

PARK - Main Result

Calculation: 6MW alternatief: Kavel IV

Wake Model N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1,234 kg/m³
Air density relative to standard 100,8 %
Hub altitude above sea level (asl) 102,0 m
Annual mean temperature at hub alt. 9,3 °C
Pressure at WTGs 1.000,8 hPa

Wake Model Parameters

Terrain type Wake decay constant
Offshore & Water areas 0,040

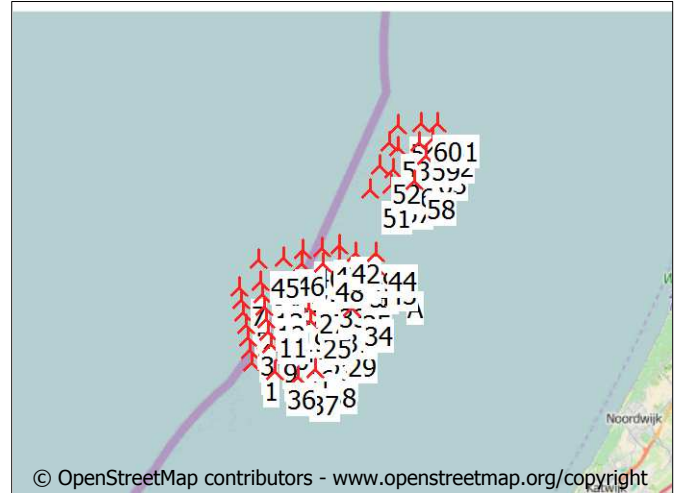
Displacement heights from objects

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 NL EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m.wws

WAsP version WAsP 10.2 RVEA0164.dll 3.0.1.100



PARK - Main Result

Calculation: 6MW alternatief: Kavel IV

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Links	WTG type			Power, rated	Rotor diameter	Hub height	Power curve		Annual Energy Park			
	Valid	Manufact.	Type-generator				Creator	Name	Result	Efficiency	Capacity factor	Free mean wind speed
				[kW]	[m]	[m]			[MWh]	[%]	[%]	[m/s]
23 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.016,6	89,55	43,8	8,44
24 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.733,3	88,41	43,2	8,44
25 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.581,5	87,82	42,9	8,44
26 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.539,2	87,63	42,9	8,44
27 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.674,6	88,14	43,1	8,44
28 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.024,4	89,50	43,8	8,44
29 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.476,5	91,37	44,6	8,44
30 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.007,7	89,51	43,7	8,44
31 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.772,6	88,58	43,3	8,44
32 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.738,3	88,42	43,2	8,44
33 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.958,8	89,27	43,7	8,44
34 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.480,6	91,37	44,6	8,44
35 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.353,5	90,86	44,4	8,44
36 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.190,3	94,15	46,0	8,43
37 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.251,1	94,42	46,1	8,43
38 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.977,8	93,36	45,6	8,43
39 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.517,4	91,41	44,7	8,44
40 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.865,9	92,77	45,4	8,44
41 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.328,7	90,72	44,4	8,44
42 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.857,7	92,78	45,4	8,44
43 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.029,7	93,53	45,7	8,44
44 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.060,1	93,64	45,7	8,44
45 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.627,5	95,75	46,8	8,44
46 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.099,9	93,68	45,8	8,44
47 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.740,2	92,30	45,1	8,44
48 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.333,5	90,71	44,4	8,44
49 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.607,5	91,83	44,9	8,44
50 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.617,1	91,87	44,9	8,44
51 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.723,6	96,28	47,0	8,44
52 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.521,2	95,58	46,6	8,43
53 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.425,3	95,33	46,4	8,43
54 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.649,9	96,31	46,9	8,42
55 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.088,3	94,01	45,8	8,43
56 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.160,6	94,20	45,9	8,43
57 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.364,2	94,96	46,3	8,43
58 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.540,3	95,73	46,7	8,43
59 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.007,7	93,79	45,6	8,42
60 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.373,5	95,33	46,3	8,42
61 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.322,1	95,19	46,2	8,42
62 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.956,4	93,67	45,5	8,42
63 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.239,6	94,67	46,1	8,43

Annual Energy results do not include any losses apart from wake losses. Additional losses and uncertainty must be considered for an investment decision.

WTG siting

UTM (north)-ETRS89 Zone: 31

	Easting	Northing	Z	Row data/Description
			[m]	
1 New	572.953	5.791.985	0,0	-9,1°, 839,4 m
2 New	572.807	5.792.812	0,0	
3 New	572.662	5.793.639	0,0	
4 New	572.516	5.794.465	0,0	
5 New	572.371	5.795.292	0,0	
6 New	572.225	5.796.118	0,0	
7 New	572.079	5.796.945	0,0	
8 New	574.341	5.792.399	0,0	-9,1°, 839,4 m
9 New	574.195	5.793.225	0,0	
10 New	574.049	5.794.052	0,0	
11 New	573.904	5.794.878	0,0	
12 New	573.758	5.795.705	0,0	

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PARK - Main Result

Calculation: 6MW alternatief: Kavel IV

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UTM (north)-ETRS89 Zone: 31

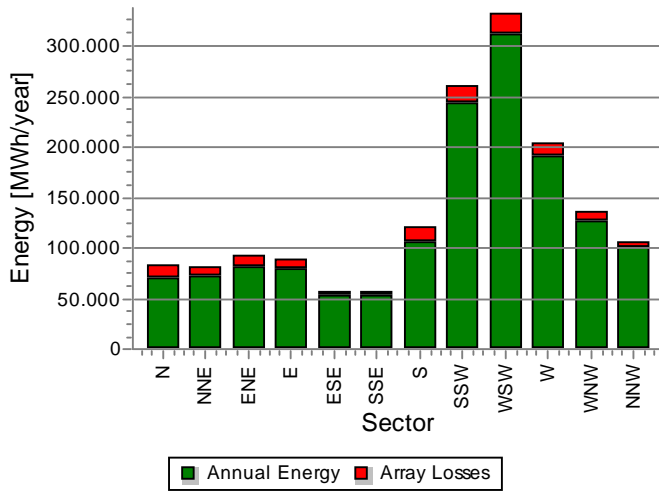
	Easting	Northing	Z	Row data/Description
			[m]	
13 New	573.612	5.796.532	0,0	
14 New	573.466	5.797.358	0,0	
15 New	575.875	5.791.985	0,0	-9,1°, 839,4 m
16 New	575.729	5.792.812	0,0	
17 New	575.583	5.793.638	0,0	
18 New	575.437	5.794.465	0,0	
19 New	575.291	5.795.291	0,0	
20 New	575.144	5.796.118	0,0	
21 New	574.998	5.796.945	0,0	
22 New	577.263	5.792.399	0,0	-9,1°, 839,4 m
23 New	577.116	5.793.225	0,0	
24 New	576.970	5.794.052	0,0	
25 New	576.824	5.794.878	0,0	
26 New	576.677	5.795.705	0,0	
27 New	576.531	5.796.531	0,0	
28 New	576.385	5.797.358	0,0	
29 New	578.504	5.793.638	0,0	-9,1°, 839,4 m
30 New	578.357	5.794.465	0,0	
31 New	578.211	5.795.291	0,0	
32 New	578.064	5.796.118	0,0	
33 New	577.917	5.796.944	0,0	
34 New	579.597	5.795.704	0,0	-9,1°, 839,4 m
35 New	579.450	5.796.531	0,0	
36 New	574.498	5.791.423	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1020)
37 New	576.041	5.791.039	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1021)
38 New	577.225	5.791.585	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1022)
39 New	576.220	5.798.604	0,0	0,9°, 900,6 m
40 New	576.221	5.799.504	0,0	
41 New	578.659	5.799.014	0,0	0,9°, 900,6 m
42 New	578.660	5.799.914	0,0	
43 New	581.098	5.798.523	0,0	0,9°, 900,6 m
44 New	581.098	5.799.424	0,0	
45 New	573.334	5.798.824	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1026)
46 New	574.955	5.798.974	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1027)
47 New	577.503	5.799.670	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1028)
48 New	577.581	5.798.637	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1029)
49 New	579.786	5.799.392	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1030)
50 New	579.834	5.798.297	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1031)
51 New	580.646	5.803.664	0,0	22,9°, 1.700,0 m
52 New	581.282	5.805.240	0,0	
53 New	581.919	5.806.816	0,0	
54 New	582.457	5.807.956	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1035)
55 New	582.480	5.806.484	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1036)
56 New	582.192	5.805.007	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1037)
57 New	582.084	5.803.972	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1038)
58 New	583.606	5.804.288	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1039)
59 New	583.862	5.806.875	0,0	6,6°, 1.300,0 m
60 New	583.989	5.808.169	0,0	
61 New	585.070	5.808.156	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1041)
62 New	584.776	5.807.118	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1042)
63 New	584.359	5.805.952	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1043)

PARK - Production Analysis

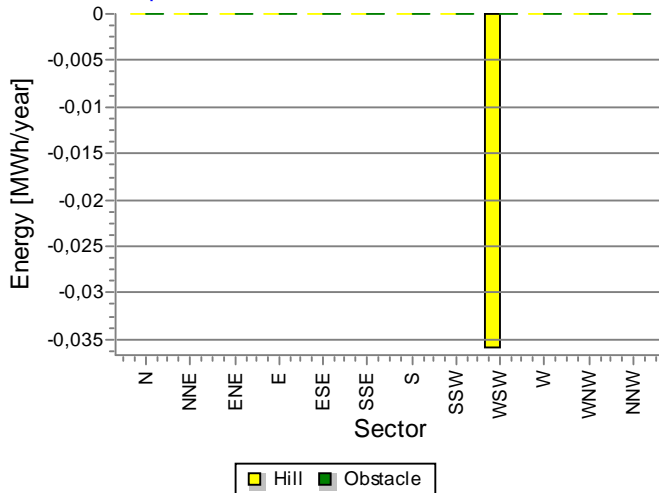
Calculation: 6MW alternatief: Kavel IVWTG: All new WTGs, Air density 1,234 kg/m³
Directional Analysis

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]	84.013,2	81.165,5	92.058,2	88.843,0	57.314,8	56.390,3	120.823,9	260.055,0	332.336,8	203.860,5	135.177,1	106.537,9	1.618.576,9
-Decrease due to array losses	[MWh]	14.763,7	9.469,6	9.966,7	8.648,5	5.270,6	3.447,4	15.755,3	15.738,3	20.553,2	12.672,8	8.679,7	5.694,0	130.659,7
Resulting energy	[MWh]	69.249,5	71.695,9	82.091,5	80.194,5	52.044,3	52.942,9	105.068,5	244.316,8	311.783,5	191.187,7	126.497,5	100.844,0	1.487.916,0
Specific energy	[kWh/m ²]													1.268
Specific energy	[kWh/kW]													3.936
Decrease due to array losses	[%]	17,6	11,7	10,8	9,7	9,2	6,1	13,0	6,1	6,2	6,2	6,4	5,3	8,07
Utilization	[%]	27,1	30,6	29,9	30,3	31,8	30,2	20,4	18,1	18,1	19,4	22,8	26,5	21,6
Operational	[Hours/year]	578	555	561	550	410	390	600	1.058	1.378	970	742	651	8.442
Full Load Equivalent	[Hours/year]	183	190	217	212	138	140	278	646	825	506	335	267	3.936

Energy vs. sector



Impact of hills and obstacles vs. sector



PARK - Power Curve Analysis

Calculation: 6MW alternatief: Kavel IVWTG: 1 - Siemens SWT-6.0-154 6000 154.0 !O! SWT-6.0-154, Hub height: 102,0 m

Name: SWT-6.0-154

Source: Standard PC and Ct Fryslan offshore wind farm, Siemens Doc E-R-WP-CTO-400000-9504-00

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m ²
11-7-2013	USER	21-4-2015	21-4-2015	25,0	Pitch	User defined	Variable	0,32

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

Vmean [m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013) [MWh]	9.537	14.649	19.654	24.160	27.993	31.082
Siemens SWT-6.0-154 6000 154.0 !O! SWT-6.0-154 [MWh]	9.360	14.342	19.280	23.759	27.577	30.641
Check value [%]	2	2	2	2	2	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

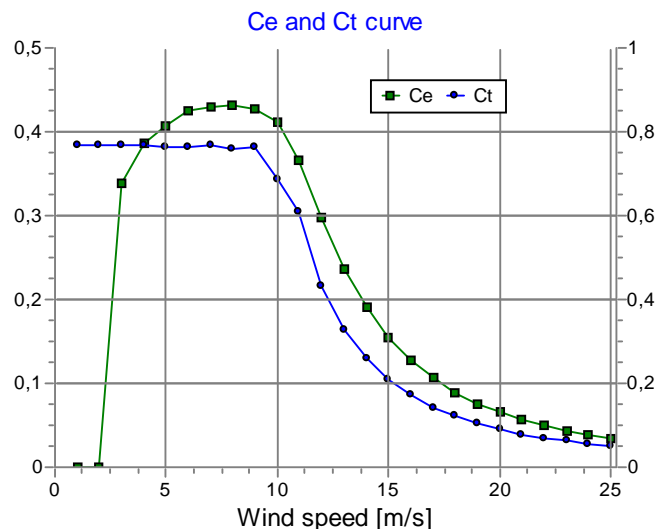
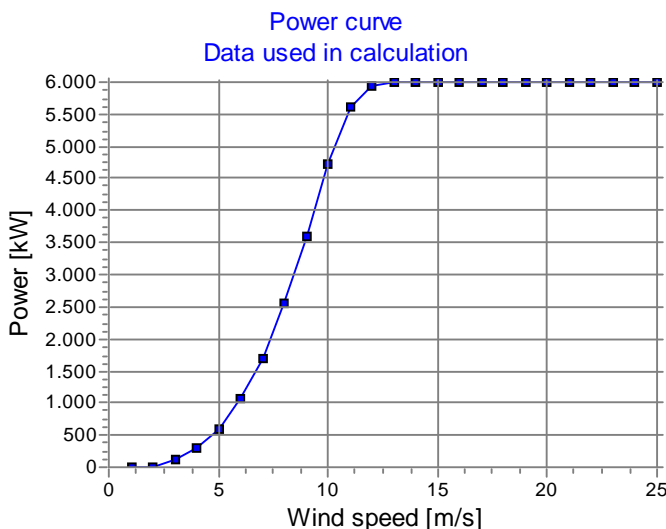
Original data, Air density: 1,225 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3,0	104,0	0,34	3,0	0,77
4,0	281,0	0,38	4,0	0,77
5,0	580,0	0,41	5,0	0,76
6,0	1.048,0	0,43	6,0	0,76
7,0	1.677,0	0,43	7,0	0,77
8,0	2.527,0	0,43	8,0	0,76
9,0	3.562,0	0,43	9,0	0,76
10,0	4.695,0	0,41	10,0	0,69
11,0	5.594,0	0,37	11,0	0,61
12,0	5.929,0	0,30	12,0	0,43
13,0	5.992,0	0,24	13,0	0,33
14,0	5.999,0	0,19	14,0	0,26
15,0	6.000,0	0,16	15,0	0,21
16,0	6.000,0	0,13	16,0	0,17
17,0	6.000,0	0,11	17,0	0,14
18,0	6.000,0	0,09	18,0	0,12
19,0	6.000,0	0,08	19,0	0,10
20,0	6.000,0	0,07	20,0	0,09
21,0	6.000,0	0,06	21,0	0,08
22,0	6.000,0	0,05	22,0	0,07
23,0	6.000,0	0,04	23,0	0,06
24,0	6.000,0	0,04	24,0	0,05
25,0	6.000,0	0,03	25,0	0,05

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,234 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

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	3,0	3,0	0,0
3,0	105,3	0,34	2,50- 3,50	53,9	56,9	0,2
4,0	283,9	0,39	3,50- 4,50	194,7	251,6	1,0
5,0	585,7	0,41	4,50- 5,50	456,4	708,0	2,9
6,0	1.057,3	0,43	5,50- 6,50	870,8	1.578,9	6,5
7,0	1.691,6	0,43	6,50- 7,50	1.421,4	3.000,3	12,3
8,0	2.547,6	0,43	7,50- 8,50	2.048,3	5.048,6	20,7
9,0	3.589,2	0,43	8,50- 9,50	2.635,0	7.683,6	31,5
10,0	4.722,0	0,41	9,50-10,50	3.007,3	10.690,8	43,9
11,0	5.606,7	0,37	10,50-11,50	3.001,1	13.691,9	56,2
12,0	5.931,8	0,30	11,50-12,50	2.641,2	16.333,1	67,0
13,0	5.992,3	0,24	12,50-13,50	2.138,0	18.471,2	75,8
14,0	5.999,1	0,19	13,50-14,50	1.657,9	20.129,1	82,6
15,0	6.000,0	0,15	14,50-15,50	1.252,9	21.382,0	87,8
16,0	6.000,0	0,13	15,50-16,50	927,1	22.309,1	91,6
17,0	6.000,0	0,11	16,50-17,50	672,2	22.981,3	94,3
18,0	6.000,0	0,09	17,50-18,50	477,2	23.458,6	96,3
19,0	6.000,0	0,08	18,50-19,50	331,2	23.789,7	97,6
20,0	6.000,0	0,07	19,50-20,50	224,2	24.013,9	98,6
21,0	6.000,0	0,06	20,50-21,50	147,9	24.161,8	99,2
22,0	6.000,0	0,05	21,50-22,50	94,8	24.256,6	99,6
23,0	6.000,0	0,04	22,50-23,50	59,1	24.315,7	99,8
24,0	6.000,0	0,04	23,50-24,50	35,7	24.351,4	99,9
25,0	6.000,0	0,03	24,50-25,50	13,3	24.364,7	100,0



Project:

715082

Licensed user:

Pondera Consult B.V.

Welbergweg 49

NL-7556 PE Hengelo

0031742489940

Andrew Beltau / a.beltau@ponderaconsult.com

Calculated:

26-10-2016 17:22/3.1.582

PARK - Terrain

Calculation: 6MW alternatief: Kavel IV **Site Data:** A - Site data: Hollandse Kust Zuid

Obstacles:

No obstacles

Roughness:

Terrain data files used in calculation:

\\sbs2011\projecten\Extern\2015\715082 MER PB kavels Hollandse Kust Zuid\TO\WP\ROUGHNESSLINE_715082_0.wpo

Min X: 545.283, Max X: 604.617, Min Y: 5.765.924, Max Y: 5.826.915, Width: 59.334 m, Height: 60.991 m

Orography:

Terrain data files used in calculation:

\\sbs2011\projecten\Extern\2015\715082 MER PB kavels Hollandse Kust Zuid\TO\WP\MAPFILES_715082_0.map

Min X: 547.001, Max X: 599.603, Min Y: 5.774.102, Max Y: 5.815.670, Width: 52.602 m, Height: 41.568 m

PARK - Wind Data Analysis

Calculation: 6MW alternatief: Kavel IV **Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 102,0

Site coordinates

UTM (north)-ETRS89 Zone: 31
East: 582.068 North: 5.796.386

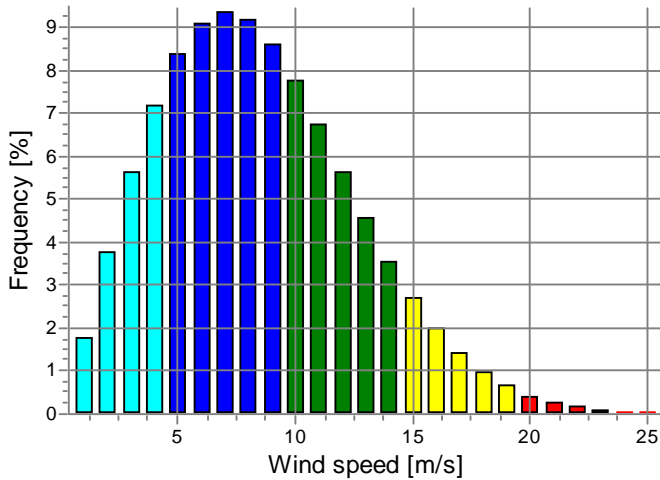
Wind statistics

NL EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m.wws

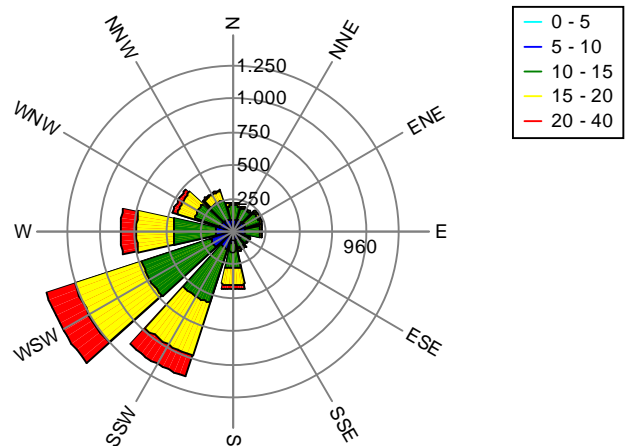
Weibull Data

Sector	Current site		k- parameter	Frequency [%]
	A- parameter [m/s]	Wind speed [m/s]		
0 N	7,96	7,05	2,275	6,8
1 NNE	7,98	7,08	2,471	6,6
2 ENE	8,41	7,47	2,600	6,6
3 E	8,30	7,37	2,564	6,5
4 ESE	7,69	6,81	2,432	4,8
5 SSE	7,87	6,97	2,213	4,6
6 S	9,75	8,64	2,182	7,1
7 SSW	11,41	10,12	2,377	12,5
8 WSW	11,30	10,01	2,322	16,3
9 W	10,25	9,08	2,092	11,5
10 WNW	9,18	8,14	2,049	8,8
11 NNW	8,53	7,56	2,100	7,7
All	9,52	8,43	2,115	100,0

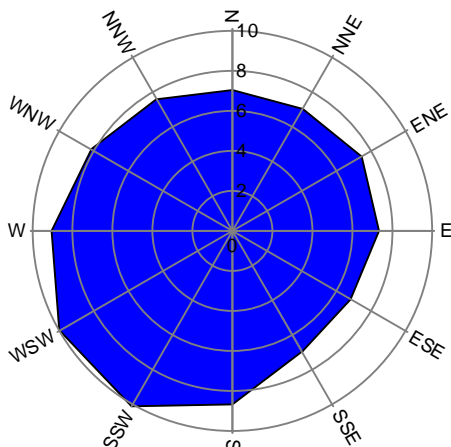
Weibull Distribution



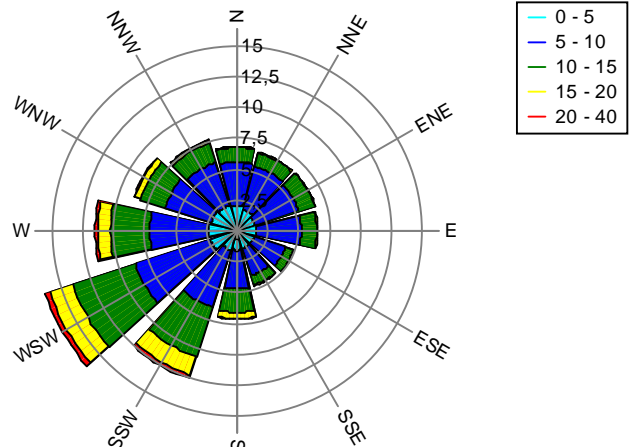
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

Calculation: 6MW alternatief: Kavel IV **Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 100,0

Site coordinates

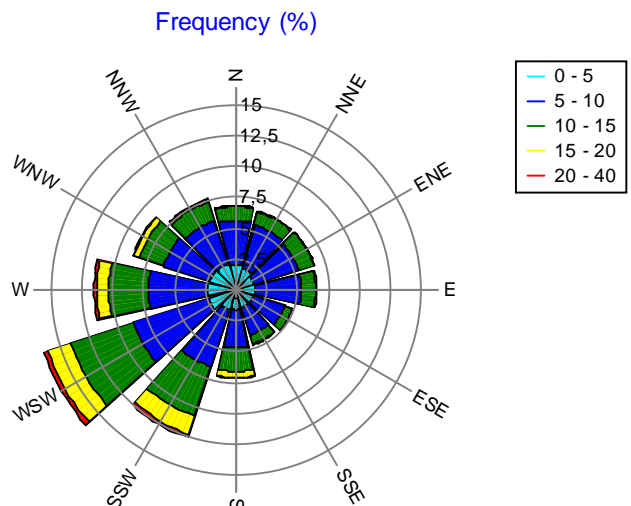
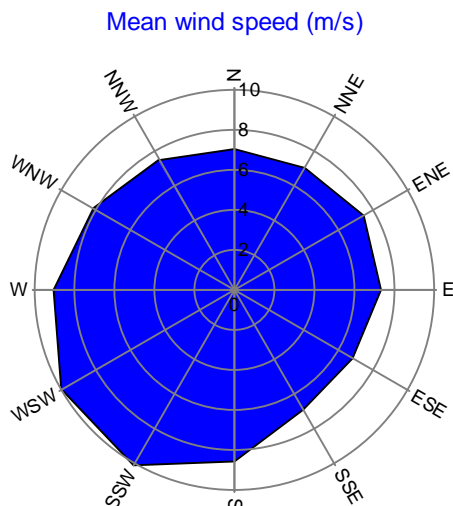
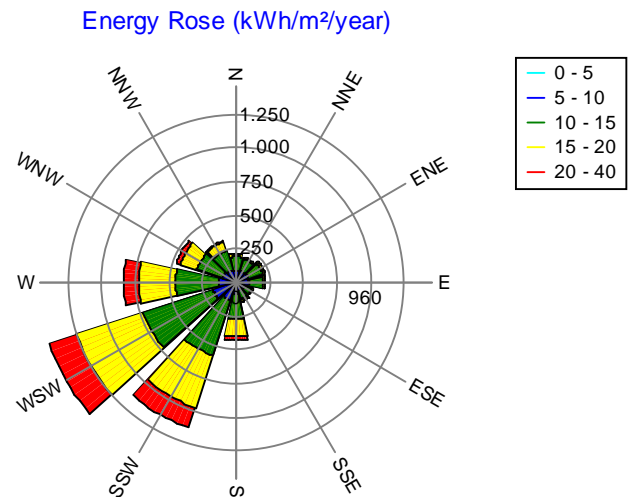
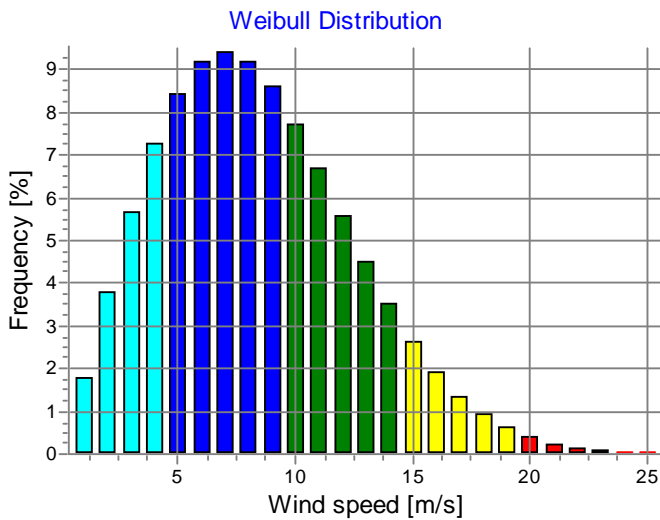
UTM (north)-ETRS89 Zone: 31
East: 582.068 North: 5.796.386

Wind statistics

NL EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m.wws

Weibull Data

Sector	Current site			
	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	7,91	7,01	2,279	6,8
1 NNE	7,93	7,03	2,475	6,6
2 ENE	8,35	7,42	2,604	6,6
3 E	8,24	7,32	2,568	6,5
4 ESE	7,64	6,77	2,432	4,8
5 SSE	7,82	6,92	2,217	4,6
6 S	9,69	8,59	2,186	7,1
7 SSW	11,36	10,07	2,381	12,5
8 WSW	11,24	9,96	2,326	16,3
9 W	10,20	9,03	2,096	11,5
10 WNW	9,12	8,08	2,053	8,8
11 NNW	8,47	7,51	2,100	7,7
All	9,47	8,38	2,119	100,0



PARK - Park power curve

Calculation: 6MW alternatief: Kavel IV

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	1.045	456	417	311	417	500	552	620	434	316	416	500	550	606
3,5	12.223	9.859	8.564	9.778	9.800	10.040	10.296	10.842	8.552	9.775	9.788	10.047	10.296	10.825
4,5	27.330	22.605	20.320	22.260	22.518	22.969	23.464	24.451	20.344	22.240	22.489	22.989	23.467	24.414
5,5	51.680	42.895	38.875	42.227	42.672	43.542	44.497	46.282	38.899	42.194	42.615	43.574	44.502	46.212
6,5	86.470	72.326	65.570	71.401	71.953	73.371	74.912	77.874	65.583	71.362	71.872	73.424	74.914	77.762
7,5	133.418	111.843	101.541	110.369	111.296	113.465	115.789	120.299	101.581	110.323	111.167	113.543	115.786	120.125
8,5	193.231	163.010	148.064	161.196	162.258	165.275	168.508	175.043	148.129	161.140	162.081	165.392	168.505	174.801
9,5	262.022	224.714	204.385	222.674	223.906	227.843	231.919	240.109	204.442	222.733	223.696	227.956	231.895	239.853
10,5	326.027	290.840	265.447	290.817	290.459	294.413	298.516	306.830	265.375	290.886	290.286	294.517	298.508	306.658
11,5	363.853	343.770	316.966	346.960	344.607	347.491	350.112	355.115	316.880	347.188	344.561	347.462	350.066	355.085
12,5	375.700	368.994	348.229	372.746	371.002	372.143	372.937	373.955	348.321	372.774	370.989	372.110	372.914	373.959
13,5	377.739	375.850	365.775	377.489	377.330	377.429	377.497	377.600	366.162	377.497	377.329	377.426	377.496	377.599
14,5	377.972	377.690	376.007	377.951	377.942	377.948	377.953	377.960	376.174	377.951	377.942	377.947	377.953	377.960
15,5	378.000	377.992	377.944	378.000	377.999	377.999	377.999	378.000	377.947	378.000	377.999	377.999	377.999	378.000
16,5	378.000	378.000	377.998	378.000	378.000	378.000	378.000	378.000	377.999	378.000	378.000	378.000	378.000	378.000
17,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
18,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
19,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
20,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
21,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
22,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
23,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
24,5	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000	378.000
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:

- 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:

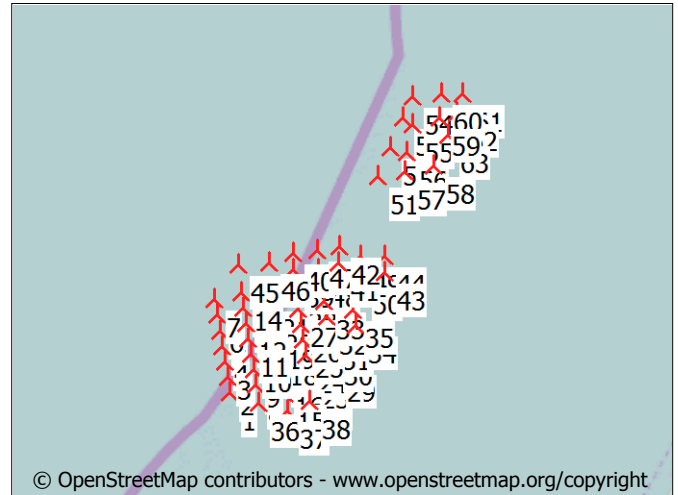
From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

PARK - WTG distances

Calculation: 6MW alternatief: Kavel IV

WTG distances

Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters	
[m]		[m]	[m]		
1	0,0	2	0,0	839	5,5
2	0,0	1	0,0	839	5,5
3	0,0	4	0,0	839	5,5
4	0,0	3	0,0	839	5,5
5	0,0	4	0,0	839	5,5
6	0,0	7	0,0	839	5,5
7	0,0	6	0,0	839	5,5
8	0,0	9	0,0	839	5,5
9	0,0	8	0,0	839	5,5
10	0,0	9	0,0	839	5,5
11	0,0	10	0,0	839	5,5
12	0,0	11	0,0	839	5,5
13	0,0	14	0,0	839	5,5
14	0,0	13	0,0	839	5,5
15	0,0	16	0,0	839	5,5
16	0,0	15	0,0	839	5,5
17	0,0	18	0,0	839	5,5
18	0,0	19	0,0	839	5,5
19	0,0	18	0,0	839	5,5
20	0,0	21	0,0	839	5,5
21	0,0	20	0,0	839	5,5
22	0,0	38	0,0	814	5,3
23	0,0	22	0,0	839	5,5
24	0,0	23	0,0	839	5,5
25	0,0	26	0,0	839	5,5
26	0,0	25	0,0	839	5,5
27	0,0	26	0,0	839	5,5
28	0,0	27	0,0	839	5,5
29	0,0	30	0,0	839	5,5
30	0,0	29	0,0	839	5,5
31	0,0	30	0,0	839	5,5
32	0,0	33	0,0	839	5,5
33	0,0	32	0,0	839	5,5
34	0,0	35	0,0	839	5,5
35	0,0	34	0,0	839	5,5
36	0,0	8	0,0	988	6,4
37	0,0	15	0,0	961	6,2
38	0,0	22	0,0	814	5,3
39	0,0	40	0,0	901	5,8
40	0,0	39	0,0	901	5,8
41	0,0	42	0,0	901	5,8
42	0,0	41	0,0	901	5,8
43	0,0	44	0,0	901	5,8
44	0,0	43	0,0	901	5,8
45	0,0	14	0,0	1.472	9,6
46	0,0	39	0,0	1.318	8,6
47	0,0	48	0,0	1.036	6,7
48	0,0	47	0,0	1.036	6,7
49	0,0	50	0,0	1.097	7,1
50	0,0	49	0,0	1.097	7,1
51	0,0	57	0,0	1.471	9,6
52	0,0	56	0,0	939	6,1
53	0,0	55	0,0	652	4,2
54	0,0	53	0,0	1.260	8,2
55	0,0	53	0,0	652	4,2
56	0,0	52	0,0	939	6,1
57	0,0	56	0,0	1.041	6,8
58	0,0	57	0,0	1.554	10,1
59	0,0	62	0,0	946	6,1
60	0,0	61	0,0	1.081	7,0
61	0,0	62	0,0	1.080	7,0
62	0,0	59	0,0	946	6,1
63	0,0	59	0,0	1.049	6,8
Min	0,0	0,0	652	4,2	
Max	0,0	0,0	1.554	10,1	



▲ New WTG

Scale 1:400.000

PARK - Wind statistics info

Calculation: 6MW alternatief: Kavel IV

Main data for wind statistic

File	\\sbs2011\projecten\Extern\2015\715082 MER PB kavels Hollandse Kust Zuid\TO\WP\NL EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m.wvs
Name	EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m
Country	Netherlands
Source	USER
Mast coordinates	UTM (north)-ETRS89 Zone: 31 East: 583.090 North: 5.792.991
Created	27-1-2016
Edited	27-1-2016
Sectors	12
WASP version	WASP 10.2 RVEA0164.dll 3.0.1.100
Displacement height	None

Additional info for wind statistic

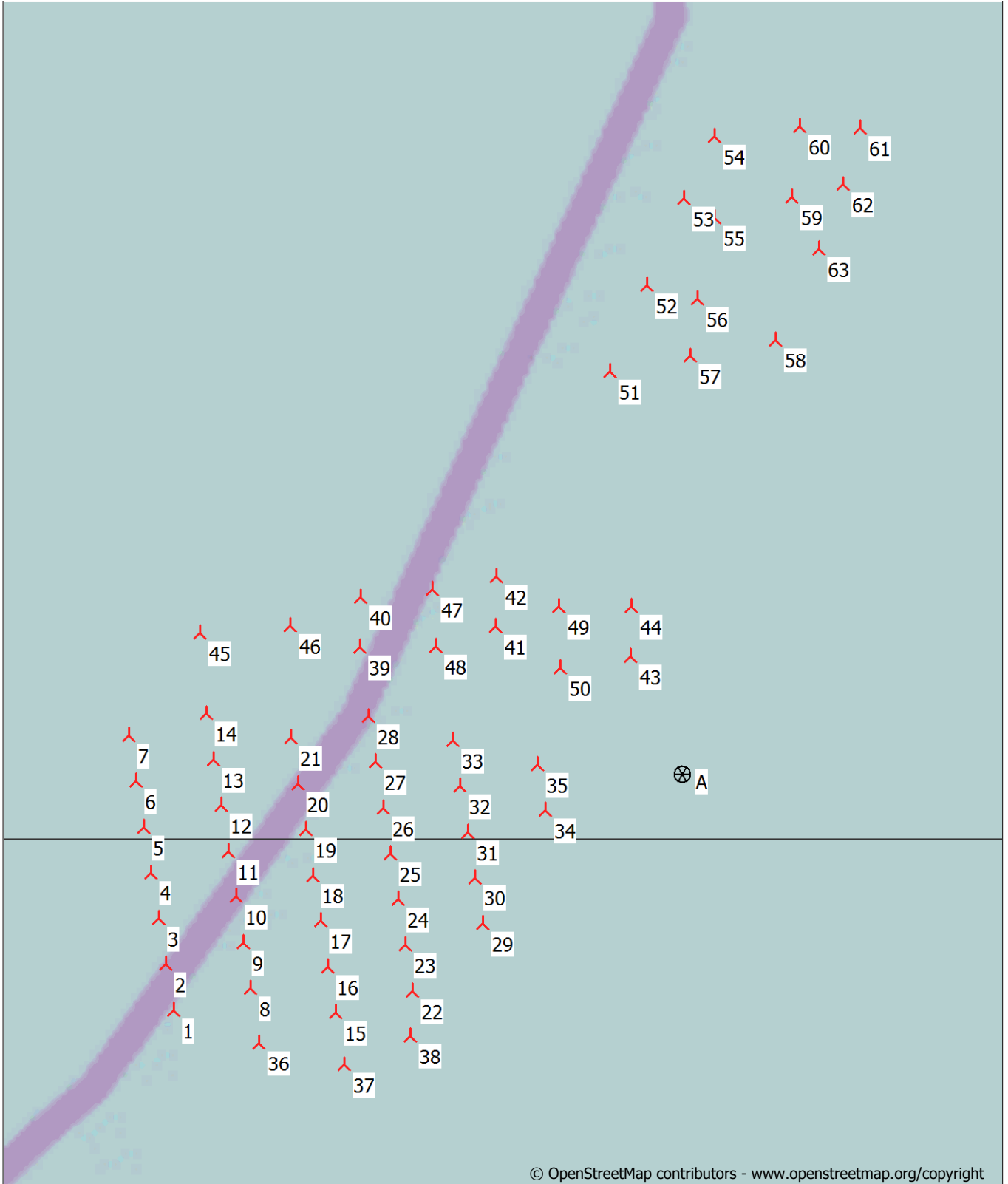
Source data	EmdERA_N52.281_E004.218 (3), 86-15
Data from	1-1-1986
Data to	30-9-2015
Measurement length	357,0 Months
Recovery rate	100,0 %
Effective measurement length	357,0 Months

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: 6MW alternatief: Kavel IV



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0 1 2 3 4 km

Map: Open Street Map 001 , Print scale 1:100.000, Map center UTM (north)-ETRS89 Zone: 31 East: 578.575 North: 5.799.604

New WTG Site Data