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Czastkowice VII 2025

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PARK - Main Result

Calculation: Rozwienica 11 WTG V 2025

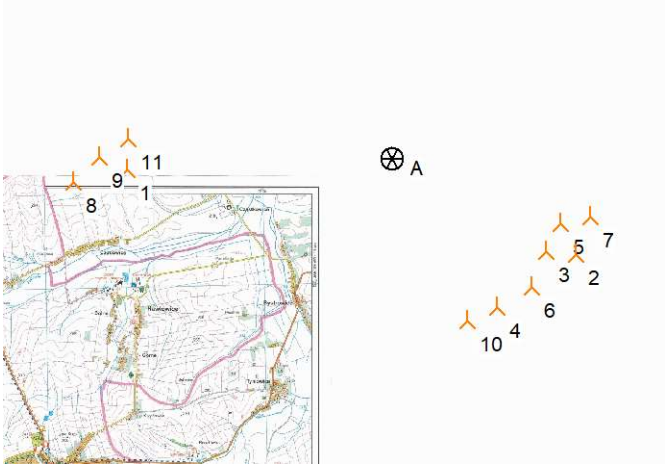
Wake Model N.O. Jensen (RISŘ/EMD)

Calculation Settings

Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1,205 kg/m3 to 1,209 kg/m3
Hub altitude above sea level (asl)	323,0 m to 355,9 m
Annual mean temperature at hub alt.	7,3 °C to 7,5 °C
Pressure at WTGs	970,4 hPa to 974,3 hPa

Wake Model Parameters
Wake Decay Constant0,075

Wind statistics PL Jaroslaw Wind Index.wws



Scale 1:125 000
New WTG Site Data

Key results for height 50,0 m above ground level

Terrain **UTM WGS84 Zone: 34**

	East	North	Name of wind distribution	Type	Wind energy [kWh/m2]	Mean wind speed [m/s]	Equivalent roughness
A	614 554	5 534 477	jaroslaw wind index	WAsP (RVEA0011 1, 0, 0, 13)	1 721	5,6	1,2

Calculated Annual Energy for Wind Farm

WTG combination	Annual Energy Result [MWh]	Annual Energy P90-12,8% [MWh]	Park Efficiency [%]	Mean WTG energy [MWh]	Capacity Factor for Result [%]	Capacity Factor for P90-12,8% [%]
Wind farm	181 852,2	158 575,1	93,2	16 532,0	41,9	36,5

Calculated Annual Energy for each of 11 new WTG's with total 49,5 MW rated power

	Terrain	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Power curve Creator	Name	Annual Energy Result [MWh]	Annual Energy P90-12,8% [MWh]	Park Efficiency [%]	Mean wind speed [m/s]
1	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 718,5	14 578	92,5	6,9
2	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	15 328,6	13 367	89,1	6,7
3	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 303,8	14 217	92,2	6,8
4	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 450,4	14 345	93,9	6,8
5	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 306,1	14 219	91,8	6,8
6	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 443,9	14 339	93,9	6,8
7	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	15 394,4	13 424	89,0	6,7
8	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	17 888,8	15 599	98,2	6,9
9	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	16 552,7	14 434	92,7	6,8
10	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	17 455,6	15 221	98,2	6,8
11	A	Yes	VESTAS	V163-4.5-4 500	4 500	163,0	113,0	EMD	Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022	17 009,4	14 832	93,0	7,0

WTG siting

UTM WGS84 Zone: 34

	East	North	Z [m]	Row data/Description
	UTM WGS84 Zone: 34			
1 New	610 164	5 534 311	233,6	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (719)
2 New	617 606	5 532 877	212,9	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (720)
3 New	617 114	5 532 940	224,4	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (721)
4 New	616 306	5 532 005	226,2	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (722)
5 New	617 359	5 533 397	220,0	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (723)
6 New	616 883	5 532 347	222,3	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (724)

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PARK - Main Result

Calculation: Rozwienica 11 WTG V 2025

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		UTM WGS84 Zone: 34 East	North	Z [m]	Row data/Description
7	New	617 851	5 533 502	210,0	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (725)
8	New	609 262	5 534 091	240,0	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (726)
9	New	609 696	5 534 511	236,6	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (727)
10	New	615 817	5 531 779	237,2	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (728)
11	New	610 167	5 534 811	242,9	VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (729)

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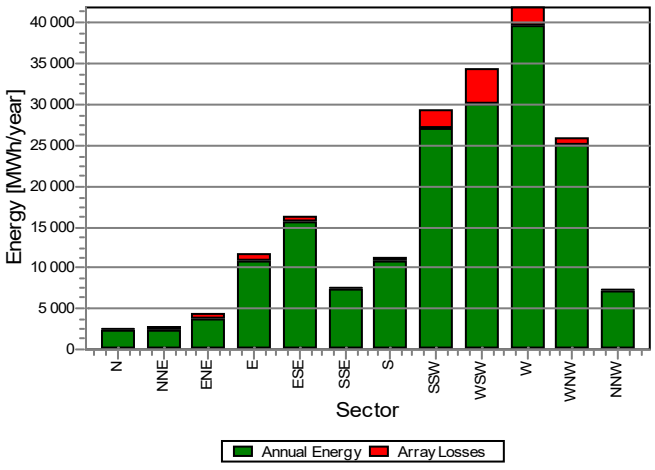
PARK - Production Analysis

Calculation: Rozwienica 11 WTG V 2025 **WTG:** All new WTG's, Air density varies with WTG position 1,205 kg/m3 - 1,209 kg/m3

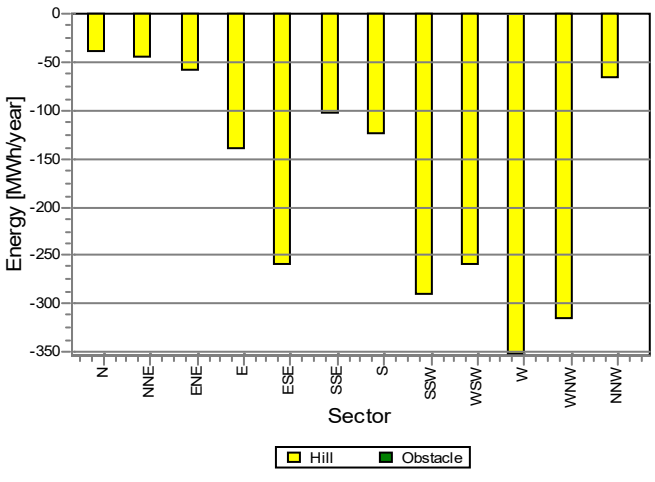
Directional Analysis

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	2 560,0	2 704,5	4 483,1	11 889,6	16 571,0	7 737,0	11 278,8	29 521,7	34 692,6	42 278,0	26 173,5	7 384,5	197 274,3
+Increase due to hills	[MWh]	-39,8	-45,8	-59,0	-140,4	-261,6	-105,2	-125,4	-291,1	-260,1	-353,4	-317,3	-68,5	-2 067,6
-Decrease due to array losses	[MWh]	164,8	386,5	821,2	937,6	683,6	221,8	432,8	2 090,9	4 376,3	2 192,7	843,8	202,5	13 354,5
Resulting energy	**[MWh]**	**2 355,3**	**2 272,2**	**3 602,9**	**10 811,6**	**15 625,8**	**7 410,0**	**10 720,6**	**27 139,7**	**30 056,2**	**39 731,9**	**25 012,4**	**7 113,5**	**181 852,2**
Specific energy	[kWh/m2]													792
Specific energy	[kWh/kW]													3 674
Increase due to hills	[%]	-1,6	-1,7	-1,3	-1,2	-1,6	-1,4	-1,1	-1,0	-0,7	-0,8	-1,2	-0,9	-1,0
Decrease due to array losses	[%]	6,5	14,5	18,6	8,0	4,2	2,9	3,9	7,2	12,7	5,2	3,3	2,8	6,8
Utilization	[%]	37,5	34,5	30,7	34,9	35,3	34,6	25,7	21,9	24,9	26,3	29,3	33,2	27,3
Operational	[Hours/year]	292	257	289	619	788	457	517	1 012	1 202	1 431	981	491	8 336
Full Load Equivalent	[Hours/year]	48	46	73	218	316	150	217	548	607	803	505	144	3 674

Energy vs. sector



Impact of hills and obstacles vs. sector



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PARK - Power Curve Analysis

Calculation: Rozwienica 11 WTG V 2025 **WTG:** 1 - VESTAS V163-4.5 4500 163.0 !O! Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022, Hub height: 113,0 m

Name: Level 0 - Calculated - PO4500-0S/PO4500 - 08-2022
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
31.08.2022	EMD	14.12.2022	15.12.2022	24,0	Pitch	User defined

Based on Document nr. 0130-7822.V00.

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

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	0	0	0	0	0	0
VESTAS V163-4.5 4500 163.0 !O! hub: 113,0 m (719)	[MWh]	9 978	14 380	18 292	21 487	23 909	25 583
Check value	[%]	0	0	0	0	0	0

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

Power curve

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

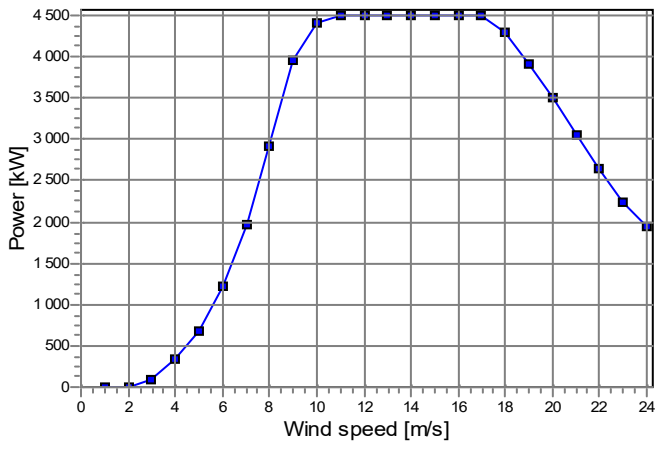
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3,0	94,0	0,27	3,0	0,87
3,5	201,0	0,37	3,5	0,84
4,0	334,0	0,41	4,0	0,83
4,5	497,0	0,43	4,5	0,82
5,0	700,0	0,44	5,0	0,82
5,5	946,0	0,44	5,5	0,82
6,0	1 241,0	0,45	6,0	0,82
6,5	1 586,0	0,45	6,5	0,81
7,0	1 989,0	0,45	7,0	0,81
7,5	2 446,0	0,45	7,5	0,80
8,0	2 960,0	0,45	8,0	0,79
8,5	3 505,0	0,45	8,5	0,76
9,0	4 004,0	0,43	9,0	0,69
9,5	4 294,0	0,39	9,5	0,59
10,0	4 432,0	0,35	10,0	0,50
10,5	4 479,0	0,31	10,5	0,42
11,0	4 497,0	0,27	11,0	0,35
11,5	4 500,0	0,23	11,5	0,30
12,0	4 500,0	0,21	12,0	0,26
12,5	4 500,0	0,18	12,5	0,23
13,0	4 500,0	0,16	13,0	0,20
13,5	4 500,0	0,14	13,5	0,18
14,0	4 500,0	0,13	14,0	0,16
14,5	4 500,0	0,12	14,5	0,15
15,0	4 500,0	0,11	15,0	0,13
15,5	4 500,0	0,10	15,5	0,12
16,0	4 500,0	0,09	16,0	0,11
16,5	4 500,0	0,08	16,5	0,10
17,0	4 493,0	0,07	17,0	0,09
17,5	4 440,0	0,07	17,5	0,08
18,0	4 303,0	0,06	18,0	0,08
18,5	4 115,0	0,05	18,5	0,07
19,0	3 920,0	0,05	19,0	0,06
19,5	3 714,0	0,04	19,5	0,05
20,0	3 494,0	0,03	20,0	0,05
20,5	3 268,0	0,03	20,5	0,04
21,0	3 047,0	0,03	21,0	0,04
21,5	2 836,0	0,02	21,5	0,03
22,0	2 636,0	0,02	22,0	0,03
22,5	2 440,0	0,02	22,5	0,03
23,0	2 248,0	0,01	23,0	0,02
23,5	2 070,0	0,01	23,5	0,02
24,0	1 939,0	0,01	24,0	0,02

Power, Efficiency and energy vs. wind speed

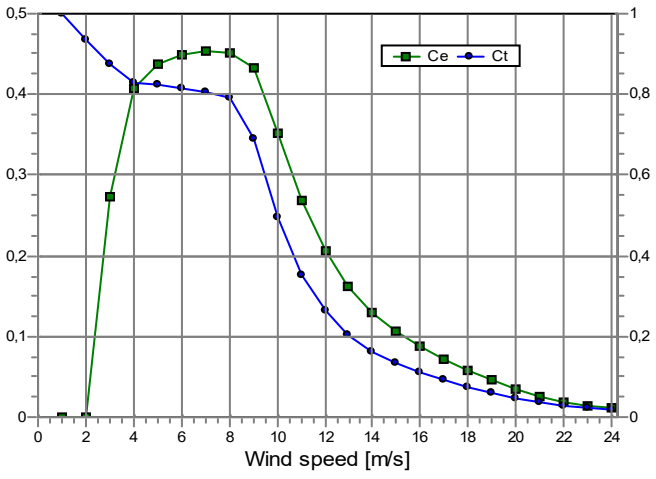
Data used in calculation, Air density: 1,206 kg/m3

Wind speed [m/s]	Power [kW]	Ce	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	92,6	0,27	2,50- 3,50	72,0	72,0	0,4
4,0	328,9	0,41	3,50- 4,50	287,3	359,3	2,1
5,0	689,4	0,44	4,50- 5,50	662,1	1 021,4	6,1
6,0	1 222,1	0,45	5,50- 6,50	1 196,8	2 218,2	13,3
7,0	1 958,8	0,45	6,50- 7,50	1 823,3	4 041,5	24,2
8,0	2 915,0	0,45	7,50- 8,50	2 408,1	6 449,6	38,6
9,0	3 967,4	0,43	8,50- 9,50	2 667,7	9 117,2	54,5
10,0	4 418,5	0,35	9,50-10,50	2 397,7	11 514,9	68,9
11,0	4 497,0	0,27	10,50-11,50	1 832,3	13 347,3	79,8
12,0	4 500,0	0,21	11,50-12,50	1 287,8	14 635,1	87,5
13,0	4 500,0	0,16	12,50-13,50	854,2	15 489,3	92,6
14,0	4 500,0	0,13	13,50-14,50	537,2	16 026,5	95,9
15,0	4 500,0	0,11	14,50-15,50	320,8	16 347,4	97,8
16,0	4 500,0	0,09	15,50-16,50	182,4	16 529,8	98,9
17,0	4 493,0	0,07	16,50-17,50	98,7	16 628,5	99,5
18,0	4 303,0	0,06	17,50-18,50	49,8	16 678,3	99,8
19,0	3 920,0	0,05	18,50-19,50	23,1	16 701,4	99,9
20,0	3 494,0	0,03	19,50-20,50	10,2	16 711,5	100,0
21,0	3 047,0	0,03	20,50-21,50	4,3	16 715,8	100,0
22,0	2 636,0	0,02	21,50-22,50	1,7	16 717,6	100,0
23,0	2 248,0	0,01	22,50-23,50	0,7	16 718,3	100,0
24,0	1 939,0	0,01	23,50-24,50	0,2	16 718,5	100,0

Power curve
Data used in calculation



Ce and Ct curve



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PARK - Terrain

Calculation: Rozwienica 11 WTG V 2025 **Site Data:** A - jaroslaw wind index

Obstacles:
0 Obstacles used

Roughness:
Calculation uses following MAP files:
C:\WindPRO Data\Projects\Czastkowice\ROUGHNESSLINE_Czastkowice XII 2022_0.wpo
Min X: 587 797, Max X: 620 765, Min Y: 5 521 274, Max Y: 5 545 701, Width: 32 968 m, Height: 24 427 m
Limited by a square on 40,0 km x 40,0 km around the current site

Orography:
Calculation uses following MAP files:
C:\WindPRO Data\Projects\Czastkowice\contures 2.WPO
Min X: 594 824, Max X: 620 139, Min Y: 5 522 659, Max Y: 5 545 628, Width: 25 314 m, Height: 22 968 m
Limited by a square on 10,0 km x 10,0 km around the current site

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PARK - Wind Data Analysis

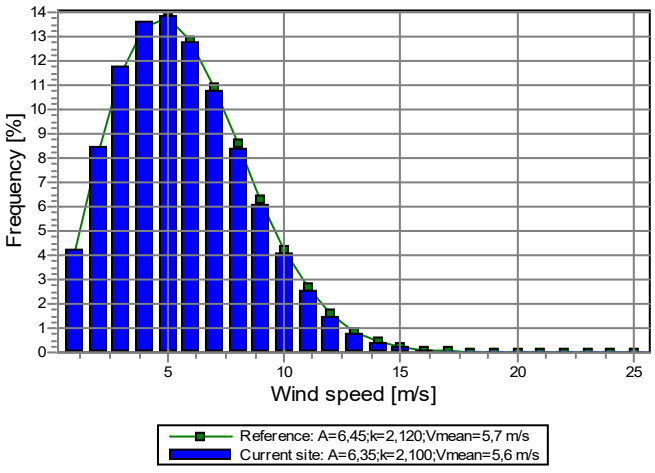
Calculation: Rozwienica 11 WTG V 2025 **Wind data:** A - jaroslaw wind index; Hub height: 50,0

Site Coordinates
UTM WGS 84 Zone: 34 East: 614 554 North: 5 534 477
Wind statistics
PL Jaroslaw Wind Index.wws

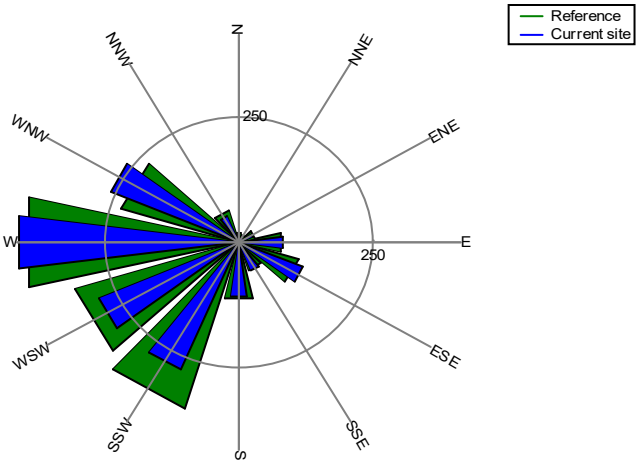
Weibull Data

	Current site				Reference: Roughness class 1		
Sector	A-parameter [m/s]	Wind speed [m/s]	k-parameter	Frequency [%]	A-parameter [m/s]	k-parameter	Frequency [%]
0 N	3,59	3,19	1,834	3,4	3,99	1,820	3,6
1 NNE	3,74	3,31	1,967	2,9	4,29	2,010	3,1
2 ENE	4,89	4,33	2,088	3,3	5,12	2,100	3,4
3 E	5,72	5,07	2,443	7,4	5,67	2,470	7,3
4 ESE	6,04	5,36	2,486	9,9	5,92	2,520	9,5
5 SSE	5,36	4,75	1,994	5,7	5,34	2,060	5,5
6 S	6,07	5,39	1,814	6,1	6,22	1,810	6,0
7 SSW	7,12	6,31	2,123	11,4	7,59	2,150	12,0
8 WSW	7,00	6,21	2,451	13,9	7,23	2,480	14,3
9 W	7,36	6,53	2,467	17,6	7,35	2,490	17,2
10 WNW	7,01	6,22	2,396	12,5	6,87	2,430	11,9
11 NNW	4,95	4,40	1,783	5,9	5,14	1,820	6,0
All	6,35	5,62	2,100	100,0	6,45	2,120	100,0

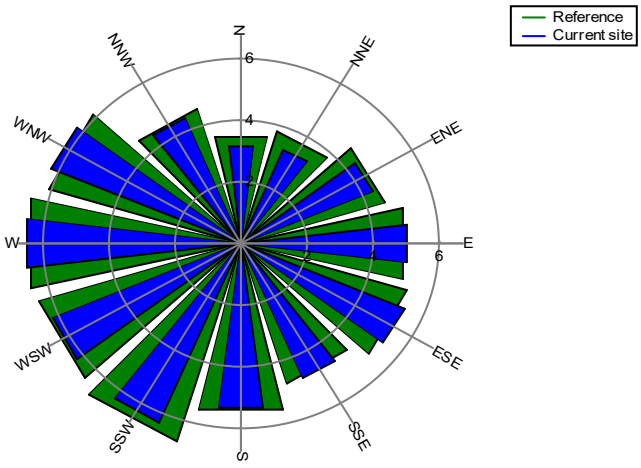
Weibull Distribution



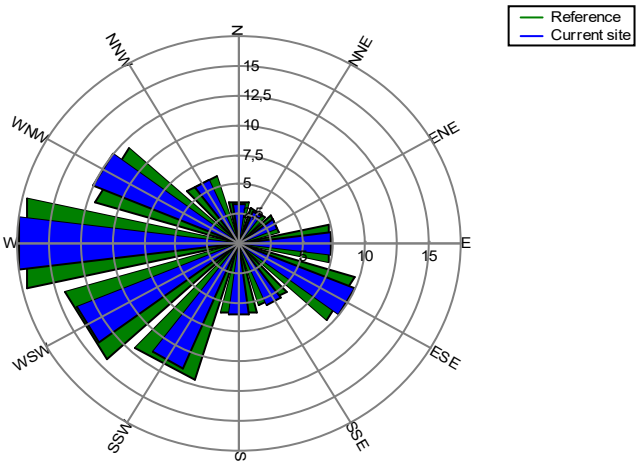
Energy Rose (kWh/m2/year)



Mean w ind speed (m/s)



Frequency (%)



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PARK - Park power curve

Calculation: Rozwienica 11 WTG V 2025

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	2 188	1 772	1 936	1 612	1 372	1 807	1 977	2 038	1 936	1 641	1 340	1 809	1 971	2 038
4,5	5 409	4 671	4 959	4 387	3 956	4 731	5 031	5 143	4 959	4 424	3 923	4 732	5 022	5 143
5,5	10 296	8 984	9 491	8 483	7 724	9 082	9 619	9 821	9 490	8 555	7 667	9 085	9 603	9 820
6,5	17 261	15 134	15 958	14 324	13 090	15 297	16 165	16 489	15 958	14 436	12 997	15 301	16 138	16 489
7,5	26 620	23 431	24 669	22 216	20 365	23 679	24 975	25 465	24 668	22 385	20 222	23 685	24 936	25 464
8,5	38 226	34 028	35 690	32 406	29 889	34 398	36 084	36 735	35 692	32 626	29 689	34 404	36 041	36 734
9,5	47 033	44 012	45 368	42 744	40 502	44 535	45 602	46 044	45 379	42 848	40 370	44 523	45 613	46 044
10,5	49 269	48 630	48 991	48 341	47 588	48 838	49 013	49 112	48 993	48 319	47 659	48 828	49 029	49 113
11,5	49 500	49 465	49 486	49 449	49 399	49 479	49 487	49 492	49 487	49 444	49 410	49 478	49 488	49 492
12,5	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500
13,5	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500
14,5	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500
15,5	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500
16,5	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500	49 500
17,5	48 840	48 918	48 884	48 949	49 001	48 908	48 877	48 865	48 884	48 946	49 005	48 908	48 878	48 865
18,5	45 265	45 497	45 397	45 591	45 748	45 468	45 376	45 340	45 397	45 581	45 758	45 468	45 379	45 340
19,5	40 854	41 061	40 972	41 145	41 284	41 036	40 953	40 921	40 972	41 136	41 293	41 035	40 955	40 921
20,5	35 948	36 131	36 052	36 205	36 328	36 109	36 036	36 007	36 052	36 197	36 336	36 108	36 038	36 007
21,5	31 196	31 334	31 275	31 390	31 483	31 318	31 263	31 241	31 275	31 384	31 489	31 317	31 264	31 241
22,5	26 840	26 948	26 902	26 992	27 064	26 935	26 892	26 875	26 902	26 987	27 068	26 935	26 893	26 875
23,5	22 770	22 848	22 814	22 879	22 931	22 838	22 807	22 795	22 815	22 876	22 935	22 838	22 808	22 795
24,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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 array 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:

1. 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.
2. 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.
3. Calculation of wind energy index based on the PARK production (see below).
4. 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.

Project:
Czastkowice VII 2025

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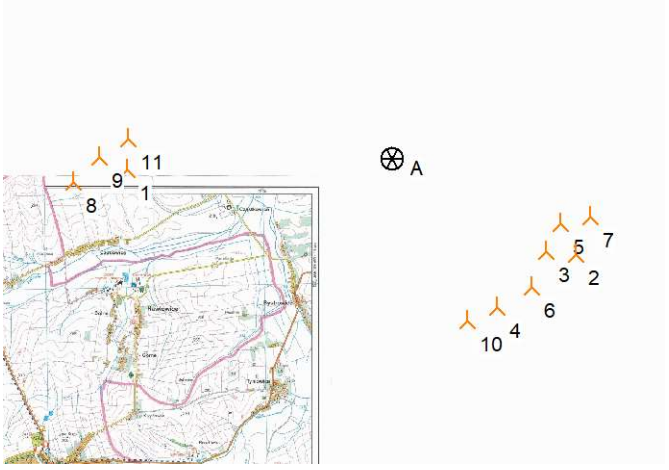
Calculated:
05.09.2025 11:50/2.6.1.252

PARK - WTG distances

Calculation: Rozwienica 11 WTG V 2025

WTG distances

	Z [m]	Nearest WTG	Z [m]	Horizontal distance [m]	Distance in rotor diameters
1	233,6	11	242,9	500	3,1
2	212,9	3	224,4	497	3,0
3	224,4	2	212,9	497	3,0
4	226,2	10	237,2	539	3,3
5	220,0	7	210,0	503	3,1
6	222,3	3	224,4	637	3,9
7	210,0	5	220,0	503	3,1
8	240,0	9	236,6	604	3,7
9	236,6	1	233,6	509	3,1
10	237,2	4	226,2	539	3,3
11	242,9	1	233,6	500	3,1



Scale 1:125 000

New WTG Site Data