimated Extreme Wind Speeds at Different Return Periods				
EWS Estimate	Wind	Statistical uncertainty estimates		
Return Period		CV	EWS+1xStdDev	EWS+2xStdDev
Year(s)	m/s	%	m/s	m/s
1	27,1	7,1	29,0	30,9
5	31,2	8,9	34,0	36,8
10	33,0	9,5	36,2	39,3
25	35,4	10,3	39,0	42,6
50	37,1	10,8	41,1	45,2
100	38,9	11,3	43,3	47,7

Based on the relative short time sampling of the Kollsnes station, the 50-year extreme wind is calculated to 37,1m/s and with a 10,8% uncertainty increases to 41,1m/s.

Further details are found in Annex 1.

6. Data Analysis Procedures

Correlation of wind speed and direction at the site and at the reference meteorological site:

The method used to determine the long-term mean wind speed at the proposed site was based on a Measure-Correlate-Predict (MCP) approach that is outlined below.

The first stage in the approach is to measure concurrent wind data from the site and a nearby reference meteorological station. For the analysis reported here the reference stations is the Hellisoy station verified by Bergen long term data. The concurrent wind data were then used to establish the correlation between the winds between the data set. Finally, the correlation was used to adjust data recorded at the long term station to calculate the wind speed that would be expected at the site.

The concurrent data were correlated by comparing wind speeds at the two locations for each of twelve 30-degree direction sectors, based on the wind direction recorded at the reference. This correlation involves two steps:

- ☐ Wind directions recorded at the two locations are compared to determine whether there are any local features influencing the directional results.
- ☐ Wind speed ratios are determined for each of the direction sectors using a linear regression analysis.

The result of the MCP analysis is a table of wind speed ratios, each corresponding to one of twelve direction sectors, these ratios are used to factor the long-term wind speed and direction frequency table at the reference location to obtain the long-term wind speed at the target location.

Site wind speed variations:

To calculate the variation of mean wind speed over the site, the computer wind flow model, WAsP is used. Details of the model and its validation are given by Troen and Petersen.

Wind flow is affected by the roughness of the ground. For the site and its surrounding areas, the surface roughness was assumed to be 2,5 for the areas with plantation, 1,5-2 for open farmland, 1-1,3 for smooth rock and grass surface and areas of water were assigned a value of Class 0.

The wind flow calculations were carried out for 30-degree steps in wind direction corresponding to the measured wind rose and results were produced as factors relative to the mast location encompassing the site area.

To determine the long-term mean wind speed at any location, the factor for each wind direction was weighted with the measured probability previously derived for the mast location. All directions were then summed to obtain the long-term mean wind speed at the required location.

7. Confidence analysis:

The following categories of uncertainty are associated with the site wind speed predictions:

1.

There is an uncertainty associated with the measurement accuracy of the anemometer. The anemometers are calibrated so a figure of 2,5 % is assumed as to account for calibration accuracy and mast effect as well as other second order effects such as over speeding, degradation and air density variations.

The anemometers are all pre calibrated before installation, the calibrated value is used in this report.

2.

The wind regime at the Kollsnes masts was derived from correlation analysis, using Hellisoy station as a long-term reference. The uncertainty associated with correlating and extrapolating between the long term data and the on-site mast is evaluated from the statistical scatter in the correlation plots. A figure of 3-5 % is assumed for uncertainty due to this matter.

3.

Wind speed data from the Kollsnes mast was measured at 50 m. However the wind turbine rotor stretches from 35m to 125m above ground level. The uncertainty associated with extrapolating between heights is calculated from an assessment of the surface

roughness and surrounding topography into a single point at hub height. Due to the uncertainty of the wind speed variations a figure of 3-5 % is assumed for uncertainty due to this matter

4.

There is an uncertainty associated with the assumption made here that the historical period for which data were available from the meteorological site is representative of the climate over longer periods. For a finite number of future years, the mean wind speed may differ from the long-term mean due to the natural variability of a random process.

A study of historical records from a number of reference stations indicates an average variability of 6% in annual mean wind speed. At the Long term stations the long-term data shows year-to-year variations 5-13%. A figure of 5% is used to define the uncertainty in assuming the long-term mean wind speed defined by a period of 20 years in length. It is also assumed to include uncertainty associated with possible minor inconsistencies in the measured data over this long period.

Special affect due to possible global warming has not been taken into account in future wind predictions.

It is assumed that the time series of wind speed is random with no systematic trends. Care is taken to ensure that consistency of the meteorological station measurement system and exposure has been maintained over the historical period and no allowance is made for uncertainties arising due to changes in either.

Uncertainties as above are added as independent errors on a root-sum-square basis to give the total uncertainty in the site wind speed prediction for the historical period considered.

PROBABILITY EXCEEDING LEVEL ON ENERGY GENERATION:**Project: Kollsnes**

Wind Turbine Generator: Vestas V90

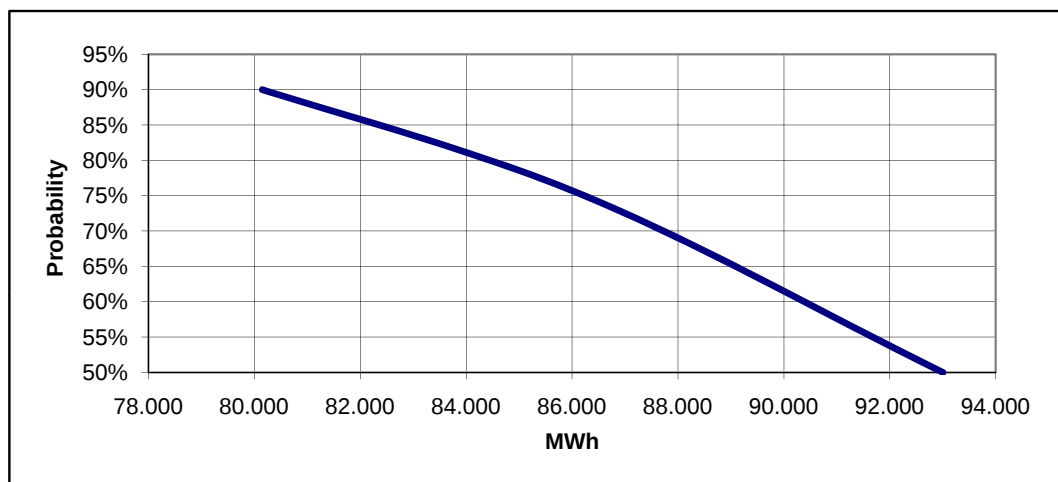
Generator size: 3 MW

Number of turbines: 10 units

Base value: 93.004 MWh

Uncertainty: 10,8% (Standard Deviation)

Probability	SD	MWh	Reduction		Equivalent full load hours
			MWh	%	
50%	10.028	93.004	-	0%	3.100
75%	10.028	86.240	6.764	7%	2.875
90%	10.028	80.153	12.851	14%	2.672

**Uncertainty evaluation:***Uncertainty in general technical matters:*

Measuring equipment:	3%
Terrain evaluation:	5%
Wind profile evaluation:	4%
Power curve of the wind turbine:	2%
Calculation methodology:	3%
Uncertainty in general technical matters:	7,8% (Rt-S-Sq)

Uncertainty in long term mean wind speed:

Reference anemometer accuracy:	3%
Variability of the campaign period:	3%
Correlation accuracy:	3%
Total uncertainty in long term mean wind speed:	5,2% (Rt-S-Sq)

Uncertainties in future mean wind speed:

Wake, roughness and topographic estimation:	2%
Future wind variation (long term):	5%
Total uncertainties in future mean wind speed:	5,4% (Rt-S-Sq)

The summarized uncertainty is then: **10,8% (Rt-S-Sq)**

All uncertainties are summarized on Root-Sum-Square basis.

8. ANNEX 1 Detailed report of measured wind speed at Kollsnes

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Calculated:
14-04-2008 12:16/

Meteo data report, height: 50,0 m

Name of meteo object: Kollsnes Wind measurement station

Data from: 09-02-2007 00:00 Data to: 04-03-2008 23:50 Observations: 56160 Observations per day: 144 Recovery rate: 100%

[illegible]

Project:

Kollsnes

Description:

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Calculated:

14-04-2008 12:16/

Meteo data report, height: 50,0 m

Name of meteo object: Kollsnes Wind measurement station

Frequency

Wind speed	Sum	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
0,00 - 0,49	155	0	0	8	1	1	46	1	4	82	3	8	1
0,50 - 1,49	806	66	60	76	84	92	62	61	61	62	67	59	56
1,50 - 2,49	2.902	323	261	276	286	253	196	217	148	263	226	182	271
2,50 - 3,49	4.581	482	406	356	385	489	413	230	180	387	390	342	521
3,50 - 4,49	5.993	590	522	299	487	932	792	317	218	303	335	402	796
4,50 - 5,49	6.285	756	406	195	482	852	1.023	432	228	379	330	368	834
5,50 - 6,49	5.748	957	197	87	389	524	1.167	616	240	333	323	272	643
6,50 - 7,49	5.065	907	99	28	223	352	1.002	668	192	270	374	323	627
7,50 - 8,49	4.435	807	28	21	117	268	772	649	282	270	361	240	620
8,50 - 9,49	4.195	598	10	0	55	178	745	892	375	293	290	208	551
9,50 - 10,49	3.912	403	7	0	27	125	726	984	402	367	263	128	480
10,50 - 11,49	3.167	272	5	0	3	86	572	872	348	343	210	81	375
11,50 - 12,49	2.555	184	0	0	1	47	405	736	318	271	191	81	321
12,50 - 13,49	1.859	147	0	0	1	37	258	606	228	193	108	38	243
13,50 - 14,49	1.358	132	0	0	0	25	171	478	187	107	65	28	165
14,50 - 15,49	965	97	0	0	1	22	95	396	109	38	44	41	122
15,50 - 16,49	694	75	0	0	0	11	55	282	65	27	31	50	98
16,50 - 17,49	530	59	0	0	1	6	33	201	64	20	27	33	86
17,50 - 18,49	399	56	0	0	0	0	14	144	59	23	20	22	61
18,50 - 19,49	233	30	0	0	0	0	7	100	17	11	12	13	43
19,50 - 20,49	159	25	0	0	0	0	4	78	9	10	1	8	24
20,50 - 21,49	77	16	0	0	0	0	1	36	2	5	2	3	12
21,50 - 22,49	50	16	0	0	0	0	1	21	2	0	0	1	9
22,50 - 23,49	15	8	0	0	0	0	0	3	0	0	0	0	4
23,50 - 24,49	13	9	0	0	0	0	0	1	0	0	0	2	1
24,50 - 25,49	6	5	0	0	0	0	0	1	0	0	0	0	0
25,50 - 26,49	1	1	0	0	0	0	0	0	0	0	0	0	0
26,50 - 27,49	1	1	0	0	0	0	0	0	0	0	0	0	0
27,50 - 28,49	1	1	0	0	0	0	0	0	0	0	0	0	0
Sum	56.160	7.023	2.001	1.346	2.543	4.300	8.560	9.022	3.738	4.057	3.673	2.933	6.964

Average Characteristic Turbulence (IEC 61400-1 ed. 3)

Wind speed	Sum	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
0,00 - 0,49													
0,50 - 1,49													
1,50 - 2,49													
2,50 - 3,49													
3,50 - 4,49	0,222	0,222	0,201	0,190	0,215	0,176	0,206	0,226	0,271	0,251	0,249	0,245	0,221
4,50 - 5,49	0,209	0,212	0,182	0,176	0,195	0,174	0,190	0,222	0,219	0,225	0,243	0,229	0,216
5,50 - 6,49	0,206	0,211	0,189	0,181	0,191	0,173	0,193	0,208	0,226	0,223	0,236	0,214	0,202
6,50 - 7,49	0,204	0,208	0,187	0,186	0,191	0,175	0,197	0,204	0,212	0,213	0,224	0,220	0,191
7,50 - 8,49	0,202	0,208	0,200	0,158	0,182	0,175	0,193	0,201	0,214	0,199	0,211	0,212	0,191
8,50 - 9,49	0,199	0,203	0,205		0,167	0,175	0,194	0,192	0,205	0,199	0,208	0,238	0,182
9,50 - 10,49	0,198	0,203	0,179		0,167	0,180	0,195	0,188	0,202	0,191	0,207	0,227	0,195
10,50 - 11,49	0,192	0,207	0,168		0,149	0,174	0,194	0,186	0,188	0,190	0,198	0,205	0,179
11,50 - 12,49	0,190	0,203				0,162	0,194	0,186	0,174	0,189	0,203	0,197	0,178
12,50 - 13,49	0,188	0,203				0,160	0,191	0,184	0,174	0,185	0,186	0,195	0,184
13,50 - 14,49	0,194	0,202				0,173	0,193	0,186	0,181	0,181	0,195	0,193	0,207
14,50 - 15,49	0,186	0,204				0,172	0,188	0,178	0,179	0,184	0,198	0,191	0,182
15,50 - 16,49	0,185	0,195				0,155	0,192	0,172	0,176	0,182	0,208	0,206	0,175
16,50 - 17,49	0,180	0,192				0,157	0,198	0,173	0,163	0,181	0,188	0,195	0,174
17,50 - 18,49	0,175	0,193					0,178	0,169	0,151	0,173	0,177	0,166	0,179
18,50 - 19,49	0,179	0,182					0,209	0,171	0,159	0,209	0,184	0,181	0,170
19,50 - 20,49	0,174	0,194					0,196	0,164	0,147	0,159		0,170	0,177
20,50 - 21,49	0,171	0,178						0,162	0,143	0,184	0,104	0,210	0,146
21,50 - 22,49	0,168	0,177						0,159	0,127				0,155
22,50 - 23,49	0,178	0,184						0,156					0,161
23,50 - 24,49	0,180	0,185									0,132		
24,50 - 25,49	0,175	0,171											
25,50 - 26,49													
26,50 - 27,49													
27,50 - 28,49													
Sum	0,202	0,209	0,190	0,182	0,195	0,176	0,197	0,193	0,204	0,207	0,220	0,222	0,197

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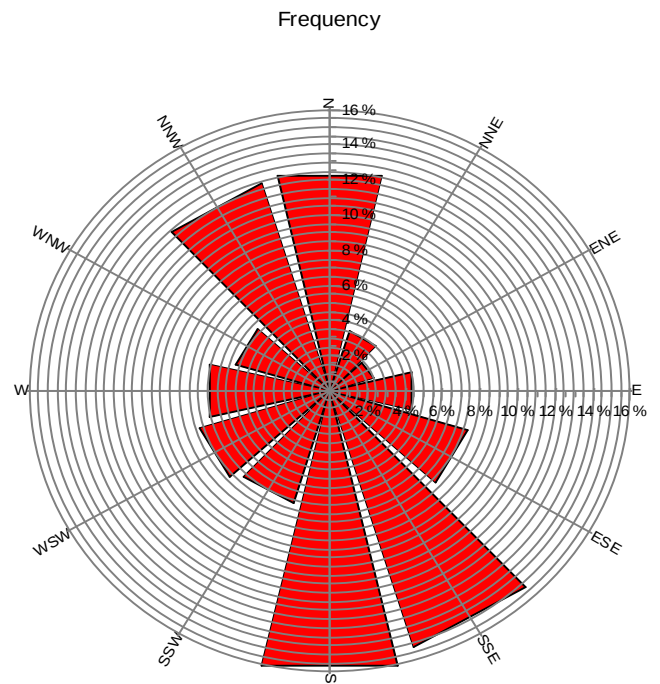
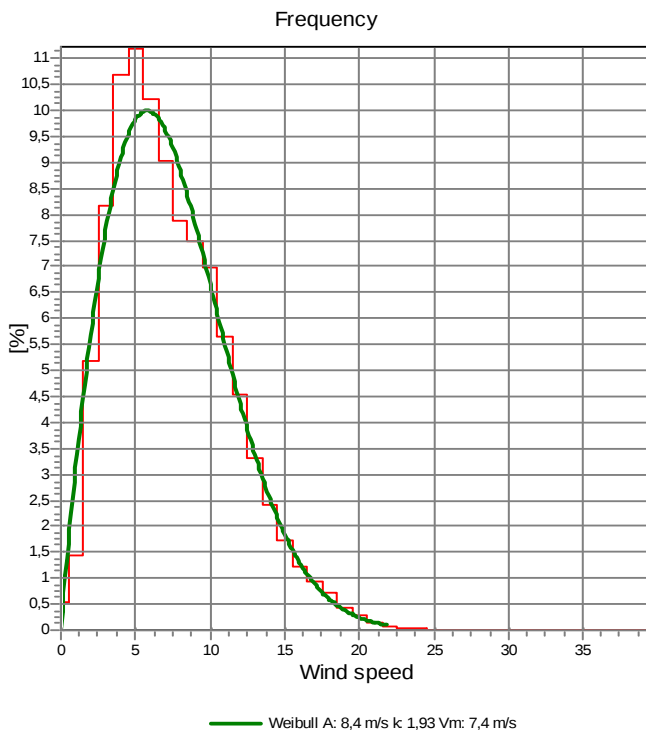
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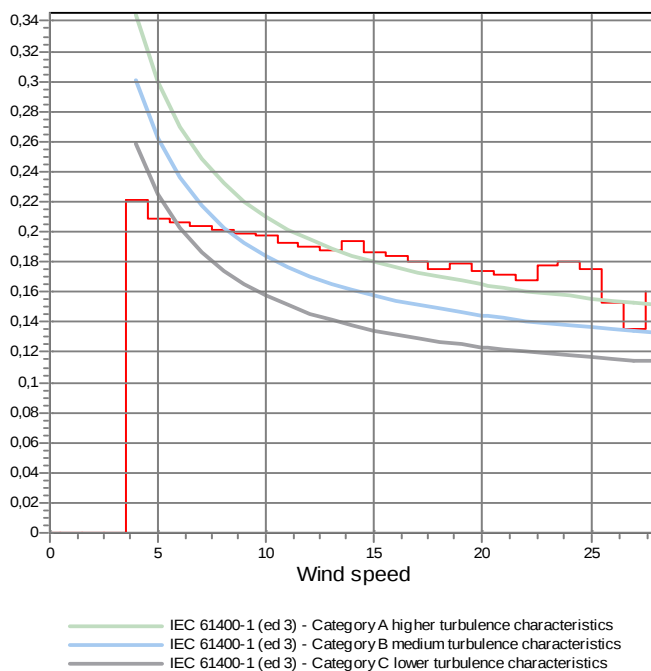
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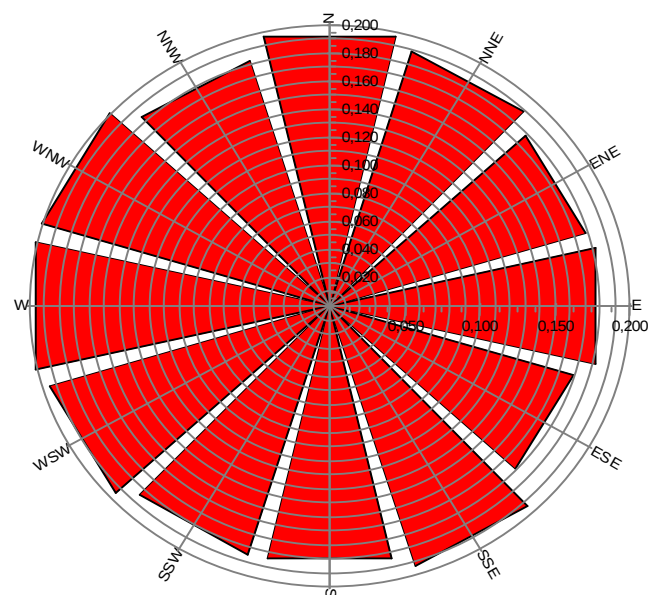
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Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



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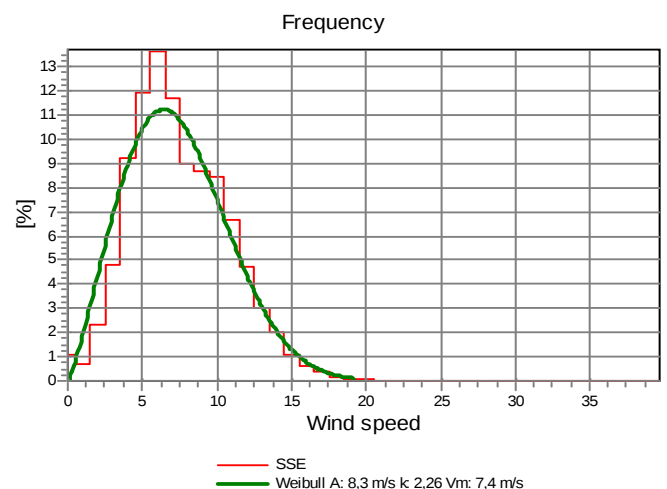
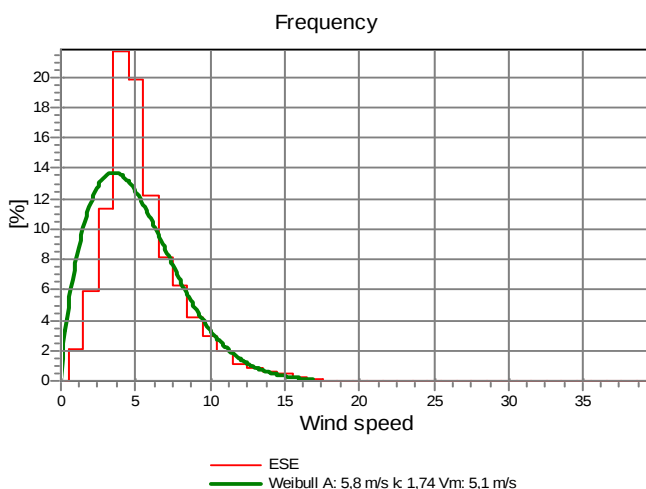
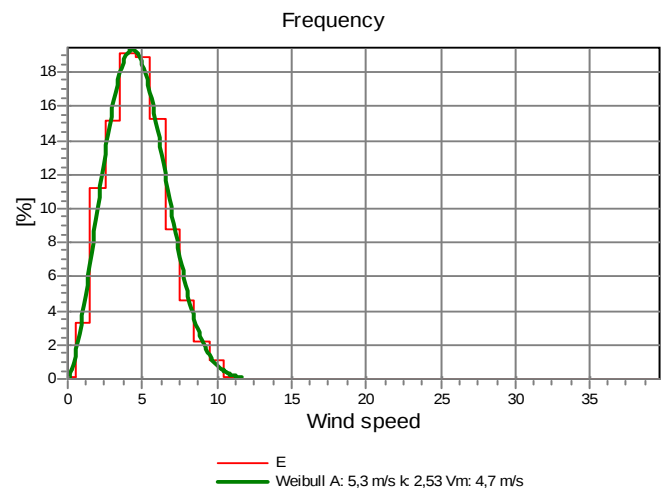
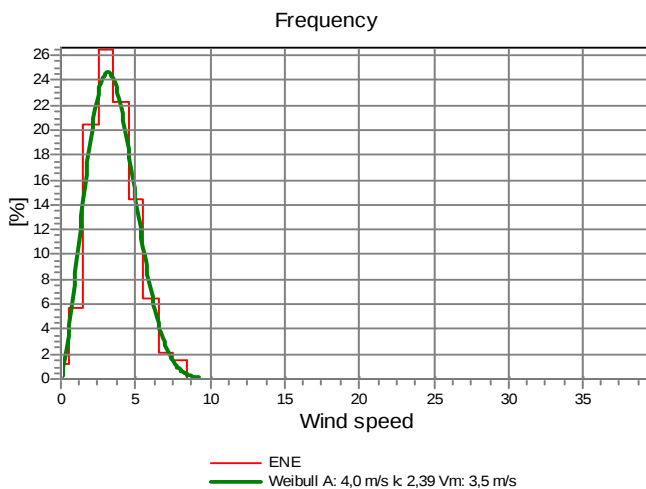
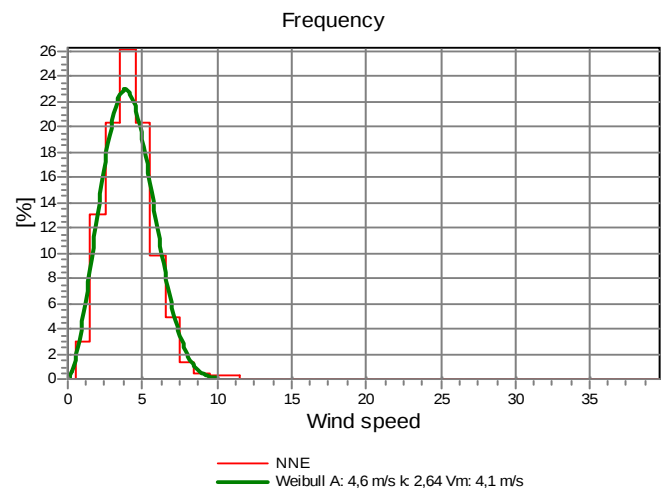
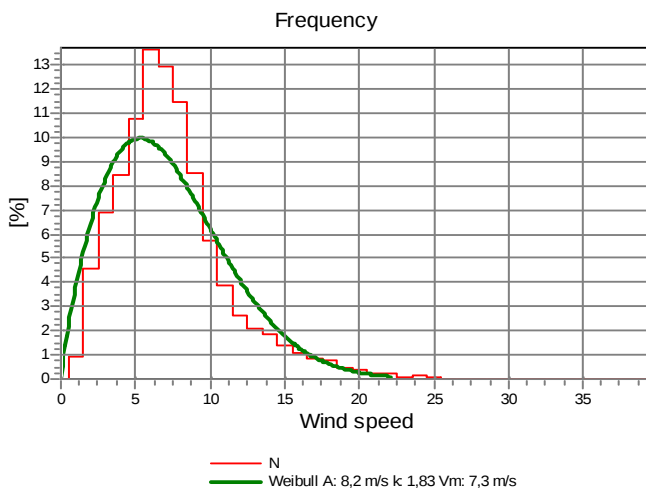
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Meteo data report, height: 50,0 m

Name of meteo object: Kollsnes Wind measurement station



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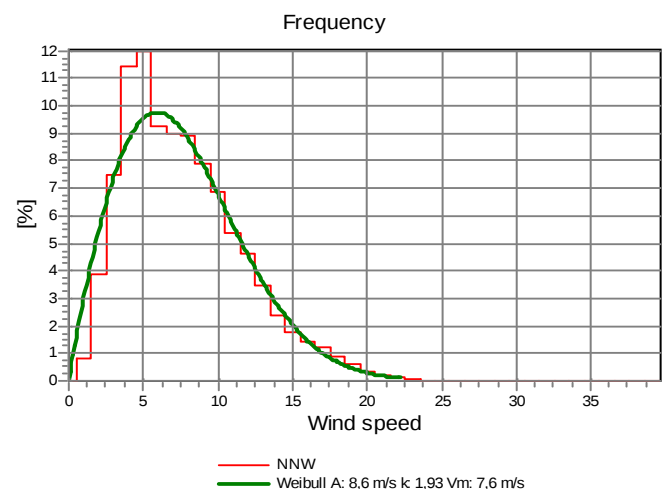
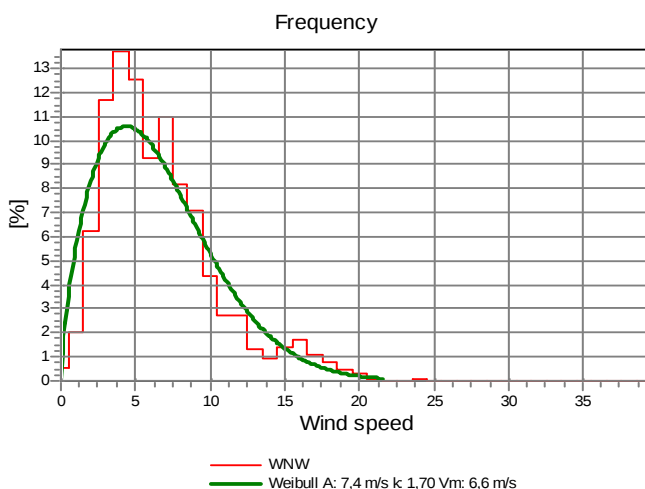
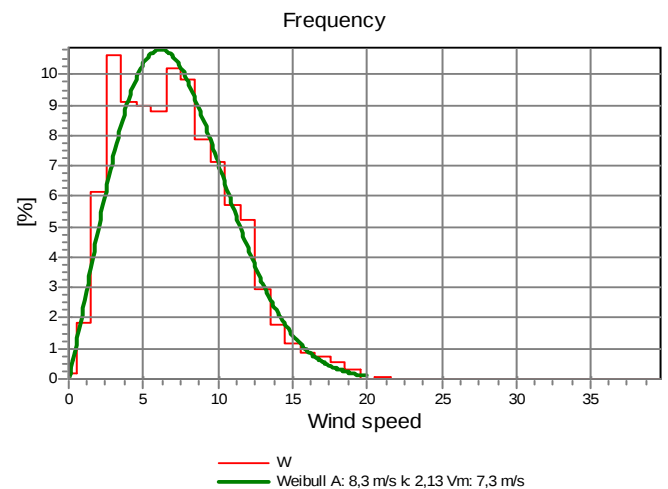
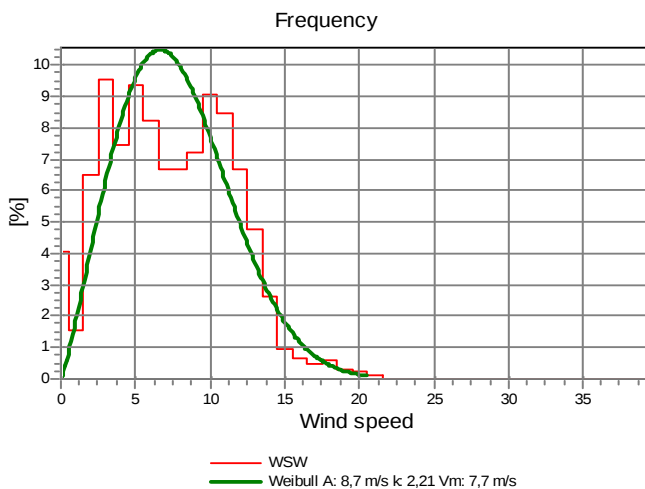
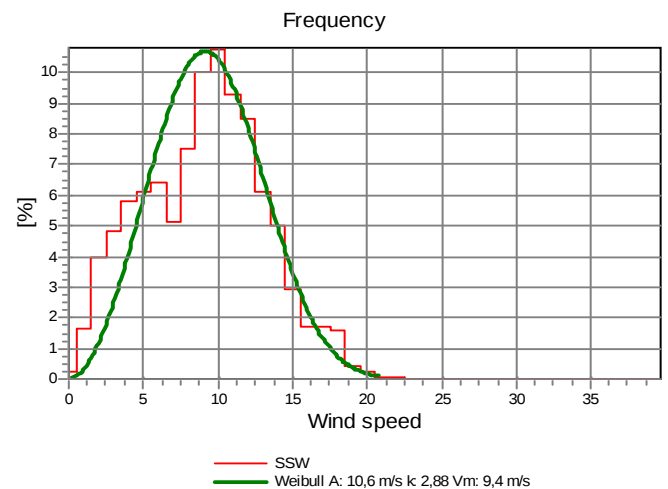
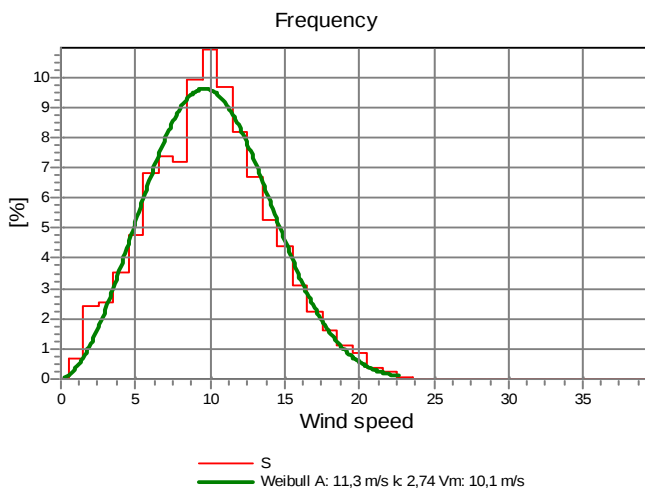
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Meteo data report, height: 50,0 m

Name of meteo object: Kollsnes Wind measurement station



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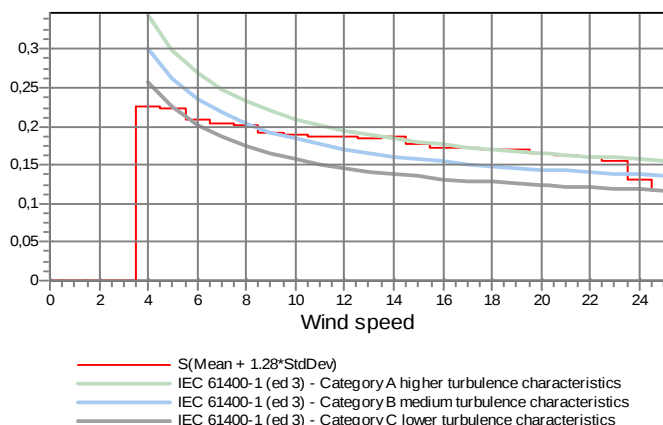
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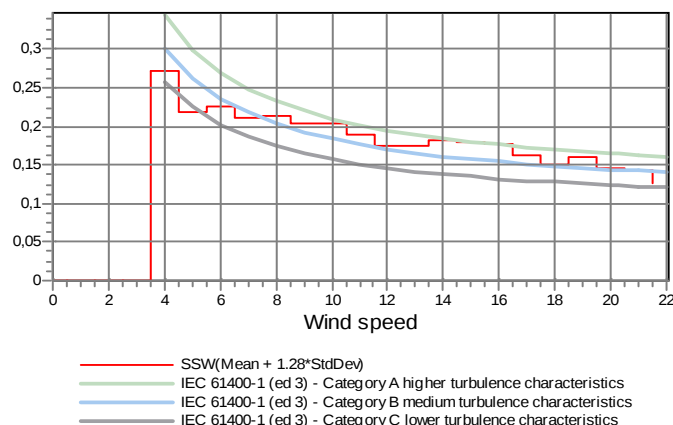
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Name of meteo object: Kollsnes Wind measurement station

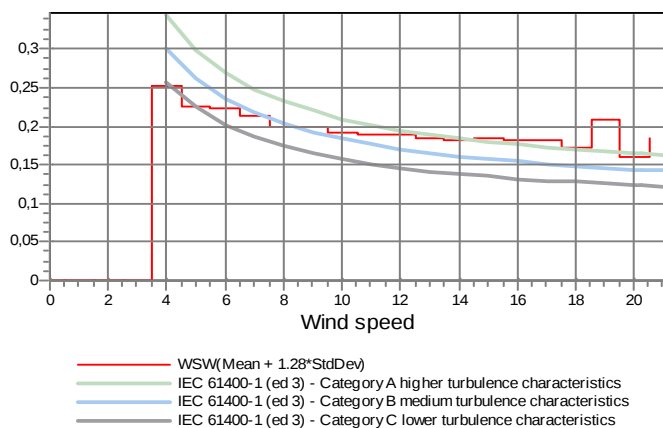
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V>4.0 m/s



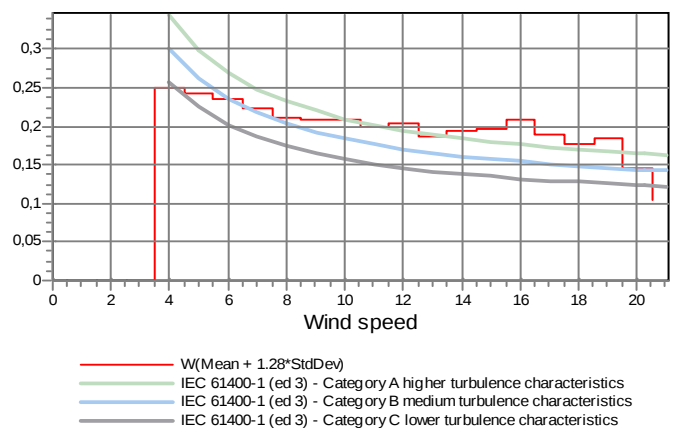
Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4.0 m/s



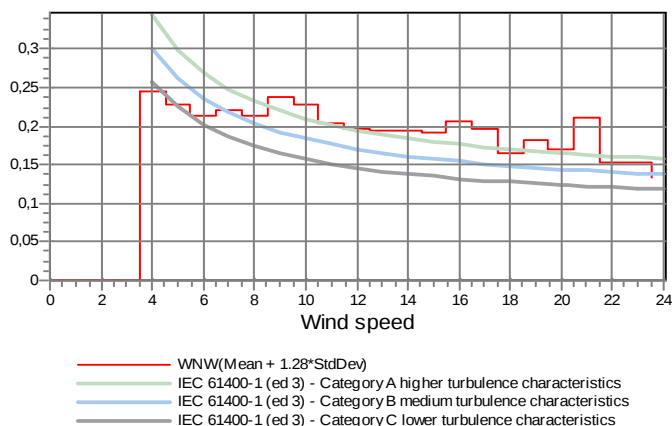
Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



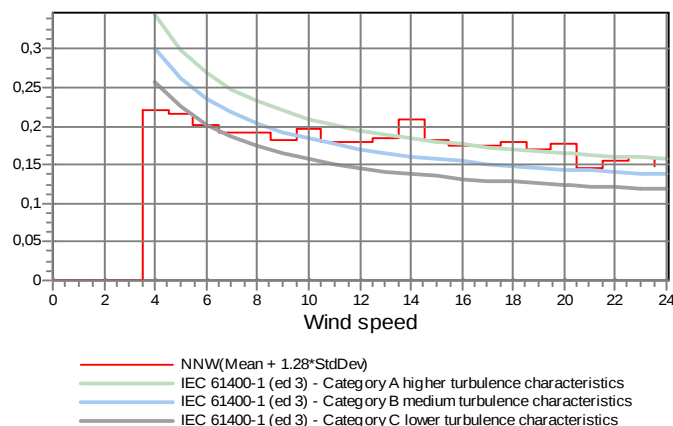
Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



Average Characteristic Turbulence (IEC 61400-1 ed. 3)
V>4,0 m/s



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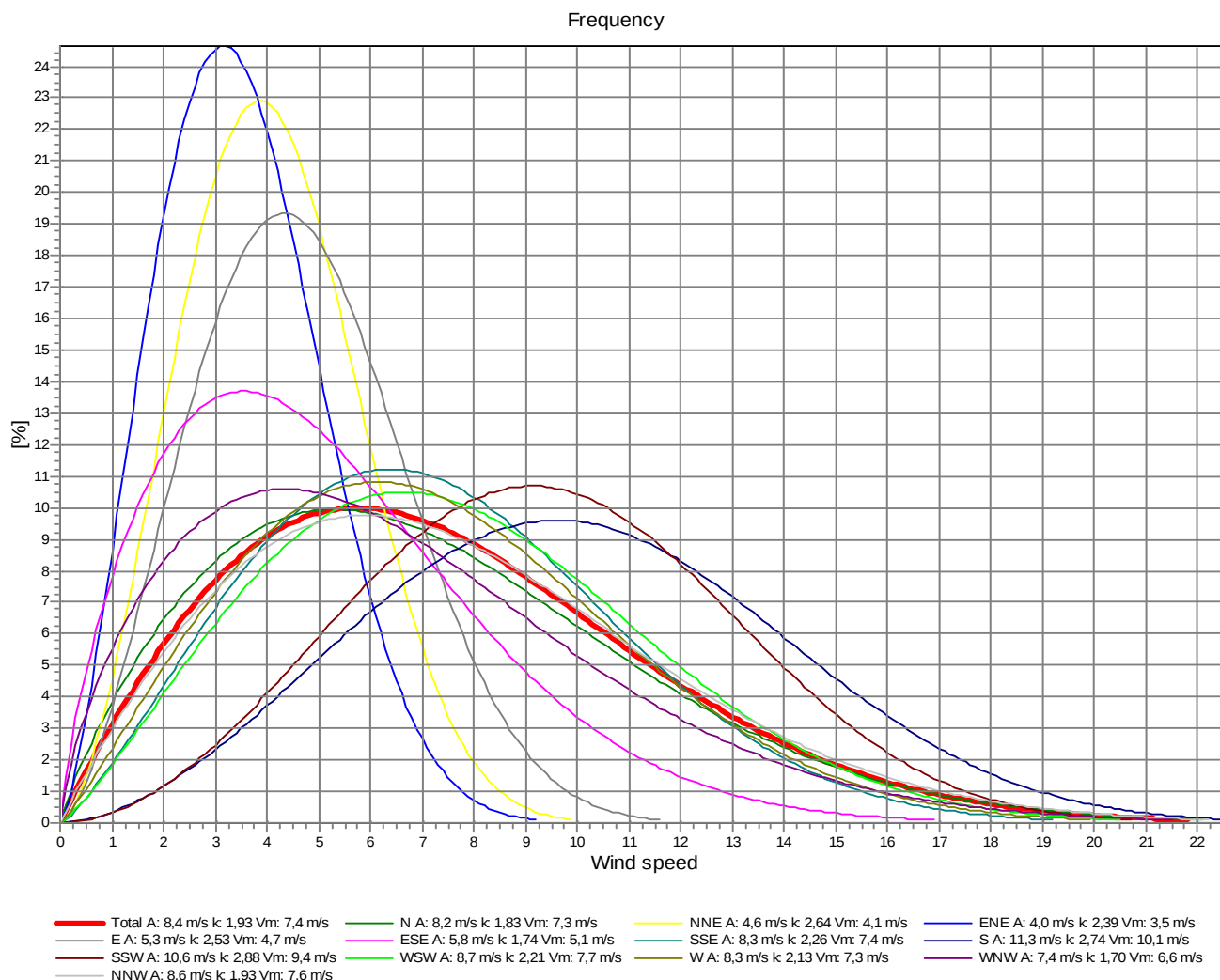
Meteo data report, height: 50,0 m

Name of meteo object: Kollsnes Wind measurement station

Weibull Data

k-parameter correction: 0,0080/m

Sector	A- parameter [m/s]	Mean wind speed [m/s]	k- parameter	Frequency	Frequency [%]	Wind shear
0-N	8,16	7,25	1,833	12,51	12,5	0,00
1-NNE	4,61	4,10	2,645	3,56	3,6	0,00
2-ENE	3,95	3,50	2,390	2,40	2,4	0,00
3-E	5,28	4,68	2,533	4,53	4,5	0,00
4-ESE	5,78	5,15	1,744	7,66	7,7	0,00
5-SSE	8,31	7,36	2,257	15,24	15,2	0,00
6-S	11,34	10,09	2,743	16,06	16,1	0,00
7-SSW	10,60	9,45	2,875	6,66	6,7	0,00
8-WSW	8,74	7,74	2,206	7,22	7,2	0,00
9-W	8,26	7,32	2,128	6,54	6,5	0,00
10-WNW	7,37	6,58	1,698	5,22	5,2	0,00
11-NNW	8,60	7,63	1,933	12,40	12,4	0,00
mean	8,39	7,44	1,933	100,00	100,0	0,00



Source Data for Extreme Wind Estimation

Source : Kollsnes

Height : 50,00 m

First record dated : 09-02-2007

Last record dated : 04-03-2008 23:50:00

Period covered : 1,07 years

Sample rate : 10 minutes

Number of samples (enabled data only) : 56160

Max wind speed : 27,60 m/s

Mean wind speed : 7,47 m/s

Extracting the Extreme Events

Samples before : 56160

Sector angle covered : 0,0-360,0 deg, removed due to sectors : 0

Threshold : 15 m/s, removed due to threshold : 53551

Independence criteria 4 days, removed due to independence : 2577

Samples after running extreme value extraction : 32

Mean wind speeds of extreme samples : 19,8 m/s

Standard deviation of extreme samples : 2,9 m/s

Extreme Events in Time Series Data (date and wind speed)

16-02-2007: 23,8 m/s 26-02-2007: 15,2 m/s 05-03-2007: 20,2 m/s

10-03-2007: 18,1 m/s 17-03-2007: 21,0 m/s 19-04-2007: 18,4 m/s

06-05-2007: 18,9 m/s 19-05-2007: 17,3 m/s 26-06-2007: 16,0 m/s

04-08-2007: 18,3 m/s 16-08-2007: 20,0 m/s 02-09-2007: 18,1 m/s

14-09-2007: 20,6 m/s 24-09-2007: 22,0 m/s 11-10-2007: 16,6 m/s

16-10-2007: 16,3 m/s 28-10-2007: 21,6 m/s 08-11-2007: 27,6 m/s

24-11-2007: 22,7 m/s 29-11-2007: 15,3 m/s 05-12-2007: 17,7 m/s

27-12-2007: 21,2 m/s 05-01-2008: 17,2 m/s 09-01-2008: 21,7 m/s

14-01-2008: 20,5 m/s 19-01-2008: 23,8 m/s 25-01-2008: 24,6 m/s

01-02-2008: 22,5 m/s 07-02-2008: 19,5 m/s 21-02-2008: 20,2 m/s

27-02-2008: 18,4 m/s 04-03-2008: 17,9 m/s

Fitted Gumbel Distribution Parameters

The estimation of the distribution parameters is based on a least squares method.

This method uses raw wind speeds when estimating the extremes.

Alpha : 0,3906

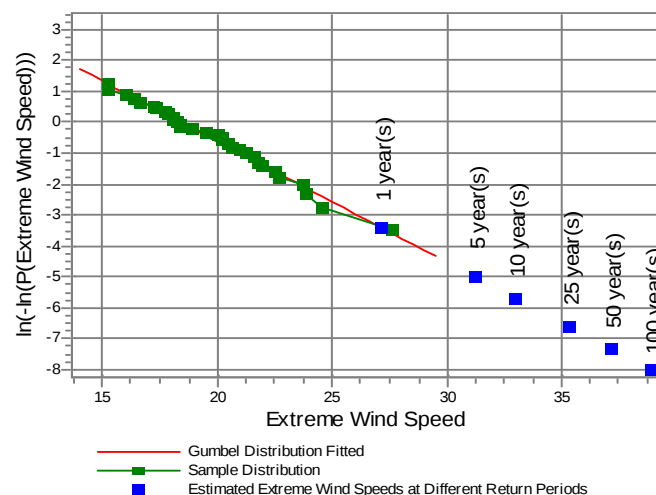
Beta : 18,4052 m/s

Mean : 19,8832 m/s

Standard deviation : 3,2839 m/s

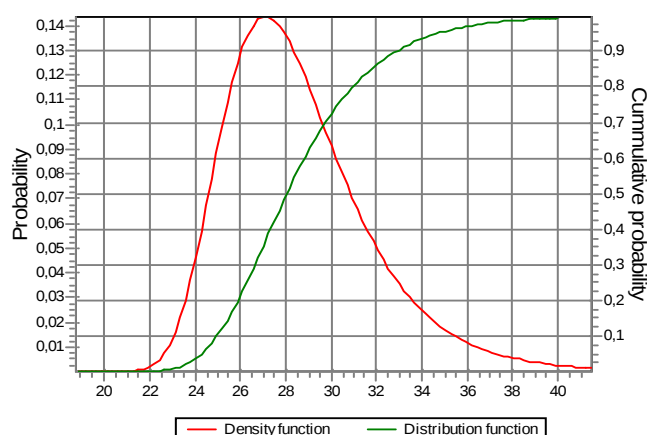
Lambda : 29,970 events per year

Summed error : 0,60648

**Estimated Extreme Wind Speeds at Different Return Periods**

EWS Estimate		Statistical uncertainty estimates		
Return Period	Wind	CV	EWS+1xStdDev	EWS+2xStdDev
Year(s)	m/s	%	m/s	m/s
1	27,1	7,1	29,0	30,9
5	31,2	8,9	34,0	36,8
10	33,0	9,5	36,2	39,3
25	35,4	10,3	39,0	42,6
50	37,1	10,8	41,1	45,2
100	38,9	11,3	43,3	47,7

The estimated extreme wind speed (EWS) is here reported as the expected maximum in the return period. The statistical uncertainty is calculated using a bootstrap resampling technique, and these uncertainty estimates are taken as the expected mean plus one and two standard deviations respectively (also the CV (CV=coefficient of variation) is shown). It is recommended that the estimates are compared with values from national structural codes of practice. Typically, estimating a 50 year extreme event with a reasonable statistical certainty would require approximately 10 years of validated data. Approximately 30-50 samples should be used in the extreme sample distribution. Please note that the extreme winds are reported with the same averaging time as your sample data.

Distribution of the Annual Extreme Value

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METEO - Wind profile detailed**WTG: VESTAS V90 3000 90.0 !O! Level 0 - - 109.4 dB(A) - 03-2007, Hub height: 80,0 m****Site Data**

Kollsnes Wind measurement station

Site Coordinates

UTM WGS 84 Zone: 31 East: 600.899 North: 6.715.098

Air density calculation mode

Individual per WTG

Result for WTG at hub altitude

1,270 kg/m3

Hub altitude above sea level (asl)

121,0 m

Annual mean temperature at hub alt.

0,6 °C

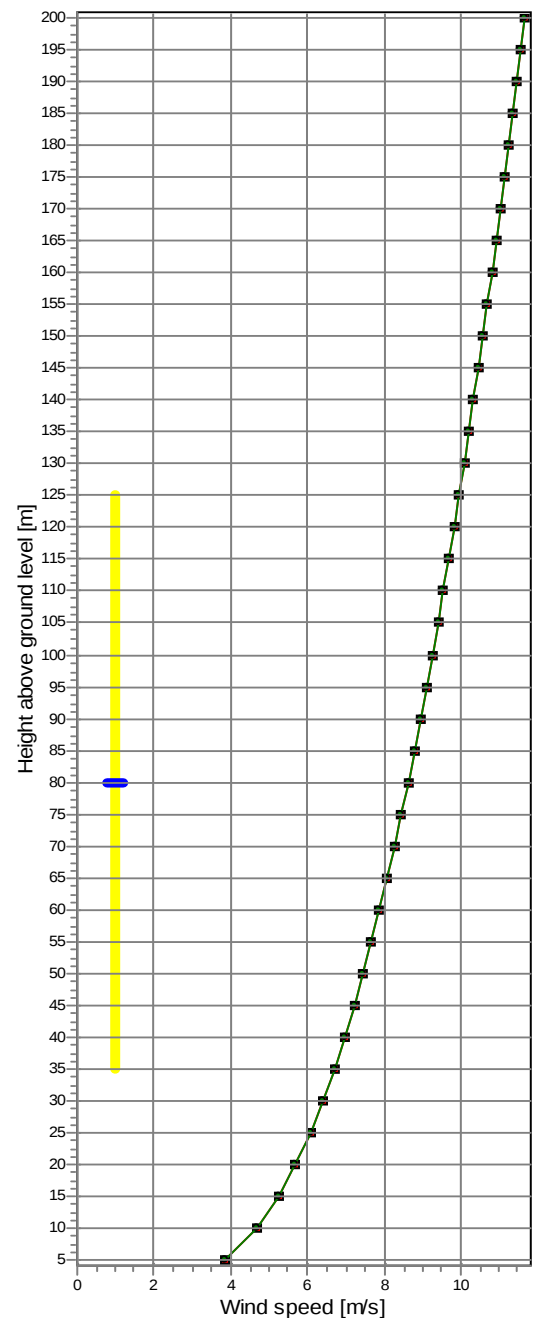
Pressure at WTGs

998,1 hPa

All sectors

Height	Mean wind speed	A- parameter	k- parameter	Wind energy	Yield	Yield change
	[m/s]	[m/s]		[kWh/m2]	[MWh]	[MWh]
5	3,83	4,2	1,49	887	2.081	-9.099
10	4,65	5,2	1,59	1.426	3.303	-7.877
15	5,22	5,8	1,66	1.892	4.303	-6.877
20	5,68	6,4	1,71	2.318	5.164	-6.015
25	6,06	6,8	1,76	2.718	5.925	-5.254
30	6,39	7,2	1,80	3.100	6.608	-4.572
35	6,69	7,5	1,84	3.468	7.227	-3.952
40	6,96	7,8	1,87	3.826	7.795	-3.384
45	7,21	8,1	1,90	4.176	8.320	-2.860
50	7,44	8,4	1,93	4.518	8.808	-2.372
55	7,66	8,6	1,96	4.854	9.263	-1.916
60	7,87	8,9	1,99	5.186	9.691	-1.488
65	8,07	9,1	2,01	5.512	10.094	-1.085
70	8,25	9,3	2,03	5.834	10.475	-704
75	8,43	9,5	2,06	6.153	10.836	-343
80	8,60	9,7	2,08	6.468	11.179	0
85	8,77	9,9	2,10	6.779	11.506	327
90	8,93	10,1	2,12	7.087	11.818	639
95	9,09	10,3	2,13	7.392	12.116	936
100	9,24	10,4	2,15	7.694	12.401	1.221
105	9,38	10,6	2,17	7.993	12.674	1.494
110	9,53	10,8	2,18	8.289	12.935	1.756
115	9,66	10,9	2,20	8.582	13.186	2.007
120	9,80	11,1	2,21	8.872	13.427	2.248
125	9,93	11,2	2,23	9.159	13.659	2.479
130	10,06	11,4	2,24	9.443	13.881	2.702
135	10,19	11,5	2,25	9.724	14.095	2.915
140	10,31	11,6	2,27	10.002	14.300	3.121
145	10,43	11,8	2,28	10.276	14.498	3.319
150	10,55	11,9	2,29	10.547	14.688	3.509
155	10,67	12,0	2,30	10.815	14.871	3.692
160	10,78	12,2	2,31	11.079	15.047	3.868
165	10,90	12,3	2,32	11.340	15.217	4.037
170	11,01	12,4	2,33	11.596	15.379	4.200
175	11,12	12,5	2,34	11.849	15.536	4.356
180	11,22	12,7	2,35	12.098	15.686	4.507
185	11,33	12,8	2,36	12.342	15.830	4.651
190	11,43	12,9	2,36	12.582	15.969	4.790
195	11,54	13,0	2,37	12.818	16.102	4.922
200	11,64	13,1	2,38	13.049	16.229	5.050

All sectors



—■— Mean wind speed
—●— Without Orography/Obstacles
| WTG rotor

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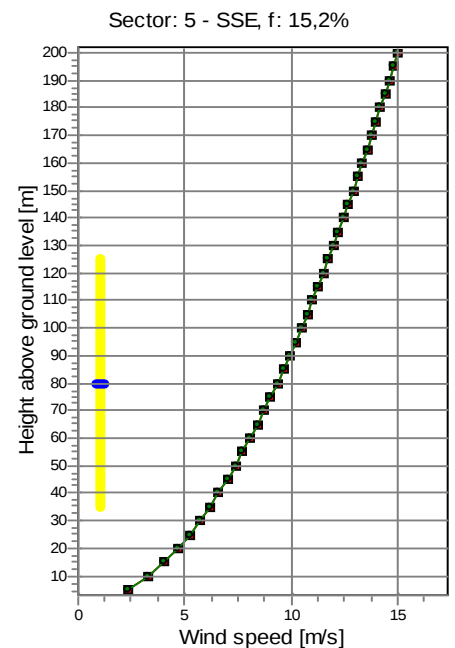
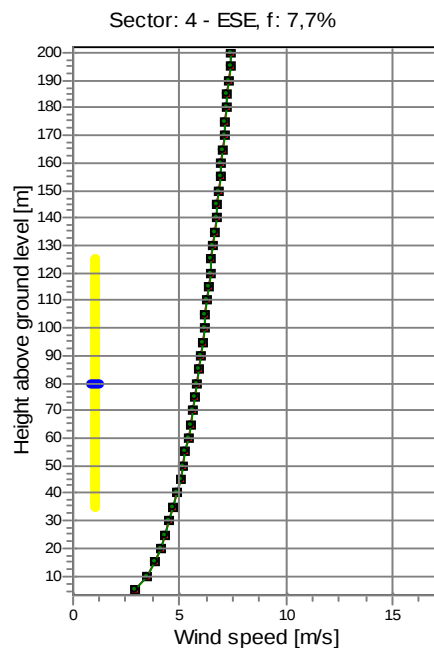
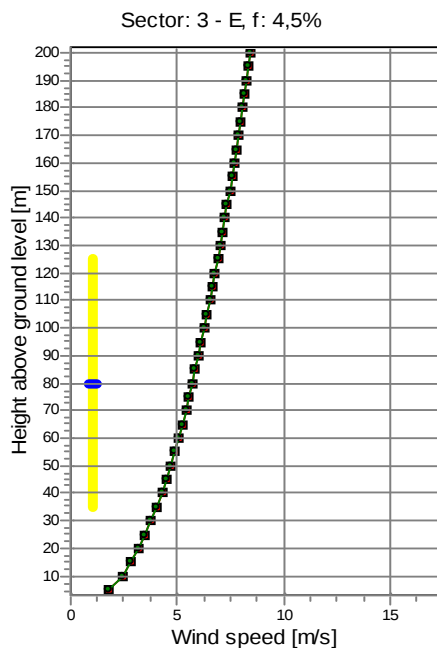
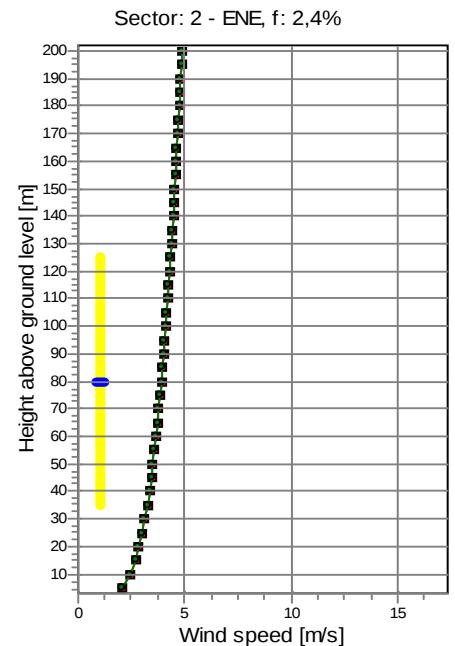
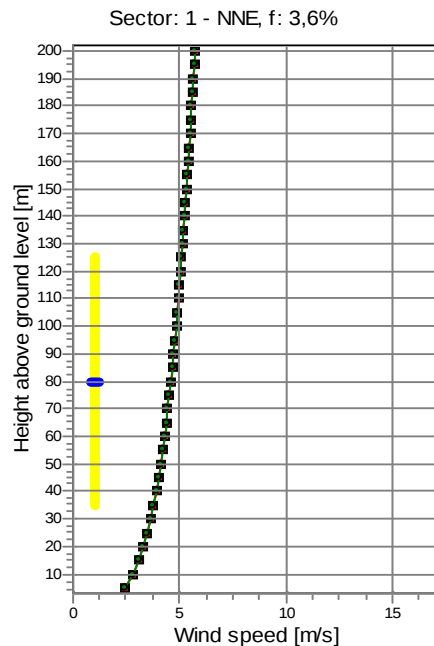
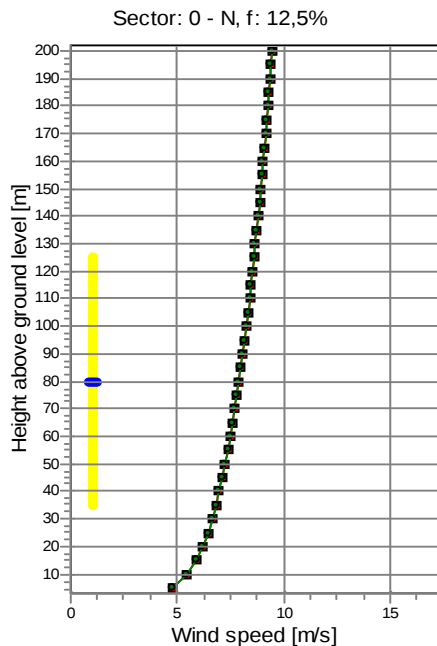
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METEO - Wind profile detailed**WTG: VESTAS V90 3000 90.0 !O! Level 0 - - 109.4 dB(A) - 03-2007, Hub height: 80,0 m**

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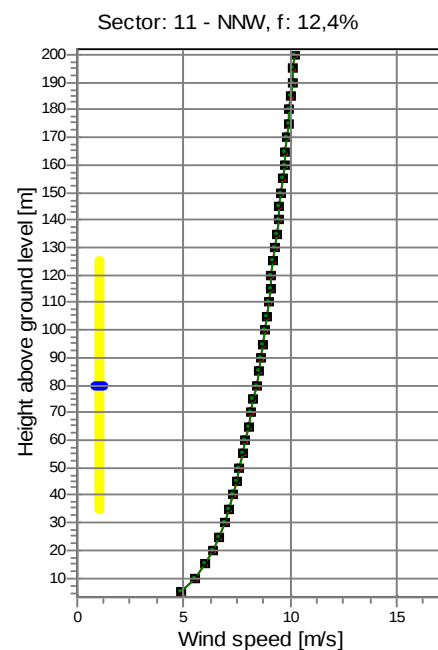
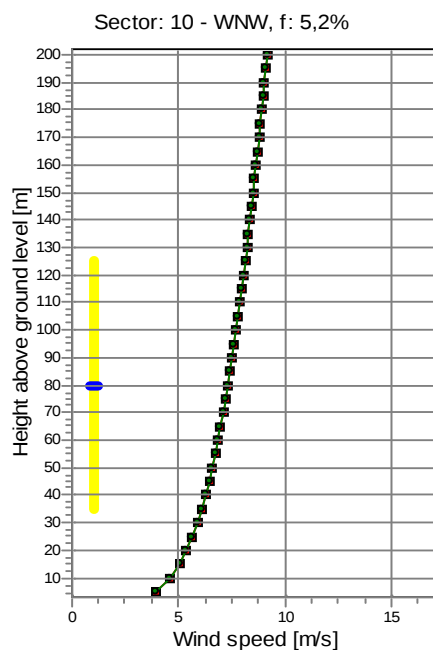
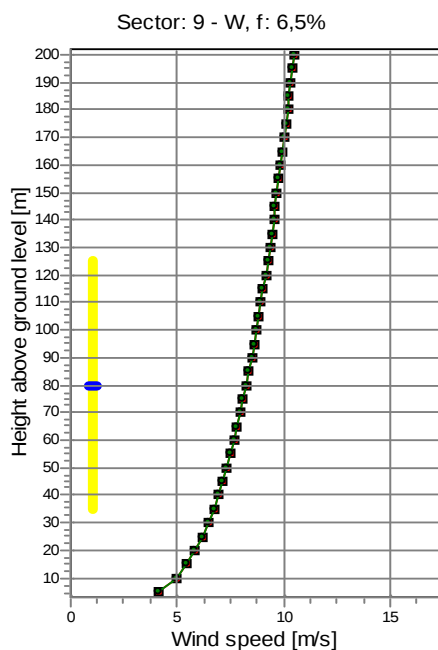
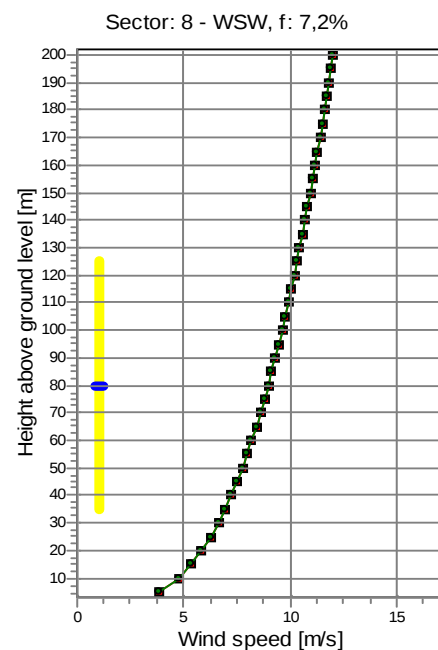
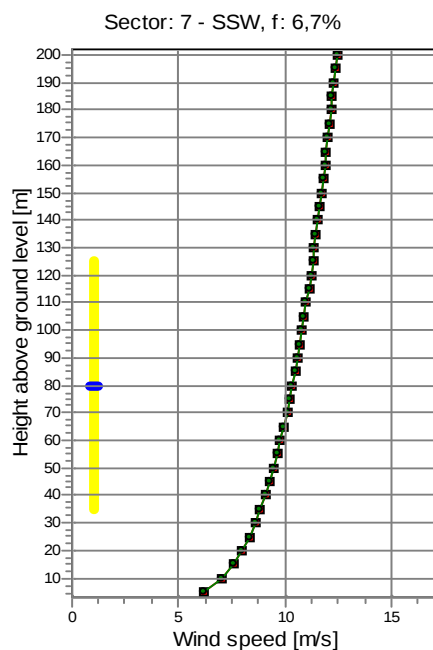
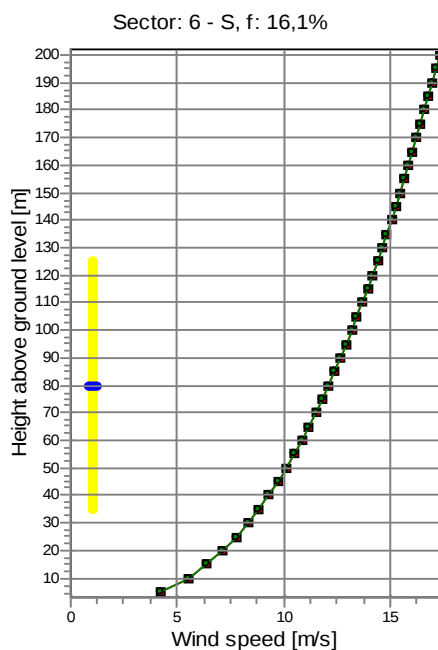
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METEO - Wind profile detailed**WTG: VESTAS V90 3000 90.0 !O! Level 0 - - 109.4 dB(A) - 03-2007, Hub height: 80,0 m**

9. ANNEX 2 MCP relations between the Long term data and Kollsnes measurements

Project:

Kollsnes

Description:

Data from file(s)

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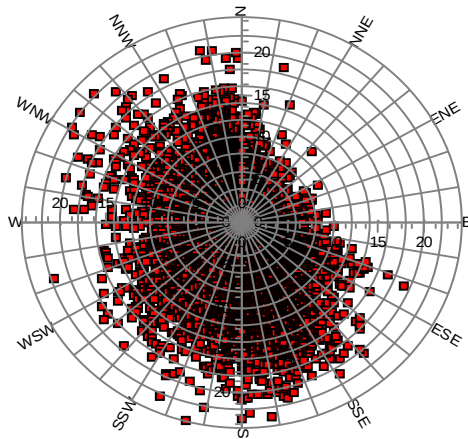
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Calculated:

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Meteo data report, height: 10,0 m

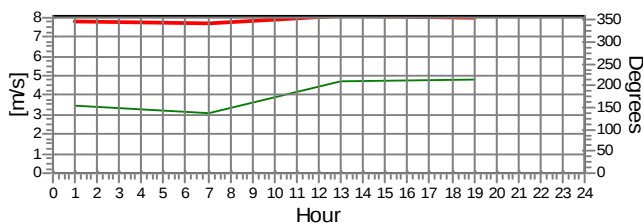
Name of meteo object: Hellsø Ny



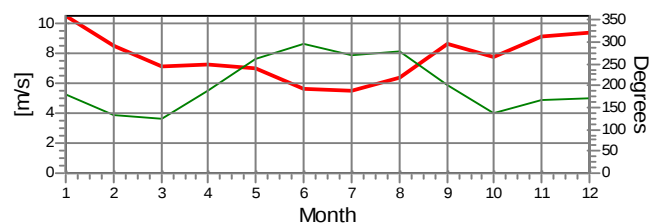
Wind speed [m/s]

Monthly mean values of wind speed in m/s

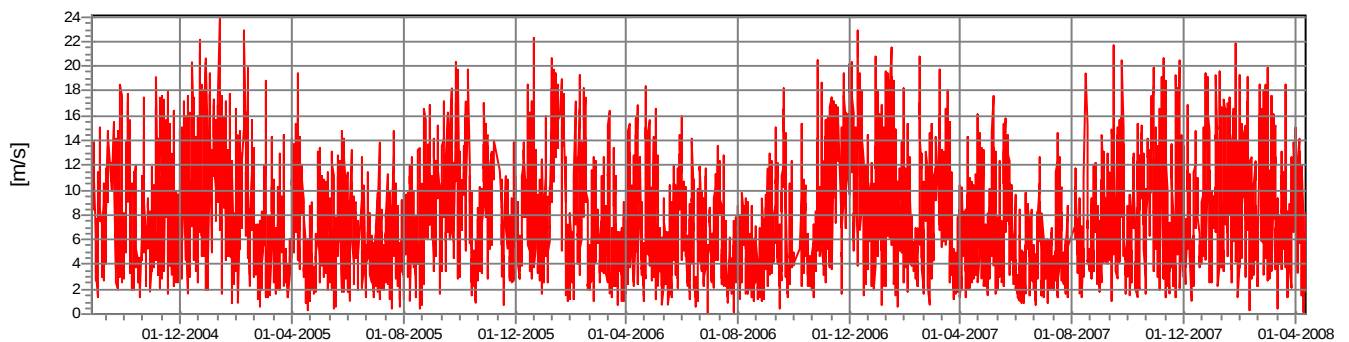
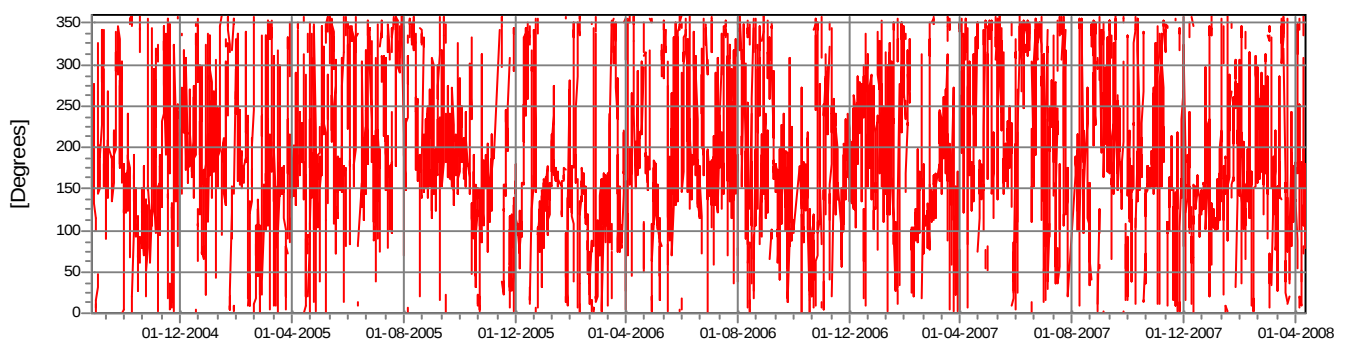
Month	2004	2005	2006	2007	2008	mean	mean of months
Jan		11,3	10,3	10,2	10,2	10,5	10,5
Feb		8,5	7,9	7,7	9,7	8,5	8,4
Mar		6,1	6,2	8,1	8,4	7,2	7,2
Apr		7,1	7,9	6,9	6,9	7,2	7,2
May		7,2	6,5	7,5		7,0	7,0
Jun		5,9	6,3	4,7		5,6	5,6
Jul			5,7	5,0		5,5	5,5
Aug	8,6	7,5	4,8	6,4		6,3	6,8
Sep	8,9	10,3	6,9	8,6		8,7	8,7
Oct	7,3	8,4	6,2	8,8		7,8	7,7
Nov	9,3	7,5	11,0	8,7		9,2	9,1
Dec	10,5	8,5	10,5	8,4		9,5	9,5
mean, all data	9,0	7,9	7,5	7,6	9,2	7,9	
mean of months	8,9	7,8	7,5	7,6	8,8		7,8



— Wind speed. Height: 10,0 m — Wind direction. Height: 10,0 m



— Wind speed. Height: 10,0 m — Wind direction. Height: 10,0 m

Wind speed**Wind direction**

Project:

Kollsnes

Description:

Data from file(s)

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Meteo data report, height: 10,0 m

Name of meteo object: Hellsøy Ny

Frequency

Wind speed	Sum	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
0,00 - 0,49	5	1	1	0	1	0	0	1	0	0	0	1	0
0,50 - 1,49	92	6	9	13	9	12	9	6	7	7	2	8	4
1,50 - 2,49	259	16	16	26	35	38	19	17	19	29	12	20	12
2,50 - 3,49	410	39	34	34	67	44	24	20	21	23	30	30	44
3,50 - 4,49	491	52	52	21	81	65	33	24	20	20	27	39	57
4,50 - 5,49	480	66	33	18	54	62	45	42	38	16	19	36	51
5,50 - 6,49	469	81	14	8	34	56	66	38	25	28	24	35	60
6,50 - 7,49	420	61	10	2	24	53	52	54	31	37	27	19	50
7,50 - 8,49	410	66	11	7	13	50	56	51	24	36	19	22	55
8,50 - 9,49	378	47	3	0	5	29	80	63	30	36	22	21	42
9,50 - 10,49	348	40	2	1	1	30	66	59	35	33	13	20	48
10,50 - 11,49	295	25	2	0	2	21	62	61	40	19	14	21	28
11,50 - 12,49	238	17	0	0	1	8	59	58	30	27	10	12	16
12,50 - 13,49	227	21	0	0	0	8	63	60	26	15	5	7	22
13,50 - 14,49	161	9	0	0	0	11	39	45	17	14	4	7	15
14,50 - 15,49	132	6	1	0	0	2	32	45	18	7	3	10	8
15,50 - 16,49	97	5	0	0	0	2	28	35	10	7	2	5	3
16,50 - 17,49	62	0	0	0	0	3	17	20	9	2	4	3	4
17,50 - 18,49	51	1	0	0	0	2	13	23	2	3	1	5	1
18,50 - 19,49	36	4	0	0	0	1	9	7	5	1	1	2	6
19,50 - 20,49	23	1	0	0	0	0	4	13	2	0	0	3	0
20,50 - 21,49	11	2	0	0	0	0	2	5	0	0	0	1	1
21,50 - 22,49	7	0	0	0	0	0	0	2	1	1	0	3	0
22,50 - 23,49	2	0	0	0	0	0	0	2	0	0	0	0	0
23,50 - 24,49	1	0	0	0	0	0	0	0	1	0	0	0	0
Sum	5.105	566	188	130	327	497	778	751	411	361	239	330	527

Project:

Kollsnes

Description:

Data from file(s)

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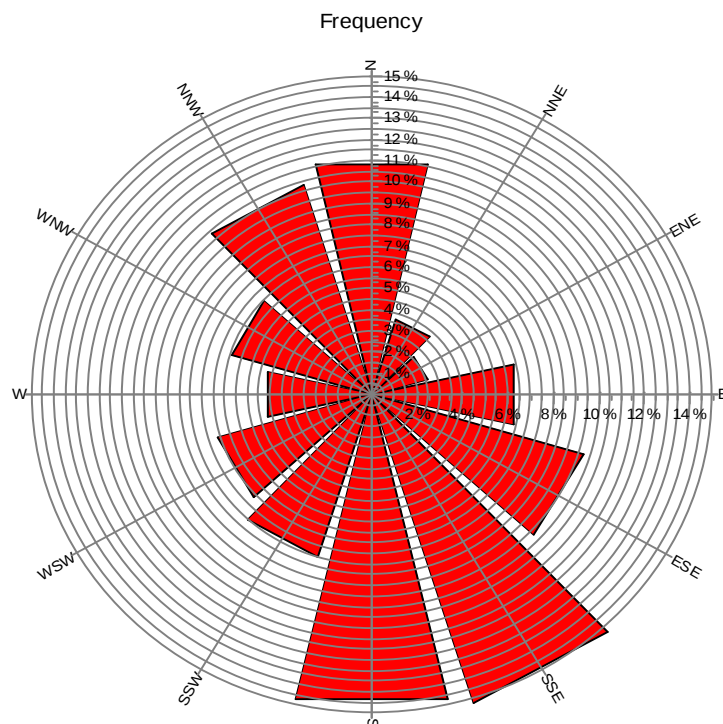
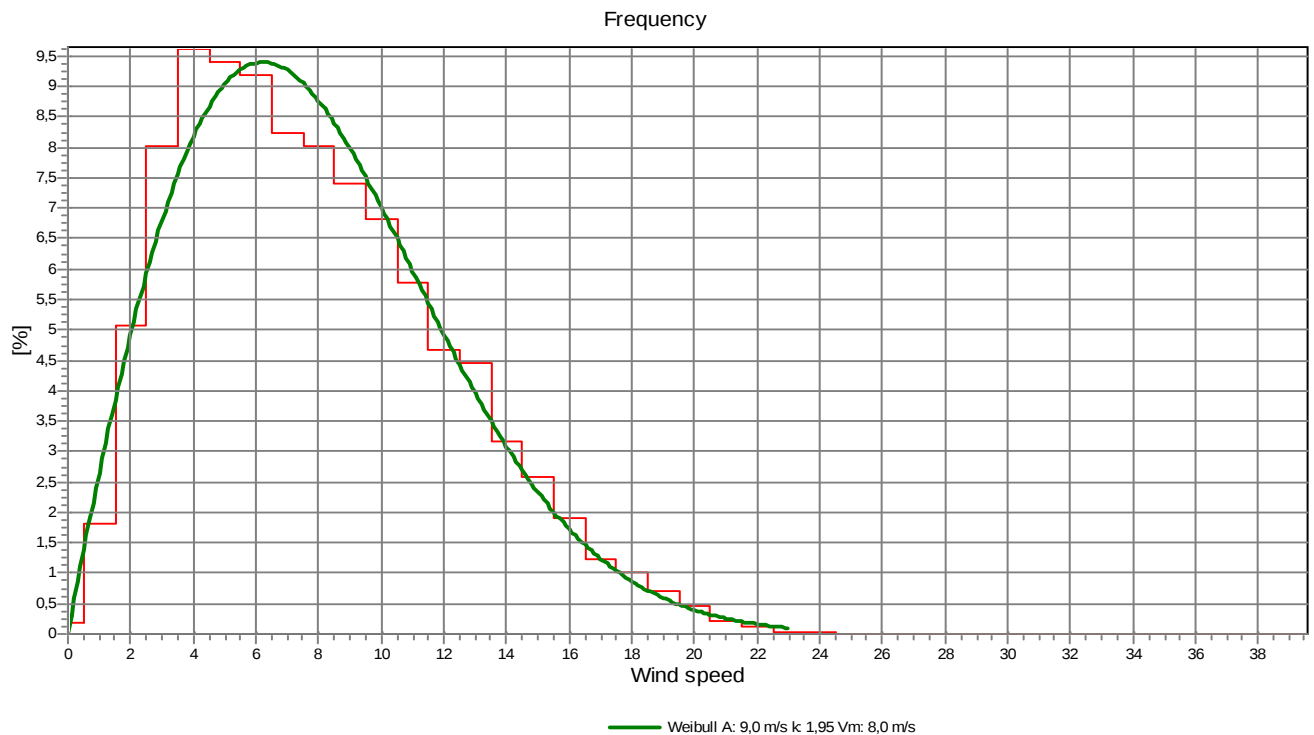
www.kentec.dk

Calculated:

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Meteo data report, height: 10,0 m

Name of meteo object: Hellsøy Ny



Project:

Kollsnes

Description:

Data from file(s)

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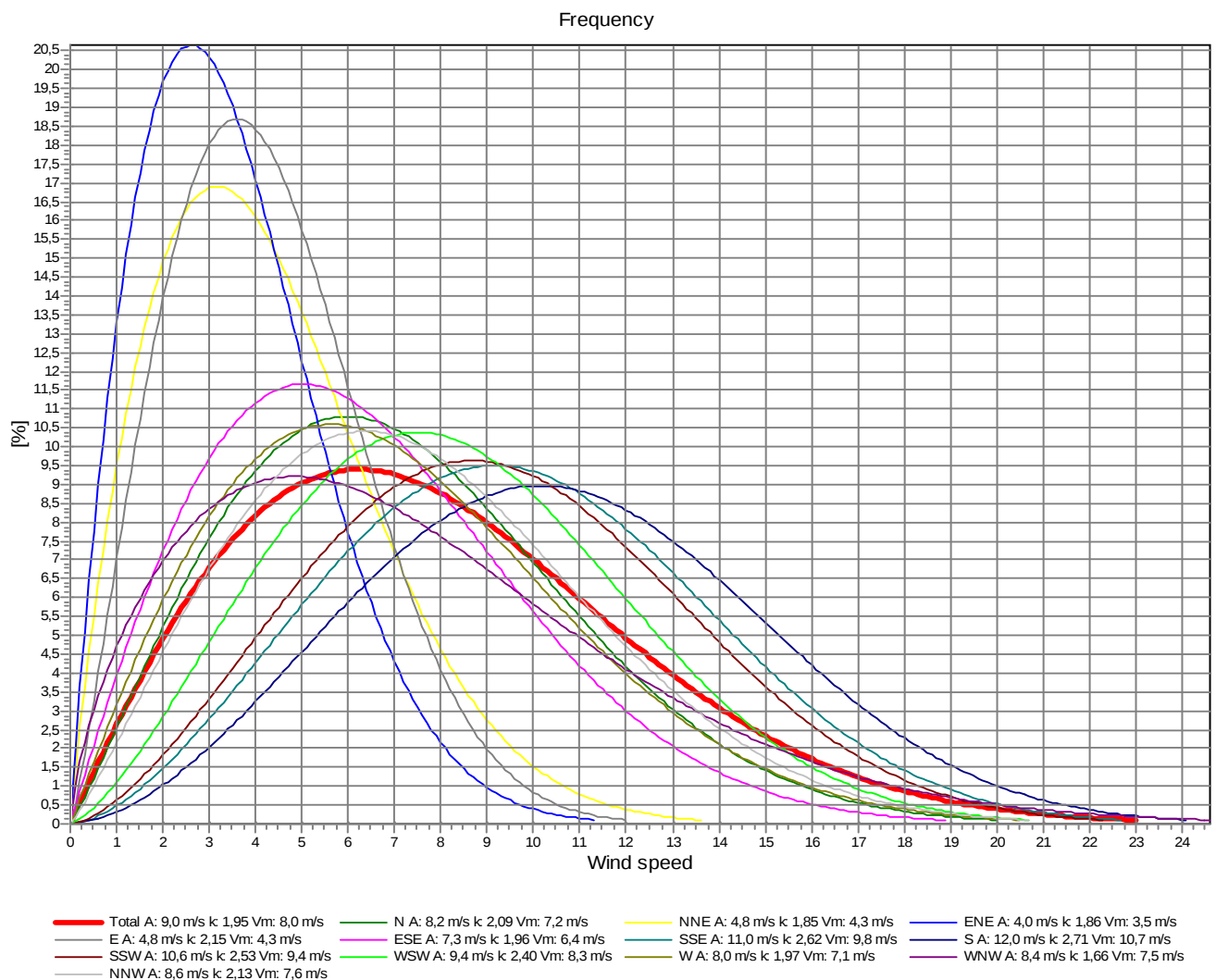
Meteo data report, height: 10,0 m

Name of meteo object: Hellsøy Ny

Weibull Data

k-parameter correction: 0,0080/m

Sector	A- parameter [m/s]	Mean wind speed [m/s]	k- parameter	Frequency	Frequency [%]	Wind shear
0-N	8,17	7,24	2,089	11,09	11,1	0,00
1-NNE	4,83	4,29	1,847	3,68	3,7	0,00
2-ENE	3,97	3,52	1,857	2,55	2,5	0,00
3-E	4,82	4,27	2,150	6,41	6,4	0,00
4-ESE	7,25	6,43	1,957	9,74	9,7	0,00
5-SSE	11,03	9,80	2,620	15,24	15,2	0,00
6-S	12,03	10,70	2,714	14,71	14,7	0,00
7-SSW	10,59	9,40	2,532	8,05	8,1	0,00
8-WSW	9,41	8,34	2,397	7,07	7,1	0,00
9-W	8,03	7,12	1,975	4,68	4,7	0,00
10-WNW	8,39	7,50	1,661	6,46	6,5	0,00
11-NNW	8,59	7,61	2,129	10,32	10,3	0,00
mean	8,99	7,97	1,953	100,00	100,0	0,00



Project:

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MCP - Measure data - overview

Meteo data objects

1: Local measurements (site data): Kollsnes Wind measurement station (height: 50,00)

First date: 09-02-2007

Last date: 04-03-2008

Time step: 10 min

Data points: 56159

Enabled: 100,0 %

Mean wind speed: 7,44 m/s

Time Series Data: Yes

2: Long term reference: Hellsø Ny (height: 10,00)

First date: 26-08-2004

Last date: 11-04-2008

Time step: 360 min

Data points: 5104

Enabled: 100,0 %

Mean wind speed: 7,97 m/s

Time Series Data: Yes

Project:

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MCP - Concurrent data - overview

Local measurements (site data): Kollsnes Wind measurement station (height: 50,00)

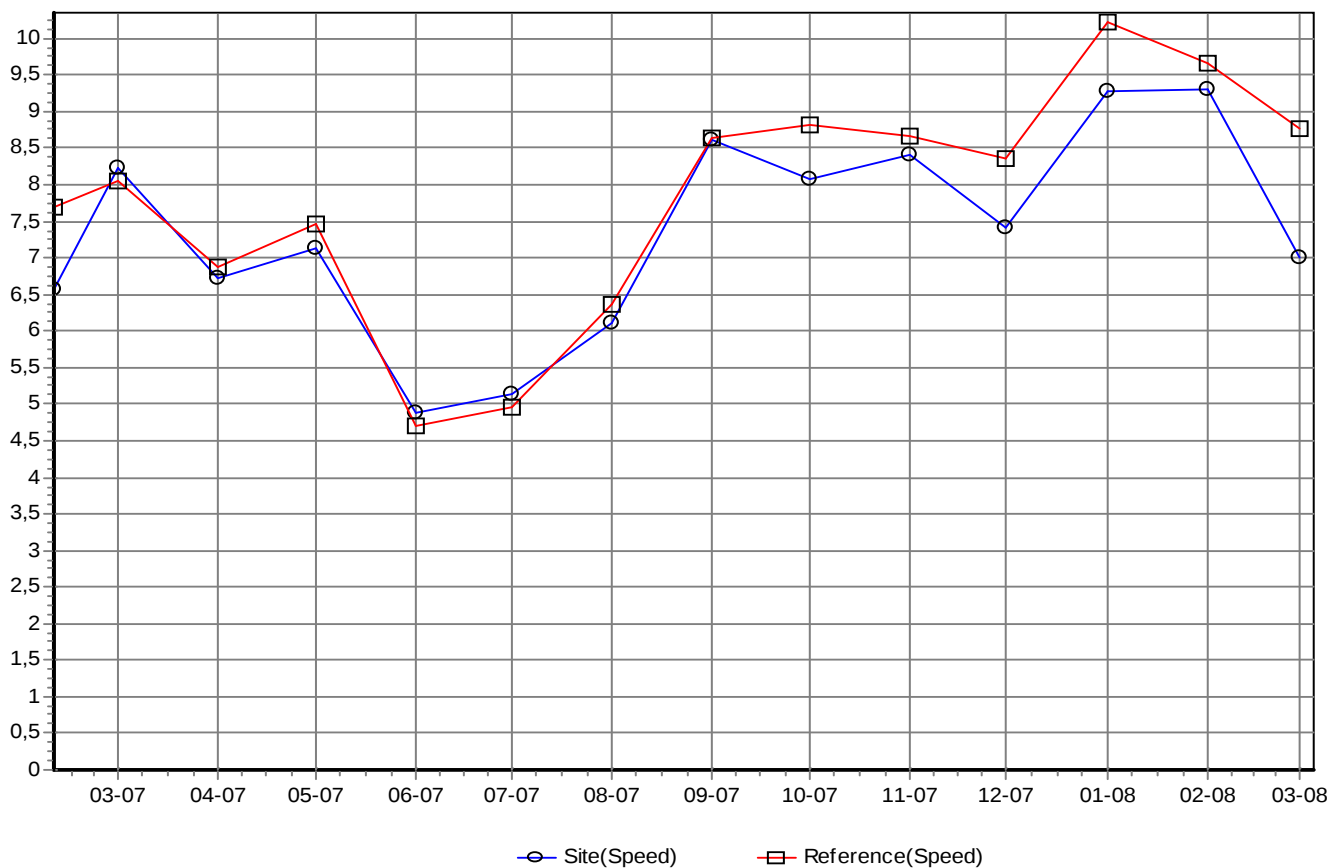
Long term reference (time series): Hellsø Ny (height: 10,00)

First observation: 09-02-2007 01:00

Last observation: 04-03-2008 19:00

Sector wise data

Sector	Count	Site wind speed		Ref wind speed		Ratio (site/ref)		Wind veer (site-ref)		Correlation
		Mean [m/s]	Standard deviation [m/s]	Mean [m/s]	Standard deviation [m/s]	Mean	Standard deviation	Mean [deg]	Standard deviation [deg]	
All	1503	7,43	4,0	7,79	4,2	0,978	0,236	7,8	22,4	0,8840
N	183	6,86	3,6	7,04	3,4	1,023	0,229	1,9	19,4	0,8453
NNE	49	4,26	1,8	4,08	1,3	1,196	0,276	17,5	30,7	0,5326
ENE	27	3,79	1,2	2,85	1,1	1,186	0,105	16,8	37,7	0,5586
E	92	4,44	2,2	4,21	1,9	1,115	0,212	11,4	30,6	0,7155
ESE	153	5,73	2,9	6,33	3,6	0,877	0,207	10,7	25,5	0,8317
SSE	242	8,36	3,4	9,85	4,0	0,860	0,163	9,5	18,5	0,8780
S	184	10,16	4,3	10,27	4,4	0,997	0,210	5,8	18,3	0,9134
SSW	110	8,75	4,2	9,18	4,4	0,970	0,140	0,7	21,2	0,9332
WSW	98	8,12	4,1	8,24	4,0	1,032	0,368	7,7	24,7	0,8158
W	86	7,47	3,8	7,17	3,7	1,069	0,305	8,1	20,2	0,8346
WNW	98	5,79	3,5	6,87	4,5	0,863	0,197	8,0	27,1	0,9190
NNW	181	8,05	4,0	7,74	3,7	1,061	0,205	9,5	15,3	0,9058
										0,8502



Project:

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MCP - Measure data - overview

Meteo data objects

1: Local measurements (site data): Kollsnes Wind measurement station (height: 50,00)

First date: 09-02-2007

Last date: 04-03-2008

Time step: 10 min

Data points: 56159

Enabled: 100,0 %

Mean wind speed: 7,44 m/s

Time Series Data: Yes

2: Long term reference: Hellsø Ny (height: 10,00)

First date: 26-08-2004

Last date: 11-04-2008

Time step: 360 min

Data points: 5104

Enabled: 100,0 %

Mean wind speed: 7,97 m/s

Time Series Data: Yes

Project:

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MCP - Detailed Statgen

Name

Kollsnes Wind measurement station (Regression MCP using Hellsøy Ny)

Source

USER

Country

Norway

Site Coordinates

UTM WGS 84 Zone: 31 East: 600.899 North: 6.715.098

Comments

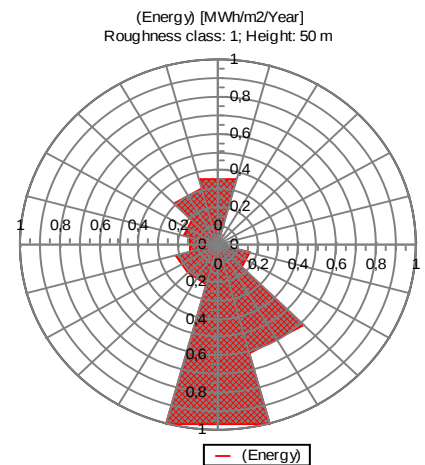
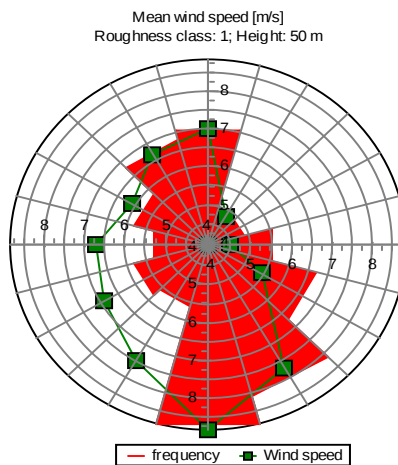
From MCP

Mean wind speed [m/s]

Roughness class/Length					
Height	0	1	2	3	
[m]	0,00 m	0,03 m	0,10 m	0,40 m	
10,0	7,14	5,03	4,38	3,46	
25,0	7,81	5,98	5,39	4,53	
50,0	8,37	6,87	6,28	5,45	
100,0	9,04	8,06	7,41	6,52	
200,0	9,93	9,85	9,00	7,88	

Wind energy [kWh/m2/Year]

Roughness class/Length					
Height	0	1	2	3	
[m]	0,00 m	0,03 m	0,10 m	0,40 m	
10,0	3.779	1.534	1.017	496	
25,0	4.821	2.415	1.772	1.060	
50,0	5.803	3.325	2.581	1.711	
100,0	7.464	5.043	3.894	2.656	
200,0	10.278	9.404	7.149	4.741	



WTG energy [kWh/m2/Year]

Normal rated WTG (0.45 kW/m2)

Roughness class/Length					
Height	0	1	2	3	
[m]	0,00 m	0,03 m	0,10 m	0,40 m	
10,0	1.115	467	-	-	
25,0	1.328	745	572	-	
50,0	1.493	1.029	839	589	
100,0	1.680	1.408	1.201	918	
200,0	1.903	1.882	1.670	1.352	

High wind rated WTG (0.55 kW/m2)

Roughness class/Length					
Height	0	1	2	3	
[m]	0,00 m	0,03 m	0,10 m	0,40 m	
10,0	1.215	468	-	-	
25,0	1.474	785	587	-	
50,0	1.671	1.113	893	607	
100,0	1.892	1.571	1.320	984	
200,0	2.159	2.134	1.880	1.504	

Low wind rated WTG (0.35 kW/m2)

Roughness class/Length					
Height	0	1	2	3	
[m]	0,00 m	0,03 m	0,10 m	0,40 m	
10,0	1.027	447	-	-	
25,0	1.200	706	544	-	
50,0	1.313	954	788	561	
100,0	1.430	1.261	1.096	857	
200,0	1.653	1.632	1.420	1.219	

Key numbers

Wind energy is relative to 3300 kWh/m2/year for roughness class 1 and 50 m hub height

WTG energy is relative to 1025 kWh/m2/year for roughness class 1 and 50 m hub height

Name	Distance [km]	Wind energy [%]	WTG energy [%]
Current wind statistic		100,8	100,4
Kollsnes (Regression MCP using Bergen Flesland)	0,0	80,8	77,3
Kollsnes (Regression MCP using Utsira fyr)	0,0	68,2	68,5
10,00 m Hellsøy	1,9	103,1	103,7

Project:

Kollsnes

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MCP - Regression MCP

1: Local measurements (site data) Kollsnes Wind measurement station
Height 50,00 m
Period 09-02-2007 to 04-03-2008 1,1 years
Mean wind speed 7,44 m/s
Filters used Not Filtered

2: Long term reference Hellsø Ny
Height 10,00 m
Period 26-08-2004 to 11-04-2008 3,6 years
Mean wind speed 7,97 m/s
Filters used Not Filtered

Calculation setup

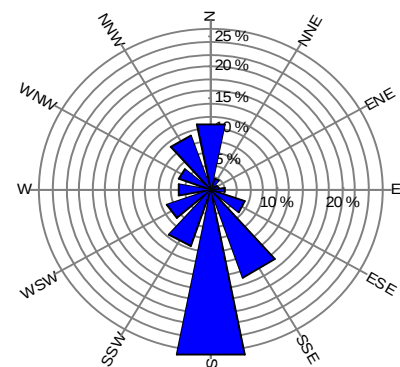
Method Find transfer function for each 1 degree
Sector window 30,00 [deg]
Skip angle differences larger than 360,00
Skip wind speeds less than 2,00
Regression model (wind speed) Linear (1st order polynomial)
Regression model (wind direction) Constant (0th order polynomial)
Wind speed model - use residual resampling Yes
Wind direction model - use residual resampling No

Results

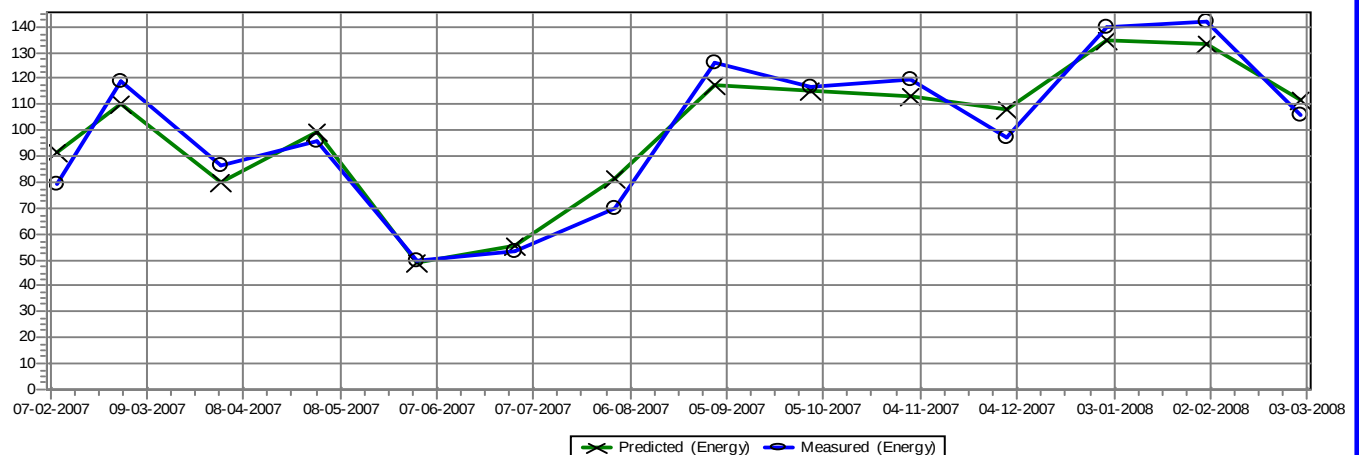
Measure height 50,0 m
Mean wind in measure height 7,60 m/s
Key height 50,0 m
Mean wind in key height 7,57 m/s
Wind energy 100,8
WTG energy 100,4
r - wind speed 0,8068
s - wind speed 2,2887 m/s
r - wind index 0,9682
s - wind index 4,6645 %
Time of calculation 14-04-2008 13:07

Expected long term WTG energy direction distribution AT SITE

Hub height: 50,0



Comparing measured and predicted data



Project:

Kollsnes

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MCP - Regression MCP report (basic/overview)**MCP method used:**

Regression MCP

Long term reference data:

Hellsø Ny

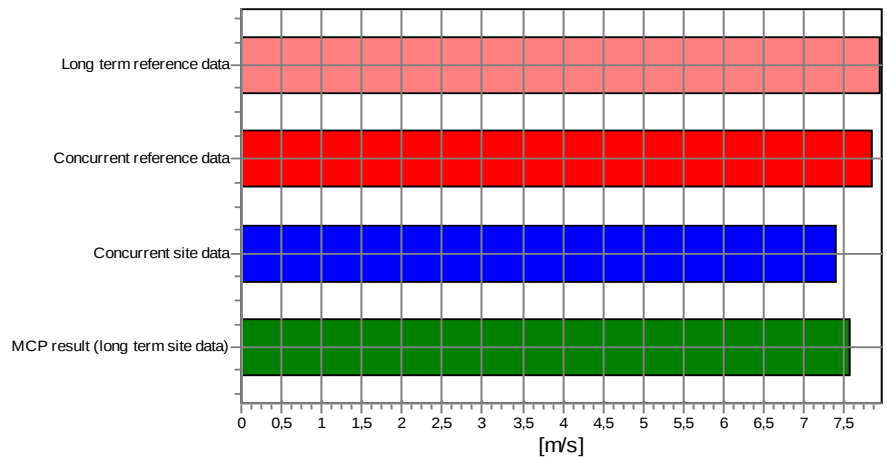
Height: 10,00

Concurrent site data:

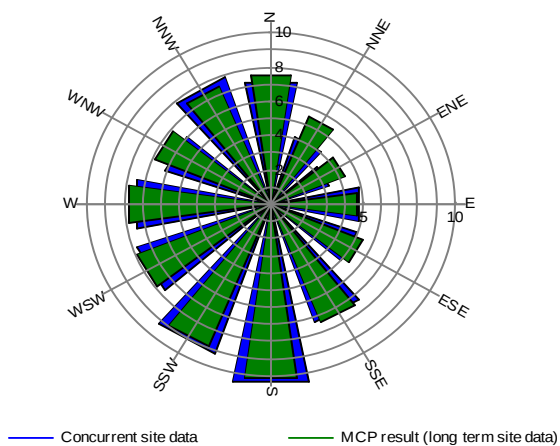
Kollsnes Wind measurement station

Height: 50,00

Mean wind speed in data

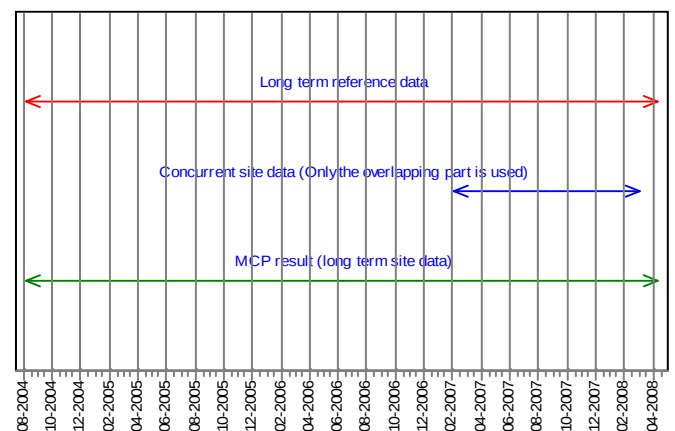
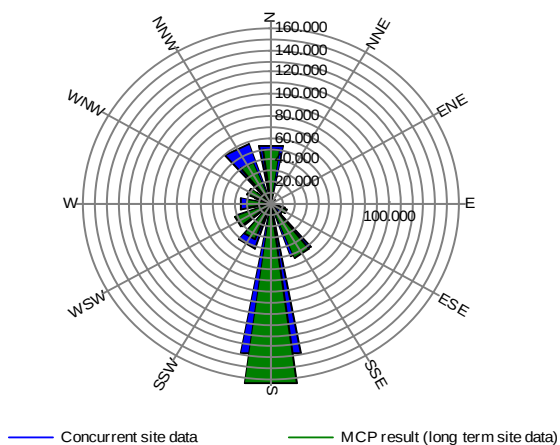


Mean value [m/s]

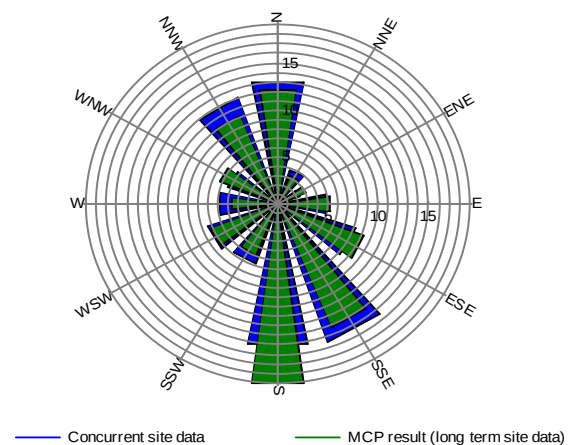


Timelines of MCP source data and result

Only the overlapping and enabled parts of the concurrent data are used

Energy [W/m²]

frequency [%]



Project:

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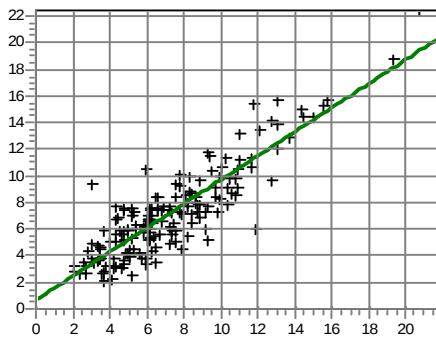
www.kentec.dk

Calculated:

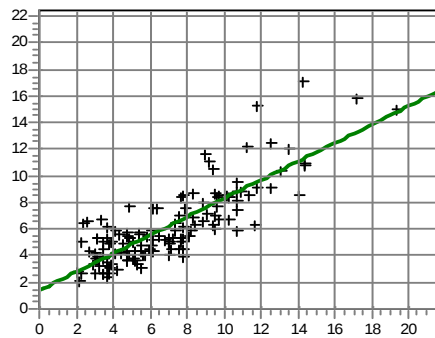
14-04-2008 13:08/2.5.7.81

MCP - Regression MCP report - details on wind speed fit

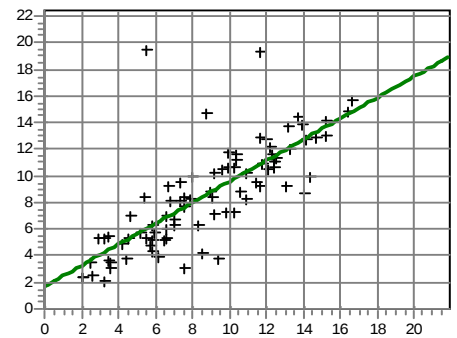
Winds in sector 0 degrees



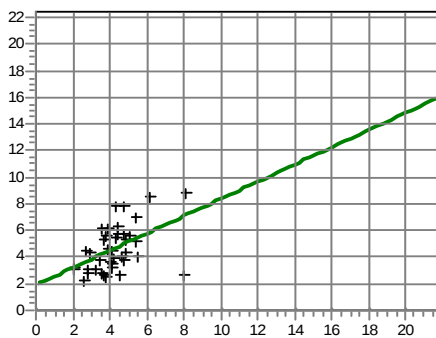
Winds in sector 120 degrees



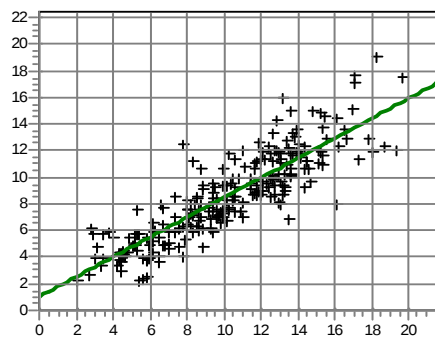
Winds in sector 240 degrees



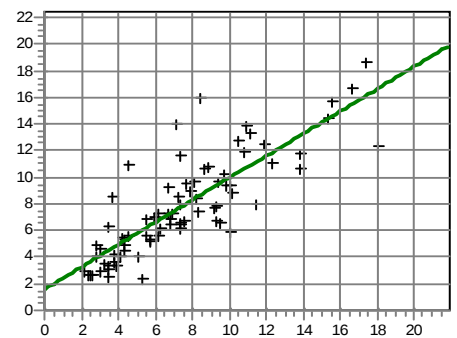
Winds in sector 30 degrees



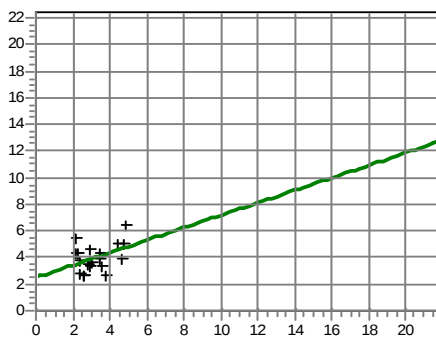
Winds in sector 150 degrees



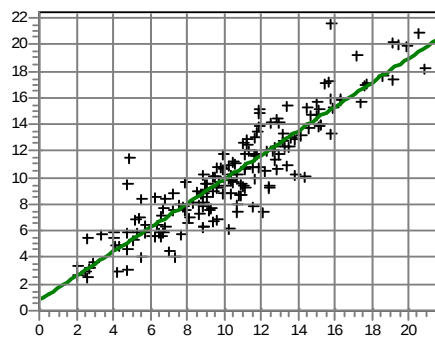
Winds in sector 270 degrees



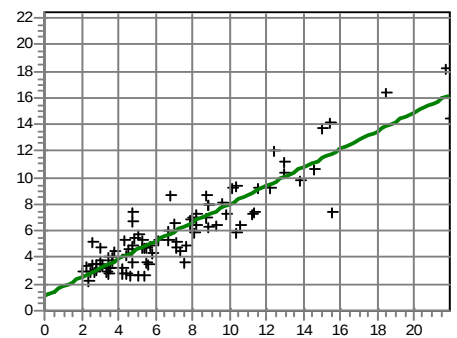
Winds in sector 60 degrees



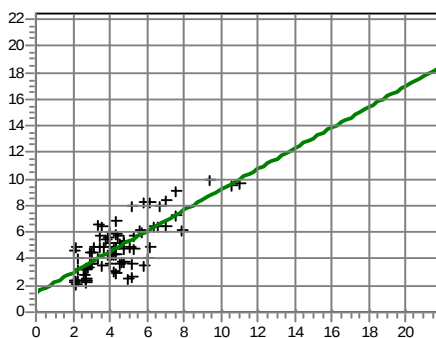
Winds in sector 180 degrees



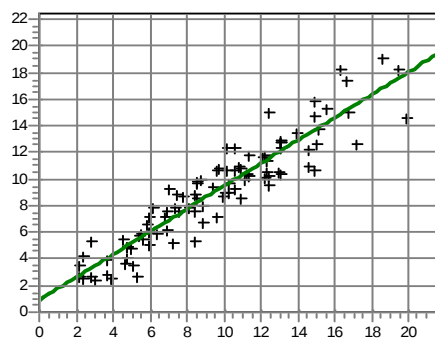
Winds in sector 300 degrees



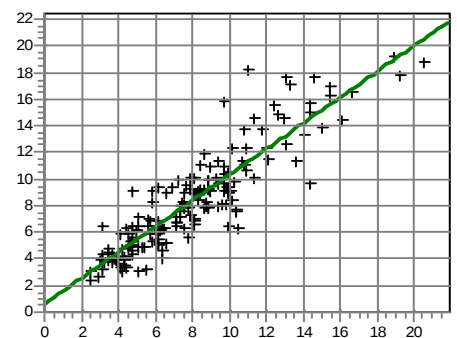
Winds in sector 90 degrees



Winds in sector 210 degrees



Winds in sector 330 degrees



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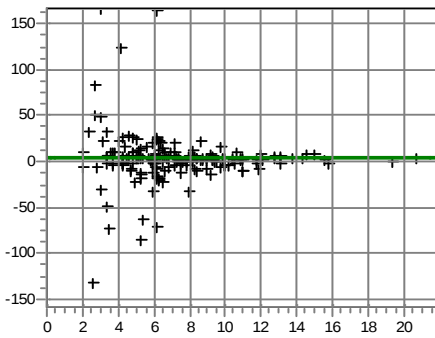
www.kentec.dk

Calculated:

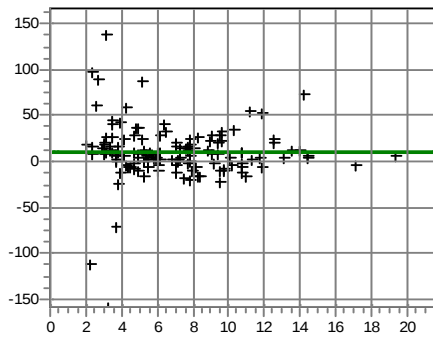
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MCP - Regression MCP report - details on wind veer fit

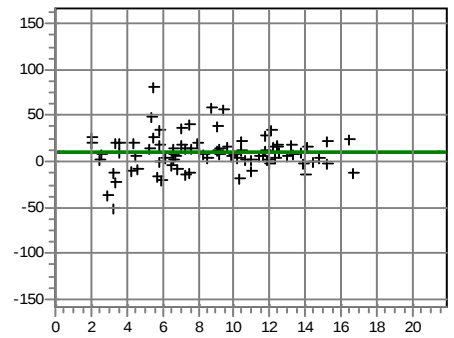
Wind veer in sector 0 degrees



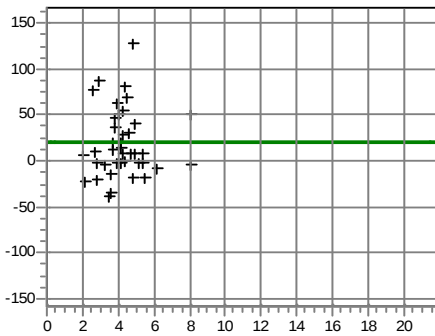
Wind veer in sector 120 degrees



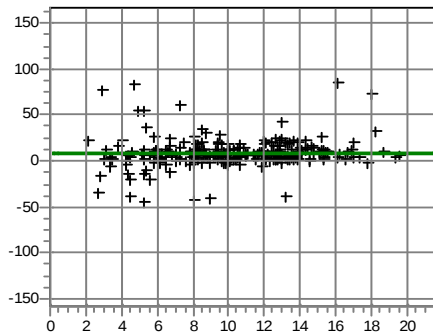
Wind veer in sector 240 degrees



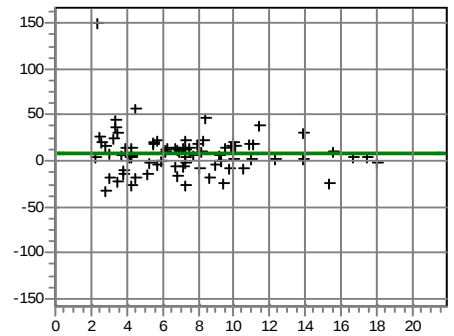
Wind veer in sector 30 degrees



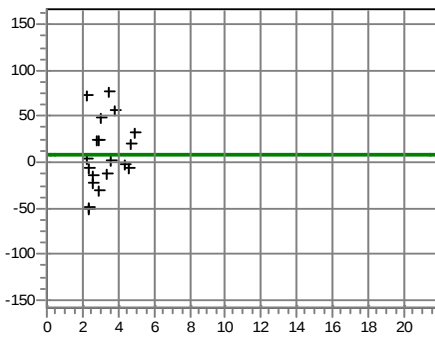
Wind veer in sector 150 degrees



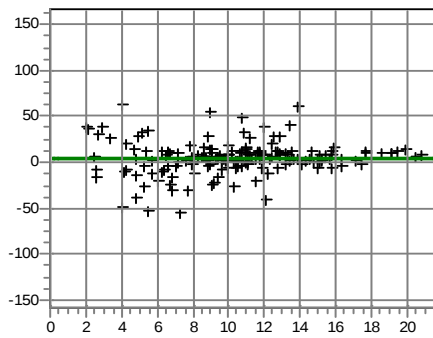
Wind veer in sector 270 degrees



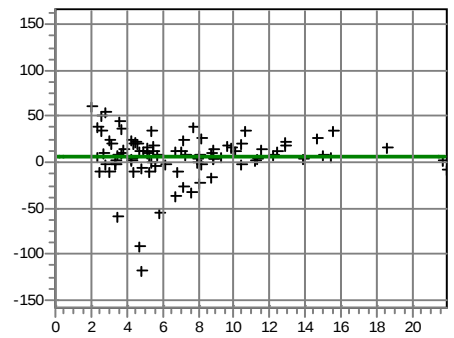
Wind veer in sector 60 degrees



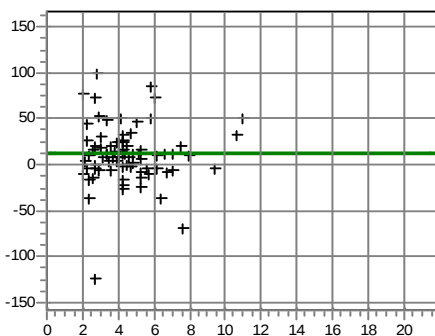
Wind veer in sector 180 degrees



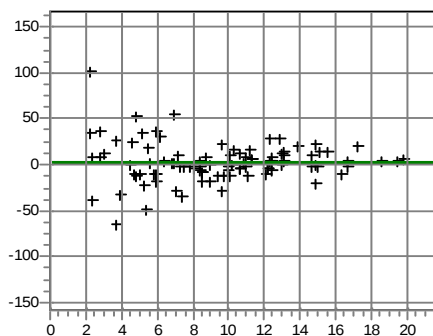
Wind veer in sector 300 degrees



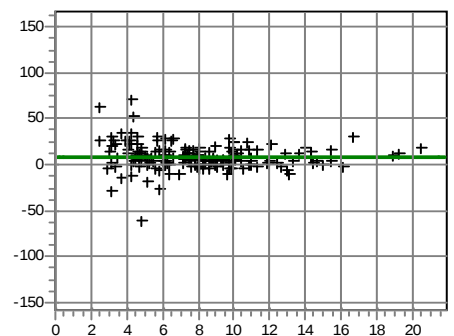
Wind veer in sector 90 degrees



Wind veer in sector 210 degrees



Wind veer in sector 330 degrees



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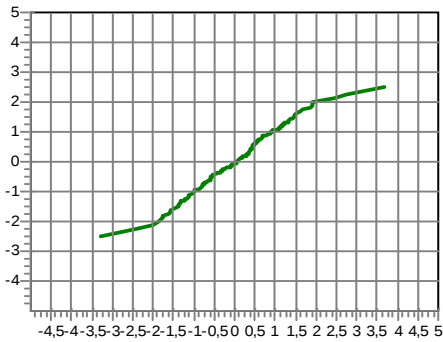
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Calculated:

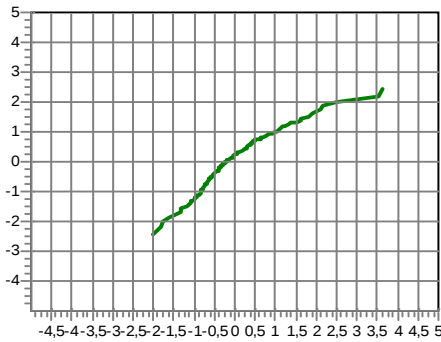
14-04-2008 13:08/2.5.7.81

MCP - Regression MCP report - details on wind speed residuals (Gauss paper)

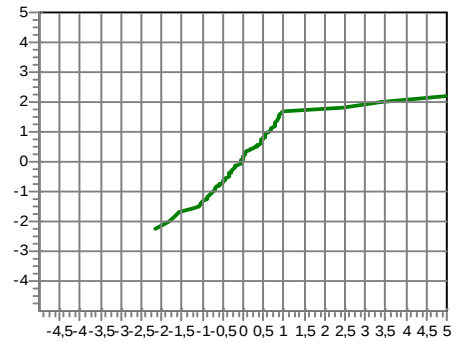
Wind Residuals (Sector 0 deg)



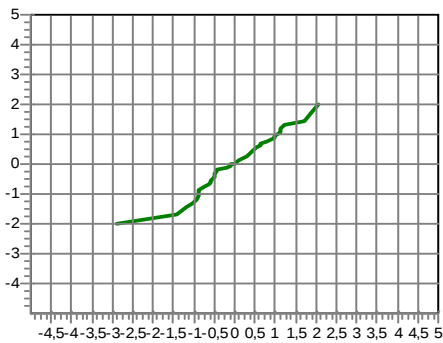
Wind Residuals (Sector 120 deg)



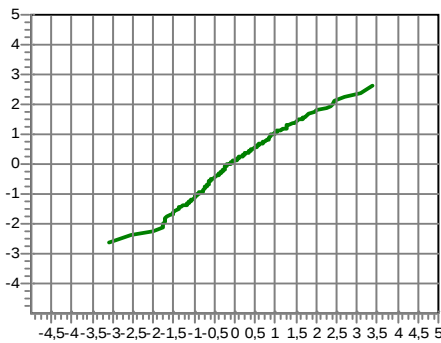
Wind Residuals (Sector 240 deg)



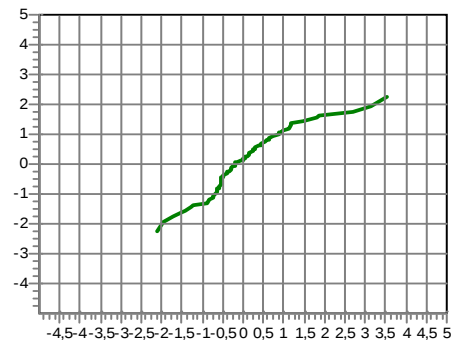
Wind Residuals (Sector 30 deg)



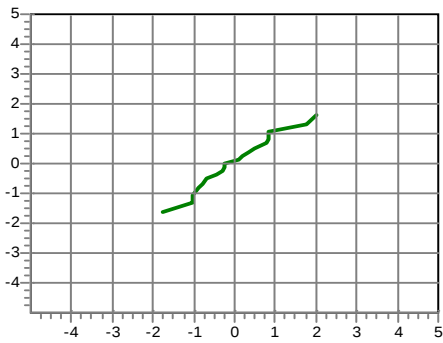
Wind Residuals (Sector 150 deg)



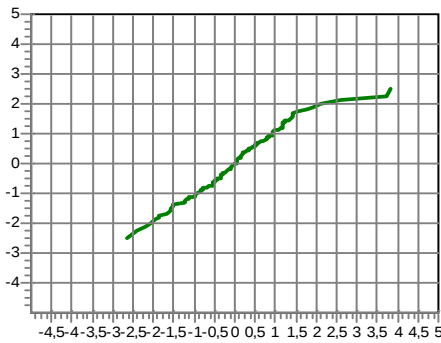
Wind Residuals (Sector 270 deg)



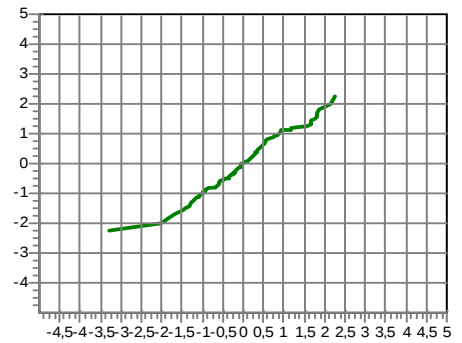
Wind Residuals (Sector 60 deg)



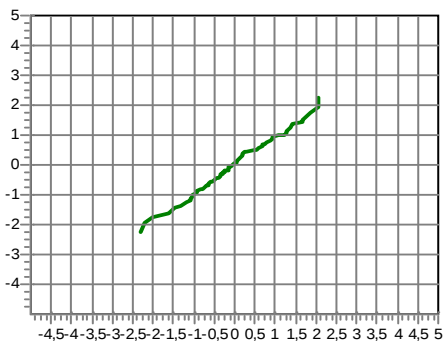
Wind Residuals (Sector 180 deg)



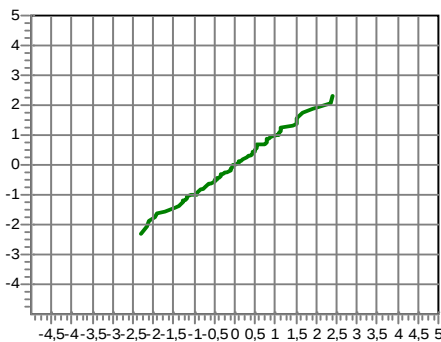
Wind Residuals (Sector 300 deg)



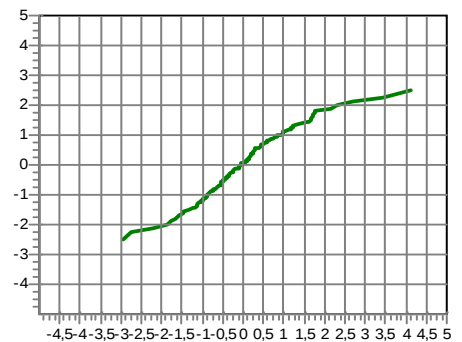
Wind Residuals (Sector 90 deg)



Wind Residuals (Sector 210 deg)



Wind Residuals (Sector 330 deg)



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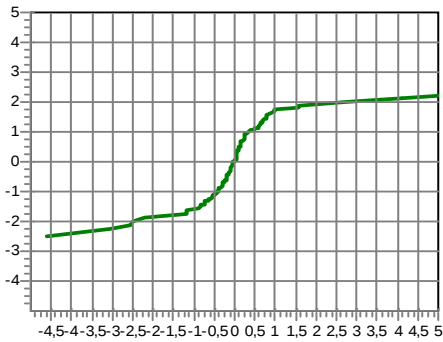
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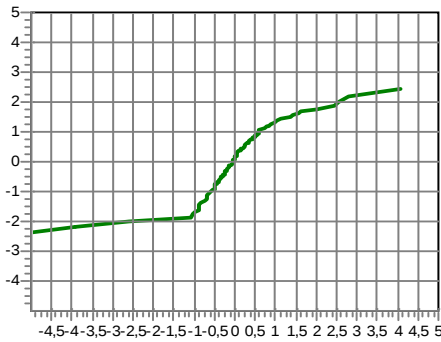
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MCP - Regression MCP report - details on wind veer residuals (Gauss paper)

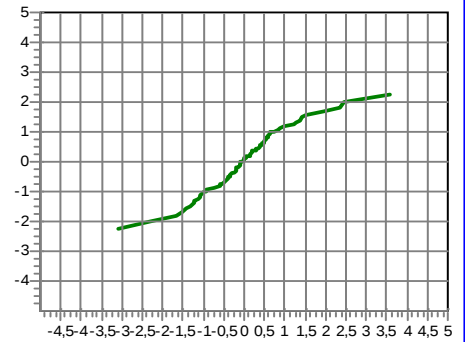
Wind Veer Residuals (Sector 0 deg)



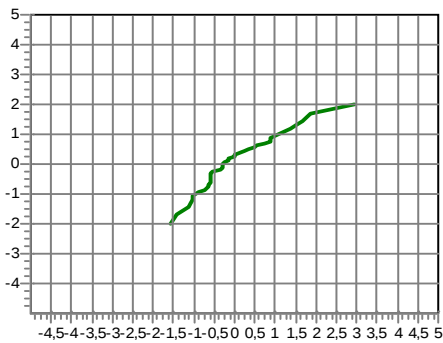
Wind Veer Residuals (Sector 120 deg)



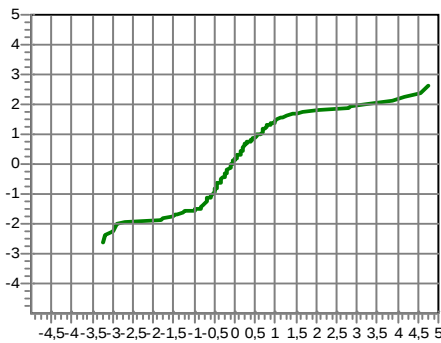
Wind Veer Residuals (Sector 240 deg)



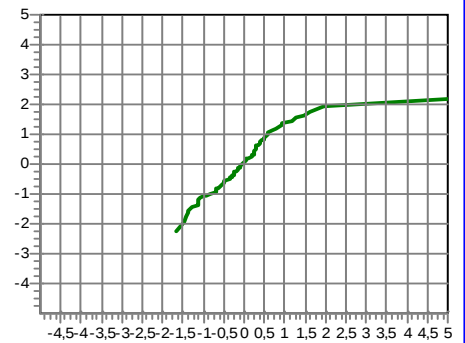
Wind Veer Residuals (Sector 30 deg)



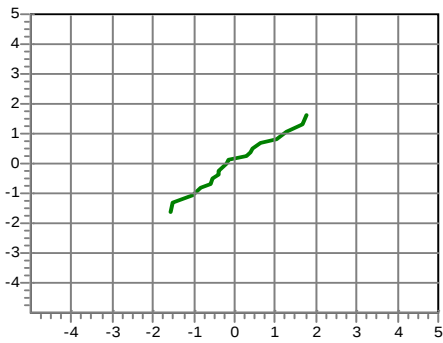
Wind Veer Residuals (Sector 150 deg)



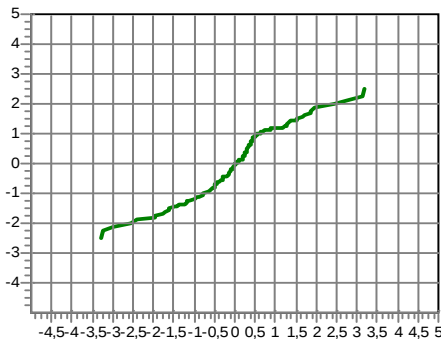
Wind Veer Residuals (Sector 270 deg)



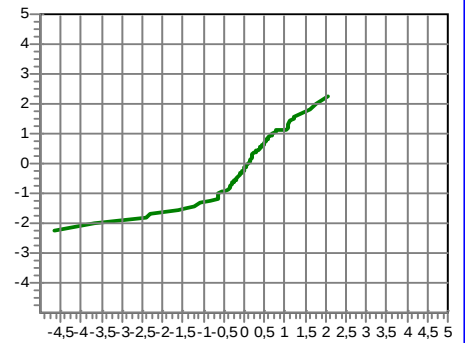
Wind Veer Residuals (Sector 60 deg)



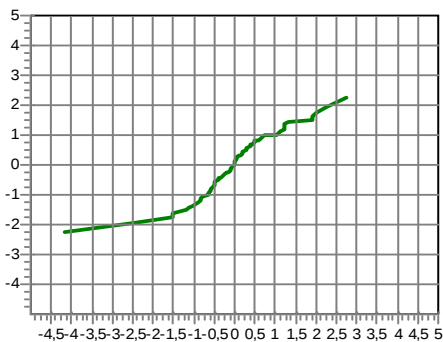
Wind Veer Residuals (Sector 180 deg)



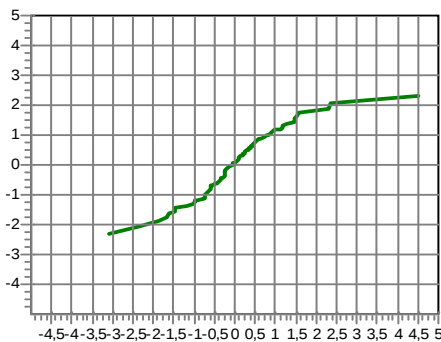
Wind Veer Residuals (Sector 300 deg)



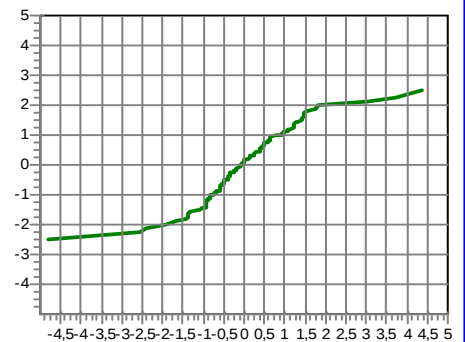
Wind Veer Residuals (Sector 90 deg)



Wind Veer Residuals (Sector 210 deg)



Wind Veer Residuals (Sector 330 deg)



10. ANNEX 3 Details of the Hellisoy station and Bergen Flesland Long term wind data.

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MCP - Measure data - overview

Meteo data objects

1: Local measurements (site data): Hellisøy Ny (height: 10,00)**First date:** 26-08-2004**Last date:** 11-04-2008**Time step:** 360 min**Data points:** 5104**Enabled:** 100,0 %**Mean wind speed:** 7,97 m/s**Time Series Data:** Yes**2: Long term reference:** Bergen Flesland (height: 10,00)**First date:** 09-03-2000**Last date:** 08-04-2008**Time step:** 139 min**Data points:** 11702**Enabled:** 100,0 %**Mean wind speed:** 3,85 m/s**Time Series Data:** Yes

Filter values

Filter for site data**Averaging time:** 360 min**Filter for reference data****Averaging time:** 360 min

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MCP - Concurrent data - overview

Local measurements (site data): Helligsøy Ny (height: 10,00) (filtered)

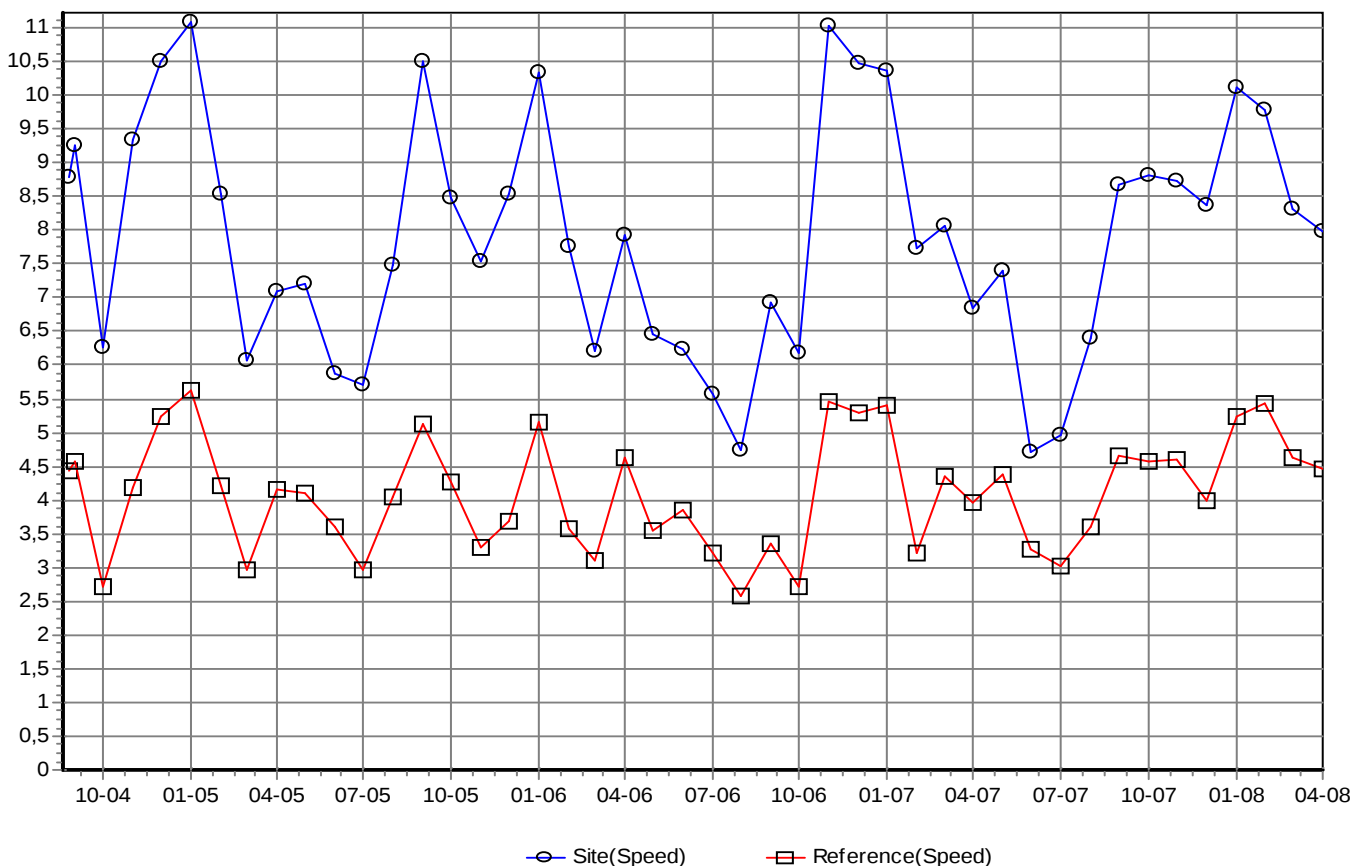
Long term reference (time series): Bergen Flesland (height: 10,00) (filtered)

First observation: 26-08-2004 18:00

Last observation: 08-04-2008 06:00

Sector wise data

Sector	Count	Site wind speed		Ref wind speed		Ratio (site/ref)		Wind veer (site-ref)		Correlation
		Mean [m/s]	Standard deviation [m/s]	Mean [m/s]	Standard deviation [m/s]	Mean	Standard deviation	Mean [deg]	Standard deviation [deg]	
All	4933	7,89	4,3	4,11	2,7	1,782	0,474	-3,5	32,7	0,8072
N	737	6,72	3,8	3,27	2,4	1,809	0,545	-4,3	34,8	0,7451
NNE	222	4,87	2,3	1,94	0,9	1,870	0,309	-5,2	45,8	0,3483
ENE	206	4,42	2,6	1,86	1,3	1,756	0,478	1,5	45,4	0,5425
E	145	5,12	2,3	1,95	1,1	1,676	0,327	0,8	33,1	0,3906
ESE	360	6,49	2,9	2,52	1,3	2,040	0,605	0,4	31,3	0,6178
SSE	951	9,47	4,1	4,46	2,3	2,022	0,431	2,3	28,4	0,8316
S	698	10,30	4,7	5,95	3,2	1,701	0,388	-3,9	28,1	0,8631
SSW	388	8,83	4,4	5,11	2,9	1,726	0,441	-8,3	29,7	0,8181
WSW	323	7,50	4,3	4,32	2,4	1,765	0,451	-7,4	38,3	0,8121
W	167	8,23	4,1	4,74	2,8	1,671	0,388	-5,6	30,0	0,8521
WNW	193	7,23	4,6	3,68	2,5	1,811	0,561	-11,9	38,7	0,7889
NNW	543	7,50	3,7	4,74	2,4	1,526	0,418	-7,6	26,5	0,7135
										0,7444



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Calculated:

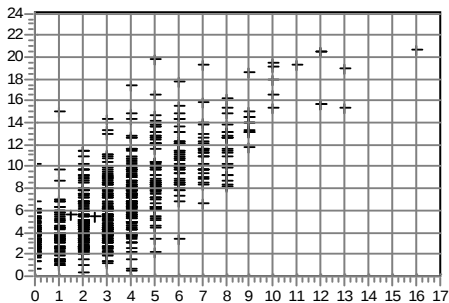
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MCP - Concurrent data - wind speeds

x-axis = Reference data (Bergen Flesland (height: 10,00)), y-axis = Site data (Hellisøy Ny (height: 10,00))

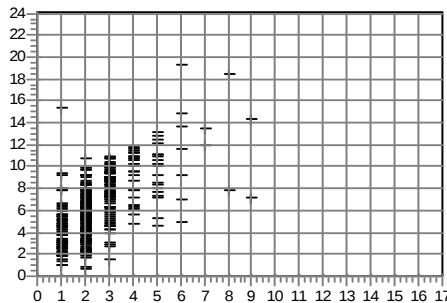
Sector from 345 to 15 degrees

Correlation: 0,7451



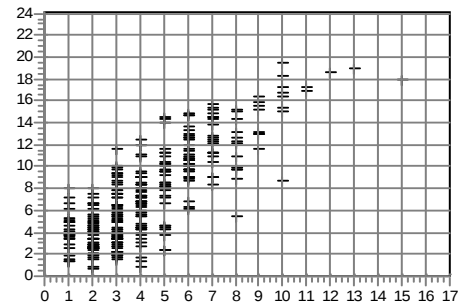
Sector from 105 to 135 degrees

Correlation: 0,6178



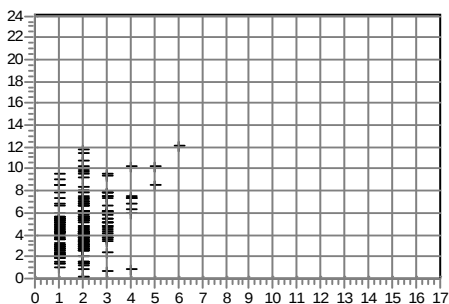
Sector from 225 to 255 degrees

Correlation: 0,8121



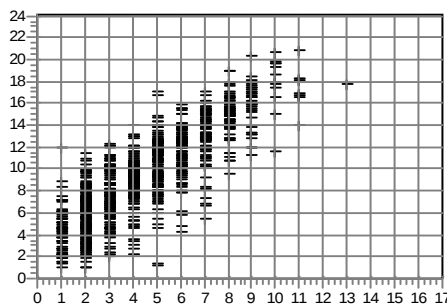
Sector from 15 to 45 degrees

Correlation: 0,3483



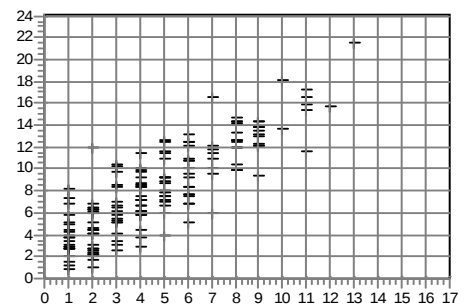
Sector from 135 to 165 degrees

Correlation: 0,8316



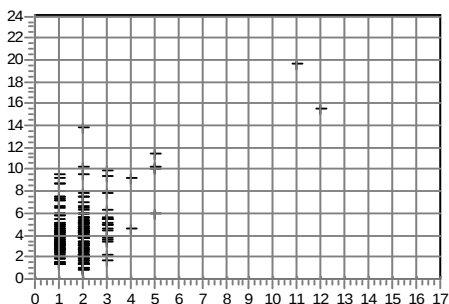
Sector from 255 to 285 degrees

Correlation: 0,8521



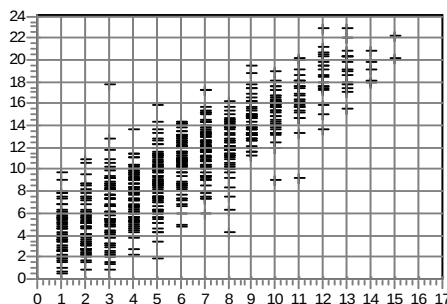
Sector from 45 to 75 degrees

Correlation: 0,5425



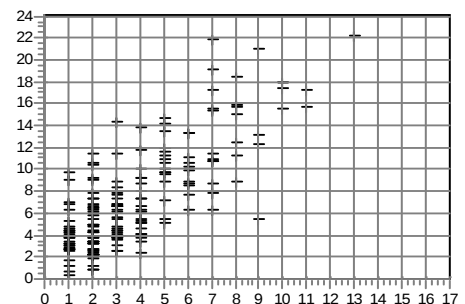
Sector from 165 to 195 degrees

Correlation: 0,8631



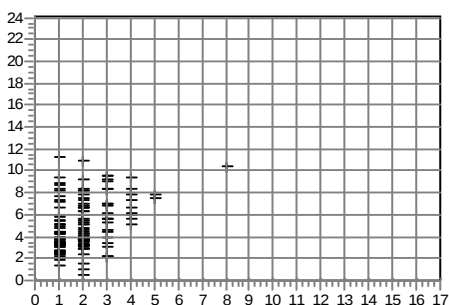
Sector from 285 to 315 degrees

Correlation: 0,7889



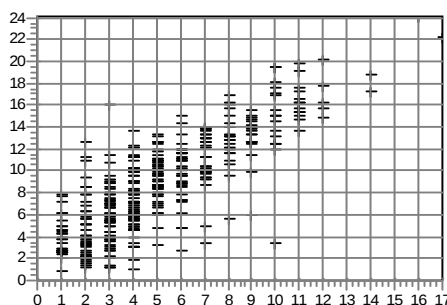
Sector from 75 to 105 degrees

Correlation: 0,3906



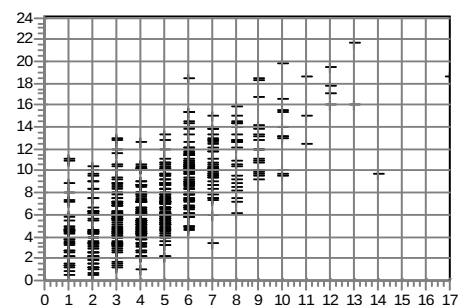
Sector from 195 to 225 degrees

Correlation: 0,8181



Sector from 315 to 345 degrees

Correlation: 0,7135



11. ANNEX 4 Details of the meteorological measurement equipment.

Adjustments based on calibration reports

Project: Kollsnes

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	Kollsnes	
	adj. factor	offset
Anemometer calibration 0482	1,0048	-0,0576
Anemometer calibration 0481	0,9980	-0,0544
Anemometer calibration 0480	1,0059	-0,0306
Anemometer calibration 3297	0,6201	0,2554
Anemometer calibration 3297	1,0122	-0,0641

Calibration:

*1) Formula used: u cal. =((u mess. - 0,35)/0,765) * X (f) cal.

		* f [Hz]	offset
ch 1	Anemometer calibration 0482	0,76869	0,2941
	NRG default:	0,7650	0,3500
	Adjustment factor *1):	1,00482	-0,0576
ch 2	Anemometer calibration 0481	0,7635	0,29487
	NRG default:	0,7650	0,3500
	Adjustment factor *1):	0,99804	-0,0544
ch 3	Anemometer calibration 0480	0,76954	0,3215
	NRG default:	0,7650	0,3500
	Adjustment factor *1):	1,00593	-0,0306
ch 4	Anemometer calibration 3297	0,63004	0,2317
	Default:	1,0160	-0,0383
	Adjustment factor *1):	0,62010	0,2554
ch 5	Anemometer calibration 3296	0,62765	0,2092
	Default:	0,7743	0,2892
	Adjustment factor *1):	0,81059	-0,0252

Ch4:			
Is	should be	adj.	New Defaults
1,00000	0,62010	1,61264	1,01603
0,00000	0,27000	-0,27000	-0,03830
Ch5:			
Is	should be	adj.	New Defaults
0,76500	0,62010	1,23367	0,77431
0,35000	0,27000	0,08000	0,28923



CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 06.02.2827

Date of issue: November 23, 2006

Type: Risø P2546A, 2 pulses, plastic cup

Serial number: 3297

Manufacturer: Risø, VEA, bygning 100, 4000 Roskilde

Client: Kjeller Vindteknikk AS, Instituttveien 18, N-2027 Kjeller, Norway

Anemometer received: November 7, 2006

Anemometer calibrated: November 21, 2006

Calibrated by: OF

Calibration procedure: MEASNET

Certificate prepared by: soh

Approved by: soh

Svend Ole Hansen

Calibration equation obtained: $v \text{ [m/s]} = 0.62765 \cdot f \text{ [Hz]} + 0.20923$

Standard uncertainty, slope: 0.00063

Standard uncertainty, offset: 0.03194

Covariance: -0.0000024 (m/s)²/Hz

Coefficient of correlation: $\rho = 0.999998$

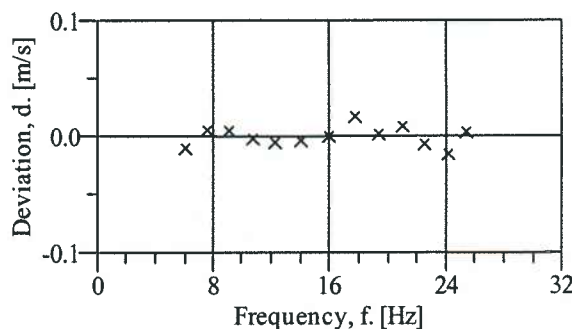
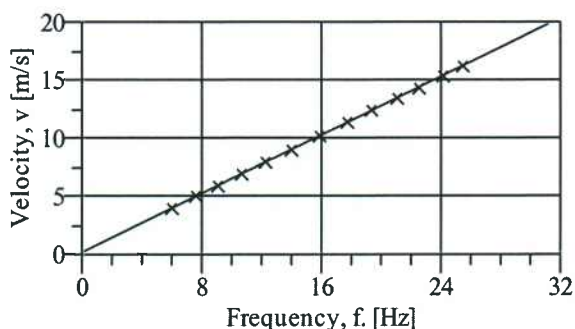
Absolute maximum deviation: 0.017 m/s at 11.326 m/s



Barometric pressure: 994.0 hPa

Relative humidity: 30.0%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.14	25.7	22.6	3.980	6.0237	-0.010	0.042
4	14.32	25.5	22.6	4.979	7.5916	0.005	0.041
6	20.40	25.5	22.6	5.942	9.1251	0.006	0.043
8	27.66	25.4	22.6	6.919	10.6933	-0.002	0.046
10	36.10	25.3	22.6	7.904	12.2663	-0.005	0.051
12	47.16	25.3	22.6	9.032	14.0618	-0.003	0.056
13-last	59.94	25.2	22.6	10.182	15.8880	0.001	0.063
11	74.15	25.3	22.6	11.326	17.6838	0.017	0.069
9	88.09	25.3	22.6	12.346	19.3342	0.002	0.075
7	103.89	25.4	22.6	13.409	21.0181	0.008	0.081
5	118.81	25.5	22.6	14.342	22.5282	-0.007	0.087
3	135.98	25.6	22.6	15.346	24.1395	-0.015	0.093
1-first	151.41	25.8	22.5	16.200	25.4714	0.003	0.098



EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
93100502	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
950610	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
P11	Pitot tube
001551	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

A real-time analysis module within the data acquisition software detects pulse frequency.



Photo of a cup anemometer in the wind tunnel. The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 "MEASNET-Test report on the calibration campaign" for further details.



CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 06.02.2754

Date of issue: November 19, 2006

Type: Risø P2546A, 2 pulses, plastic cup

Serial number: 3296

Manufacturer: Risø, VEA, bygning 100, 4000 Roskilde

Client: Kjeller Vindteknikk AS, Instituttveien 18, N-2027 Kjeller, Norway

Anemometer received: November 7, 2006

Anemometer calibrated: November 13, 2006

Calibrated by: TMH

Calibration procedure: MEASNET

Certificate prepared by: soh

Approved by: soh

Svend Ole Hansen

Calibration equation obtained: $v \text{ [m/s]} = 0.63004 \cdot f \text{ [Hz]} + 0.23170$

Standard uncertainty, slope: 0.00072

Standard uncertainty, offset: 0.03296

Covariance: -0.0000032 (m/s)²/Hz

Coefficient of correlation: $\rho = 0.999997$

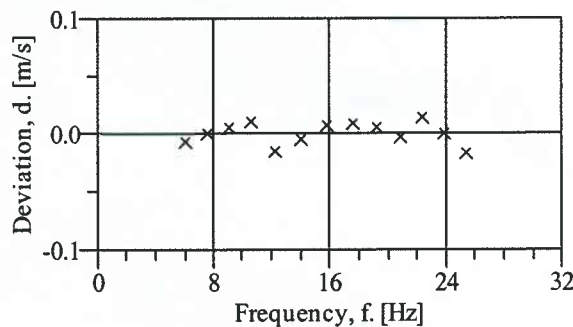
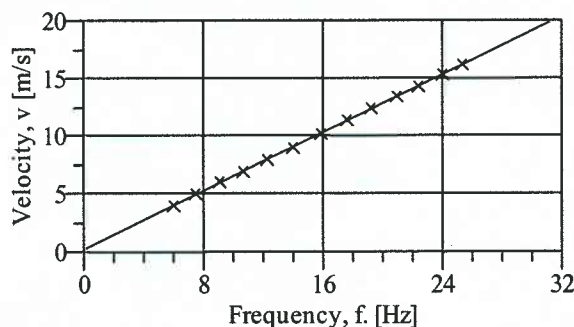
Absolute maximum deviation: -0.017 m/s at 16.201 m/s



Barometric pressure: 989.6 hPa

Relative humidity: 27.8%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.10	27.6	22.5	3.993	5.9808	-0.007	0.043
4	14.11	27.4	22.4	4.970	7.5214	-0.001	0.041
6	20.27	27.3	22.4	5.956	9.0762	0.005	0.043
8	27.41	27.2	22.4	6.923	10.6047	0.010	0.047
10	35.99	27.1	22.4	7.933	12.2479	-0.016	0.051
12	46.67	27.0	22.4	9.031	13.9758	-0.006	0.057
13-last	59.48	27.0	22.4	10.195	15.8034	0.006	0.063
11	73.31	27.0	22.4	11.320	17.5846	0.009	0.070
9	87.22	27.1	22.4	12.350	19.2255	0.005	0.076
7	102.41	27.2	22.4	13.384	20.8806	-0.003	0.082
5	117.95	27.3	22.4	14.366	22.4121	0.014	0.088
3	133.95	27.5	22.4	15.314	23.9389	0.000	0.094
1-first	149.77	27.7	22.5	16.201	25.3738	-0.017	0.099



EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
93100502	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
950610	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
P11	Pitot tube
001551	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

A real-time analysis module within the data acquisition software detects pulse frequency.

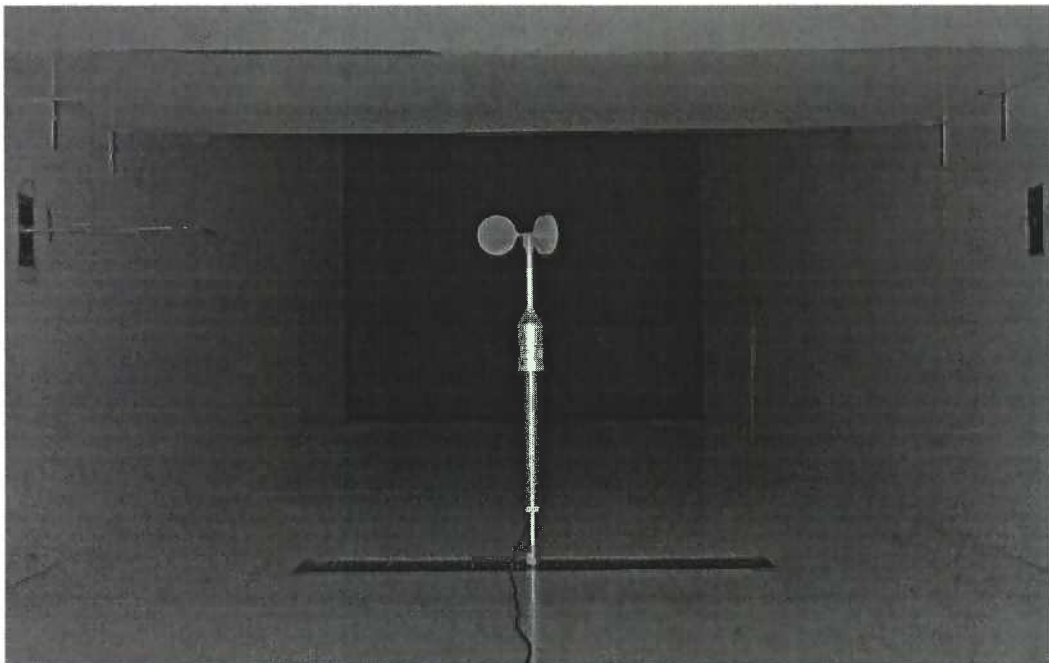


Photo of a cup anemometer in the wind tunnel. The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 "MEASNET-Test report on the calibration campaign" for further details.



CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 06.02.2717

Date of issue: November 15, 2006

Type: NRG #40

Serial number: KV-99 *KVT 0482*

Manufacturer: NRG Systems, 110 Commerce Street, Hinesburg, Vermont 05461, USA

Client: Kjeller Vindteknikk AS, Instituttveien 18, N-2027 Kjeller, Norway

Anemometer received: November 2, 2006

Anemometer calibrated: November 11, 2006

Calibrated by: hr

Calibration procedure: MEASNET

Certificate prepared by: soh

Approved by: soh *Svend Ole Hansen*

Calibration equation obtained: v [m/s] = $0.76869 \cdot f$ [Hz] + 0.29410

Standard uncertainty, slope: 0.00110

Standard uncertainty, offset: 0.03842

Covariance: -0.0000089 (m/s)²/Hz

Coefficient of correlation: $\rho = 0.999993$

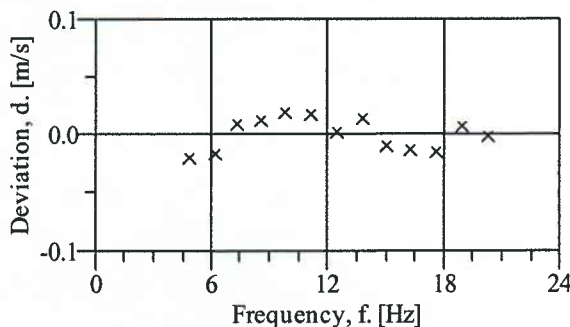
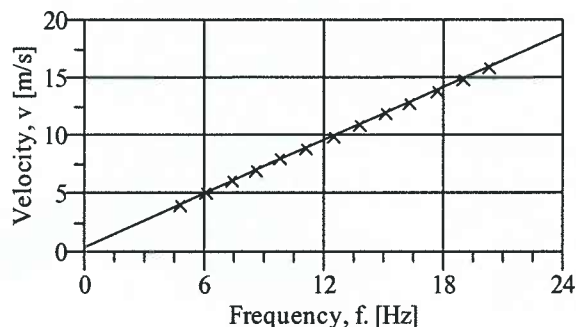
Absolute maximum deviation: -0.020 m/s at 4.001 m/s



Barometric pressure: 997.6 hPa

Relative humidity: 28.9%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.25	26.4	22.6	4.001	4.8488	-0.020	0.042
4	14.39	26.3	22.6	4.989	6.1308	-0.018	0.041
6	20.51	26.1	22.5	5.954	7.3516	0.009	0.043
8	27.65	26.1	22.5	6.912	8.5946	0.011	0.046
10	35.75	26.0	22.5	7.859	9.8170	0.018	0.051
12	45.42	25.9	22.5	8.858	11.1182	0.018	0.056
13-last	56.57	25.9	22.5	9.885	12.4740	0.002	0.061
11	69.28	25.9	22.5	10.940	13.8323	0.013	0.067
9	81.70	26.0	22.5	11.881	15.0865	-0.010	0.073
7	94.59	26.1	22.5	12.786	16.2696	-0.014	0.078
5	110.95	26.2	22.5	13.850	17.6568	-0.016	0.084
3	128.46	26.3	22.6	14.907	19.0002	0.008	0.090
1-first	145.38	26.6	22.6	15.866	20.2590	-0.001	0.096



EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
93100502	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
950610	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
P11	Pitot tube
001551	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

A real-time analysis module within the data acquisition software detects pulse frequency.

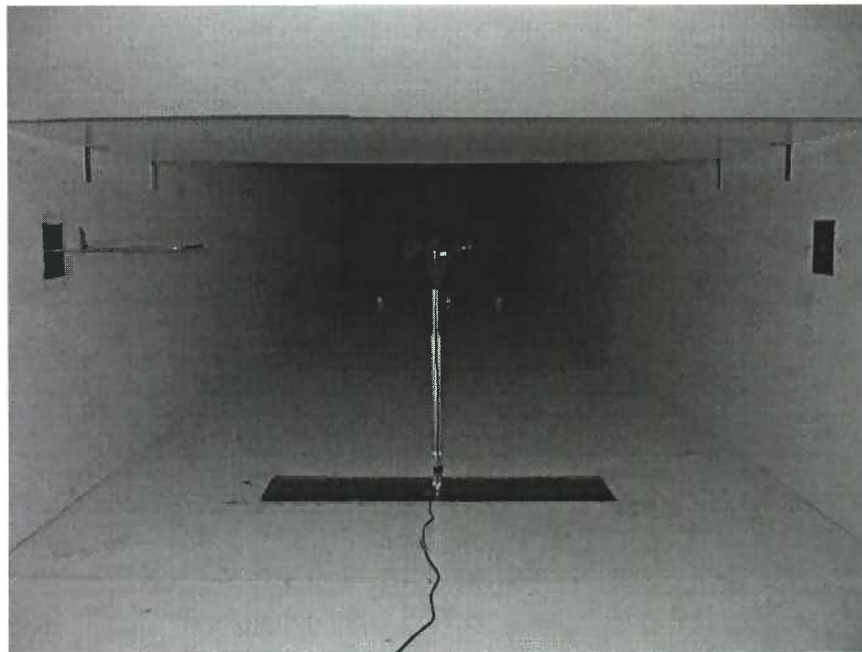


Photo of a cup anemometer in the wind tunnel. The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 "MEASNET-Test report on the calibration campaign" for further details.



CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 06.02.2716

Date of issue: November 15, 2006

Type: NRG #40

Serial number: KV-97 *KVT 0481*

Manufacturer: NRG Systems, 110 Commerce Street, Hinesburg, Vermont 05461, USA

Client: Kjeller Vindteknikk AS, Instituttveien 18, N-2027 Kjeller, Norway

Anemometer received: November 2, 2006

Anemometer calibrated: November 11, 2006

Calibrated by: hr

Calibration procedure: MEASNET

Certificate prepared by: soh

Approved by: soh *Svend Ole Hansen*

Calibration equation obtained: $v \text{ [m/s]} = 0.76350 \cdot f \text{ [Hz]} + 0.29487$

Standard uncertainty, slope: 0.00187

Standard uncertainty, offset: 0.06523

Covariance: $-0.0000256 \text{ (m/s)}^2/\text{Hz}$

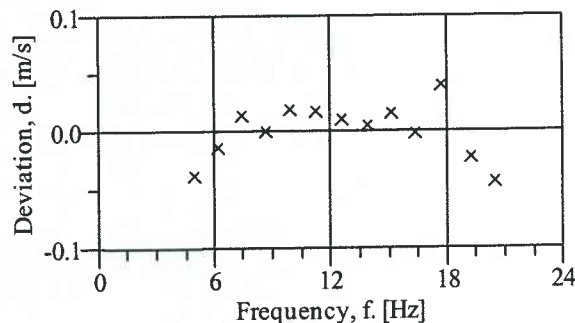
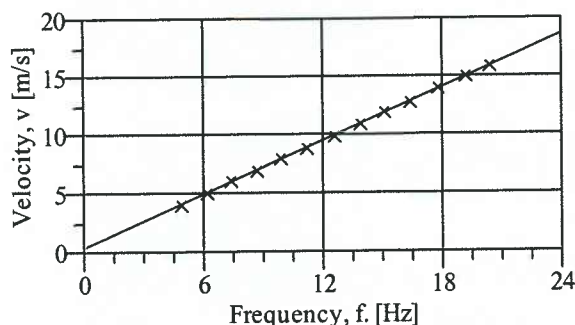
Coefficient of correlation: $\rho = 0.999981$

Absolute maximum deviation: -0.043 m/s at 15.863 m/s

Barometric pressure: 998.2 hPa

Relative humidity: 29.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty $u_c \text{ (k=2)}$ [m/s]
2	9.25	25.8	22.5	3.995	4.8971	-0.039	0.042
4	14.40	25.6	22.5	4.983	6.1587	-0.014	0.041
6	20.62	25.5	22.5	5.962	7.4054	0.013	0.043
8	27.62	25.5	22.5	6.899	8.6509	-0.001	0.046
10	35.91	25.4	22.5	7.866	9.8903	0.020	0.051
12	45.61	25.3	22.5	8.864	11.2009	0.017	0.056
13-last	56.81	25.3	22.5	9.893	12.5564	0.011	0.061
11	69.31	25.3	22.5	10.928	13.9198	0.005	0.067
9	81.75	25.4	22.5	11.869	15.1397	0.015	0.072
7	95.31	25.5	22.5	12.818	16.4036	-0.001	0.078
5	111.90	25.6	22.5	13.891	17.7552	0.040	0.084
3	129.57	25.7	22.5	14.950	19.2250	-0.023	0.091
1-first	145.75	26.0	22.5	15.863	20.4468	-0.043	0.096



EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
93100502	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
950610	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
P11	Pitot tube
001551	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

A real-time analysis module within the data acquisition software detects pulse frequency.

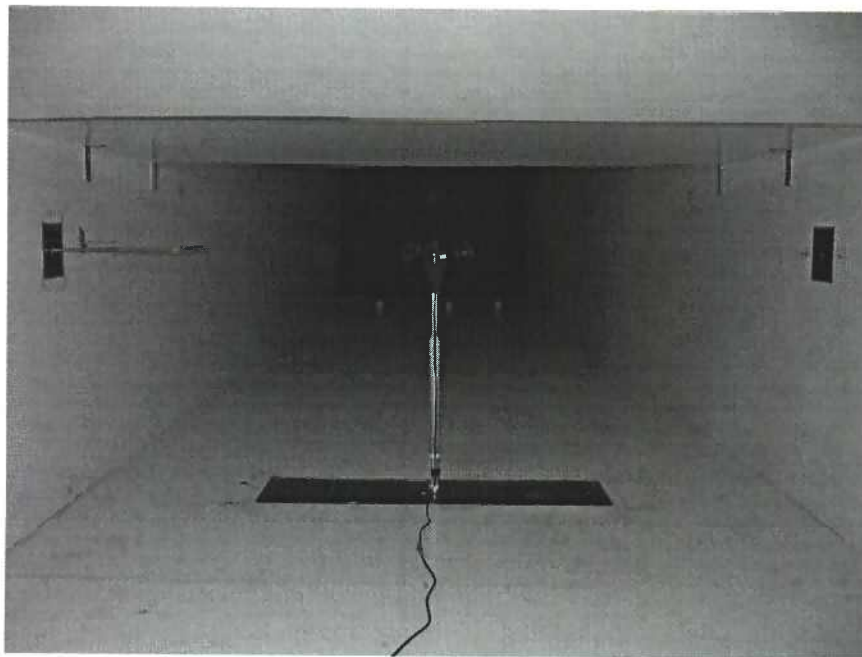


Photo of a cup anemometer in the wind tunnel. The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 "MEASNET-Test report on the calibration campaign" for further details.



CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 06.02.2715

Date of issue: November 15, 2006

Type: NRG #40

Serial number: KV-96 *KVT 0480*

Manufacturer: NRG Systems, 110 Commerce Street, Hinesburg, Vermont 05461, USA

Client: Kjeller Vindteknikk AS, Instituttveien 18, N-2027 Kjeller, Norway

Anemometer received: November 2, 2006

Anemometer calibrated: November 11, 2006

Calibrated by: hr

Calibration procedure: MEASNET

Certificate prepared by: soh

Approved by: soh

Calibration equation obtained: $v \text{ [m/s]} = 0.76954 \cdot f \text{ [Hz]} + 0.32152$

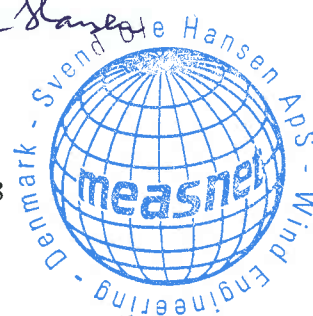
Standard uncertainty, slope: 0.00145

Standard uncertainty, offset: 0.04629

Covariance: -0.0000155 (m/s)²/Hz

Coefficient of correlation: $\rho = 0.999988$

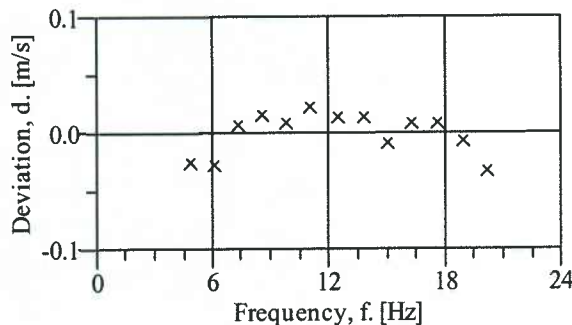
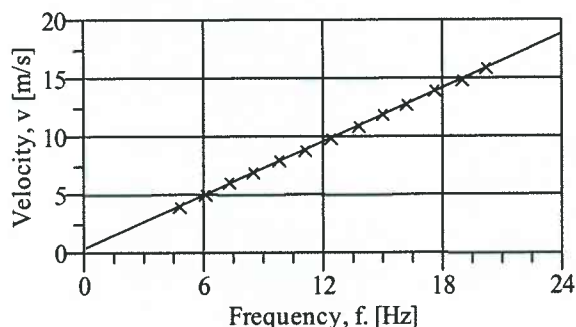
Absolute maximum deviation: -0.033 m/s at 15.864 m/s



Barometric pressure: 998.5 hPa

Relative humidity: 29.3%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u _c (k=2) [m/s]
2	9.32	25.5	22.6	4.007	4.8225	-0.026	0.042
4	14.37	25.4	22.6	4.976	6.0852	-0.028	0.041
6	20.64	25.3	22.6	5.961	7.3192	0.007	0.043
8	27.69	25.2	22.6	6.905	8.5334	0.016	0.046
10	35.79	25.2	22.6	7.849	9.7708	0.008	0.050
12	45.60	25.1	22.5	8.858	11.0634	0.023	0.056
13-last	57.06	25.1	22.5	9.909	12.4408	0.014	0.061
11	69.35	25.1	22.6	10.924	13.7592	0.015	0.067
9	81.78	25.2	22.6	11.864	15.0102	-0.008	0.072
7	95.55	25.3	22.6	12.826	16.2376	0.009	0.078
5	112.11	25.4	22.6	13.896	17.6273	0.009	0.084
3	128.96	25.5	22.6	14.906	18.9615	-0.007	0.090
1-first	145.95	25.7	22.6	15.864	20.2397	-0.033	0.096



EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
93100502	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
950610	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
P11	Pitot tube
001551	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

A real-time analysis module within the data acquisition software detects pulse frequency.

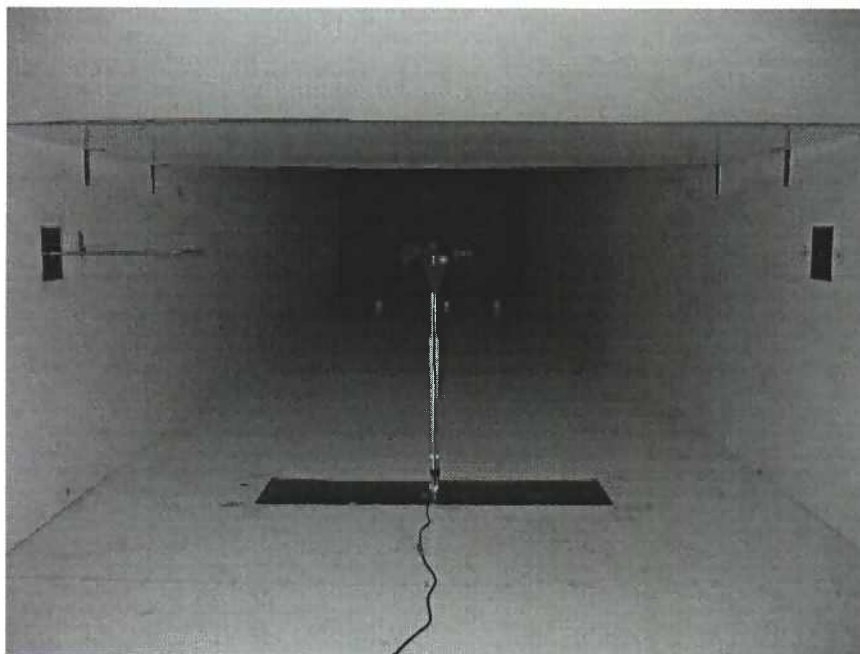


Photo of a cup anemometer in the wind tunnel. The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 "MEASNET-Test report on the calibration campaign" for further details.

P2546A Cup Anemometer

Features

- Low threshold speed
- Low distance constant
- Negligible overspeeding
- Angular response independent of wind speed
- Fully tested temperature performance
- Symmetrical geometry
- No external power source
- Bounce free reed switch

Description

The P2546A Cup Anemometer is a sturdy wind sensor solely constructed by durable materials such as anodized aluminium and stainless steel.

The wind speed is sensed by a three-cup rotor assembly. Permanent magnets mounted on the shaft causes a switch to close and open two times per revolution.

The switch has no bounce and it is equipped with a special built-in mechanism, which reduces the variation in operating time over the frequency range. This feature provides the possibility of obtaining the instantaneous wind speed by measuring the time interval of each revolution.

Specifications

Measuring range	0...70 m/s
Starting threshold	< 0.4 m/s
Distance constant	$\ell_0 = 1.81 \pm 0.04$ m
Standard Calibration	$U = A_0 + B_0 \times f$
Wind speed	U [m/s]
Offset ("starting speed")	$A_0 = 0.27$ m/s
Gain	$B_0 = 0.6201$ m
Output frequency	f [Hz]
Standard deviation of offset	0.014 m/s
Standard deviation of gain	0.027 m
Variation among units	$\pm 1\%$
Nonlinearity	<0.04 m/s
Temperature influence, -15...60°C	< 0.05 m/s

Switching characteristics

Signal type	potential free contact closure
Duty cycle	40...60%
Max switching voltage	30 V
Max. recommended switching current	10 mA
Series resistance	330 Ω , 1 W
Operating temperature range	-35...60°C



The specifications are based on 80 wind tunnel calibrations performed according to the Measnet Cup Anemometer Calibration Procedure.

The specified offset and gain figures represent the mean values of these calibrations.

Variation among units designates the maximum deviation of any unit from the straight line representing these mean values.

All units are run-in for 225 hours at 9 m/s, in order to reduce the initial bearing friction to a level close to the steady state value.

After run-in, bearing friction is tested at -15 °C and at room temperature. The allowed limits for this test assures that the temperature influence on the calibration is within the specified limit.

SPECIFICATIONS

NRG #200P Wind Direction Vane

FEATURES

- The standard wind direction vane used in the wind energy industry
- Simple, durable design
- Corrosion-resistant materials



The NRG #200P wind direction vane is the industry standard wind direction vane used worldwide. The thermoplastic and stainless steel components resist corrosion and contribute to a high strength-to-weight ratio. The vane is directly connected to a precision conductive plastic potentiometer located in the main body. An analog voltage output directly proportional to the wind direction is produced when a constant DC excitation voltage is applied to the potentiometer. A rubber terminal boot is included.

SPECIFICATIONS

Description	Sensor type	continuous rotation potentiometric wind direction vane
	Applications	• wind resource assessment • meteorological studies • environmental monitoring
	Sensor range	360° mechanical, continuous rotation
	Instrument compatibility	all NRG loggers
Output signal	Signal type	Analog DC voltage from conductive plastic potentiometer, 10K ohms
	Transfer function	Output signal is a ratiometric voltage
	Accuracy	potentiometer linearity within 1%
	Dead band	8° Maximum, 4° Typical
	Output signal range	0 V to excitation voltage (excluding deadband)
Power requirements	Supply voltage	Regulated potentiometer excitation of 1 V to 15 V DC
Response characteristics	Threshold	1 m/s (2.2 miles per hour)
Installation	Mounting	onto a 13 mm (0.5 inch) diameter mast with cotter pin and set screw
	Tools required	0.25 inch nut driver, petroleum jelly, electrical tape
Environmental	Operating temperature range	-55 °C to 60 °C (-67 °F to 140 °F)

Global leaders in wind assessment technology



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SPECIFICATIONS

NRG #40 Anemometer

FEATURES

- The standard anemometer used in the wind energy industry
- Short distance constant
- Simple, durable design



The NRG #40 anemometer is the industry standard anemometer used worldwide. NRG #40 anemometers have recorded wind speeds of 96 m/s (214 mph). Their low moment of inertia and unique bearings permit very rapid response to gusts and lulls. Because of their output linearity, these sensors are ideal for use with various data retrieval systems. A four pole magnet induces a sine wave voltage into a coil producing an output signal with a frequency proportional to wind speed. The #40 is constructed of rugged Lexan cups molded in one piece for repeatable performance. A rubber terminal boot is included.

SPECIFICATIONS

Description	Sensor type	3-cup anemometer
	Applications	• wind resource assessment • meteorological studies • environmental monitoring
	Sensor range	1 m/s to 96 m/s (2.2 mph to 214 mph) (highest recorded)
	Instrument compatibility	all NRG loggers
Output signal	Signal type	low level AC sine wave, frequency linearly proportional to windspeed
	Transfer function	$m/s = (Hz \times 0.765) + 0.35$ [miles per hour = $(Hz \times 1.711) + 0.78$]
	Accuracy	within 0.1 m/s (0.2 mph) for the range 5 m/s to 25 m/s (11 mph to 55 mph)
	Calibration	calibrated version available
	Output signal range	0 Hz to 125 Hz (highest recorded)
Response characteristics	Threshold	0.78 m/s (1.75 miles per hour)

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SPECIFICATIONS

	Distance constant (63% recovery)	3.0 m (10 feet)
	Moment of inertia	$68 \times 10^{-6} \text{ S-ft}^2$
	Swept diameter of rotor	190 mm (7.5 inches)
Installation	Mounting	onto a 13 mm (0.5 inch) diameter mast with cotter pin and set screw
	Tools required	0.25 inch nut driver, petroleum jelly, electrical tape
Environmental	Operating temperature range	-55 °C to 60 °C (-67 °F to 140 °F)
	Operating humidity range	0 to 100% RH
Physical	Connections	4-40 brass hex nut/post terminals
	Weight	0.14 kg (0.3 pounds)
	Dimensions	• 3 cups of conical cross-section, 51 mm (2 inches) dia. • 81 mm (3.2 inches) overall assembly height
Materials	Cups	one piece injection-molded black polycarbonate
	Body	housing is black ABS plastic
	Shaft	beryllium copper, fully hardened
	Bearing	modified Teflon, self-lubricating
	Magnet	Indox 1, 25 mm (1 inch) diameter, 13 mm (0.5 inch) long, 4 poles
	Coil	single coil, bobbin wound, 4100 turns of #41 wire, shielded for ESD protection
	Boot	protective PVC sensor terminal boot included
	Terminals	brass

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FEATURES

Designed to be easy to install, and durable in any climate. Wherever you need to measure the wind, no matter how demanding the environment, Symphonie and the "plug and play" iPacks make data collection as easy as reading your email.

- **Wind industry specific and preconfigured to industry standards. All features for wind energy assessment built in. No complex configuration.**
- **Convenient "plug and play" Signal Conditioning Modules (SCM) for additional sensor inputs. Preconfigured for sensor type.**
- **Uses Non-volatile Multi-Media Flash Cards. Cards are available most anywhere in the world and are safer for data storage than RAM memory cards.**
- **Average, Standard Deviation, Maximum and Minimum values for all sensor channels at every 10 minute interval. Set up is done for you.**
- **Free data retriever software is included and produces versatile tab-delimited text files. Data files can be used with wide range of data processing software, including SQL databases, MS Excel, MS Access, and more. Supports international numeric formats.**
- **Easy to read 4 line x 20 character display provides easy to understand real-time data and configuration information.**
- **Dedicated navigation buttons (up, down, left, right, home), plus a data entry keypad. Full-text, menu-driven display is easy to use.**
- **Separate Lithium battery-backed real-time clock for accurate and reliable time stamping.**
- **Runs on two alkaline "D" cells (included) for up to one year, depending on sensor configuration. Batteries available anywhere.**
- **Rugged, non-corroding, weather-proof polycarbonate enclosure.**
- **Optional iPacks provide solar/battery power and automatic remote data download capabilities via Internet email. Support for AMPS cellular, GSM cellular, and dial-up phone lines.**

Symphonie

INTERNET ENABLED

Internet-Enabled Data Loggers

The revolutionary Symphonie data logger gives you all the accuracy and durability of other NRG loggers, but allows you to collect data without ever leaving your desk. Symphonie works with a standard data card or with any NRG manufactured iPack which sends data reports to your Internet provider over an embedded standard or cellular phone. You get an email with an attached data file at any interval you choose.

Symphonie has been engineered to be simple to set-up and use. We supply you with Plug-in Signal Conditioning Modules (SCM) that are preconfigured to work with sensors from NRG or other manufacturers. The Symphonie logger supports over a year's worth of data on non-volatile Multi-Media (MMC) Flash Cards. iPacks are "plug and play", with battery, modem and phone already installed.

As with all products from NRG, the Symphonie system is rugged, straightforward, and allows for a wide variety of customized preferences for sensor inputs and data processing to meet your individual needs and specifications.

ORDERING INFORMATION

Symphonie Logger (Item 3147)

iPack Kits

- **AMPS cellular (Item 3162)**
- **GSM cellular (Item 3164)**
- **Dial-up (Item 3161)**
- **PV/Battery only (Item 3166)**

Accessories

- **SCM Card**
- **Shelter box (Item 3159)**
- **PV Panel (Item 3160)**
- **MultiMedia Card (Item 3157)**
- **MMC Card Reader (Item 3158)**

SPECIFICATIONS

Symphonie Logger

COUNTER INPUTS (6):

- 3 inputs for NRG #40 Maximum Anemometers or compatible.
- 3 configurable counter inputs for additional anemometers or rain gauge.
- All channels have built in over-voltage and electromagnetic interference protection.

ANALOG INPUTS (6):

- 2 inputs for NRG #200P Wind Direction Vane or compatible.
- 4 configurable analog inputs for additional direction vanes, temperature, solar pyranometer, barometric pressure, relative humidity, etc.
- All channels have built in over-voltage and electromagnetic interference protection.

DATA STORAGE:

- Average, standard deviation, maximum and minimum values stored for each channel, plus time stamp, for each 10 minute interval.
- Data is stored in internal non-volatile memory and written to the removable flash memory card once per hour.
- 680 days data storage capacity on standard 16 MB MultiMedia Card. MMC Card Format is compatible with Windows™ Operating System.

DATA SAMPLING:

- 2 second sampling interval. Symphonie Loggers constantly count accumulated wind run over each 2 second interval.
- 10 minute fixed averaging interval.

RESOLUTION:

- Counters Average: Measured resolution is 0.5 Hz. Stored resolution is 0.1% of the value stored.
- Analogs Average: Measured resolution is 0.1% of full scale (1024 counts). Stored resolution is 0.1% of the value stored.
- Standard Deviation (all channels): stored resolution is 4% of the value stored.
- Min / Max (all channels): stored resolution is 0.3% of the value stored.

LOGGER DISPLAY:

- 4 line x 20 Character LCD with full text menu.
- Adjustable display contrast.
- Display readable from -30 to 55 C (-22° to 130° F).
- 16 key pad (6 navigation keys plus numeric/phone pad) with audible feedback.

LOGGER DISPLAY FUNCTIONS:

- Display Units and scaling are user configurable. Defaults are provided for all channels based on channel type.

Logger Display Functions, continued

- Instantaneous Input values (2 second sample updates) for all 12 channels.
- Flash card status
- Time and date
- Site number (user assigned)
- Battery status
- iPack status

REAL TIME CLOCK:

- Programmable, date and time auto-adjust for leap years.
- Separate Lithium battery keeps clock powered even if main batteries fail.
- Accuracy: +/- 3 minutes per month.

INTERFACE:

- 25 pin connector to any NRG iPack (Dial-up, AMPS, GSM) for automatic remote data transfer via Internet.

CONNECTIONS:

- All sensor connections to one 37 pin connector.
- Field wiring panel included for signal inputs.
- Separate #10 stud for Earth connection.

POWER REQUIREMENTS:

- Uses two "D" alkaline cells. Nominal voltage: 1.5 Volts. Minimum voltage 0.9 Volts. Battery life approximately one year, depending on configuration.
- Optional NRG iPack modules provide solar / battery or external power options for unlimited life.

ENVIRONMENTAL:

- Operating Temperature: -40 to 65 C (-40° to 149° F).
- Operating humidity: 0-100% RH non-condensing.
- Note: Display readable from -30 to 55 C (-22° to 130° F).

SIZE:

- Logger overall: 22.2 cm height, 18.8 cm width, 7.7 cm thick (8.7 x 7.4 x 3.0 in.).
- iPack overall: 22.2 cm height, 18.8 cm width, 5.1 cm depth (8.7 x 7.4 x 2.0 in.).

WEIGHT:

- Logger: 1.3 kg (2.60 lbs), including batteries.
- iPack: 1.4 kg (3.22 lbs), including batteries.

ENCLOSURE:

- Weatherproof polycarbonate; meets NEMA type 4, 4X and 13, and IEC: IP65 specifications.

MOUNTING:

- From the back, with four logger mounting screws.

WARRANTY:

- 2 year limited warranty.

Meets or exceeds Industry Standards



12. ANNEX 5 Energy considerations.

Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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Calculated:

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PARK - Main Result**Calculation:** Langtids vind V90 3MW 102 + 107dB**Wake Model**

N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1,269 kg/m ³ to 1,272 kg/m ³
Hub altitude above sea level (asl)	104,8 m to 132,4 m
Annual mean temperature at hub alt.	0,6 °C to 0,7 °C
Pressure at WTGs	996,7 hPa to 1.000,1 hPa

Wake Model Parameters

Wake Decay Constant 0,075

Wind statistics

NO Kollsnes Wind Station (Regression MCP using Hellisoy).wws

Key results for height 50,0 m above ground level**Terrain UTM WGS84 Zone: 31**

East	North	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A 600.896	6.715.100	Kolsness	WASP (RVEA0011 1, 0, 0, 13)	4.537	7,6	0,5

Calculated Annual Energy for Wind Farm

WTG combination	Annual Energy		Park Efficiency [%]	Mean WTG energy [MWh]	Capacity Factor for	
	Result [MWh]	Uncertainty-10,8% [MWh]			Result [%]	Uncertainty-10,8% [%]
Wind farm	93.004,5	82.960,0	93,9	9.300,4	35,4	31,5

Calculated Annual Energy for each of 10 new WTG's with total 30,0 MW rated power

Terrain	WTG type			Power	Diam.	Height	Power curve		Annual Energy Result [MWh]	Park Efficiency [%]	Mean wind speed [m/s]	
	Valid	Manufact.	Type				Circle radius	Creator Name				
1 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 4 -- 102.8 dB(A) - 03-2007	8.652,4	7.718	96,4	8,7
2 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 4 -- 102.8 dB(A) - 03-2007	8.425,9	7.516	94,9	8,6
3 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 4 -- 102.8 dB(A) - 03-2007	8.460,2	7.546	93,5	8,7
4 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 4 -- 102.8 dB(A) - 03-2007	7.698,2	6.867	92,0	8,3
5 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	9.668,0	8.624	91,8	8,3
6 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	9.899,7	8.831	91,8	8,5
7 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	10.149,2	9.053	94,8	8,4
8 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	10.095,8	9.005	94,0	8,5
9 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	9.871,7	8.806	93,1	8,4
10 A	Yes	VESTAS	V90	3.000	90,0	80,0	135,0	EMD Level 1 -- 107.8 dB(A) - 03-2007	10.083,3	8.994	96,6	8,3

WTG siting**UTM WGS84 Zone: 31**

	East	North	Z [m]	Row data/Description
1 New	601.077	6.715.322	52,4	VESTAS V90 3000 90.0 !O! hub: 80,0 m (101)
2 New	601.355	6.714.977	50,0	VESTAS V90 3000 90.0 !O! hub: 80,0 m (102)
3 New	601.483	6.714.524	50,0	VESTAS V90 3000 90.0 !O! hub: 80,0 m (103)
4 New	601.476	6.714.059	25,0	VESTAS V90 3000 90.0 !O! hub: 80,0 m (104)
5 New	601.614	6.713.666	25,0	VESTAS V90 3000 90.0 !O! hub: 80,0 m (105)
6 New	601.925	6.713.766	35,2	VESTAS V90 3000 90.0 !O! hub: 80,0 m (106)
7 New	602.183	6.713.913	40,7	VESTAS V90 3000 90.0 !O! hub: 80,0 m (107)
8 New	601.664	6.713.219	26,6	VESTAS V90 3000 90.0 !O! hub: 80,0 m (108)
9 New	601.986	6.713.364	36,2	VESTAS V90 3000 90.0 !O! hub: 80,0 m (109)
10 New	601.804	6.712.787	24,8	VESTAS V90 3000 90.0 !O! hub: 80,0 m (110)

Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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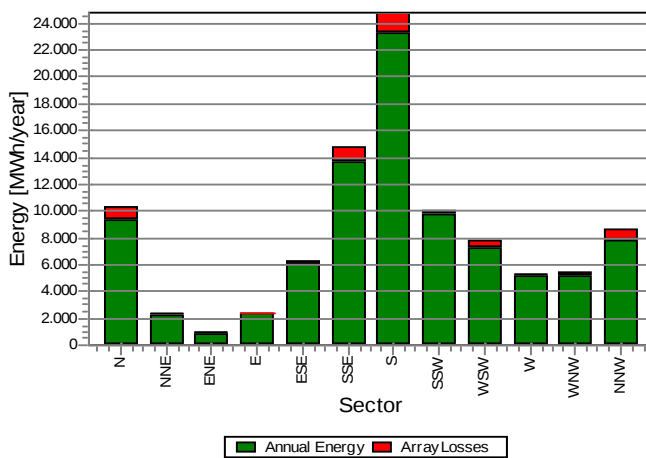
PARK - Production Analysis

Calculation: Langtids vind V90 3MW 102 + 107dB **WTG:** All new WTG's, Air density varies with WTG position 1,269 kg/m3 - 1,272 kg/m3

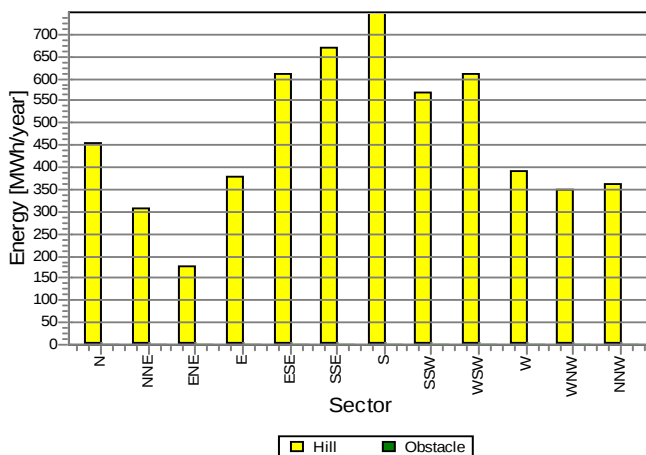
Directional Analysis

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	9.873,7	2.025,3	846,2	2.021,9	5.707,2	14.053,7	24.047,2	9.436,6	7.152,6	4.904,2	5.082,7	8.281,6	93.433,0
+Increase due to hills	[MWh]	456,0	306,3	175,2	379,2	612,6	668,5	750,0	570,0	611,3	390,4	347,7	361,5	5.628,7
-Decrease due to array losses	[MWh]	976,1	110,3	117,0	81,8	260,1	1.124,7	1.555,9	270,8	472,2	101,5	207,0	779,9	6.057,2
Resulting energy	[MWh]	9.353,6	2.221,4	904,5	2.319,3	6.059,7	13.597,5	23.241,2	9.735,7	7.291,8	5.193,2	5.223,5	7.863,2	93.004,5
Specific energy	[kWh/m2]													1.462
Specific energy	[kWh/kW]													3.100
Increase due to hills	[%]	4,6	15,1	20,7	18,8	10,7	4,8	3,1	6,0	8,5	8,0	6,8	4,4	6,0
Decrease due to array losses	[%]	9,4	4,7	11,5	3,4	4,1	7,6	6,3	2,7	6,1	1,9	3,8	9,0	6,1
Utilization	[%]	25,6	31,5	34,7	37,9	30,9	26,4	20,4	21,3	21,3	23,4	24,4	24,9	23,7
Operational	[Hours/year]	863	294	262	466	771	1.150	1.382	593	545	402	508	769	8.006
Full Load Equivalent	[Hours/year]	312	74	30	77	202	453	775	325	243	173	174	262	3.100

Energy vs. sector



Impact of hills and obstacles vs. sector



Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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PARK - Power Curve Analysis**Calculation:** Langtids vind V90 3MW 102 + 107dB **WTG:** 1 - VESTAS V90 3000 90.0 !O! Level 4 - - 102.8 dB(A) - 03-2007, Hub height: 80,0 m**Name:** Level 4 - - 102.8 dB(A) - 03-2007**Source:** Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed	Power control	CT curve type
19-03-2007	EMD	23-08-2004	20-11-2007	[m/s] 25,0	Pitch	User defined

Power curves based on item no: 950011.R11 dated 2007-03-19.

Ct-values based on item no: 950020.R2 dated 2006-03-07

Please contact Vestas for information on latest power curve.

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2.972	5.077	7.277	9.571	11.471	13.103
VESTAS V90 3000 90.0 !O! hub: 80,0 m (101)	[MWh]	2.897	4.458	6.095	7.732	9.300	10.725
Check value	[%]	3	14	19	24	23	22

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTG's performs quite similar - only specific power loading (kW/m²) 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.

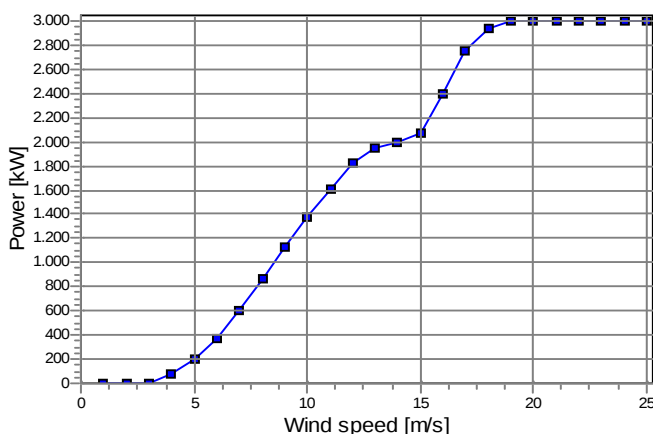
Power curveOriginal data from Windcat, Air density: 1,225 kg/m³

Wind speed	Power	Ce	Wind speed	Ct curve
[m/s]	[kW]		[m/s]	
4,0	77,0	0,31	4,0	0,86
5,0	190,0	0,39	5,0	0,84
6,0	353,0	0,42	6,0	0,83
7,0	578,0	0,43	7,0	0,83
8,0	840,0	0,42	8,0	0,83
9,0	1.094,0	0,39	9,0	0,81
10,0	1.336,0	0,34	10,0	0,74
11,0	1.568,0	0,30	11,0	0,66
12,0	1.770,0	0,26	12,0	0,57
13,0	1.911,0	0,22	13,0	0,47
14,0	1.960,0	0,18	14,0	0,38
15,0	2.038,0	0,15	15,0	0,30
16,0	2.361,0	0,14	16,0	0,24
17,0	2.728,0	0,14	17,0	0,20
18,0	2.923,0	0,12	18,0	0,17
19,0	2.984,0	0,11	19,0	0,14
20,0	2.997,0	0,09	20,0	0,12
21,0	3.000,0	0,08	21,0	0,10
22,0	3.000,0	0,07	22,0	0,09
23,0	3.000,0	0,06	23,0	0,08
24,0	3.000,0	0,05	24,0	0,07
25,0	3.000,0	0,05	25,0	0,06

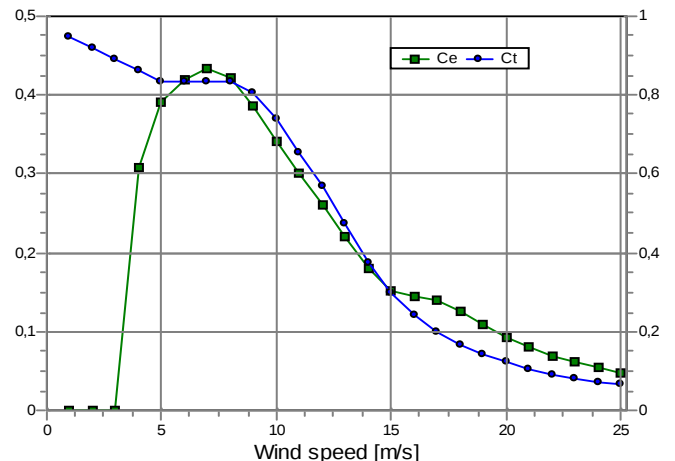
Power, Efficiency and energy vs. wind speedData used in calculation, Air density: 1,269 kg/m³

Wind speed	Power	Ce	Interval	Energy	Acc. Energy	Relative
[m/s]	[kW]		[m/s]	[MWh]	[MWh]	[%]
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	5,7	5,7	0,1
4,0	79,7	0,31	3,50- 4,50	50,9	56,5	0,7
5,0	196,8	0,39	4,50- 5,50	148,5	205,0	2,4
6,0	365,5	0,42	5,50- 6,50	289,0	494,0	5,7
7,0	598,5	0,43	6,50- 7,50	467,3	961,3	11,1
8,0	869,9	0,42	7,50- 8,50	647,3	1.608,5	18,6
9,0	1.132,9	0,39	8,50- 9,50	788,0	2.396,6	27,7
10,0	1.381,0	0,34	9,50- 10,50	870,2	3.266,8	37,8
11,0	1.615,5	0,30	10,50- 11,50	892,1	4.159,0	48,1
12,0	1.817,7	0,26	11,50- 12,50	855,1	5.014,0	57,9
13,0	1.956,0	0,22	12,50- 13,50	763,3	5.777,4	66,8
14,0	1.999,6	0,18	13,50- 14,50	640,9	6.418,3	74,2
15,0	2.072,3	0,15	14,50- 15,50	532,8	6.951,1	80,3
16,0	2.392,8	0,14	15,50- 16,50	455,4	7.406,4	85,6
17,0	2.755,5	0,14	16,50- 17,50	380,8	7.787,3	90,0
18,0	2.942,7	0,13	17,50- 18,50	294,4	8.081,7	93,4
19,0	2.994,0	0,11	18,50- 19,50	210,5	8.292,2	95,8
20,0	2.997,0	0,09	19,50- 20,50	142,7	8.434,9	97,5
21,0	3.000,0	0,08	20,50- 21,50	93,3	8.528,1	98,6
22,0	3.000,0	0,07	21,50- 22,50	59,0	8.587,1	99,2
23,0	3.000,0	0,06	22,50- 23,50	36,1	8.623,2	99,7
24,0	3.000,0	0,05	23,50- 24,50	21,4	8.644,5	99,9
25,0	3.000,0	0,05	24,50- 25,50	7,8	8.652,4	100,0

Power curve
Data used in calculation



Ce and Ct curve



Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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Calculated:

14-04-2008 13:25/2.5.7.83

PARK - Wind Data Analysis**Calculation:** Langtids vind V90 3MW 102 + 107dB **Wind data:** A - Kolsness; Hub height: 50,0**Site Coordinates**

UTM WGS 84 Zone: 31 East: 600.896 North: 6.715.100

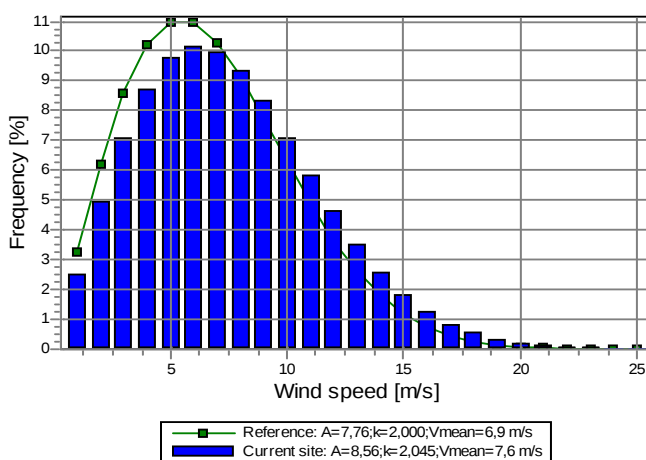
Wind statistics

NO Kollsnes Wind Station (Regression MCP using Hellisoy).wws

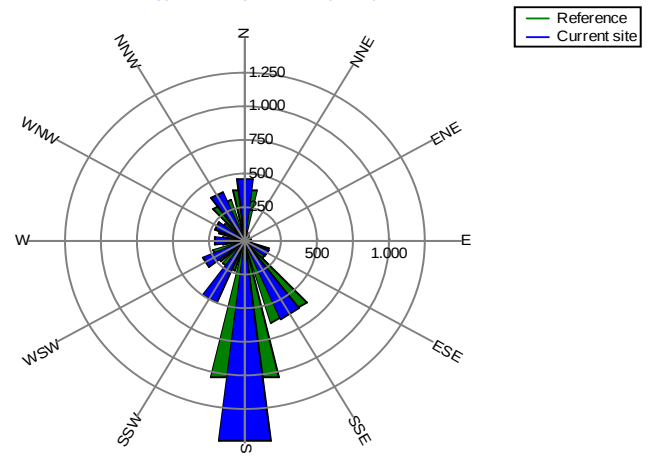
Weibull Data

Sector	Current site			Frequency [%]	Reference: Roughness class 1		
	A- parameter [m/s]	Wind speed [m/s]	k- parameter		A- parameter [m/s]	k- parameter	Frequency [%]
0 N	8,43	7,46	2,193	11,3	7,93	2,160	11,1
1 NNE	6,23	5,52	2,178	3,4	5,40	2,170	3,1
2 ENE	5,03	4,46	2,287	3,2	4,45	2,200	3,2
3 E	5,38	4,78	2,521	5,5	5,07	2,400	5,8
4 ESE	6,40	5,67	2,053	9,4	6,15	1,920	9,9
5 SSE	8,73	7,73	2,303	14,6	8,69	2,310	14,9
6 S	11,17	9,92	2,650	18,2	9,95	2,560	17,5
7 SSW	10,42	9,24	2,521	7,2	8,42	2,370	5,9
8 WSW	8,87	7,86	2,186	6,6	7,80	2,040	6,7
9 W	8,65	7,66	2,135	4,8	7,55	2,010	4,9
10 WNW	7,74	6,86	1,908	6,1	6,88	1,790	6,8
11 NNW	8,29	7,34	2,072	9,8	7,52	2,000	10,2
All	8,56	7,59	2,045	100,0	7,76	2,000	100,0

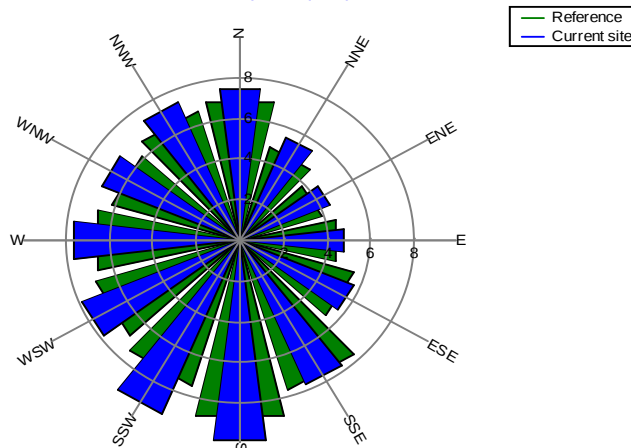
Weibull Distribution



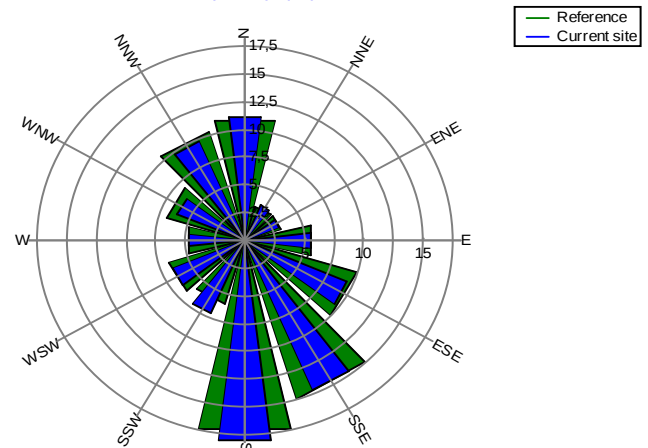
Energy Rose (kWh/m2/year)



Mean wind speed (m/s)



Frequency (%)



Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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PARK - WTG distances**Calculation:** Langtids vind V90 3MW 102 + 107dB**WTG distances**

Z	Nearest WTG	Z	Horizontal distance	Distance in
[m]		[m]	[m]	rotor diameters
1 52,4	2 50,0		443	4,9
2 50,0	1 52,4		443	4,9
3 50,0	4 25,0		465	5,2
4 25,0	5 25,0		416	4,6
5 25,0	6 35,2		327	3,6
6 35,2	7 40,7		297	3,3
7 40,7	6 35,2		297	3,3
8 26,6	9 36,2		353	3,9
9 36,2	8 26,6		353	3,9
10 24,8	8 26,6		454	5,0

Project:

Kollsnes

Description:

Resultatet er baseret på målte data korreleret med
langtids data fra Bergen samt Utsira Fyr.

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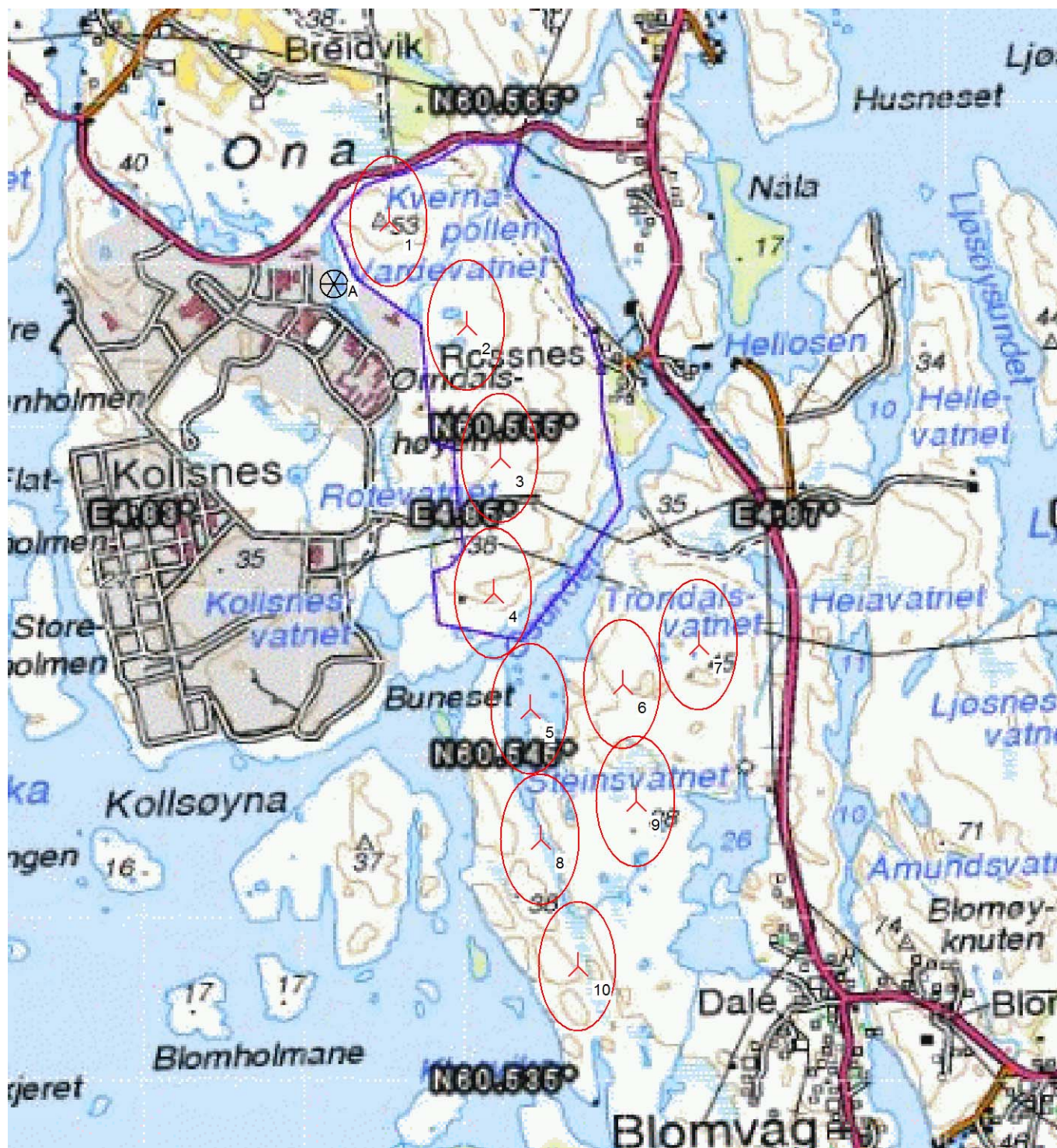
www.kentec.dk

Calculated:

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PARK - Kolsness ATLAS

Calculation: Langtids vind V90 3MW 102 + 107dB **File:** Kolsness ATLAS.bmi



0 250 500 750 1000m

Map: Kolsness ATLAS , Print scale 1:20.000, Map center UTM WGS 84 Zone: 31 East: 601.539 North: 6.714.055

⚓ New WTG

⊗ Site Data