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<b>ELABORAZIONI</b> I.A.T. Consulenza e progetti S.r.l. con socio unico - Via Giua s.n.c. - Z.I. CACIP, 09122 Cagliari (CA) Tel./Fax +39.070.658297 Web www.iatprogetti.it		<b>PAGINA</b> 1 di 2

# REGIONE SARDEGNA

## Provincia del Sud Sardegna

### Parco eolico "Ennas"

#### - Comuni di Suelli e Selegas -



<b>OGGETTO</b> <b>PROGETTO DEFINITIVO</b>	<b>TITOLO</b> <b>STIMA PRODUCIBILITA' DEL PARCO EOLICO</b>
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<b>PROGETTAZIONE</b> I.A.T. CONSULENZA E PROGETTI S.R.L. ING. GIUSEPPE FRONGIA	<table border="0"> <tr> <td data-bbox="821 1505 1101 1850"> <b>GRUPPO DI PROGETTAZIONE</b>            Ing. Giuseppe Frongia            (coordinatore e responsabile)            Ing. Marianna Barbarino            Ing. Enrica Batzella            Pian.Terr. Andrea Cappai            Ing. Gianfranco Corda            Ing. Paolo Desogus            Pian. Terr. Veronica Fais            Ing. Gianluca Melis            Ing. Andrea Onnis            Pian. Terr. Eleonora Re            Ing. Elisa Roych            Ing. Marco Utzeri         </td> <td data-bbox="1129 1505 1465 1850"> <b>CONTRIBUTI SPECIALISTICI</b>            Ce.Pi.Sar (Chiroterrofauna)            Ing. Antonio Dedoni (acustica)            Dott. Geol. Maria Francesca Lobina(Geologia)            Agr. Dott. Nat. Nicola Manis (Pedologia)            Dott. Nat. Francesco Mascia (Flora)            Dott. Nat. Maurizio Medda (Fauna)            Dott. Matteo Tatti (Archeologia)            Dott.ssa Alice Nozza (Archeologia)         </td> </tr> </table>	<b>GRUPPO DI PROGETTAZIONE</b> Ing. Giuseppe Frongia (coordinatore e responsabile) Ing. Marianna Barbarino Ing. Enrica Batzella Pian.Terr. Andrea Cappai Ing. Gianfranco Corda Ing. Paolo Desogus Pian. Terr. Veronica Fais Ing. Gianluca Melis Ing. Andrea Onnis Pian. Terr. Eleonora Re Ing. Elisa Roych Ing. Marco Utzeri	<b>CONTRIBUTI SPECIALISTICI</b> Ce.Pi.Sar (Chiroterrofauna) Ing. Antonio Dedoni (acustica) Dott. Geol. Maria Francesca Lobina(Geologia) Agr. Dott. Nat. Nicola Manis (Pedologia) Dott. Nat. Francesco Mascia (Flora) Dott. Nat. Maurizio Medda (Fauna) Dott. Matteo Tatti (Archeologia) Dott.ssa Alice Nozza (Archeologia)
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Cod. pratica 2021/0260 Nome File: **BLTX-SU-A3** Stima producibilita del parco eolico

0	Giugno 2023	Emissione	IAT	GF	GF
<b>REV.</b>	<b>DATA</b>	<b>DESCRIZIONE</b>	<b>ESEG.</b>	<b>CONTR.</b>	<b>APPR.</b>

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## PARK - Main Result

### Calculation: PARK

#### Wake Model N.O. Jensen (RISØ/EMD) Park 2 2018

Calculation performed in UTM (north)-WGS84 Zone: 32  
At the site centre the difference between grid north and true north is: 0,1°

**Power curve correction method**  
New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>  
Air density calculation method  
Height dependent, temperature from climate station  
Station: CAGLIARI/ELMA V3 2014  
Base temperature: 16,5 °C at 5,0 m  
Base pressure: 1013,3 hPa at 0,0 m  
Air density for Site center in key hub height: 310,0 m + 115,0 m = 1,170 kg/m³ -> 95,5 % of Std  
Relative humidity: 0,0 %

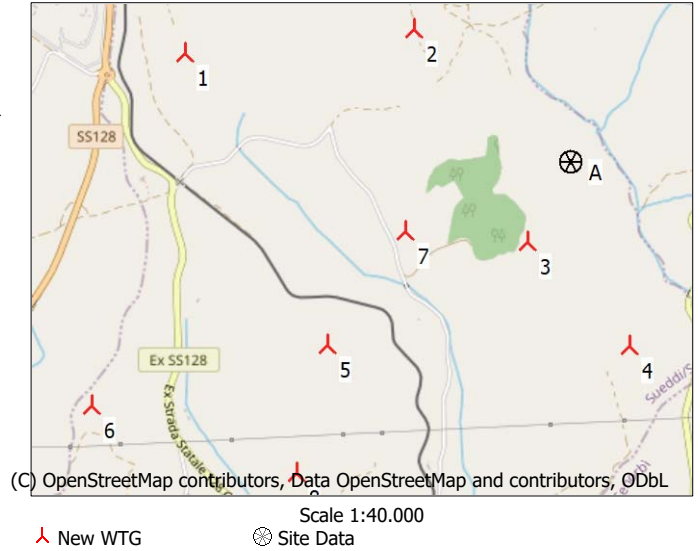
**Wake Model Parameters**  
Terrain type Wake decay constant  
DTU default onshore 0,090 Hub height independent

#### Omnidirectional displacement height from objects

**Wake calculation settings**  
Angle [°] Wind speed [m/s]  
start end step start end step  
0,5 360,0 1,0 0,5 30,5 1,0

**Wind statistics** IT Datos meteorologicos - 100.00 m.wvs

**WASP version** WASP 12 Version 12.08.0022



### Key results for height 115,0 m above ground level

#### Terrain UTM (north)-ETRS89 Zone: 32

Easting	Northing	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness	
A	513.485	4.382.317	WASP	WASP (WASP 12 Version 12.08.0022)	2.849	6,3	1,9

### Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	Result-10,0% [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Wake loss [%]	Specific results*			
					Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
Wind farm	151.104,9	135.994,4	158.318,2	4,6	31,3	16.999,3	2.742	6,6

\* Based on Result-10,0%

### Calculated Annual Energy for each of 8 new WTGs with total 49,6 MW rated power

Links	WTG type			Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Power curve Creator Name	Annual Energy			
	Valid	Manufact.	Type-generator					Result [MWh/y]	Result-10,0% [MWh/y]	Wake loss [%]	Free mean wind speed [m/s]
1	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	18.847,7	16.963	2,5	6,49
2	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	18.815,6	16.934	2,2	6,48
3	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	18.740,2	16.866	6,1	6,64
4	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	20.146,1	18.131	6,3	6,99
5	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	19.716,5	17.745	4,9	6,80
6	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	20.571,3	18.514	2,9	6,91
7	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	16.219,5	14.598	8,2	6,12
8	A	Yes	Siemens Gamesa	SG 6.0-170-6.200	6.200	170,0	115,0 EMD (AM 0, 6,2MW) - 1.225 kg/m3	18.048,0	16.243	3,6	6,34

### WTG siting

#### UTM (north)-ETRS89 Zone: 32

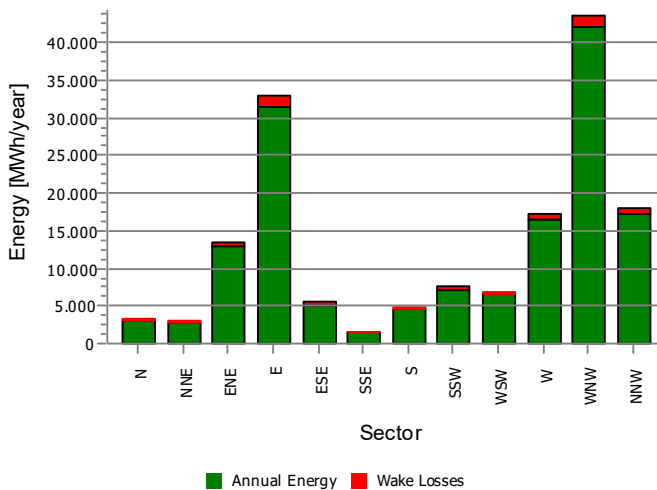
	Easting	Northing	Z [m]	Row data/Description
1 New	511.448	4.382.884	360,0	AG01
2 New	512.656	4.383.014	363,3	AG02
3 New	513.262	4.381.895	364,3	AG03
4 New	513.800	4.381.348	385,0	AG04
5 New	512.202	4.381.351	360,0	AG05
6 New	510.955	4.381.030	346,3	AG06
7 New	512.614	4.381.947	311,1	AG07
8 New	512.042	4.380.676	306,7	AG08

## PARK - Production Analysis

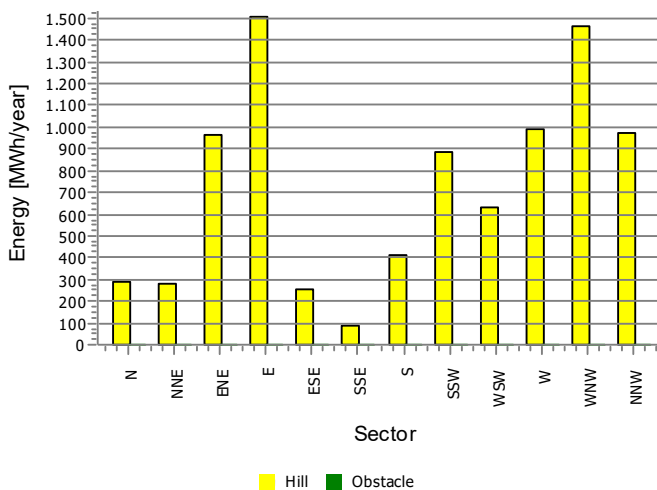
**Calculation:** PARK **WTG:** All new WTGs, Air density varies with WTG position 1,161 kg/m<sup>3</sup> - 1,170 kg/m<sup>3</sup>  
**Directional Analysis**

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]	2.989,4	2.716,3	12.521,5	31.503,2	5.208,9	1.503,2	4.467,2	6.747,1	6.302,6	16.350,3	42.142,9	17.116,7	149.569,3
+Increase due to hills [MWh]	285,1	283,4	967,8	1.507,5	250,5	89,7	413,0	889,1	627,0	993,5	1.465,2	977,1	8.748,9
-Decrease due to wake losses [MWh]	141,3	197,7	459,2	1.550,8	302,0	66,2	243,1	556,8	309,0	986,6	1.634,2	766,3	7.213,3
<b>Resulting energy [MWh]</b>	<b>3.133,1</b>	<b>2.802,0</b>	<b>13.030,1</b>	<b>31.459,9</b>	<b>5.157,5</b>	<b>1.526,7</b>	<b>4.637,1</b>	<b>7.079,4</b>	<b>6.620,6</b>	<b>16.357,2</b>	<b>41.973,9</b>	<b>17.327,4</b>	<b>151.104,9</b>
Specific energy [kWh/m <sup>2</sup> ]													832
Specific energy [kWh/kW]													3.046
Increase due to hills [%]	9,5	10,4	7,7	4,8	4,8	6,0	9,2	13,2	9,9	6,1	3,5	5,7	5,85
Decrease due to wake losses [%]	4,3	6,6	3,4	4,7	5,5	4,2	5,0	7,3	4,5	5,7	3,7	4,2	4,56
Utilization [%]	29,6	25,0	21,7	22,4	28,3	26,3	32,1	33,5	25,9	24,3	22,5	32,3	24,6
Operational [Hours/year]	284	306	700	1.194	363	186	391	671	505	799	1.572	874	7.846
Full Load Equivalent [Hours/year]	63	56	263	634	104	31	93	143	133	330	846	349	3.046

Energy vs. sector



Impact of hills and obstacles vs. sector



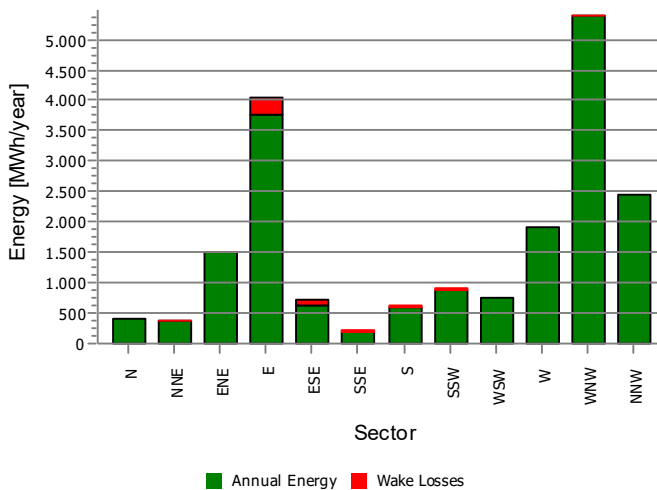
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 1 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,164 kg/m<sup>3</sup>  
**Directional Analysis**

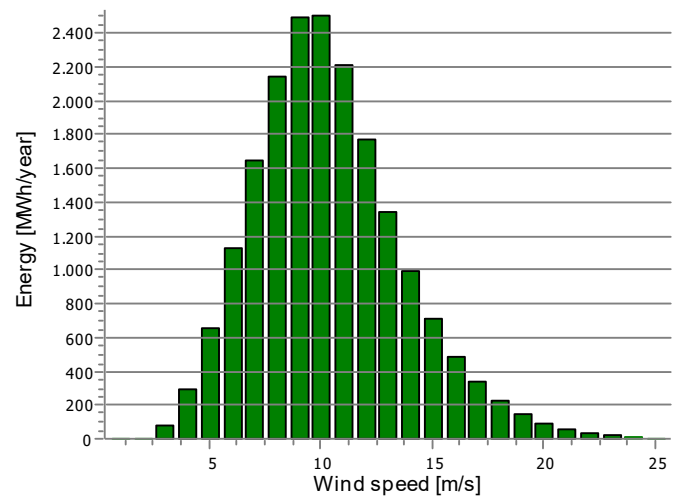
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	370,6	356,7	1.488,3	4.050,1	705,3	200,9	580,5	836,1	746,5	1.909,6	5.293,1	2.302,6	18.840,0
+Increase due to hills	[MWh]	32,6	20,6	19,2	8,9	18,5	13,6	53,9	60,0	13,0	5,1	100,9	149,9	496,3
-Decrease due to wake losses	[MWh]	0,0	0,0	6,8	299,0	98,7	20,7	33,6	29,7	0,0	0,0	0,0	0,0	488,6
<b>Resulting energy</b>	<b>[MWh]</b>	<b>403,2</b>	<b>377,3</b>	<b>1.500,7</b>	<b>3.760,0</b>	<b>625,1</b>	<b>193,8</b>	<b>600,7</b>	<b>866,4</b>	<b>759,5</b>	<b>1.914,7</b>	<b>5.394,0</b>	<b>2.452,4</b>	<b>18.847,7</b>
Specific energy	[kWh/m <sup>2</sup> ]													830
Specific energy	[kWh/kW]													3.040
Increase due to hills	[%]	8,8	5,8	1,3	0,2	2,6	6,8	9,3	7,2	1,7	0,3	1,9	6,5	2,63
Decrease due to wake losses	[%]	0,0	0,0	0,5	7,4	13,6	9,6	5,3	3,3	0,0	0,0	0,0	0,0	2,53
Directional Distribution	[%]	2,1	2,0	7,8	21,0	3,7	1,1	3,3	4,6	3,9	9,9	27,9	12,7	100,0
Utilization	[%]	31,0	27,3	24,0	22,9	25,6	24,6	32,3	35,8	28,8	27,5	24,0	33,1	26,1
Operational	[Hours/year]	285	313	667	1.197	375	193	406	669	480	752	1.577	921	7.835
Full Load Equivalent	[Hours/year]	65	61	242	606	101	31	97	140	122	309	870	396	3.040
A- parameter*)	[m/s]	5,2	4,5	6,9	9,0	6,3	4,3	5,7	5,3	5,5	7,5	9,1	7,7	7,3
Mean wind speed*)	[m/s]	4,7	4,2	6,2	8,0	5,6	4,0	5,1	4,8	5,0	6,6	8,0	6,8	6,5
k- parameter		1,43	1,21	1,52	2,08	1,62	1,17	1,65	1,71	1,42	1,80	2,06	2,21	1,70
Frequency	[%]	3,6	4,0	8,5	15,3	4,8	2,5	5,2	8,5	6,1	9,6	20,1	11,8	100,0
Power density	[W/m <sup>2</sup> ]													360

\*) Influence of wake losses not included

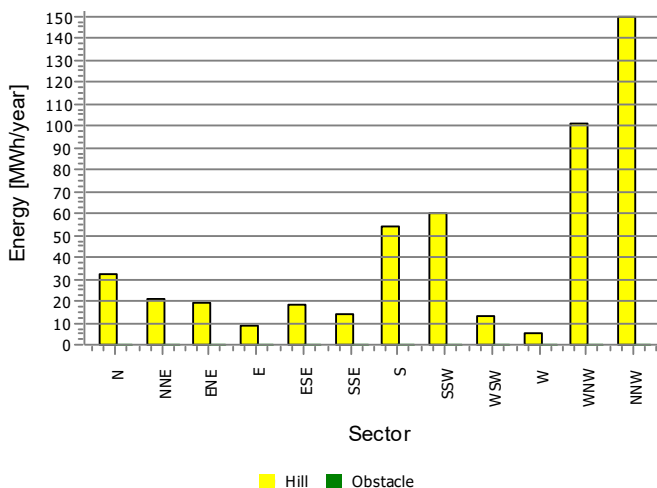
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



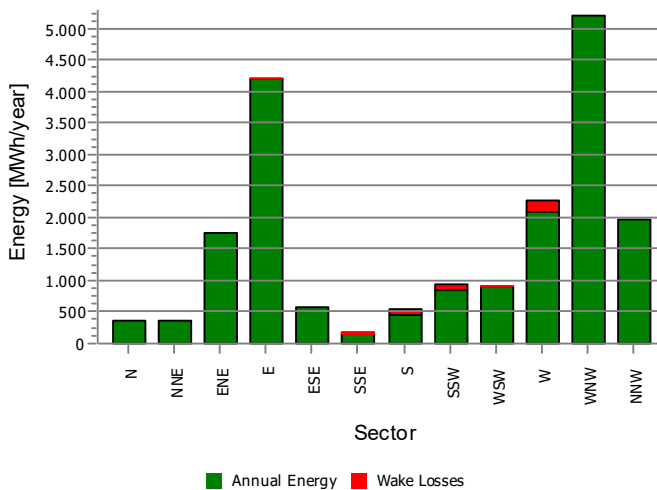
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 2 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,164 kg/m<sup>3</sup>  
**Directional Analysis**

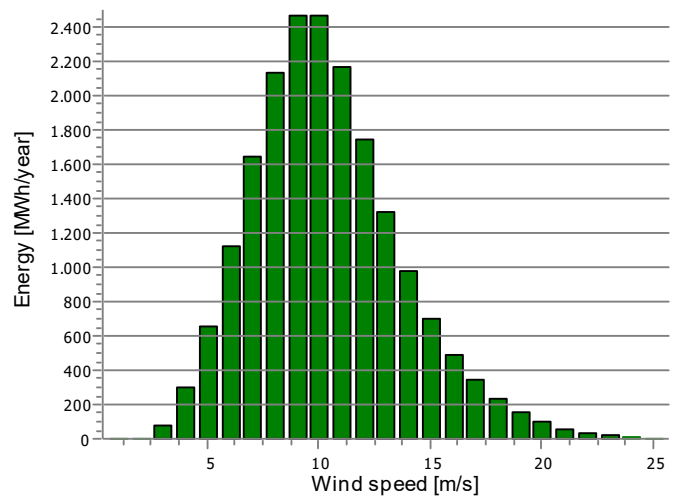
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	359,7	325,0	1.631,3	4.041,7	587,3	172,5	542,3	853,0	828,2	2.173,4	5.207,0	2.006,8	18.728,3
+Increase due to hills	[MWh]	5,7	24,9	118,1	162,0	-2,1	-4,4	8,6	79,7	76,8	103,0	-9,2	-52,9	510,2
-Decrease due to wake losses	[MWh]	0,0	0,0	0,0	0,0	0,0	26,4	111,5	84,2	9,8	191,1	0,0	0,0	422,8
<b>Resulting energy</b>	<b>[MWh]</b>	<b>365,4</b>	<b>350,0</b>	<b>1.749,4</b>	<b>4.203,8</b>	<b>585,3</b>	<b>141,7</b>	<b>439,4</b>	<b>848,5</b>	<b>895,3</b>	<b>2.085,3</b>	<b>5.197,7</b>	<b>1.953,9</b>	<b>18.815,6</b>
Specific energy	[kWh/m <sup>2</sup> ]													829
Specific energy	[kWh/kW]													3.035
Increase due to hills	[%]	1,6	7,7	7,2	4,0	-0,4	-2,6	1,6	9,3	9,3	4,7	-0,2	-2,6	2,72
Decrease due to wake losses	[%]	0,0	0,0	0,0	0,0	0,0	15,7	20,2	9,0	1,1	8,4	0,0	0,0	2,20
Directional Distribution	[%]	1,9	1,8	9,1	21,9	3,0	0,9	2,9	4,8	4,7	11,8	27,0	10,2	100,0
Utilization	[%]	32,3	27,9	22,5	24,0	31,6	24,1	27,8	33,6	27,2	24,0	24,7	36,2	25,9
Operational	[Hours/year]	276	303	716	1.216	342	175	376	674	525	833	1.551	833	7.819
Full Load Equivalent	[Hours/year]	59	56	282	678	94	23	71	137	144	336	838	315	3.035
A- parameter*)	[m/s]	5,1	4,4	7,3	9,1	5,9	3,9	5,5	5,4	5,8	7,8	8,9	7,2	7,3
Mean wind speed*)	[m/s]	4,6	4,1	6,5	8,1	5,3	3,7	4,9	4,8	5,3	6,9	7,9	6,4	6,5
k- parameter		1,44	1,21	1,53	2,07	1,60	1,14	1,65	1,72	1,43	1,82	2,06	2,25	1,69
Frequency	[%]	3,5	3,9	9,2	15,6	4,4	2,2	4,8	8,6	6,7	10,7	19,8	10,6	100,0
Power density	[W/m <sup>2</sup> ]													362

\*) Influence of wake losses not included

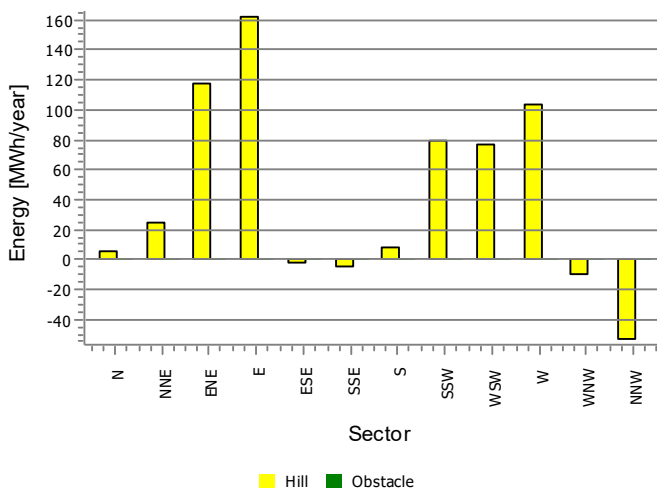
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



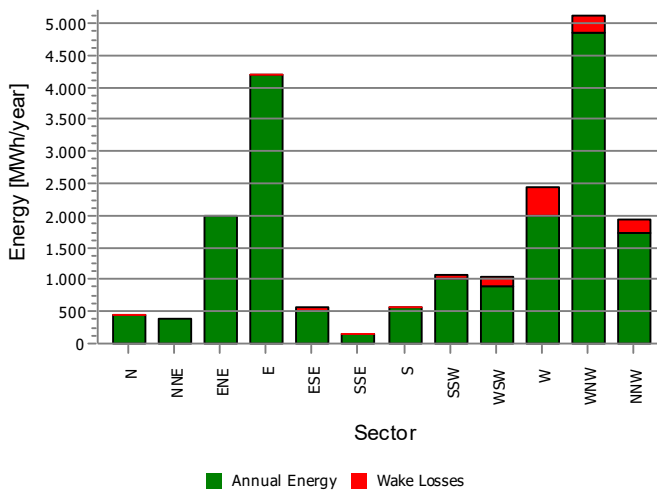
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 3 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,164 kg/m<sup>3</sup>  
**Directional Analysis**

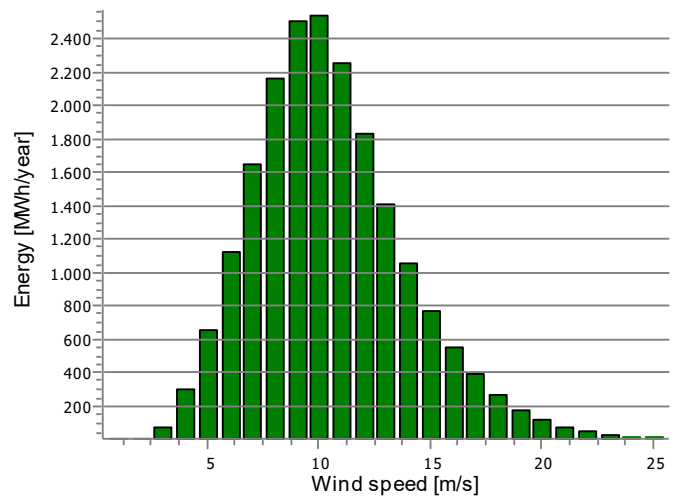
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	421,4	340,0	1.736,6	3.875,3	548,9	164,0	531,8	872,7	880,3	2.237,7	5.059,6	1.954,9	18.623,1
+Increase due to hills	[MWh]	36,1	61,2	253,2	308,2	8,2	-0,5	47,3	192,8	162,9	209,0	59,4	-6,8	1.331,0
-Decrease due to wake losses	[MWh]	0,0	0,0	0,0	0,0	58,5	19,1	0,0	39,4	161,4	452,0	271,7	211,8	1.214,0
<b>Resulting energy</b>	<b>[MWh]</b>	<b>457,5</b>	<b>401,2</b>	<b>1.989,8</b>	<b>4.183,5</b>	<b>498,6</b>	<b>144,3</b>	<b>579,1</b>	<b>1.026,1</b>	<b>881,9</b>	<b>1.994,6</b>	<b>4.847,3</b>	<b>1.736,3</b>	<b>18.740,2</b>
Specific energy	[kWh/m <sup>2</sup> ]													826
Specific energy	[kWh/kW]													3.023
Increase due to hills	[%]	8,6	18,0	14,6	8,0	1,5	-0,3	8,9	22,1	18,5	9,3	1,2	-0,3	7,15
Decrease due to wake losses	[%]	0,0	0,0	0,0	0,0	10,5	11,7	0,0	3,7	15,5	18,5	5,3	10,9	6,08
Directional Distribution	[%]	2,3	2,0	10,0	21,0	2,8	0,8	2,9	5,3	5,2	12,3	25,7	9,8	100,0
Utilization	[%]	31,8	26,2	21,4	22,8	28,3	25,2	33,8	34,1	21,9	20,4	23,0	31,8	24,0
Operational	[Hours/year]	302	312	764	1.182	331	171	372	691	552	857	1.513	814	7.859
Full Load Equivalent	[Hours/year]	74	65	321	675	80	23	93	165	142	322	782	280	3.023
A- parameter*)	[m/s]	5,5	4,7	7,6	9,3	5,9	3,9	5,7	5,7	6,1	8,1	9,0	7,3	7,4
Mean wind speed*)	[m/s]	5,0	4,4	6,9	8,3	5,3	3,7	5,1	5,1	5,6	7,2	8,0	6,4	6,6
k- parameter		1,52	1,21	1,56	2,06	1,59	1,14	1,63	1,72	1,44	1,83	2,06	2,25	1,69
Frequency	[%]	3,8	4,0	9,7	15,0	4,2	2,2	4,7	8,8	7,0	10,9	19,3	10,4	100,0
Power density	[W/m <sup>2</sup> ]													388

\*) Influence of wake losses not included

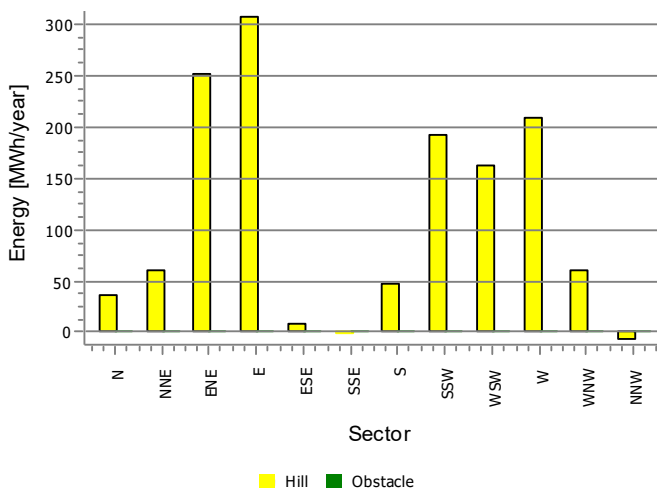
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



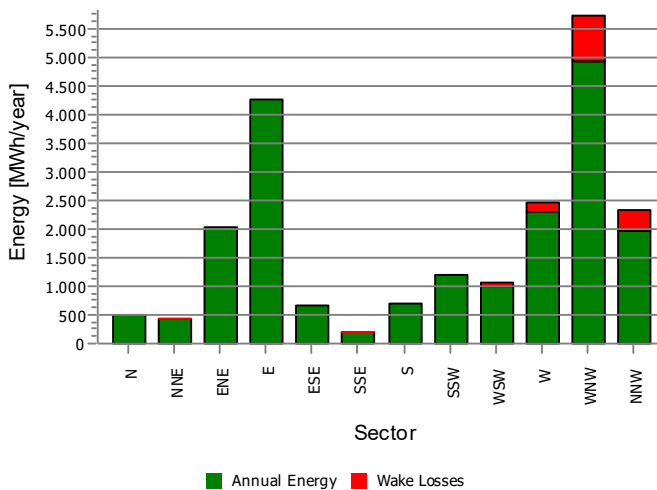
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 4 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,161 kg/m<sup>3</sup>  
**Directional Analysis**

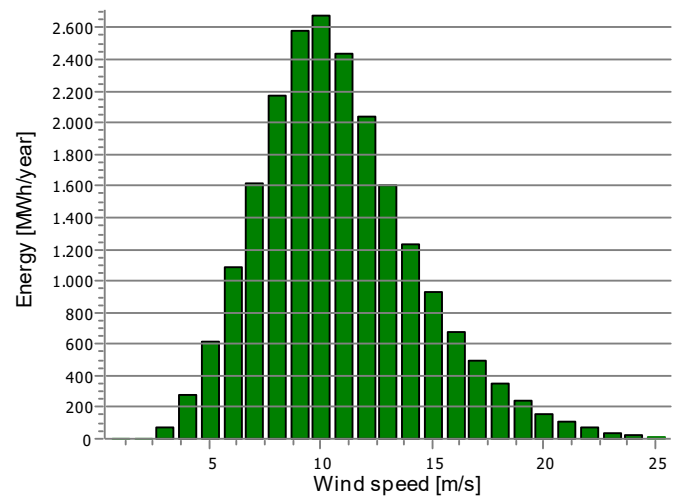
Sector	0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy [MWh]	400,8	339,4	1.673,4	3.712,3	579,1	168,8	547,5	878,5	832,2	2.120,3	5.202,1	1.993,6	18.448,0
+Increase due to hills [MWh]	96,5	95,7	347,1	543,9	87,7	27,5	137,0	308,7	217,9	355,4	520,0	318,5	3.055,8
-Decrease due to wake losses [MWh]	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	44,1	186,4	789,2	338,2	1.357,8
<b>Resulting energy [MWh]</b>	<b>497,3</b>	<b>435,0</b>	<b>2.020,5</b>	<b>4.256,3</b>	<b>666,8</b>	<b>196,3</b>	<b>684,4</b>	<b>1.187,3</b>	<b>1.006,0</b>	<b>2.289,3</b>	<b>4.932,9</b>	<b>1.974,0</b>	<b>20.146,1</b>
Specific energy [kWh/m <sup>2</sup> ]													888
Specific energy [kWh/kW]													3.249
Increase due to hills [%]	24,1	28,2	20,7	14,7	15,1	16,3	25,0	35,1	26,2	16,8	10,0	16,0	16,56
Decrease due to wake losses [%]	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,2	7,5	13,8	14,6	6,31
Directional Distribution [%]	2,3	2,0	9,4	19,8	3,1	0,9	3,2	5,5	4,9	11,5	26,6	10,8	100,0
Utilization [%]	29,4	24,5	20,2	21,9	29,2	26,6	31,6	33,8	23,5	21,5	18,5	28,1	22,3
Operational [Hours/year]	300	311	753	1.179	345	179	387	698	533	829	1.567	850	7.931
Full Load Equivalent [Hours/year]	80	70	326	686	108	32	110	191	162	369	796	318	3.249
A- parameter*) [m/s]	5,8	4,9	7,9	9,6	6,3	4,2	6,1	6,0	6,3	8,4	9,7	7,8	7,8
Mean wind speed*) [m/s]	5,2	4,6	7,1	8,5	5,7	4,0	5,4	5,3	5,7	7,5	8,6	6,9	7,0
k- parameter	1,49	1,21	1,55	2,06	1,60	1,15	1,64	1,72	1,43	1,82	2,06	2,25	1,70
Frequency [%]	3,8	3,9	9,5	14,9	4,4	2,3	4,9	8,8	6,7	10,4	19,8	10,7	100,0
Power density [W/m <sup>2</sup> ]													446

\*) Influence of wake losses not included

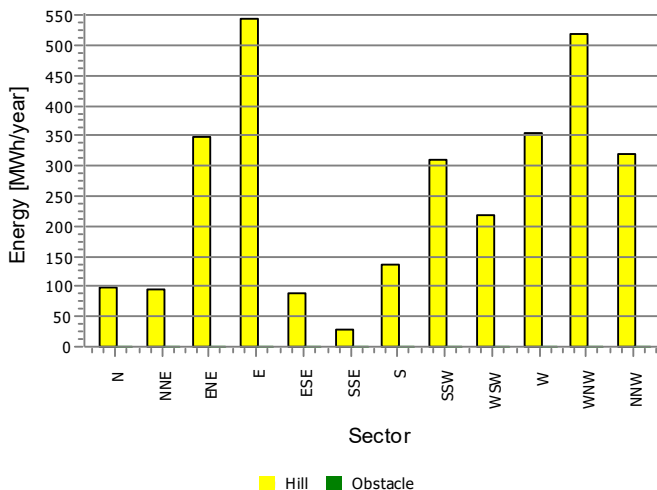
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



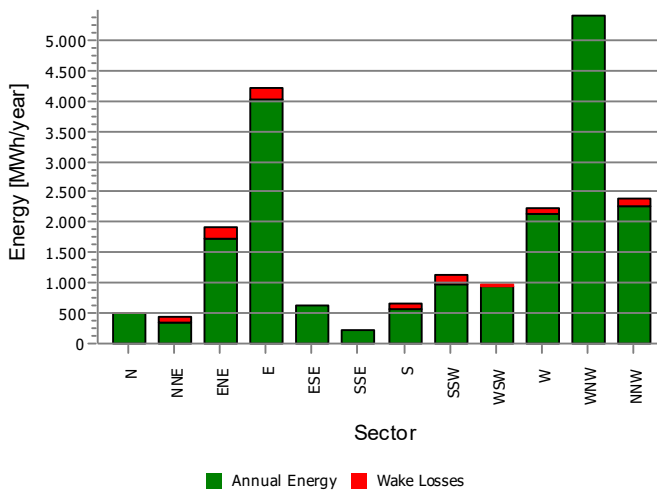
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 5 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,164 kg/m<sup>3</sup>  
**Directional Analysis**

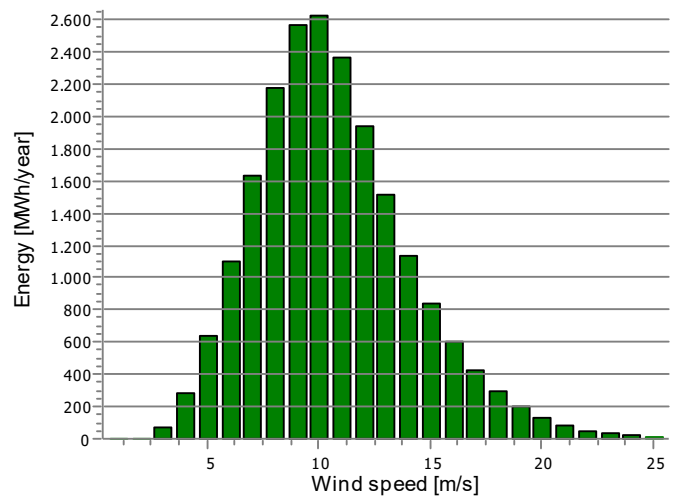
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	420,3	365,6	1.670,7	3.903,7	582,6	186,6	554,3	868,2	828,5	2.031,2	5.139,3	2.163,3	18.714,5
+Increase due to hills	[MWh]	83,3	82,8	246,8	317,4	44,1	21,1	115,8	247,5	154,6	197,6	265,1	231,6	2.007,7
-Decrease due to wake losses	[MWh]	15,6	100,2	187,9	196,5	0,0	0,0	96,6	130,8	41,3	92,3	0,0	144,4	1.005,7
<b>Resulting energy</b>	<b>[MWh]</b>	<b>488,0</b>	<b>348,3</b>	<b>1.729,6</b>	<b>4.024,6</b>	<b>626,8</b>	<b>207,7</b>	<b>573,5</b>	<b>985,0</b>	<b>941,8</b>	<b>2.136,5</b>	<b>5.404,4</b>	<b>2.250,5</b>	<b>19.716,5</b>
Specific energy	[kWh/m <sup>2</sup> ]													869
Specific energy	[kWh/kW]													3.180
Increase due to hills	[%]	19,8	22,6	14,8	8,1	7,6	11,3	20,9	28,5	18,7	9,7	5,2	10,7	10,73
Decrease due to wake losses	[%]	3,1	22,3	9,8	4,7	0,0	0,0	14,4	11,7	4,2	4,1	0,0	6,0	4,85
Directional Distribution	[%]	2,4	2,2	9,3	20,4	3,0	1,0	3,2	5,4	4,7	10,8	26,1	11,6	100,0
Utilization	[%]	28,9	19,4	19,3	21,6	30,2	26,7	27,6	30,7	24,8	24,1	22,9	30,5	23,8
Operational	[Hours/year]	308	324	739	1.182	340	184	391	701	524	796	1.538	877	7.904
Full Load Equivalent	[Hours/year]	79	56	279	649	101	34	92	159	152	345	872	363	3.180
A- parameter*)	[m/s]	5,7	4,9	7,6	9,4	6,2	4,3	6,0	5,8	6,1	8,0	9,3	7,8	7,6
Mean wind speed*)	[m/s]	5,2	4,6	6,9	8,4	5,5	4,1	5,3	5,2	5,6	7,1	8,3	6,9	6,8
k- parameter		1,49	1,21	1,56	2,08	1,60	1,16	1,64	1,71	1,44	1,81	2,06	2,22	1,71
Frequency	[%]	3,9	4,1	9,4	15,0	4,3	2,3	4,9	8,9	6,6	10,1	19,5	11,1	100,0
Power density	[W/m <sup>2</sup> ]													411

\*) Influence of wake losses not included

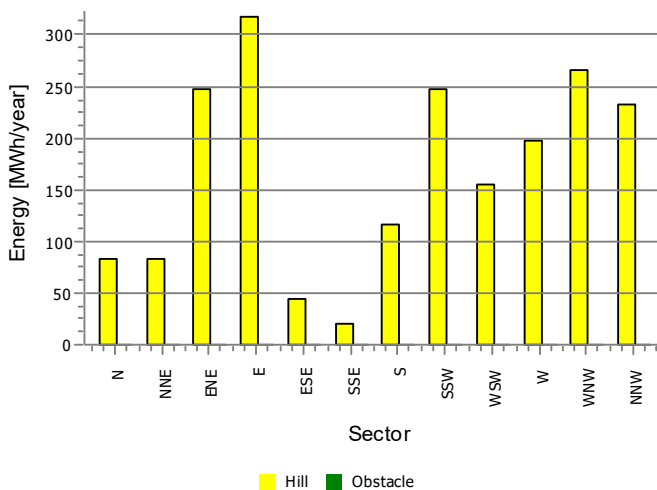
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector





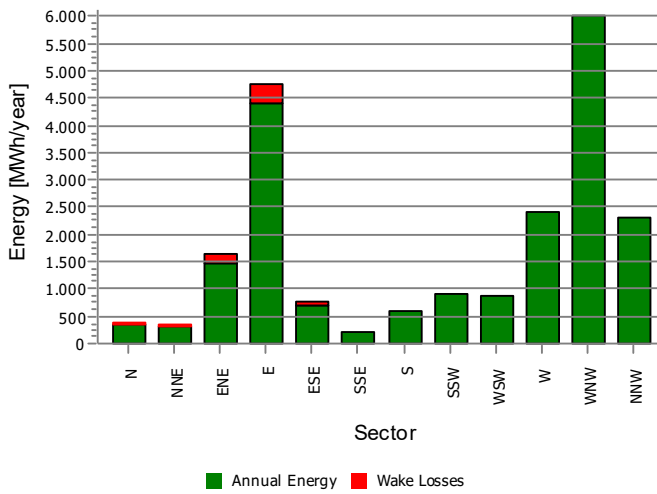
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 6 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,166 kg/m<sup>3</sup>  
**Directional Analysis**

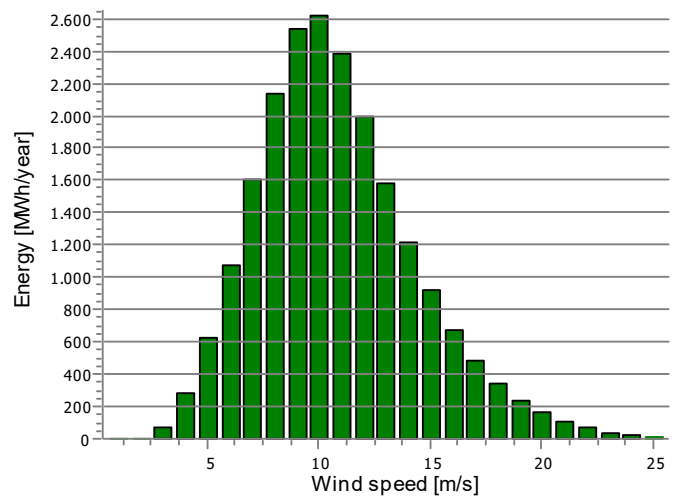
Sector	0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy [MWh]	340,5	310,8	1.462,3	4.216,5	649,5	190,9	525,8	791,8	762,9	2.071,8	5.410,8	2.060,2	18.793,8
+Increase due to hills [MWh]	32,6	36,5	189,2	528,2	107,9	23,1	54,7	115,5	123,2	325,2	602,6	245,5	2.384,3
-Decrease due to wake losses [MWh]	10,7	18,4	170,0	352,6	55,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	606,9
<b>Resulting energy [MWh]</b>	<b>362,4</b>	<b>328,9</b>	<b>1.481,6</b>	<b>4.392,1</b>	<b>702,2</b>	<b>214,0</b>	<b>580,5</b>	<b>907,4</b>	<b>886,0</b>	<b>2.397,0</b>	<b>6.013,4</b>	<b>2.305,7</b>	<b>20.571,3</b>
Specific energy [kWh/m <sup>2</sup> ]													906
Specific energy [kWh/kW]													3.318
Increase due to hills [%]	9,6	11,8	12,9	12,5	16,6	12,1	10,4	14,6	16,1	15,7	11,1	11,9	12,69
Decrease due to wake losses [%]	2,9	5,3	10,3	7,4	7,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,87
Directional Distribution [%]	1,8	1,6	7,8	22,4	3,6	1,0	2,7	4,3	4,2	11,3	28,4	10,9	100,0
Utilization [%]	29,8	25,8	19,6	19,4	25,9	26,4	34,3	36,6	26,7	24,0	21,2	33,0	23,1
Operational [Hours/year]	261	291	679	1.265	369	186	378	650	505	828	1.628	854	7.894
Full Load Equivalent [Hours/year]	58	53	239	708	113	35	94	146	143	387	970	372	3.318
A- parameter*) [m/s]	5,3	4,5	7,3	9,8	6,5	4,3	5,7	5,5	5,9	8,2	9,7	7,8	7,7
Mean wind speed*) [m/s]	4,8	4,2	6,6	8,7	5,9	4,1	5,1	4,9	5,3	7,3	8,6	6,9	6,9
k- parameter	1,43	1,21	1,51	2,07	1,60	1,16	1,66	1,72	1,42	1,80	2,05	2,24	1,68
Frequency [%]	3,3	3,7	8,6	16,0	4,7	2,4	4,8	8,2	6,4	10,5	20,6	10,8	100,0
Power density [W/m <sup>2</sup> ]													439

\*) Influence of wake losses not included

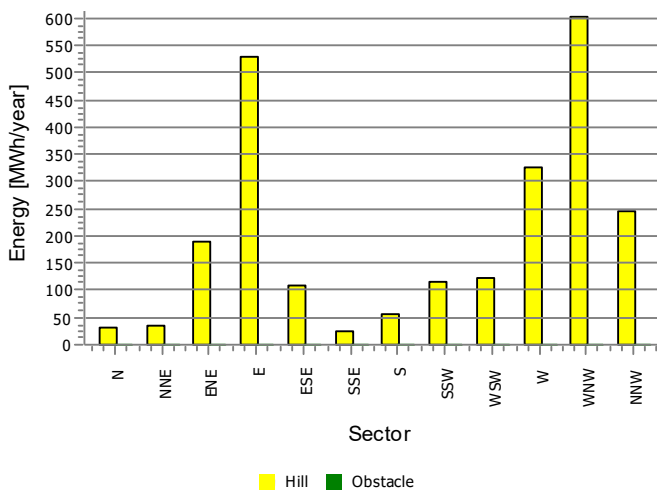
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



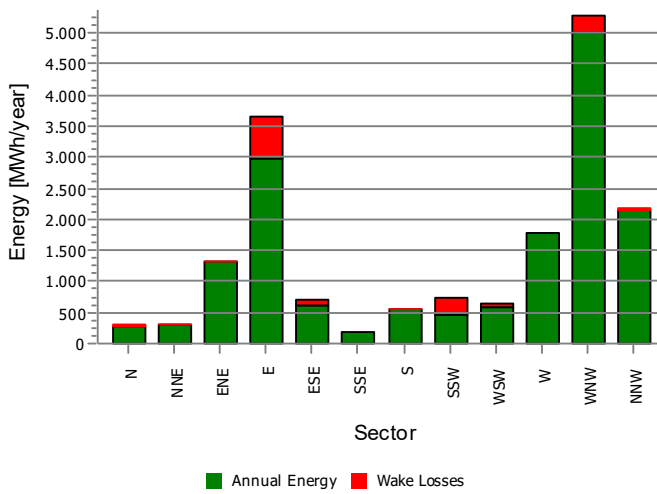
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 7 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,170 kg/m<sup>3</sup>  
**Directional Analysis**

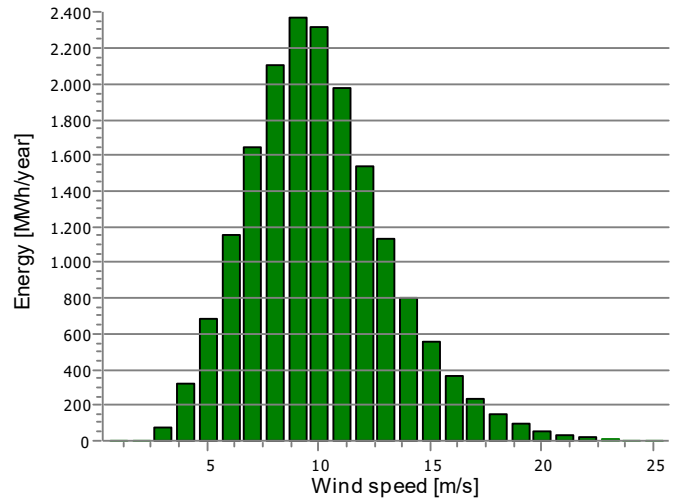
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	327,6	327,0	1.444,4	3.903,3	745,6	199,6	585,4	822,7	727,1	1.932,3	5.460,8	2.256,8	18.732,6
+Increase due to hills	[MWh]	-19,4	-31,1	-130,9	-247,6	-34,7	-6,5	-36,6	-95,3	-77,5	-139,6	-179,3	-72,3	-1.070,7
-Decrease due to wake losses	[MWh]	46,7	0,1	0,0	685,1	89,6	0,0	1,5	272,8	52,5	0,0	270,8	23,3	1.442,3
<b>Resulting energy</b>	<b>[MWh]</b>	<b>261,5</b>	<b>295,8</b>	<b>1.313,5</b>	<b>2.970,6</b>	<b>621,4</b>	<b>193,1</b>	<b>547,3</b>	<b>454,6</b>	<b>597,1</b>	<b>1.792,7</b>	<b>5.010,7</b>	<b>2.161,1</b>	<b>16.219,5</b>
Specific energy	[kWh/m <sup>2</sup> ]													715
Specific energy	[kWh/kW]													2.616
Increase due to hills	[%]	-5,9	-9,5	-9,1	-6,3	-4,7	-3,3	-6,2	-11,6	-10,7	-7,2	-3,3	-3,2	-5,72
Decrease due to wake losses	[%]	15,1	0,0	0,0	18,7	12,6	0,0	0,3	37,5	8,1	0,0	5,1	1,1	8,17
Directional Distribution	[%]	1,7	1,7	7,4	20,7	4,0	1,1	3,1	4,1	3,7	10,2	29,9	12,4	100,0
Utilization	[%]	27,9	29,8	26,5	22,3	27,3	29,2	36,0	24,3	28,4	29,3	24,3	35,0	26,3
Operational	[Hours/year]	265	291	646	1.175	390	195	400	645	466	755	1.605	900	7.732
Full Load Equivalent	[Hours/year]	42	48	212	479	100	31	88	73	96	289	808	349	2.616
A- parameter*)	[m/s]	4,6	4,1	6,4	8,4	6,1	4,0	5,3	4,9	5,1	7,1	8,7	7,2	6,9
Mean wind speed*)	[m/s]	4,2	3,9	5,8	7,4	5,4	3,8	4,7	4,4	4,7	6,3	7,7	6,4	6,1
k- parameter		1,38	1,20	1,51	2,07	1,62	1,17	1,66	1,72	1,41	1,79	2,05	2,22	1,69
Frequency	[%]	3,4	3,8	8,4	15,2	5,0	2,5	5,2	8,3	6,0	9,8	20,8	11,6	100,0
Power density	[W/m <sup>2</sup> ]													309

\*) Influence of wake losses not included

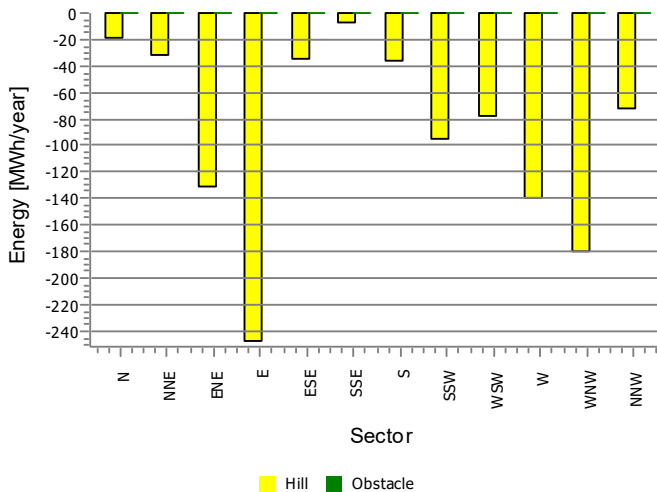
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



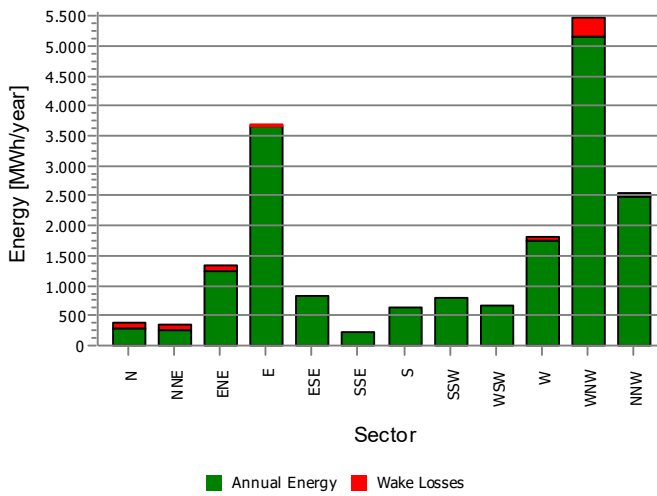
## PARK - Production Analysis

**Calculation:** PARK **WTG:** 8 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m, Air density: 1,170 kg/m<sup>3</sup>  
**Directional Analysis**

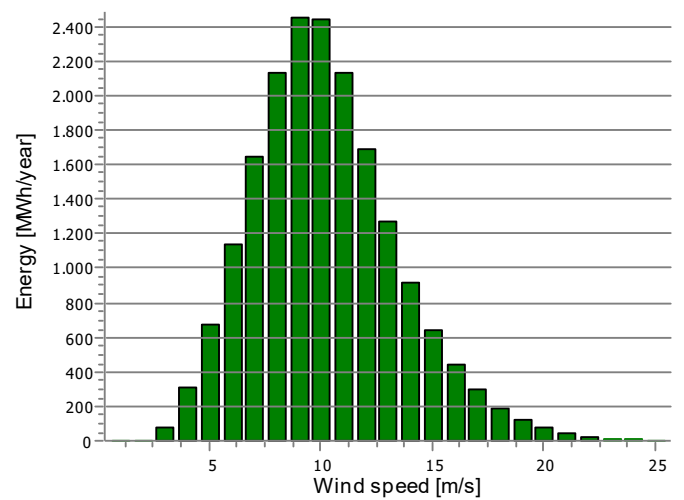
Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	348,5	351,7	1.414,5	3.800,3	810,6	219,9	599,8	824,1	696,9	1.874,0	5.370,3	2.378,5	18.689,1
+Increase due to hills	[MWh]	17,6	-7,1	-75,0	-113,6	20,8	15,9	32,4	-19,9	-43,9	-62,1	105,7	163,5	34,2
-Decrease due to wake losses	[MWh]	68,4	79,0	94,5	17,5	0,0	0,0	0,0	0,0	0,0	64,8	302,5	48,6	675,3
<b>Resulting energy</b>	<b>[MWh]</b>	<b>297,8</b>	<b>265,5</b>	<b>1.245,0</b>	<b>3.669,1</b>	<b>831,4</b>	<b>235,8</b>	<b>632,1</b>	<b>804,2</b>	<b>653,0</b>	<b>1.747,1</b>	<b>5.173,5</b>	<b>2.493,4</b>	<b>18.048,0</b>
Specific energy	[kWh/m <sup>2</sup> ]													795
Specific energy	[kWh/kW]													2.911
Increase due to hills	[%]	5,1	-2,0	-5,3	-3,0	2,6	7,2	5,4	-2,4	-6,3	-3,3	2,0	6,9	0,18
Decrease due to wake losses	[%]	18,7	22,9	7,1	0,5	0,0	0,0	0,0	0,0	0,0	3,6	5,5	1,9	3,61
Directional Distribution	[%]	2,0	1,8	7,2	19,7	4,4	1,3	3,4	4,3	3,5	9,7	29,2	13,6	100,0
Utilization	[%]	25,4	21,8	24,0	26,4	29,5	27,4	34,8	37,8	30,4	27,6	22,6	32,2	26,5
Operational	[Hours/year]	277	300	640	1.155	413	205	419	645	458	745	1.595	945	7.797
Full Load Equivalent	[Hours/year]	48	43	201	592	134	38	102	130	105	282	834	402	2.911
A- parameter*)	[m/s]	5,0	4,4	6,5	8,6	6,4	4,3	5,6	5,2	5,2	7,2	9,0	7,7	7,1
Mean wind speed*)	[m/s]	4,5	4,1	5,9	7,6	5,8	4,1	5,0	4,6	4,7	6,4	8,0	6,8	6,3
k- parameter		1,40	1,21	1,52	2,07	1,64	1,19	1,66	1,71	1,41	1,79	2,05	2,20	1,70
Frequency	[%]	3,6	3,9	8,2	14,8	5,3	2,6	5,4	8,3	5,9	9,6	20,5	12,1	100,0
Power density	[W/m <sup>2</sup> ]													340

\*) Influence of wake losses not included

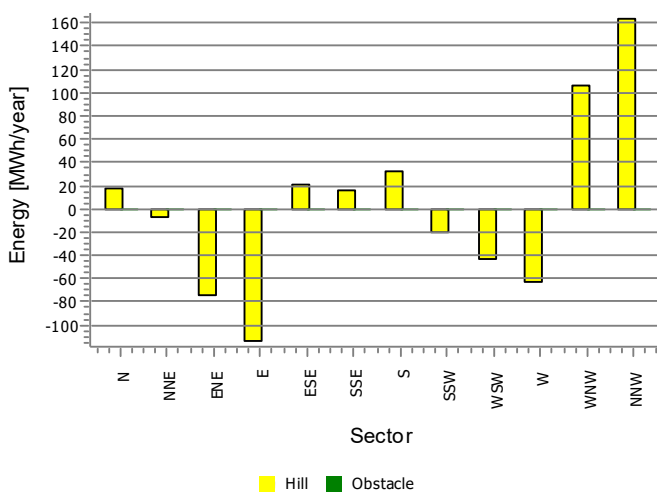
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 1 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

Siemens Gamesa Renewable Energy and its affiliates reserve the right to change the above specifications without prior notice.

### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

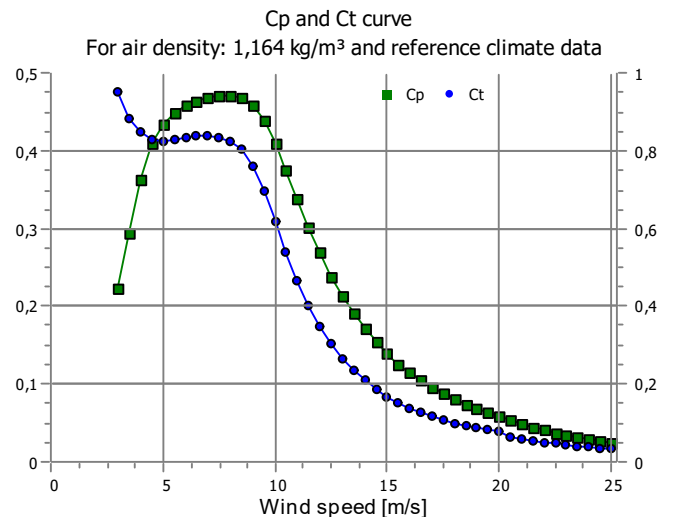
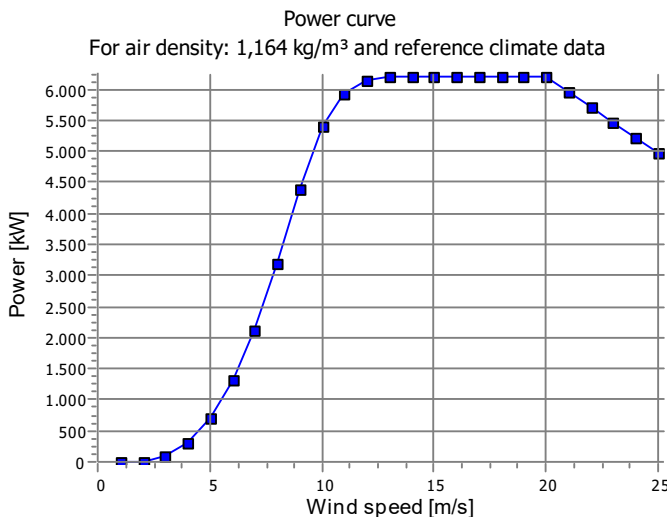
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,164 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,7	0,22	2,50-3,50	72,2	72,2	0,4
4,0	307,1	0,36	3,50-4,50	289,8	362,0	1,9
5,0	716,9	0,43	4,50-5,50	640,9	1.002,9	5,3
6,0	1.305,8	0,46	5,50-6,50	1.093,4	2.096,3	11,1
7,0	2.118,2	0,47	6,50-7,50	1.601,3	3.697,6	19,6
8,0	3.184,6	0,47	7,50-8,50	2.091,9	5.789,5	30,7
9,0	4.403,8	0,46	8,50-9,50	2.423,0	8.212,6	43,6
10,0	5.403,4	0,41	9,50-10,50	2.438,2	10.650,8	56,5
11,0	5.934,6	0,34	10,50-11,50	2.149,5	12.800,3	67,9
12,0	6.129,8	0,27	11,50-12,50	1.726,9	14.527,2	77,1
13,0	6.184,7	0,21	12,50-13,50	1.312,4	15.839,7	84,0
14,0	6.197,2	0,17	13,50-14,50	962,6	16.802,3	89,1
15,0	6.199,1	0,14	14,50-15,50	686,5	17.488,8	92,8
16,0	6.200,0	0,11	15,50-16,50	477,4	17.966,2	95,3
17,0	6.200,0	0,10	16,50-17,50	324,1	18.290,2	97,0
18,0	6.200,0	0,08	17,50-18,50	214,9	18.505,2	98,2
19,0	6.200,0	0,07	18,50-19,50	139,4	18.644,6	98,9
20,0	6.200,0	0,06	19,50-20,50	87,8	18.732,4	99,4
21,0	5.956,0	0,05	20,50-21,50	53,1	18.785,4	99,7
22,0	5.708,0	0,04	21,50-22,50	31,0	18.816,4	99,8
23,0	5.460,0	0,03	22,50-23,50	17,7	18.834,2	99,9
24,0	5.212,0	0,03	23,50-24,50	10,0	18.844,1	100,0
25,0	4.964,0	0,02	24,50-25,50	3,6	18.847,7	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 2 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

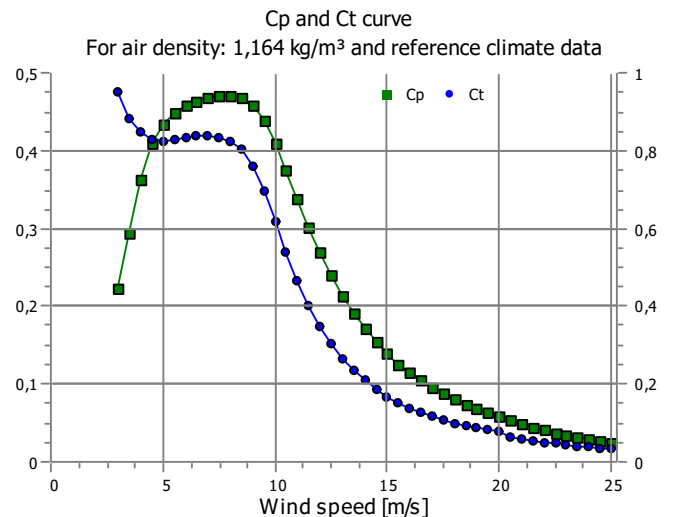
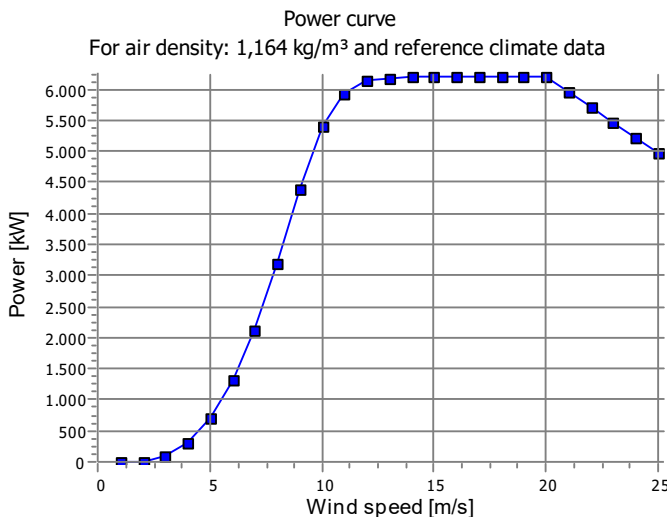
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,164 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,6	0,22	2,50-3,50	72,8	72,8	0,4
4,0	307,0	0,36	3,50-4,50	292,5	365,3	1,9
5,0	716,7	0,43	4,50-5,50	646,7	1.012,0	5,4
6,0	1.305,4	0,46	5,50-6,50	1.101,3	2.113,3	11,2
7,0	2.117,5	0,47	6,50-7,50	1.607,7	3.721,1	19,8
8,0	3.183,5	0,47	7,50-8,50	2.091,1	5.812,2	30,9
9,0	4.402,4	0,46	8,50-9,50	2.410,8	8.222,9	43,7
10,0	5.402,3	0,41	9,50-10,50	2.415,7	10.638,6	56,5
11,0	5.934,0	0,34	10,50-11,50	2.123,4	12.762,1	67,8
12,0	6.129,6	0,27	11,50-12,50	1.704,5	14.466,5	76,9
13,0	6.184,6	0,21	12,50-13,50	1.297,8	15.764,3	83,8
14,0	6.197,2	0,17	13,50-14,50	956,5	16.720,8	88,9
15,0	6.199,1	0,14	14,50-15,50	687,5	17.408,3	92,5
16,0	6.200,0	0,11	15,50-16,50	483,0	17.891,3	95,1
17,0	6.200,0	0,10	16,50-17,50	332,0	18.223,3	96,9
18,0	6.200,0	0,08	17,50-18,50	223,0	18.446,5	98,0
19,0	6.200,0	0,07	18,50-19,50	147,0	18.593,5	98,8
20,0	6.200,0	0,06	19,50-20,50	94,0	18.687,5	99,3
21,0	5.956,0	0,05	20,50-21,50	57,8	18.745,4	99,6
22,0	5.708,0	0,04	21,50-22,50	34,4	18.779,8	99,8
23,0	5.460,0	0,03	22,50-23,50	20,1	18.799,9	99,9
24,0	5.212,0	0,03	23,50-24,50	11,6	18.811,4	100,0
25,0	4.964,0	0,02	24,50-25,50	4,2	18.815,6	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 3 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

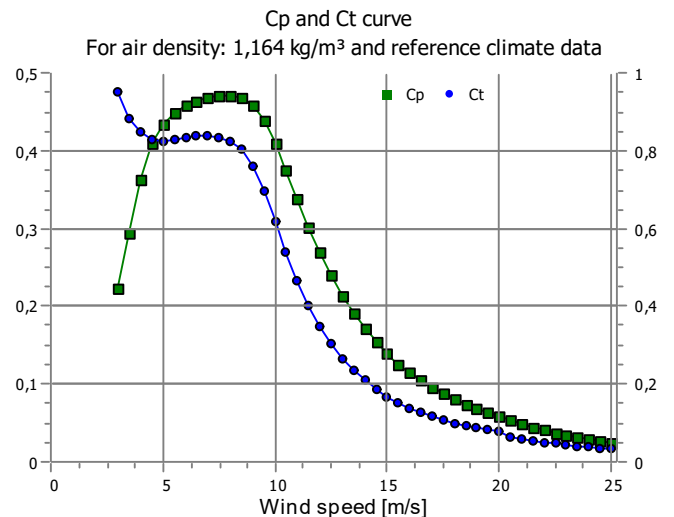
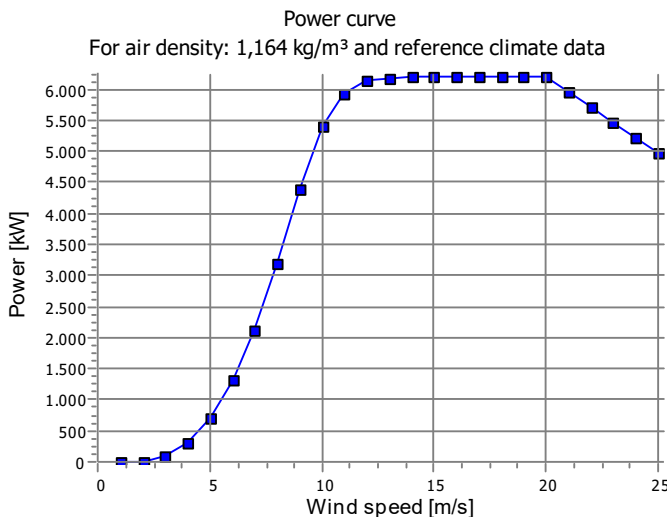
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
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5,0	758,0	0,44	5,0	0,82
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6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,164 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,6	0,22	2,50-3,50	68,0	68,0	0,4
4,0	306,9	0,36	3,50-4,50	274,8	342,9	1,8
5,0	716,6	0,43	4,50-5,50	612,0	954,9	5,1
6,0	1.305,3	0,46	5,50-6,50	1.050,0	2.004,9	10,7
7,0	2.117,3	0,47	6,50-7,50	1.544,9	3.549,8	18,9
8,0	3.183,2	0,47	7,50-8,50	2.026,3	5.576,2	29,8
9,0	4.402,0	0,46	8,50-9,50	2.356,9	7.933,0	42,3
10,0	5.401,9	0,41	9,50-10,50	2.384,2	10.317,2	55,1
11,0	5.933,8	0,34	10,50-11,50	2.117,3	12.434,5	66,4
12,0	6.129,5	0,27	11,50-12,50	1.718,7	14.153,2	75,5
13,0	6.184,6	0,21	12,50-13,50	1.324,7	15.477,8	82,6
14,0	6.197,2	0,17	13,50-14,50	989,3	16.467,2	87,9
15,0	6.199,1	0,14	14,50-15,50	721,5	17.188,6	91,7
16,0	6.200,0	0,11	15,50-16,50	515,0	17.703,6	94,5
17,0	6.200,0	0,10	16,50-17,50	360,1	18.063,8	96,4
18,0	6.200,0	0,08	17,50-18,50	246,8	18.310,6	97,7
19,0	6.200,0	0,07	18,50-19,50	165,9	18.476,4	98,6
20,0	6.200,0	0,06	19,50-20,50	108,5	18.584,9	99,2
21,0	5.956,0	0,05	20,50-21,50	68,3	18.653,2	99,5
22,0	5.708,0	0,04	21,50-22,50	41,7	18.694,9	99,8
23,0	5.460,0	0,03	22,50-23,50	25,0	18.719,9	99,9
24,0	5.212,0	0,03	23,50-24,50	14,8	18.734,7	100,0
25,0	4.964,0	0,02	24,50-25,50	5,5	18.740,2	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 4 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

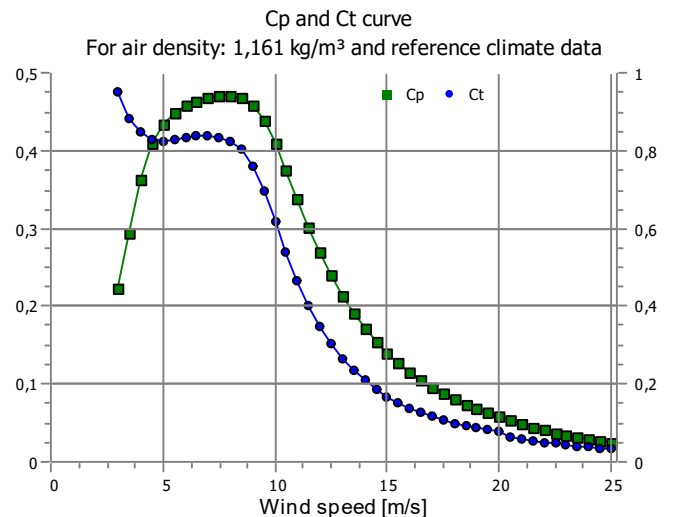
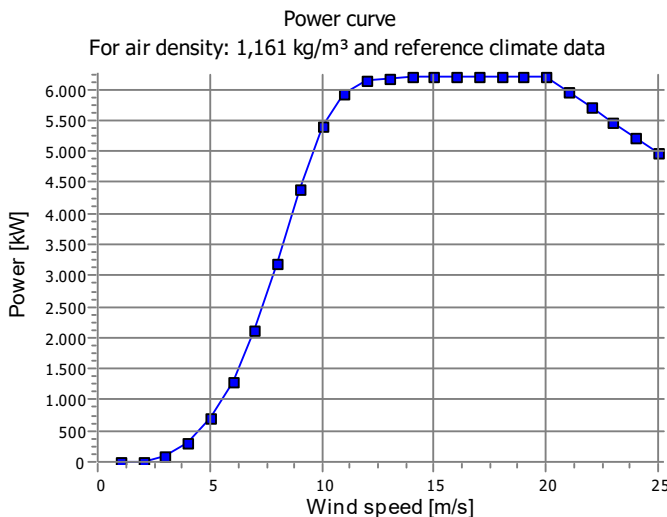
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,161 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,3	0,22	2,50-3,50	63,3	63,3	0,3
4,0	306,1	0,36	3,50-4,50	257,9	321,3	1,6
5,0	715,0	0,43	4,50-5,50	581,5	902,8	4,5
6,0	1.302,5	0,46	5,50-6,50	1.013,3	1.916,1	9,5
7,0	2.112,9	0,47	6,50-7,50	1.518,6	3.434,7	17,0
8,0	3.176,8	0,47	7,50-8,50	2.033,7	5.468,4	27,1
9,0	4.393,9	0,46	8,50-9,50	2.420,0	7.888,4	39,2
10,0	5.395,2	0,41	9,50-10,50	2.508,4	10.396,8	51,6
11,0	5.930,4	0,34	10,50-11,50	2.285,5	12.682,3	63,0
12,0	6.128,4	0,27	11,50-12,50	1.904,7	14.587,1	72,4
13,0	6.184,3	0,21	12,50-13,50	1.507,7	16.094,8	79,9
14,0	6.197,2	0,17	13,50-14,50	1.156,8	17.251,6	85,6
15,0	6.199,0	0,14	14,50-15,50	867,1	18.118,7	89,9
16,0	6.200,0	0,11	15,50-16,50	636,6	18.755,3	93,1
17,0	6.200,0	0,10	16,50-17,50	458,4	19.213,7	95,4
18,0	6.200,0	0,08	17,50-18,50	323,9	19.537,6	97,0
19,0	6.200,0	0,07	18,50-19,50	224,6	19.762,2	98,1
20,0	6.200,0	0,06	19,50-20,50	151,8	19.914,0	98,8
21,0	5.956,0	0,05	20,50-21,50	98,8	20.012,7	99,3
22,0	5.708,0	0,04	21,50-22,50	62,3	20.075,1	99,6
23,0	5.460,0	0,03	22,50-23,50	38,6	20.113,7	99,8
24,0	5.212,0	0,03	23,50-24,50	23,5	20.137,2	100,0
25,0	4.964,0	0,02	24,50-25,50	8,9	20.146,1	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 5 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

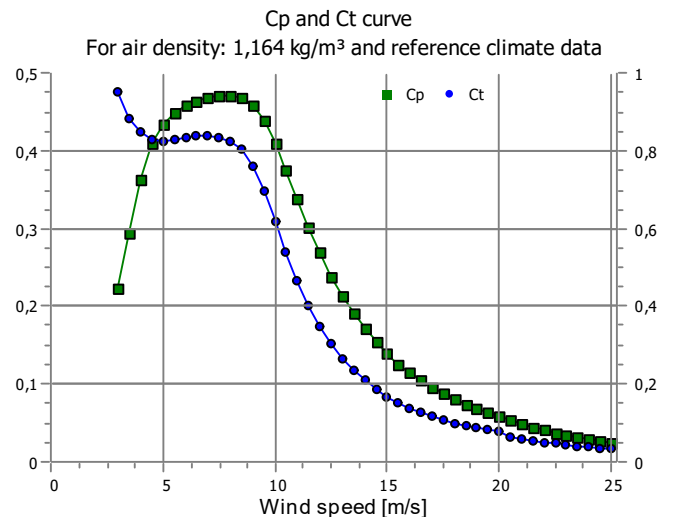
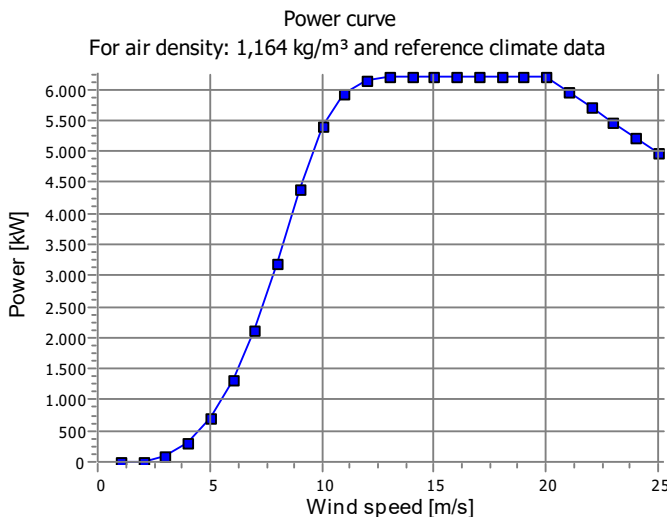
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,164 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,7	0,22	2,50-3,50	66,8	66,8	0,3
4,0	307,1	0,36	3,50-4,50	270,6	337,4	1,7
5,0	716,9	0,43	4,50-5,50	606,2	943,6	4,8
6,0	1.305,8	0,46	5,50-6,50	1.048,3	1.991,9	10,1
7,0	2.118,2	0,47	6,50-7,50	1.558,3	3.550,2	18,0
8,0	3.184,6	0,47	7,50-8,50	2.068,6	5.618,8	28,5
9,0	4.403,8	0,46	8,50-9,50	2.437,5	8.056,3	40,9
10,0	5.403,4	0,41	9,50-10,50	2.498,7	10.555,0	53,5
11,0	5.934,6	0,34	10,50-11,50	2.248,4	12.803,4	64,9
12,0	6.129,8	0,27	11,50-12,50	1.847,8	14.651,2	74,3
13,0	6.184,7	0,21	12,50-13,50	1.440,0	16.091,2	81,6
14,0	6.197,2	0,17	13,50-14,50	1.085,6	17.176,8	87,1
15,0	6.199,1	0,14	14,50-15,50	797,8	17.974,6	91,2
16,0	6.200,0	0,11	15,50-16,50	573,1	18.547,7	94,1
17,0	6.200,0	0,10	16,50-17,50	403,0	18.950,6	96,1
18,0	6.200,0	0,08	17,50-18,50	277,6	19.228,2	97,5
19,0	6.200,0	0,07	18,50-19,50	187,4	19.415,6	98,5
20,0	6.200,0	0,06	19,50-20,50	123,2	19.538,8	99,1
21,0	5.956,0	0,05	20,50-21,50	77,9	19.616,7	99,5
22,0	5.708,0	0,04	21,50-22,50	47,7	19.664,5	99,7
23,0	5.460,0	0,03	22,50-23,50	28,7	19.693,2	99,9
24,0	5.212,0	0,03	23,50-24,50	17,0	19.710,2	100,0
25,0	4.964,0	0,02	24,50-25,50	6,3	19.716,5	100,0





## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 6 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

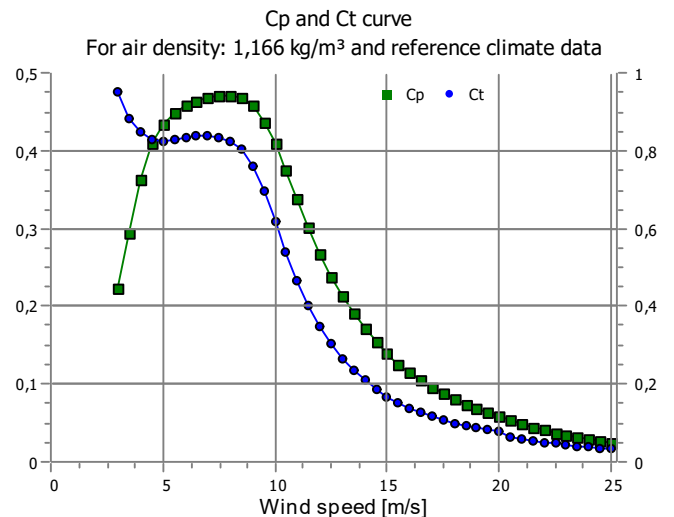
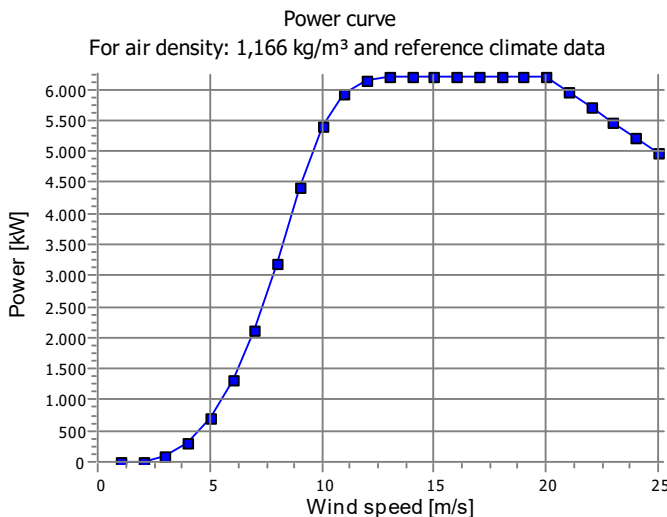
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,166 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	79,9	0,22	2,50-3,50	67,1	67,1	0,3
4,0	307,7	0,36	3,50-4,50	271,1	338,3	1,6
5,0	718,0	0,43	4,50-5,50	605,4	943,7	4,6
6,0	1.307,6	0,46	5,50-6,50	1.046,0	1.989,7	9,7
7,0	2.121,1	0,47	6,50-7,50	1.557,1	3.546,8	17,2
8,0	3.188,8	0,47	7,50-8,50	2.075,0	5.621,7	27,3
9,0	4.409,2	0,46	8,50-9,50	2.460,5	8.082,3	39,3
10,0	5.407,9	0,41	9,50-10,50	2.544,6	10.626,9	51,7
11,0	5.936,9	0,34	10,50-11,50	2.316,5	12.943,4	62,9
12,0	6.130,5	0,27	11,50-12,50	1.932,4	14.875,7	72,3
13,0	6.184,9	0,21	12,50-13,50	1.533,5	16.409,3	79,8
14,0	6.197,3	0,17	13,50-14,50	1.180,8	17.590,1	85,5
15,0	6.199,1	0,14	14,50-15,50	888,7	18.478,8	89,8
16,0	6.200,0	0,11	15,50-16,50	655,2	19.133,9	93,0
17,0	6.200,0	0,10	16,50-17,50	473,5	19.607,4	95,3
18,0	6.200,0	0,08	17,50-18,50	335,5	19.942,9	96,9
19,0	6.200,0	0,07	18,50-19,50	233,0	20.175,9	98,1
20,0	6.200,0	0,06	19,50-20,50	157,4	20.333,3	98,8
21,0	5.956,0	0,05	20,50-21,50	102,1	20.435,4	99,3
22,0	5.708,0	0,04	21,50-22,50	64,1	20.499,5	99,7
23,0	5.460,0	0,03	22,50-23,50	39,3	20.538,8	99,8
24,0	5.212,0	0,03	23,50-24,50	23,6	20.562,5	100,0
25,0	4.964,0	0,02	24,50-25,50	8,8	20.571,3	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 7 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

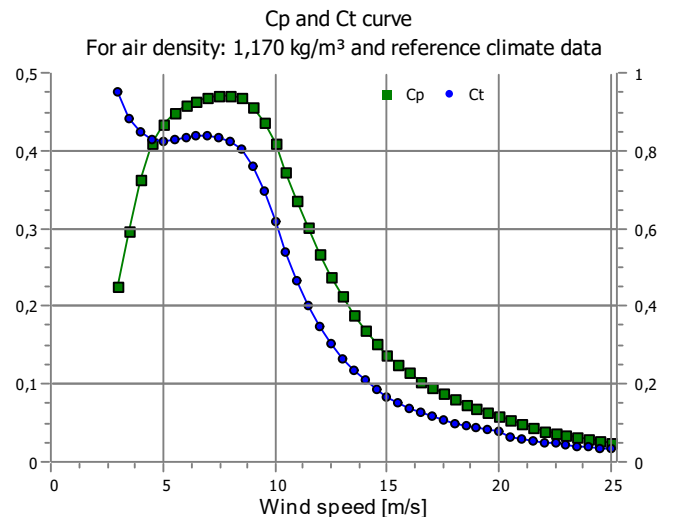
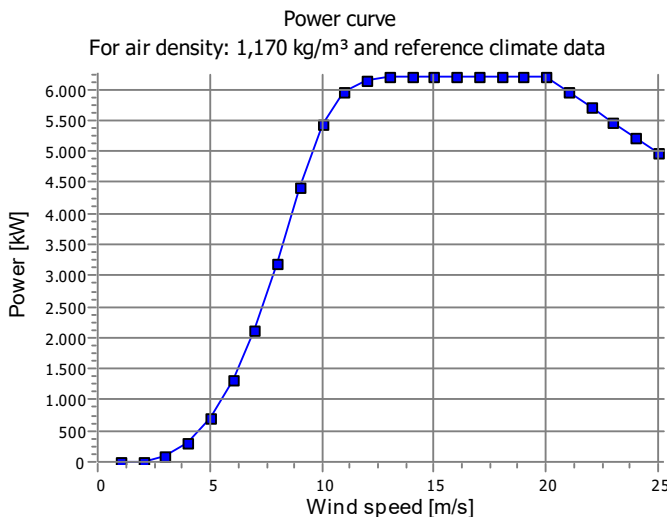
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
6,0	1.376,0	0,46	6,0	0,83
6,5	1.771,0	0,46	6,5	0,84
7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
11,0	6.028,0	0,33	11,0	0,47
11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,170 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	80,6	0,22	2,50-3,50	73,2	73,2	0,5
4,0	309,0	0,36	3,50-4,50	290,2	363,3	2,2
5,0	720,7	0,43	4,50-5,50	631,3	994,6	6,1
6,0	1.312,3	0,46	5,50-6,50	1.056,5	2.051,1	12,6
7,0	2.128,5	0,47	6,50-7,50	1.514,3	3.565,4	22,0
8,0	3.199,8	0,47	7,50-8,50	1.931,4	5.496,8	33,9
9,0	4.423,1	0,46	8,50-9,50	2.178,7	7.675,5	47,3
10,0	5.419,4	0,41	9,50-10,50	2.129,4	9.804,9	60,5
11,0	5.942,7	0,34	10,50-11,50	1.819,1	11.624,0	71,7
12,0	6.132,5	0,27	11,50-12,50	1.413,9	13.038,0	80,4
13,0	6.185,3	0,21	12,50-13,50	1.038,5	14.076,4	86,8
14,0	6.197,4	0,17	13,50-14,50	735,2	14.811,6	91,3
15,0	6.199,1	0,14	14,50-15,50	505,5	15.317,1	94,4
16,0	6.200,0	0,11	15,50-16,50	338,4	15.655,4	96,5
17,0	6.200,0	0,10	16,50-17,50	220,8	15.876,2	97,9
18,0	6.200,0	0,08	17,50-18,50	140,5	16.016,8	98,7
19,0	6.200,0	0,07	18,50-19,50	87,3	16.104,0	99,3
20,0	6.200,0	0,06	19,50-20,50	52,6	16.156,6	99,6
21,0	5.956,0	0,05	20,50-21,50	30,3	16.186,9	99,8
22,0	5.708,0	0,04	21,50-22,50	16,9	16.203,8	99,9
23,0	5.460,0	0,03	22,50-23,50	9,2	16.212,9	100,0
24,0	5.212,0	0,03	23,50-24,50	4,9	16.217,8	100,0
25,0	4.964,0	0,02	24,50-25,50	1,7	16.219,5	100,0



## PARK - Power Curve Analysis

**Calculation:** PARK **WTG:** 8 - Siemens Gamesa SG 6.0-170 6200 170.0 !O!, Hub height: 115,0 m

**Name:** (AM 0, 6.2MW) - 1.225 kg/m<sup>3</sup>

**Source:** SGRE

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m <sup>2</sup>
25/03/2020	EMD	11/02/2020	25/03/2020	25,0	Pitch	User defined	Variable	0,27

Rev. 0

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### HP curve comparison - Note: For standard air density

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	11.298	16.928	22.249	26.906	30.781	33.846
Siemens Gamesa SG 6.0-170 6200 170.0 !O! (AM 0, 6.2MW) - 1.225 kg/m <sup>3</sup>	[MWh]	11.518	17.201	22.531	27.152	30.939	33.855
Check value	[%]	-2	-2	-1	-1	-1	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m<sup>2</sup>) 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 the windPRO manual.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

### Power curve

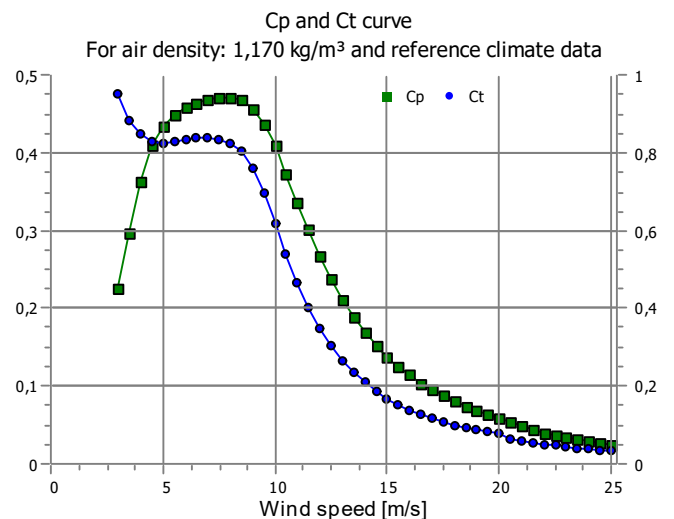
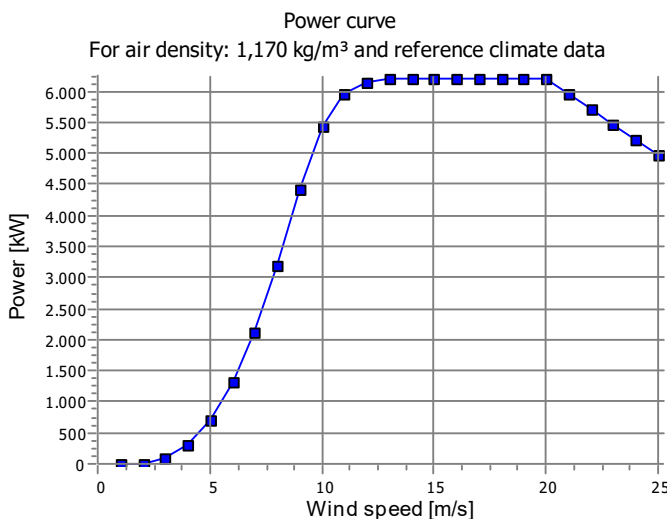
Original data, Air density: 1,225 kg/m<sup>3</sup>

Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
3,0	89,0	0,24	3,0	0,95
3,5	178,0	0,30	3,5	0,88
4,0	328,0	0,37	4,0	0,85
4,5	522,0	0,41	4,5	0,83
5,0	758,0	0,44	5,0	0,82
5,5	1.040,0	0,45	5,5	0,83
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7,0	2.230,0	0,47	7,0	0,84
7,5	2.758,0	0,47	7,5	0,84
8,0	3.351,0	0,47	8,0	0,83
8,5	3.988,0	0,47	8,5	0,80
9,0	4.617,0	0,46	9,0	0,76
9,5	5.166,0	0,43	9,5	0,70
10,0	5.584,0	0,40	10,0	0,62
10,5	5.862,0	0,36	10,5	0,54
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11,5	6.117,0	0,29	11,5	0,40
12,0	6.161,0	0,26	12,0	0,35
12,5	6.183,0	0,23	12,5	0,30
13,0	6.192,0	0,20	13,0	0,27
13,5	6.197,0	0,18	13,5	0,24
14,0	6.199,0	0,16	14,0	0,21
14,5	6.199,0	0,15	14,5	0,19
15,0	6.200,0	0,13	15,0	0,17
15,5	6.200,0	0,12	15,5	0,15
16,0	6.200,0	0,11	16,0	0,14
16,5	6.200,0	0,10	16,5	0,13
17,0	6.200,0	0,09	17,0	0,12
17,5	6.200,0	0,08	17,5	0,11
18,0	6.200,0	0,08	18,0	0,10
18,5	6.200,0	0,07	18,5	0,09
19,0	6.200,0	0,07	19,0	0,09
19,5	6.200,0	0,06	19,5	0,08
20,0	6.200,0	0,06	20,0	0,08
20,5	6.080,0	0,05	20,5	0,07
21,0	5.956,0	0,05	21,0	0,06
21,5	5.832,0	0,04	21,5	0,06
22,0	5.708,0	0,04	22,0	0,05
22,5	5.584,0	0,04	22,5	0,05
23,0	5.460,0	0,03	23,0	0,04
23,5	5.336,0	0,03	23,5	0,04
24,0	5.212,0	0,03	24,0	0,04
24,5	5.088,0	0,02	24,5	0,03
25,0	4.964,0	0,02	25,0	0,03

### Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,170 kg/m<sup>3</sup> New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Cp	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1,0	0,0	0,00	0,50-1,50	0,0	0,0	0,0
2,0	0,0	0,00	1,50-2,50	0,0	0,0	0,0
3,0	80,6	0,22	2,50-3,50	73,8	73,8	0,4
4,0	309,2	0,36	3,50-4,50	294,6	368,4	2,0
5,0	721,1	0,43	4,50-5,50	646,6	1.015,0	5,6
6,0	1.312,9	0,46	5,50-6,50	1.094,2	2.109,2	11,7
7,0	2.129,4	0,47	6,50-7,50	1.589,5	3.698,7	20,5
8,0	3.201,2	0,47	7,50-8,50	2.058,7	5.757,5	31,9
9,0	4.424,8	0,46	8,50-9,50	2.362,1	8.119,6	45,0
10,0	5.420,8	0,41	9,50-10,50	2.351,4	10.471,0	58,0
11,0	5.943,5	0,34	10,50-11,50	2.048,6	12.519,6	69,4
12,0	6.132,8	0,27	11,50-12,50	1.625,8	14.145,4	78,4
13,0	6.185,4	0,21	12,50-13,50	1.220,1	15.365,5	85,1
14,0	6.197,4	0,17	13,50-14,50	882,9	16.248,4	90,0
15,0	6.199,2	0,14	14,50-15,50	620,8	16.869,2	93,5
16,0	6.200,0	0,11	15,50-16,50	425,2	17.294,4	95,8
17,0	6.200,0	0,10	16,50-17,50	284,1	17.578,5	97,4
18,0	6.200,0	0,08	17,50-18,50	185,4	17.763,9	98,4
19,0	6.200,0	0,07	18,50-19,50	118,2	17.882,1	99,1
20,0	6.200,0	0,06	19,50-20,50	73,2	17.955,3	99,5
21,0	5.956,0	0,05	20,50-21,50	43,4	17.998,7	99,7
22,0	5.708,0	0,04	21,50-22,50	24,9	18.023,6	99,9
23,0	5.460,0	0,03	22,50-23,50	14,0	18.037,6	99,9
24,0	5.212,0	0,03	23,50-24,50	7,7	18.045,3	100,0
25,0	4.964,0	0,02	24,50-25,50	2,7	18.048,0	100,0



Project:  
**Suelli**

Licensed user:  
**Premier Engineering and Procurement SL**  
Avenida Diagonal Plaza 14, Edificio 46  
ES-50197 Zaragoza

Javier Viar / jviar@premier-pv.com  
Calculated:  
23/07/2023 19:12/3.6.366

## **PARK - Terrain**

**Calculation:** PARK **Site Data:** A - WASP

### **Obstacles:**

0 Obstacles used

### **Roughness:**

Terrain data files used in calculation:

\\srv\eolica\ESTUDIOS\ITALIA\E1 Italia\SPEOL210006 Suelli\3 WindPRO\ROUGHNESSLINE\_ONLINEDATA\_1.wpo  
Min X: 505.240, Max X: 519.774, Min Y: 4.374.425, Max Y: 4.389.497, Width: 14.534 m, Height: 15.072 m

### **Orography:**

Terrain data files used in calculation:

\\srv\eolica\ESTUDIOS\ITALIA\E1 Italia\SPEOL210006 Suelli\3 WindPRO\CONTOURLINE\_ONLINEDATA\_1.wpo  
Min X: 502.255, Max X: 522.254, Min Y: 4.371.903, Max Y: 4.391.967, Width: 19.999 m, Height: 20.063 m

## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 50,0

### Site coordinates

UTM (north)-ETRS89 Zone: 32  
East: 513.485 North: 4.382.317

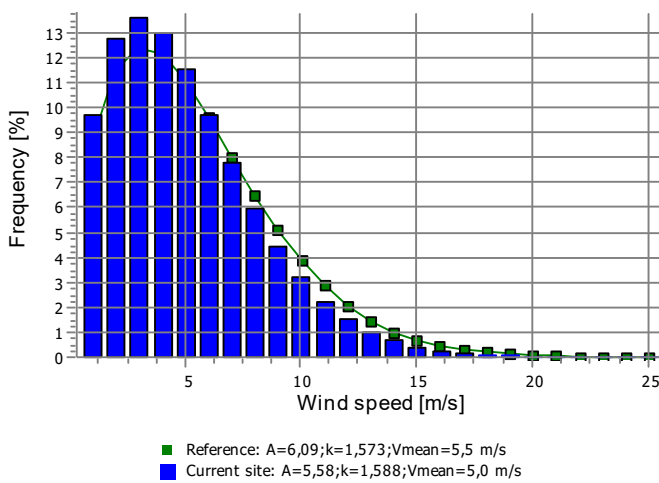
### Wind statistics

IT Datos meteorologicos - 100.00 m.wws

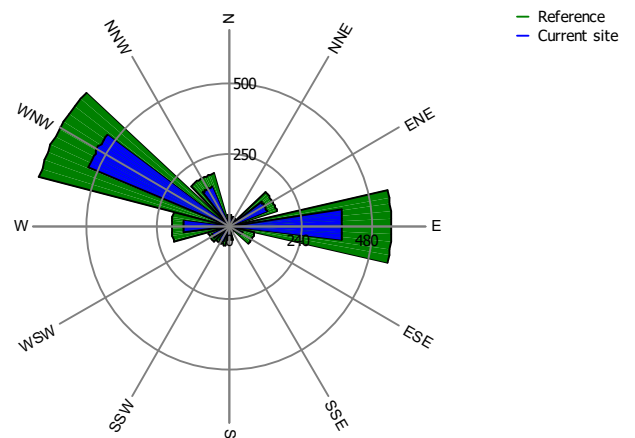
### Weibull Data

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	3,91	3,59	1,342	3,6	4,42	1,408	3,7
1 NNE	3,40	3,25	1,131	3,9	3,47	1,119	3,6
2 ENE	5,22	4,74	1,432	8,6	5,56	1,424	8,6
3 E	7,07	6,27	1,939	15,3	7,87	1,916	15,7
4 ESE	4,66	4,20	1,506	4,6	5,53	1,529	5,2
5 SSE	3,13	3,03	1,088	2,4	3,37	1,076	2,3
6 S	4,33	3,90	1,541	5,1	4,59	1,537	4,8
7 SSW	4,10	3,67	1,604	8,6	4,40	1,615	8,4
8 WSW	4,22	3,88	1,326	6,2	4,47	1,318	6,2
9 W	5,73	5,12	1,682	9,7	6,18	1,666	9,6
10 WNW	7,07	6,27	1,904	20,3	7,67	1,900	20,3
11 NNW	5,75	5,10	2,064	11,5	6,24	2,057	11,6
All	5,58	5,01	1,588	100,0	6,09	1,573	100,0

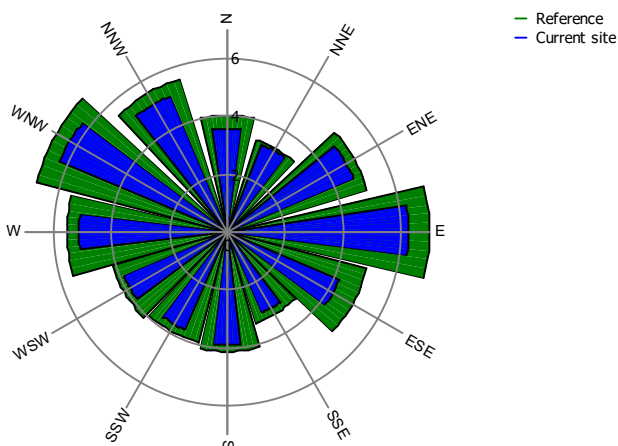
Weibull Distribution



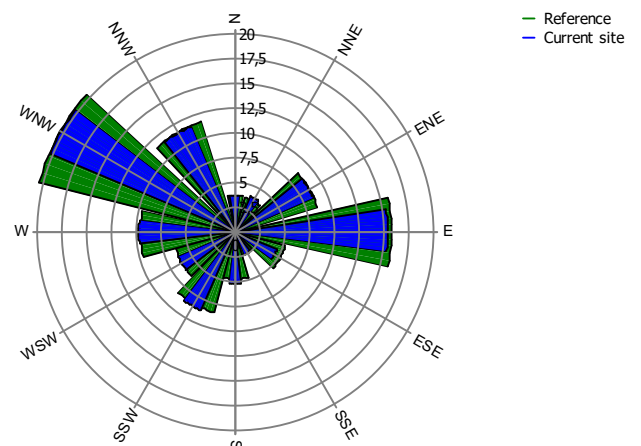
Energy Rose (kWh/m<sup>2</sup>/year)



Mean wind speed (m/s)



Frequency (%)



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

UTM (north)-ETRS89 Zone: 32  
East: 513.485 North: 4.382.317

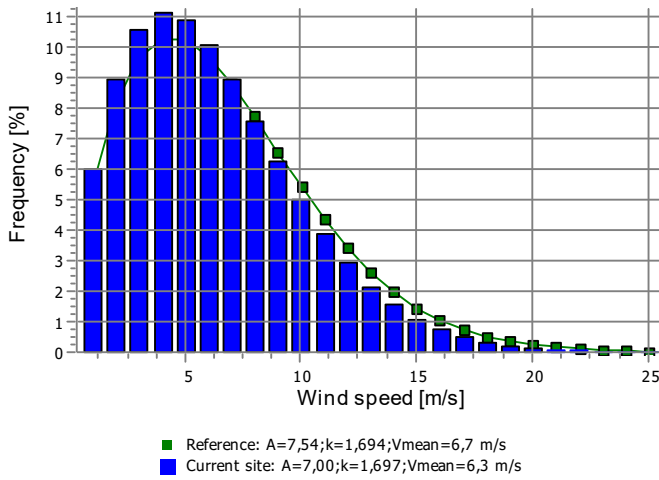
### Wind statistics

IT Datos meteorologicos - 100.00 m.wws

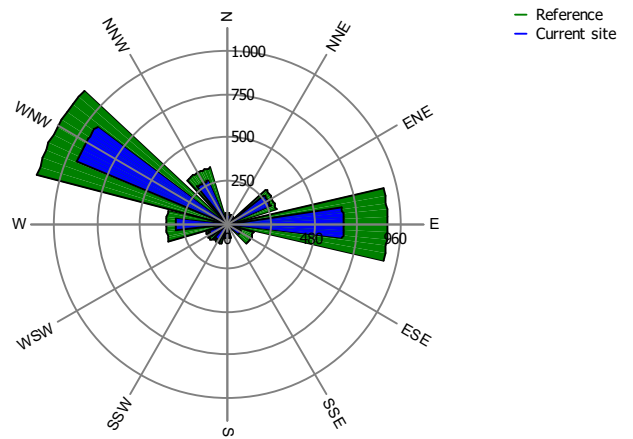
### Weibull Data

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	4,95	4,50	1,428	3,6	5,55	1,517	3,7
1 NNE	4,37	4,11	1,205	3,9	4,40	1,200	3,6
2 ENE	6,71	6,06	1,514	8,6	6,97	1,532	8,6
3 E	8,63	7,65	2,080	15,4	9,56	2,084	15,7
4 ESE	5,87	5,26	1,607	4,6	6,92	1,648	5,2
5 SSE	3,97	3,77	1,158	2,4	4,27	1,156	2,3
6 S	5,48	4,90	1,650	5,1	5,74	1,656	4,8
7 SSW	5,18	4,62	1,717	8,6	5,49	1,741	8,4
8 WSW	5,37	4,88	1,420	6,2	5,62	1,419	6,2
9 W	7,27	6,47	1,803	9,8	7,71	1,795	9,6
10 WNW	8,78	7,77	2,057	20,3	9,35	2,064	20,3
11 NNW	7,23	6,40	2,225	11,5	7,75	2,221	11,6
All	7,00	6,25	1,697	100,0	7,54	1,694	100,0

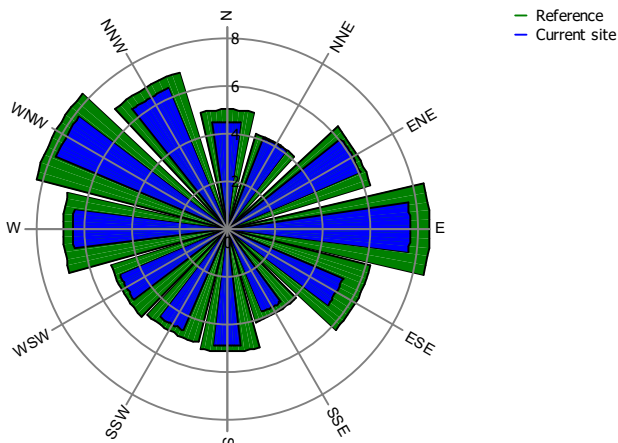
Weibull Distribution



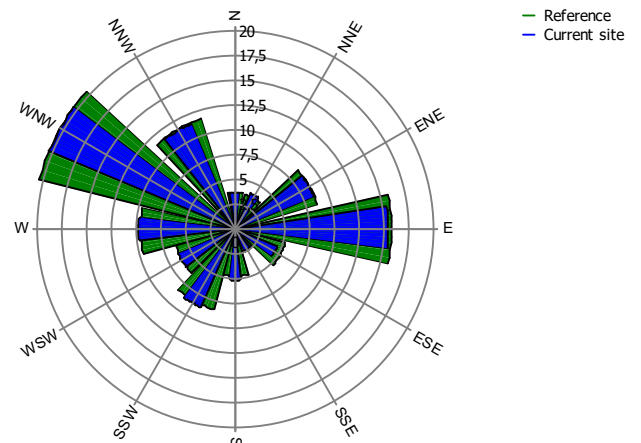
Energy Rose (kWh/m<sup>2</sup>/year)



Mean wind speed (m/s)



Frequency (%)



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

UTM (north)-ETRS89 Zone: 32  
East: 511.448 North: 4.382.884  
AG01

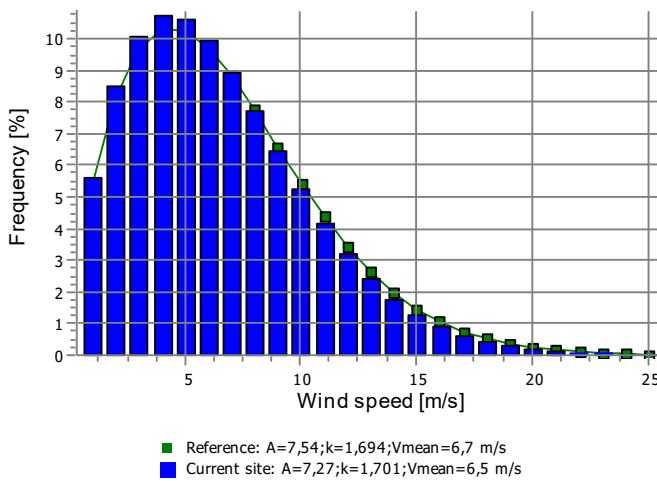
### Wind statistics

IT Datos meteorologicos - 100.00 m.wws

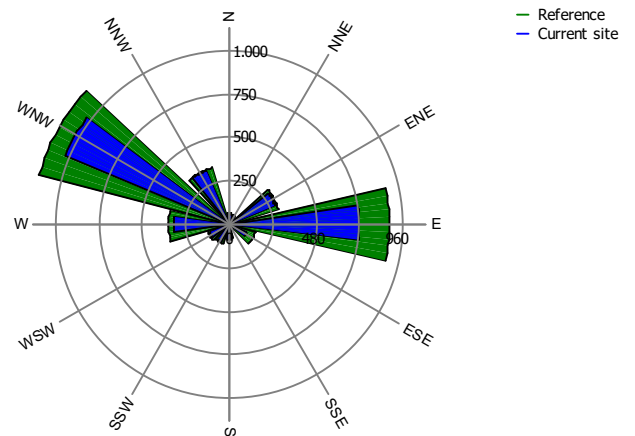
### Weibull Data

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	5,21	4,73	1,432	3,6	5,55	1,517	3,7
1 NNE	4,52	4,24	1,209	4,0	4,40	1,200	3,6
2 ENE	6,89	6,21	1,521	8,5	6,97	1,532	8,6
3 E	8,99	7,96	2,084	15,3	9,56	2,084	15,7
4 ESE	6,30	5,65	1,615	4,8	6,92	1,648	5,2
5 SSE	4,26	4,04	1,166	2,5	4,27	1,156	2,3
6 S	5,67	5,07	1,654	5,2	5,74	1,656	4,8
7 SSW	5,34	4,76	1,713	8,5	5,49	1,741	8,4
8 WSW	5,51	5,01	1,420	6,1	5,62	1,419	6,2
9 W	7,47	6,64	1,803	9,6	7,71	1,795	9,6
10 WNW	9,07	8,03	2,057	20,1	9,35	2,064	20,3
11 NNW	7,66	6,79	2,209	11,8	7,75	2,221	11,6
All	7,27	6,49	1,701	100,0	7,54	1,694	100,0

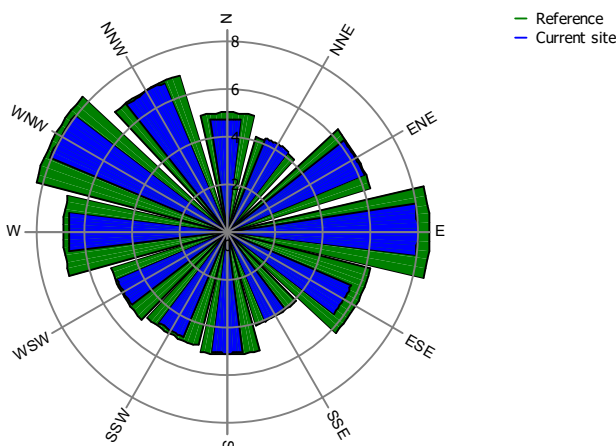
Weibull Distribution



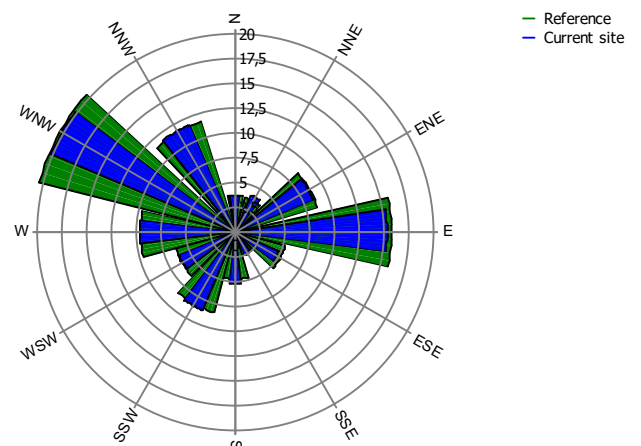
Energy Rose (kWh/m<sup>2</sup>/year)



Mean wind speed (m/s)



Frequency (%)



## PARK - Wind Data Analysis

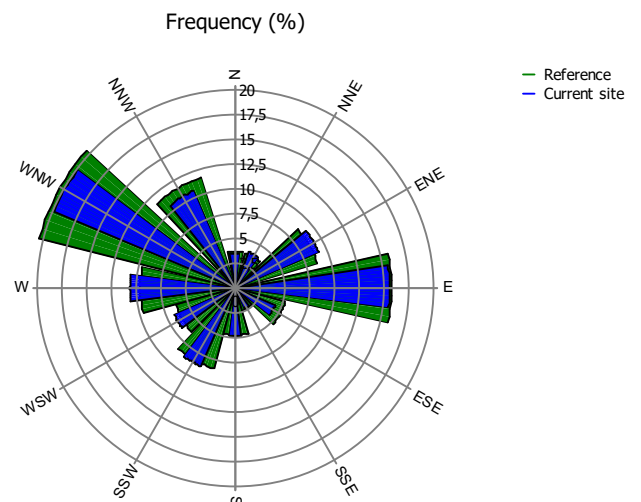
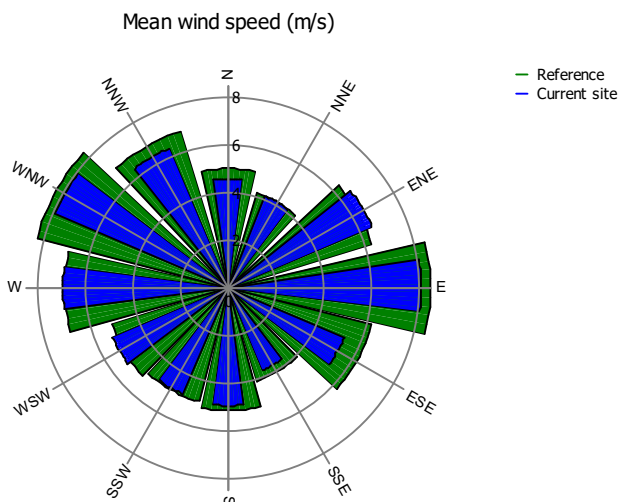
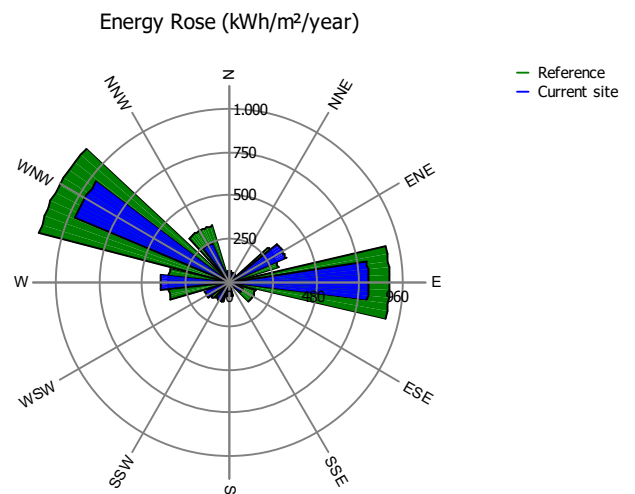
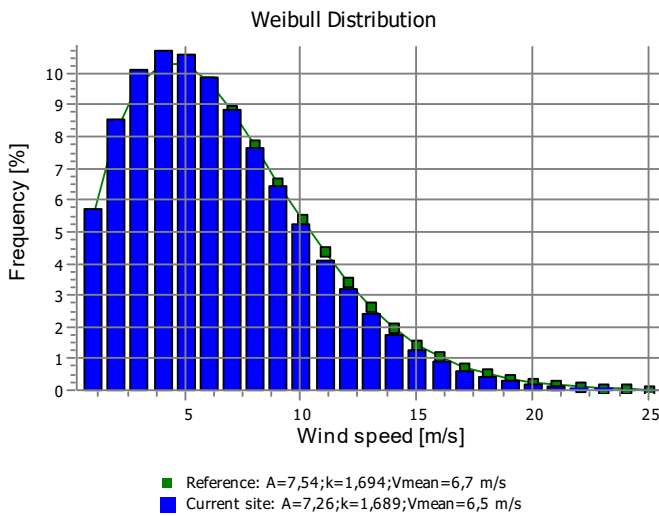
**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

**Site coordinates**  
UTM (north)-ETRS89 Zone: 32  
East: 512.656 North: 4.383.014  
AG02

**Wind statistics**  
IT Datos meteorologicos - 100.00 m.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	5,05	4,58	1,443	3,5	5,55	1,517	3,7
1 NNE	4,41	4,14	1,205	3,9	4,40	1,200	3,6
2 ENE	7,26	6,54	1,529	9,2	6,97	1,532	8,6
3 E	9,12	8,08	2,068	15,6	9,56	2,084	15,7
4 ESE	5,89	5,28	1,600	4,4	6,92	1,648	5,2
5 SSE	3,91	3,73	1,143	2,2	4,27	1,156	2,3
6 S	5,50	4,92	1,646	4,8	5,74	1,656	4,8
7 SSW	5,42	4,83	1,725	8,6	5,49	1,741	8,4
8 WSW	5,79	5,26	1,432	6,7	5,62	1,419	6,2
9 W	7,81	6,94	1,822	10,7	7,71	1,795	9,6
10 WNW	8,92	7,90	2,057	19,8	9,35	2,064	20,3
11 NNW	7,17	6,35	2,252	10,6	7,75	2,221	11,6
All	7,26	6,48	1,689	100,0	7,54	1,694	100,0





## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

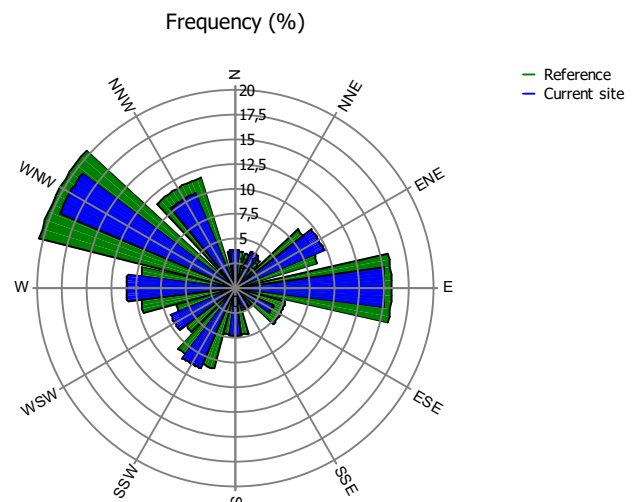
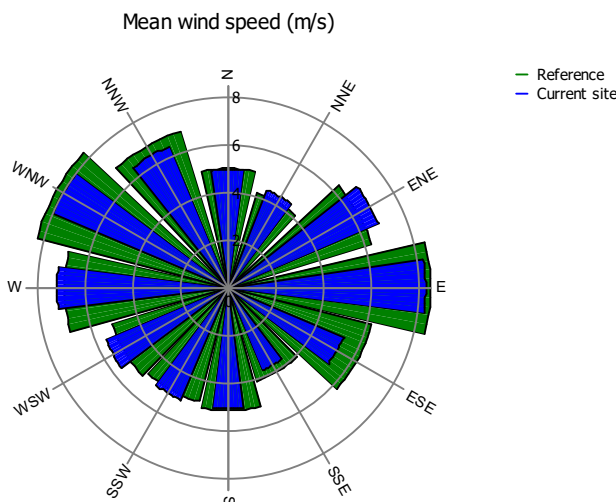
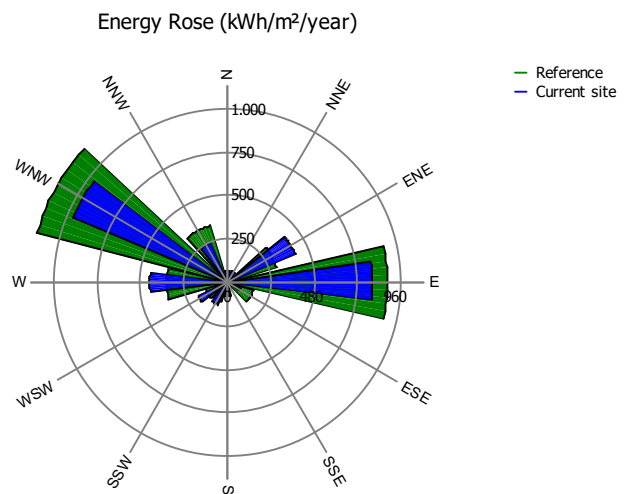
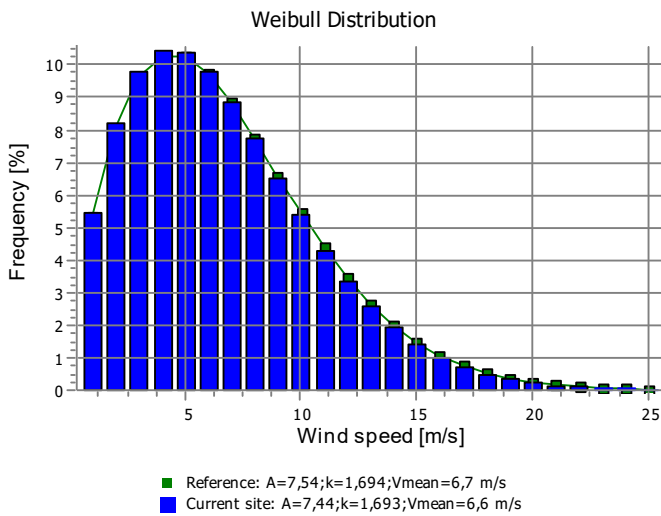
UTM (north)-ETRS89 Zone: 32  
East: 513.262 North: 4.381.895  
AG03

### Wind statistics

IT Datos meteorologicos - 100.00 m.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	5,49	4,95	1,518	3,8	5,55	1,517	3,7
1 NNE	4,69	4,41	1,209	4,0	4,40	1,200	3,6
2 ENE	7,63	6,86	1,557	9,7	6,97	1,532	8,6
3 E	9,34	8,27	2,057	15,0	9,56	2,084	15,7
4 ESE	5,85	5,25	1,592	4,2	6,92	1,648	5,2
5 SSE	3,91	3,73	1,143	2,2	4,27	1,156	2,3
6 S	5,66	5,07	1,635	4,7	5,74	1,656	4,8
7 SSW	5,70	5,08	1,721	8,8	5,49	1,741	8,4
8 WSW	6,14	5,57	1,443	7,0	5,62	1,419	6,2
9 W	8,07	7,17	1,830	10,9	7,71	1,795	9,6
10 WNW	9,01	7,99	2,057	19,3	9,35	2,064	20,3
11 NNW	7,26	6,43	2,252	10,4	7,75	2,221	11,6
All	7,44	6,64	1,693	100,0	7,54	1,694	100,0



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

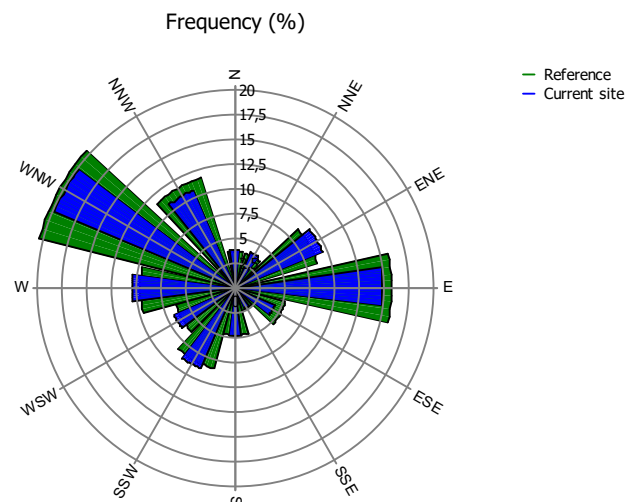
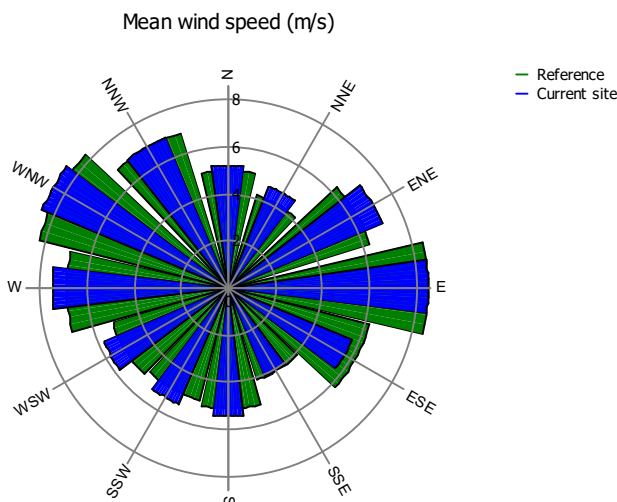
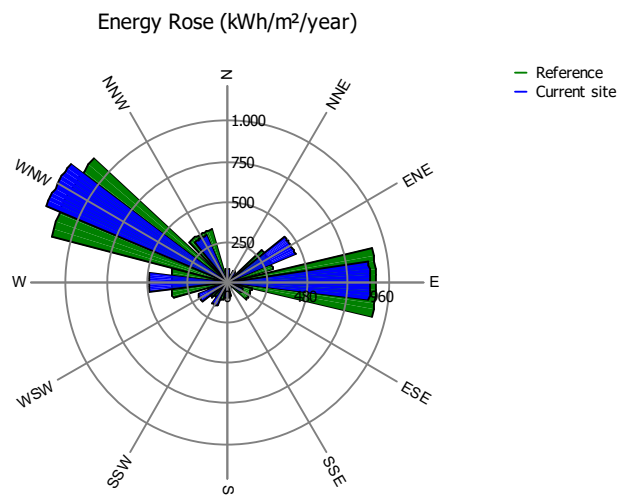
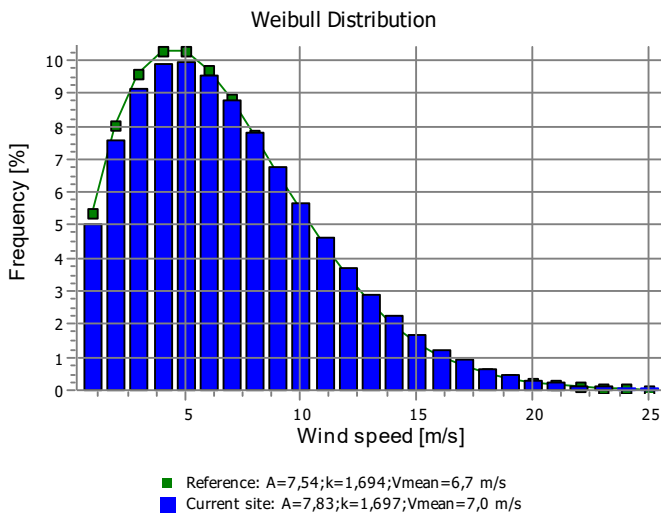
UTM (north)-ETRS89 Zone: 32  
East: 513.800 North: 4.381.348  
AG04

### Wind statistics

IT Datos meteorologicos - 100.00 m.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	5,76	5,20	1,486	3,8	5,55	1,517	3,7
1 NNE	4,94	4,64	1,205	3,9	4,40	1,200	3,6
2 ENE	7,87	7,08	1,549	9,5	6,97	1,532	8,6
3 E	9,57	8,48	2,061	14,9	9,56	2,084	15,7
4 ESE	6,34	5,69	1,604	4,4	6,92	1,648	5,2
5 SSE	4,23	4,03	1,146	2,3	4,27	1,156	2,3
6 S	6,07	5,43	1,639	4,9	5,74	1,656	4,8
7 SSW	6,00	5,35	1,721	8,8	5,49	1,741	8,4
8 WSW	6,33	5,75	1,432	6,7	5,62	1,419	6,2
9 W	8,41	7,47	1,818	10,4	7,71	1,795	9,6
10 WNW	9,67	8,57	2,057	19,8	9,35	2,064	20,3
11 NNW	7,82	6,92	2,252	10,7	7,75	2,221	11,6
All	7,83	6,99	1,697	100,0	7,54	1,694	100,0



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

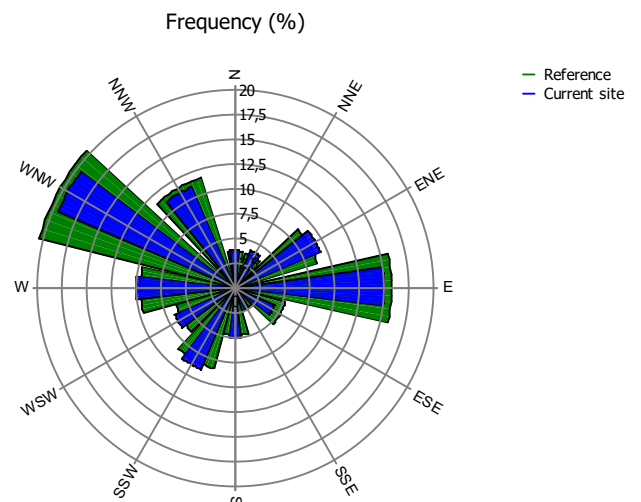
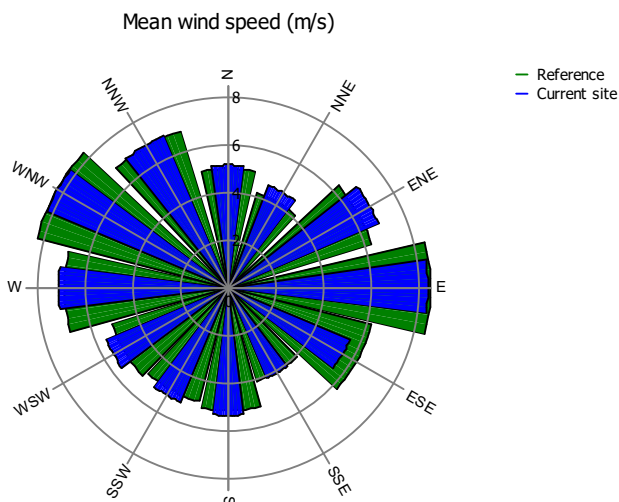
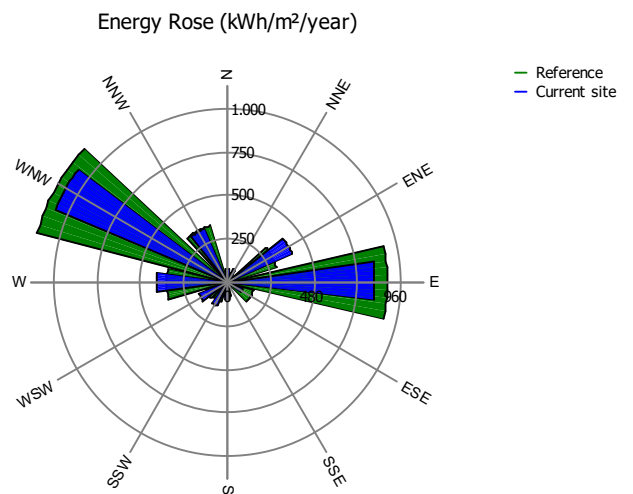
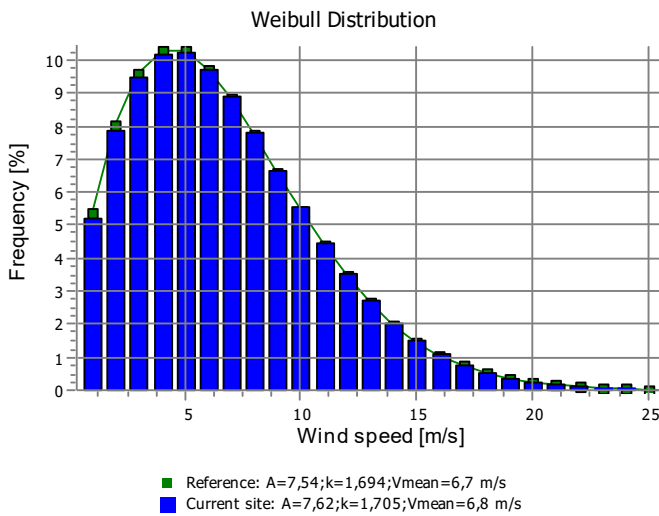
UTM (north)-ETRS89 Zone: 32  
East: 512.202 North: 4.381.351  
AG05

### Wind statistics

IT Datos meteorologicos - 100.00 m.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	5,71	5,16	1,494	3,9	5,55	1,517	3,7
1 NNE	4,91	4,61	1,213	4,1	4,40	1,200	3,6
2 ENE	7,64	6,87	1,557	9,4	6,97	1,532	8,6
3 E	9,43	8,36	2,076	15,0	9,56	2,084	15,7
4 ESE	6,16	5,52	1,604	4,3	6,92	1,648	5,2
5 SSE	4,31	4,09	1,162	2,3	4,27	1,156	2,3
6 S	5,96	5,33	1,639	4,9	5,74	1,656	4,8
7 SSW	5,79	5,17	1,713	8,9	5,49	1,741	8,4
8 WSW	6,12	5,56	1,439	6,6	5,62	1,419	6,2
9 W	8,00	7,11	1,814	10,1	7,71	1,795	9,6
10 WNW	9,33	8,26	2,057	19,5	9,35	2,064	20,3
11 NNW	7,81	6,92	2,217	11,1	7,75	2,221	11,6
All	7,62	6,80	1,705	100,0	7,54	1,694	100,0



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

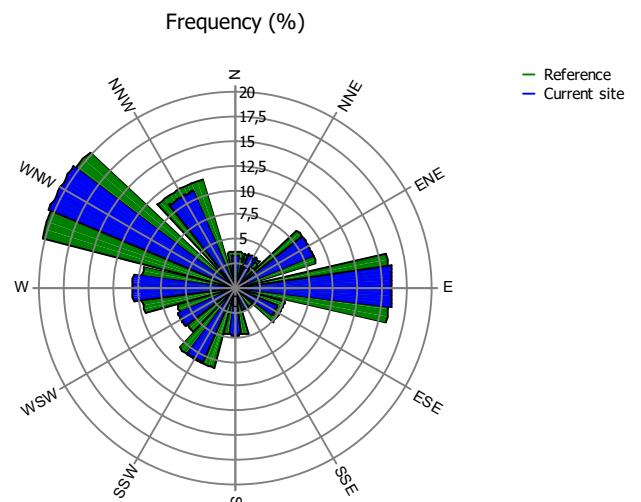
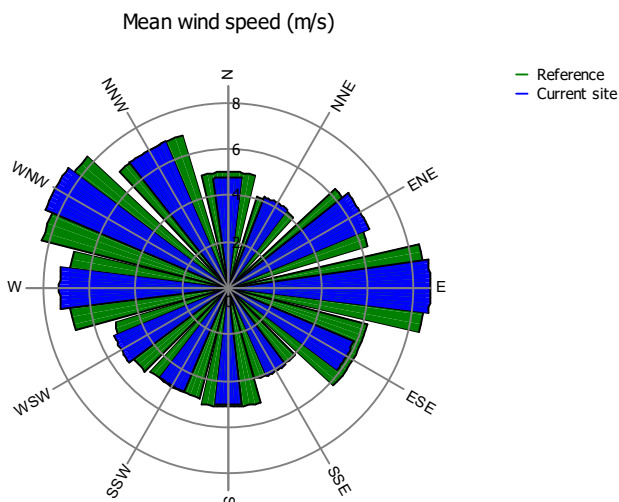
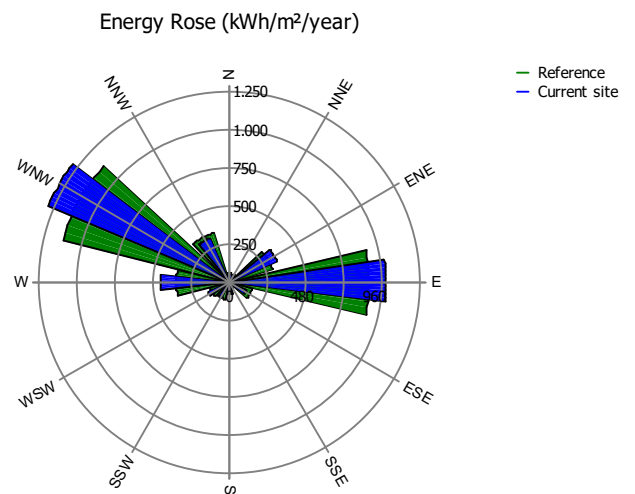
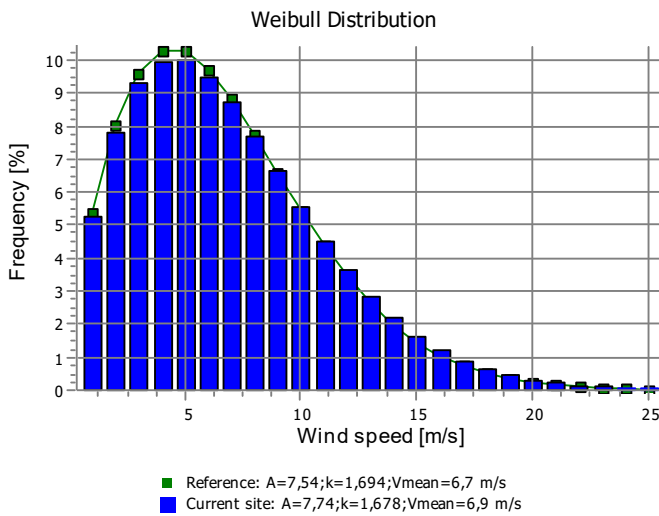
UTM (north)-ETRS89 Zone: 32  
East: 510.955 North: 4.381.030  
AG06

### Wind statistics

IT Datos meteorologicos - 100.00 m.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	5,25	4,77	1,432	3,3	5,55	1,517	3,7
1 NNE	4,50	4,23	1,205	3,7	4,40	1,200	3,6
2 ENE	7,29	6,57	1,510	8,6	6,97	1,532	8,6
3 E	9,83	8,71	2,068	16,0	9,56	2,084	15,7
4 ESE	6,55	5,87	1,600	4,7	6,92	1,648	5,2
5 SSE	4,35	4,12	1,162	2,4	4,27	1,156	2,3
6 S	5,65	5,05	1,658	4,8	5,74	1,656	4,8
7 SSW	5,45	4,86	1,721	8,2	5,49	1,741	8,4
8 WSW	5,86	5,33	1,420	6,4	5,62	1,419	6,2
9 W	8,18	7,28	1,803	10,5	7,71	1,795	9,6
10 WNW	9,72	8,61	2,053	20,6	9,35	2,064	20,3
11 NNW	7,76	6,87	2,236	10,8	7,75	2,221	11,6
All	7,74	6,91	1,678	100,0	7,54	1,694	100,0



## PARK - Wind Data Analysis

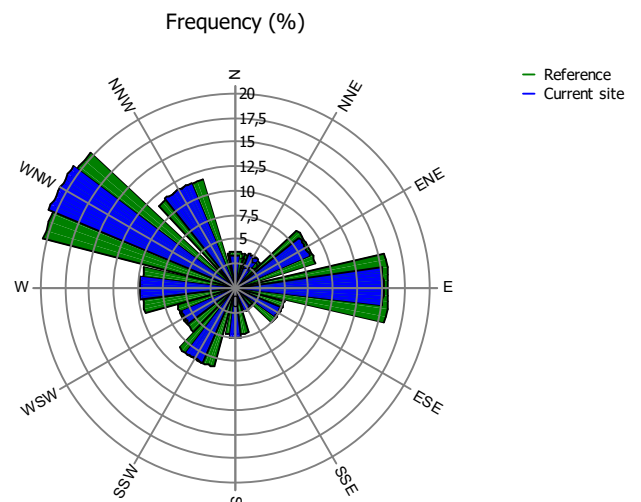
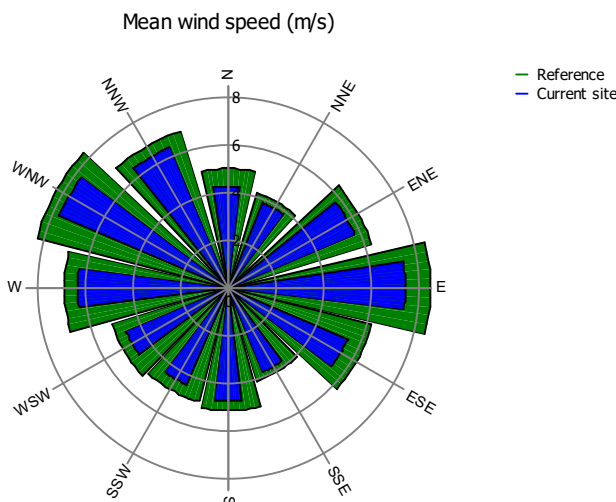
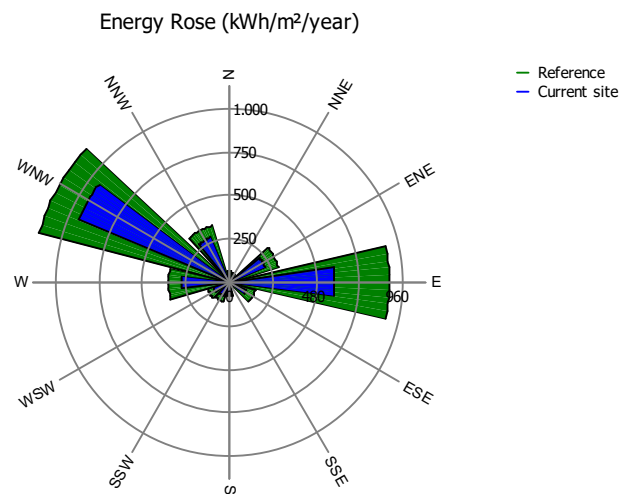
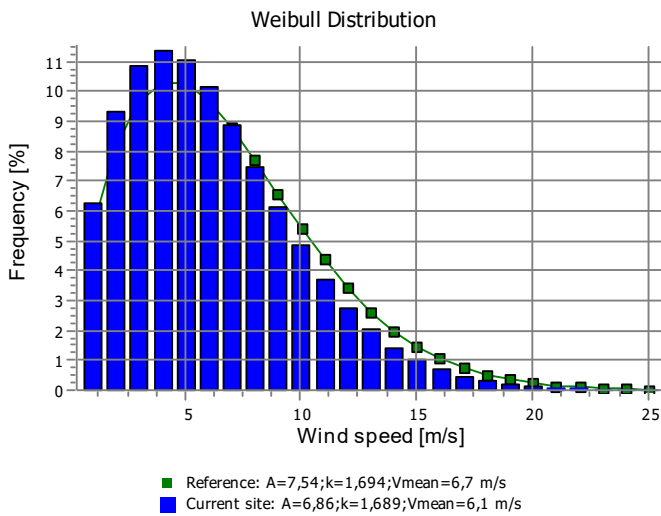
**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

**Site coordinates**  
UTM (north)-ETRS89 Zone: 32  
East: 512.614 North: 4.381.947  
AG07

**Wind statistics**  
IT Datos meteorologicos - 100.00 m.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	4,65	4,24	1,385	3,4	5,55	1,517	3,7
1 NNE	4,09	3,85	1,201	3,8	4,40	1,200	3,6
2 ENE	6,38	5,75	1,514	8,4	6,97	1,532	8,6
3 E	8,37	7,42	2,068	15,2	9,56	2,084	15,7
4 ESE	6,06	5,43	1,623	5,0	6,92	1,648	5,2
5 SSE	3,99	3,78	1,170	2,5	4,27	1,156	2,3
6 S	5,31	4,74	1,658	5,2	5,74	1,656	4,8
7 SSW	4,94	4,41	1,721	8,3	5,49	1,741	8,4
8 WSW	5,11	4,65	1,412	6,0	5,62	1,419	6,2
9 W	7,09	6,31	1,795	9,8	7,71	1,795	9,6
10 WNW	8,71	7,72	2,053	20,8	9,35	2,064	20,3
11 NNW	7,23	6,41	2,221	11,6	7,75	2,221	11,6
All	6,86	6,12	1,689	100,0	7,54	1,694	100,0



## PARK - Wind Data Analysis

**Calculation:** PARK **Wind data:** A - WASP; Hub height: 115,0

### Site coordinates

UTM (north)-ETRS89 Zone: 32  
East: 512.042 North: 4.380.676  
AG08

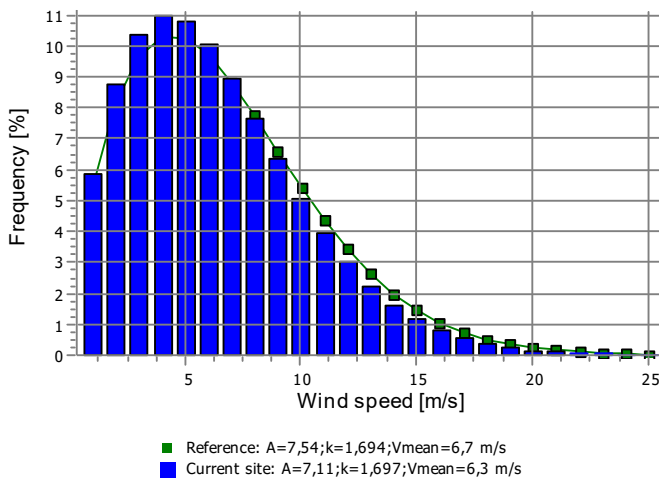
### Wind statistics

IT Datos meteorologicos - 100.00 m.wws

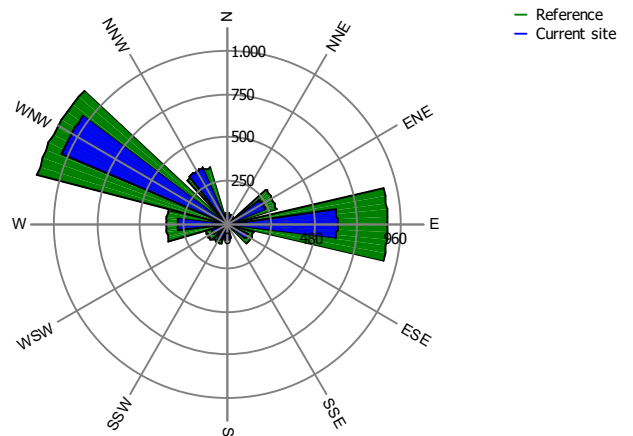
### Weibull Data

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	4,98	4,54	1,396	3,6	5,55	1,517	3,7
1 NNE	4,39	4,12	1,213	3,9	4,40	1,200	3,6
2 ENE	6,52	5,88	1,518	8,2	6,97	1,532	8,6
3 E	8,57	7,59	2,068	14,8	9,56	2,084	15,7
4 ESE	6,44	5,76	1,643	5,3	6,92	1,648	5,2
5 SSE	4,35	4,10	1,186	2,6	4,27	1,156	2,3
6 S	5,56	4,97	1,658	5,4	5,74	1,656	4,8
7 SSW	5,16	4,60	1,713	8,3	5,49	1,741	8,4
8 WSW	5,19	4,72	1,412	5,9	5,62	1,419	6,2
9 W	7,23	6,43	1,795	9,6	7,71	1,795	9,6
10 WNW	9,05	8,02	2,049	20,5	9,35	2,064	20,3
11 NNW	7,68	6,80	2,197	12,1	7,75	2,221	11,6
All	7,11	6,34	1,697	100,0	7,54	1,694	100,0

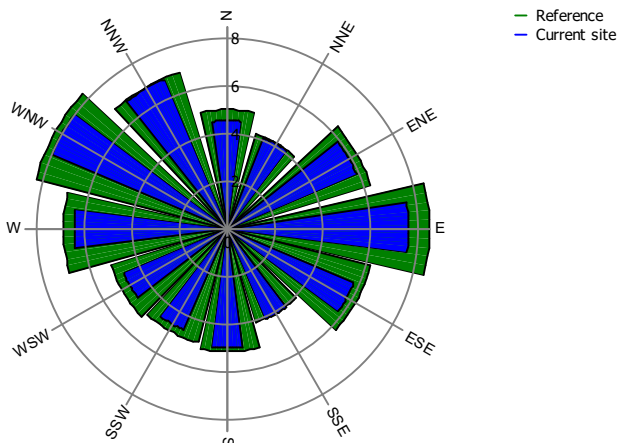
Weibull Distribution



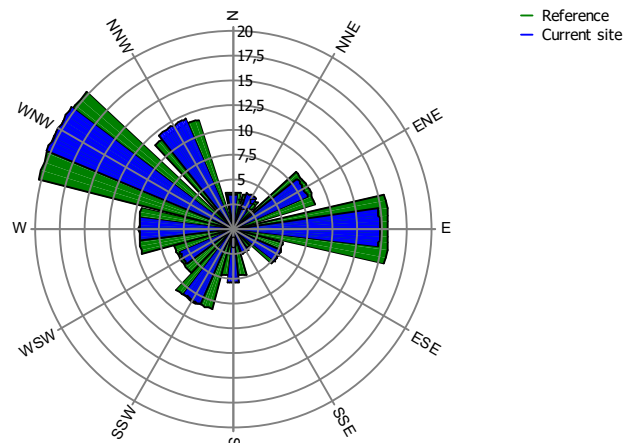
Energy Rose (kWh/m<sup>2</sup>/year)



Mean wind speed (m/s)



Frequency (%)



## PARK - Park power curve

### Calculation: PARK

Wind speed [m/s]	Power													
	Free WTGs [kW]	Park WTGs [kW]	N [kW]	NNE [kW]	ENE [kW]	E [kW]	ESE [kW]	SSE [kW]	S [kW]	SSW [kW]	WSW [kW]	W [kW]	WNW [kW]	NNW [kW]
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3,5	1.339	1.150	1.184	1.123	1.190	1.109	1.150	1.190	1.182	1.115	1.190	1.110	1.150	1.190
4,5	3.938	3.492	3.577	3.439	3.577	3.396	3.489	3.585	3.578	3.430	3.575	3.395	3.491	3.586
5,5	7.897	7.112	7.260	7.010	7.262	6.945	7.112	7.276	7.265	7.000	7.259	6.946	7.112	7.279
6,5	13.467	12.173	12.414	12.010	12.416	11.896	12.171	12.446	12.425	11.995	12.411	11.898	12.173	12.449
7,5	20.983	19.009	19.377	18.760	19.381	18.589	19.003	19.425	19.394	18.735	19.375	18.588	19.008	19.428
8,5	30.375	27.778	28.256	27.414	28.287	27.230	27.771	28.324	28.278	27.383	28.282	27.230	27.781	28.331
9,5	39.688	37.356	37.762	36.874	37.885	36.874	37.363	37.851	37.761	36.873	37.890	36.880	37.371	37.862
10,5	45.819	44.680	44.861	44.302	44.992	44.458	44.707	44.933	44.848	44.352	45.000	44.455	44.699	44.930
11,5	48.491	48.167	48.218	48.039	48.265	48.104	48.178	48.243	48.211	48.068	48.266	48.099	48.173	48.236
12,5	49.331	49.261	49.273	49.237	49.281	49.249	49.264	49.277	49.272	49.242	49.281	49.246	49.263	49.276
13,5	49.543	49.530	49.533	49.526	49.534	49.528	49.531	49.533	49.532	49.527	49.534	49.528	49.531	49.533
14,5	49.592	49.590	49.591	49.589	49.591	49.590	49.590	49.590	49.590	49.589	49.591	49.589	49.590	49.590
15,5	49.600	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599	49.599
16,5	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600
17,5	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600
18,5	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600
19,5	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600	49.600
20,5	48.640	48.745	48.718	48.761	48.722	48.761	48.743	48.726	48.730	48.759	48.724	48.773	48.747	48.728
21,5	46.656	46.727	46.714	46.740	46.711	46.741	46.726	46.711	46.714	46.740	46.711	46.741	46.726	46.711
22,5	44.672	44.735	44.724	44.747	44.721	44.748	44.735	44.721	44.724	44.747	44.721	44.748	44.735	44.721
23,5	42.688	42.744	42.734	42.754	42.732	42.755	42.743	42.732	42.734	42.754	42.732	42.755	42.743	42.732
24,5	40.704	40.753	40.745	40.763	40.743	40.764	40.753	40.743	40.745	40.763	40.743	40.764	40.753	40.743
25,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

#### Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes wake losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in windPRO.

#### The park power curve can be used for:

- Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
- Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
- Calculation of wind energy index based on the PARK production (see below).
- Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in windPRO (PPV-model).

#### Note:

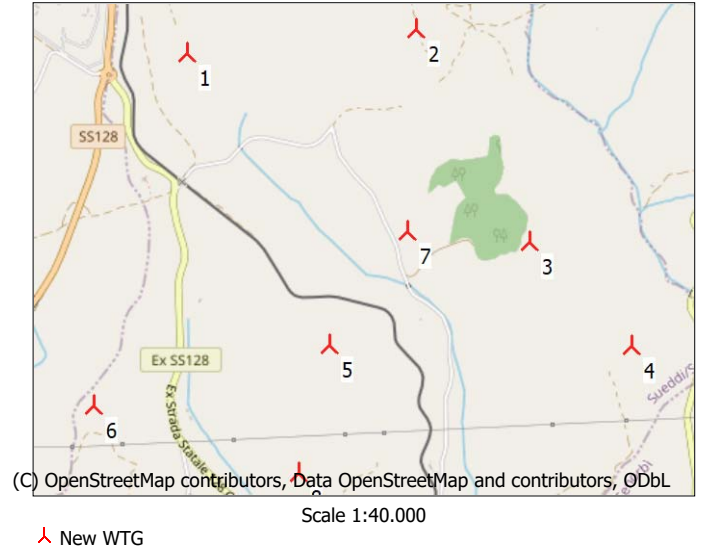
From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

## PARK - WTG distances

Calculation: PARK

### WTG distances

Z	Nearest WTG	Z	Horizontal distance [m]	Distance in rotor diameters	
1	360,0	2	363,3	1.215	7,1
2	363,3	7	311,1	1.068	6,3
3	364,3	7	311,1	650	3,8
4	385,0	3	364,3	767	4,5
5	360,0	8	306,7	694	4,1
6	346,3	8	306,7	1.143	6,7
7	311,1	3	364,3	650	3,8
8	306,7	5	360,0	694	4,1
<b>Min</b>	<b>306,7</b>	<b>306,7</b>	<b>650</b>	<b>3,8</b>	<b>7,1</b>
<b>Max</b>	<b>385,0</b>	<b>364,3</b>	<b>1.215</b>	<b>7,1</b>	





## PARK - Wind statistics info

**Calculation:** PARK

### Main data for wind statistic

**File** \\srv\eolica\ESTUDIOS\ITALIA\E1 Italia\SPEOL210006 Suelli\3 WindPRO\IT Datos meteorologicos - 100.00 m.wws  
**Name** Datos meteorologicos - 100.00 m  
**Country** Italy  
**Source** USER  
**Mast coordinates** UTM (north)-ETRS89 Zone: 32 East: 513.487 North: 4.382.312  
**Created** 23/07/2023  
**Edited** 23/07/2023  
**Sectors** 12  
**WAsP version** WAsP 12 Version 12.08.0022  
**Coordinate system** UTM (north)-WGS84 Zone: 32  
**Displacement height** None

### Additional info for wind statistic

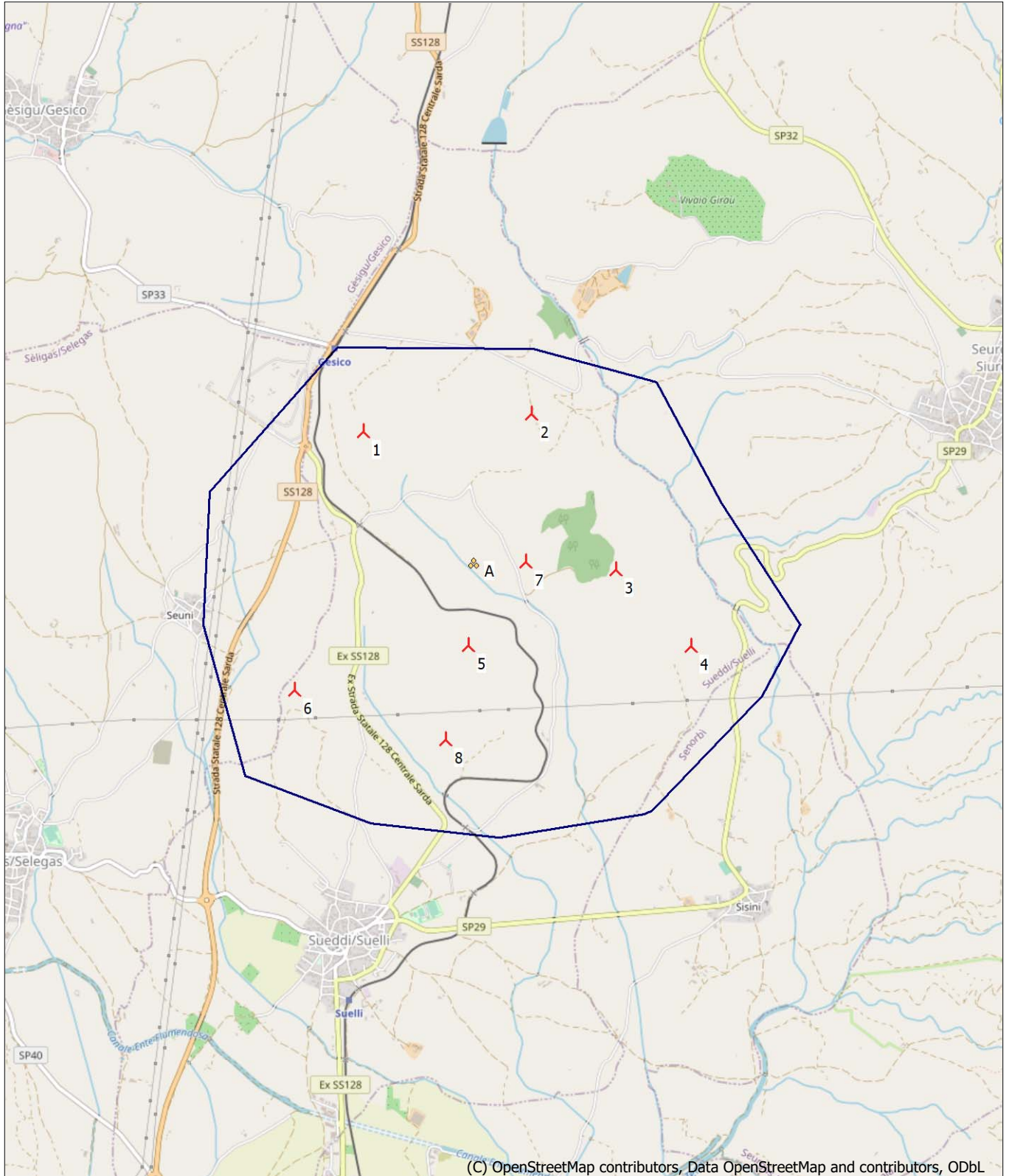
**Source data** Datos meteorologicos  
**Data from** 01/01/1999  
**Data to** 01/07/2023  
**Measurement length** 293,9 Months  
**Recovery rate** 100,0 %  
**Effective measurement length** 293,9 Months

### Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WAsP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WAsP CFD should always use WAsP CFD calculated wind statistics.

## PARK - Map

Calculation: PARK



(C) OpenStreetMap contributors, Data OpenStreetMap and contributors, ODbL

0 500 1000 1500 2000 m

Map: EMD OpenStreetMap , Print scale 1:40.000, Map center UTM (north)-ETRS89 Zone: 32 East: 512.443 North: 4.381.732

🚧 New WTG      🏠 WTG area