Project:
715082

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Calculated:
26-10-2016 17:22/3.1.582

PARK - Main Result

Calculation: 6MW alternatief: Kavel III

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

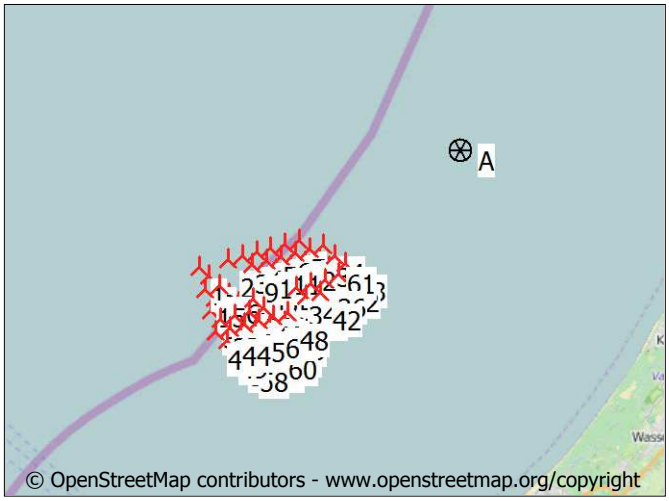
Displacement heights from objects

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



Scale 1:500.000

New WTG Site Data

Key results for height 100,0 m above ground level

Terrain UTM (north)-ETRS89 Zone: 31

	Easting	Northing	Name of wind distribution	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]	Equivalent roughness
A	582.068	5.796.386	Site data: Hollandse Kust Zuid	WAsP (WAsP 10.2 RVEA0164.dll 3.0.1.100)	5.718	8,4	-1,0

Calculated Annual Energy for Wind Farm

				Specific results¤)			
WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
Wind farm	1.400.867,5	1.611.830,9	86,9	42,3	22.236,0	3.706	8,4

¤) Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 63 new WTGs with total 378,0 MW rated power

	WTG type							Power curve		Annual Energy	Park		
Links	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Creator	Name	Result [MWh]	Efficiency [%]	Capacity factor [%]	Free mean wind speed [m/s]
1 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	24.550,2	96,19	46,7	8,38
2 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.667,2	92,52	45,0	8,39
3 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.226,0	90,70	44,2	8,40
4 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.785,9	88,92	43,3	8,41
5 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.532,6	87,86	42,8	8,41
6 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.457,3	87,52	42,7	8,42
7 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.715,0	88,47	43,2	8,42
8 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.656,0	92,63	45,0	8,38
9 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.492,3	87,83	42,8	8,40
10 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.902,4	85,45	41,6	8,41
11 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.662,4	84,46	41,2	8,41
12 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.735,1	84,70	41,3	8,42
13 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.011,6	85,75	41,9	8,42
14 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.721,3	88,49	43,2	8,42
15 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.774,8	93,17	45,2	8,37
16 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.805,3	89,26	43,4	8,38
17 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.992,2	85,86	41,8	8,40
18 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.460,8	83,73	40,8	8,41
19 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.371,4	83,33	40,6	8,41
20 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.397,9	83,40	40,7	8,42
21 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.781,8	84,87	41,4	8,42
22 A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.912,4	89,75	43,6	8,38

To be continued on next page...

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26-10-2016 17:22/3.1.582

PARK - Main Result

Calculation: 6MW alternatief: Kavel III

...continued from previous page

		WTG type						Power curve		Annual Energy	Park		
	Links	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	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	22.118,2	86,56	42,1	8,38
24	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.933,9	85,76	41,7	8,39
25	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.758,8	84,94	41,4	8,40
26	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.564,6	84,13	41,0	8,41
27	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.320,2	83,14	40,5	8,41
28	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.489,8	83,79	40,9	8,42
29	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.939,8	85,52	41,7	8,42
30	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.488,1	92,09	44,7	8,37
31	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.156,4	86,77	42,1	8,38
32	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.588,3	84,46	41,0	8,39
33	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.470,8	83,94	40,8	8,39
34	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.883,3	85,39	41,6	8,41
35	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.758,7	84,88	41,4	8,41
36	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.048,8	85,99	41,9	8,41
37	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.737,4	89,13	43,2	8,37
38	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.712,6	85,03	41,3	8,38
39	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.229,8	83,06	40,4	8,39
40	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.316,7	83,34	40,5	8,39
41	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.467,6	87,70	42,7	8,41
42	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.705,6	88,61	43,2	8,41
43	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.522,5	92,31	44,7	8,36
44	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.198,4	87,02	42,2	8,37
45	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.352,1	83,62	40,6	8,38
46	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	20.959,7	82,03	39,9	8,39
47	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.170,5	82,79	40,3	8,39
48	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.890,0	85,55	41,6	8,40
49	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.144,1	90,80	44,0	8,37
50	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.945,8	86,02	41,7	8,37
51	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.368,8	83,69	40,6	8,38
52	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.273,2	83,26	40,4	8,39
53	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.748,2	85,06	41,3	8,39
54	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.122,2	90,74	44,0	8,37
55	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.004,8	86,27	41,8	8,37
56	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.612,4	84,65	41,1	8,38
57	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	21.884,9	85,66	41,6	8,39
58	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.373,0	91,72	44,4	8,37
59	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.727,2	89,10	43,2	8,37
60	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.668,6	88,79	43,1	8,38
61	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.662,9	88,31	43,1	8,42
62	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	22.877,1	89,21	43,5	8,42
63	A	No	Siemens	SWT-6.0-154-6.000	6.000	154,0	102,0	USER	SWT-6.0-154	23.059,7	89,89	43,8	8,42

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 [m]	Row data/Description
1	New	564.771	5.788.336	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (986)
2	New	566.669	5.788.877	0,0	74,8°, 986,6 m
3	New	567.618	5.789.147	0,0	
4	New	568.567	5.789.418	0,0	
5	New	569.515	5.789.689	0,0	
6	New	570.464	5.789.960	0,0	
7	New	571.413	5.790.231	0,0	
8	New	565.439	5.787.757	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (988)
9	New	568.286	5.788.569	0,0	74,8°, 986,6 m
10	New	569.235	5.788.839	0,0	
11	New	570.183	5.789.111	0,0	
12	New	571.132	5.789.382	0,0	

To be continued on next page...

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PARK - Main Result

Calculation: 6MW alternatief: Kavel III

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UTM (north)-ETRS89 Zone: 31

		Easting	Northing	Z [m]	Row data/Description
13	New	572.081	5.789.653	0,0	
14	New	573.029	5.789.925	0,0	
15	New	565.159	5.786.908	0,0	74,8°, 986,6 m
16	New	566.108	5.787.178	0,0	
17	New	568.954	5.787.990	0,0	74,8°, 986,6 m
18	New	569.903	5.788.261	0,0	
19	New	570.851	5.788.532	0,0	
20	New	571.800	5.788.803	0,0	
21	New	572.749	5.789.075	0,0	
22	New	565.827	5.786.329	0,0	74,8°, 986,6 m
23	New	566.776	5.786.599	0,0	
24	New	567.725	5.786.870	0,0	
25	New	569.622	5.787.411	0,0	74,8°, 986,6 m
26	New	570.571	5.787.682	0,0	
27	New	571.520	5.787.954	0,0	
28	New	572.468	5.788.225	0,0	
29	New	573.417	5.788.497	0,0	
30	New	565.546	5.785.479	0,0	74,8°, 986,6 m
31	New	566.495	5.785.750	0,0	
32	New	567.444	5.786.020	0,0	
33	New	568.393	5.786.291	0,0	
34	New	571.239	5.787.104	0,0	74,8°, 986,6 m
35	New	572.188	5.787.375	0,0	
36	New	573.136	5.787.647	0,0	
37	New	566.215	5.784.900	0,0	74,8°, 986,6 m
38	New	567.164	5.785.171	0,0	
39	New	568.112	5.785.441	0,0	
40	New	569.061	5.785.712	0,0	
41	New	571.907	5.786.526	0,0	74,8°, 986,6 m
42	New	572.856	5.786.797	0,0	
43	New	565.934	5.784.051	0,0	74,8°, 986,6 m
44	New	566.883	5.784.321	0,0	
45	New	567.832	5.784.592	0,0	
46	New	568.780	5.784.863	0,0	
47	New	569.729	5.785.134	0,0	
48	New	570.678	5.785.405	0,0	
49	New	566.700	5.783.531	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (999)
50	New	567.598	5.783.825	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1000)
51	New	568.561	5.784.167	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1001)
52	New	569.486	5.784.452	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1002)
53	New	570.487	5.784.747	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1003)
54	New	567.326	5.783.022	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1004)
55	New	568.299	5.783.345	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1005)
56	New	569.243	5.783.697	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1006)
57	New	570.214	5.784.086	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1007)
58	New	568.036	5.782.618	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1008)
59	New	569.036	5.783.027	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1009)
60	New	569.947	5.783.459	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1010)
61	New	573.756	5.789.251	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1011)
62	New	574.086	5.788.066	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1012)
63	New	574.483	5.788.729	0,0	Siemens SWT-6.0-154 6000 154.0 !O! hub: 102,0 m (TOT: 179,0 m) (1013)

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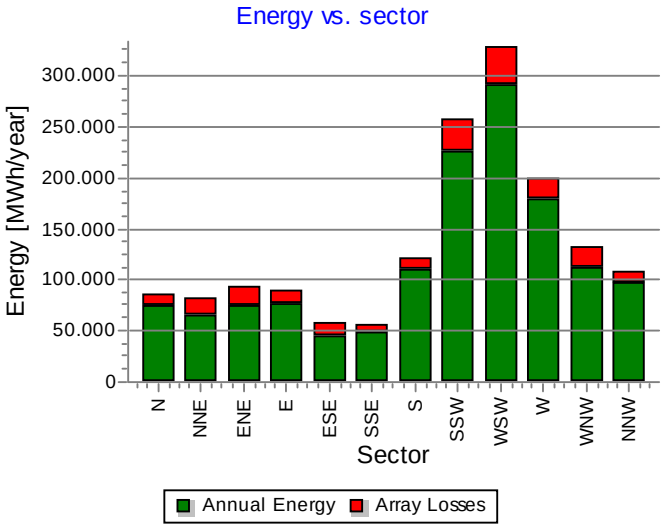
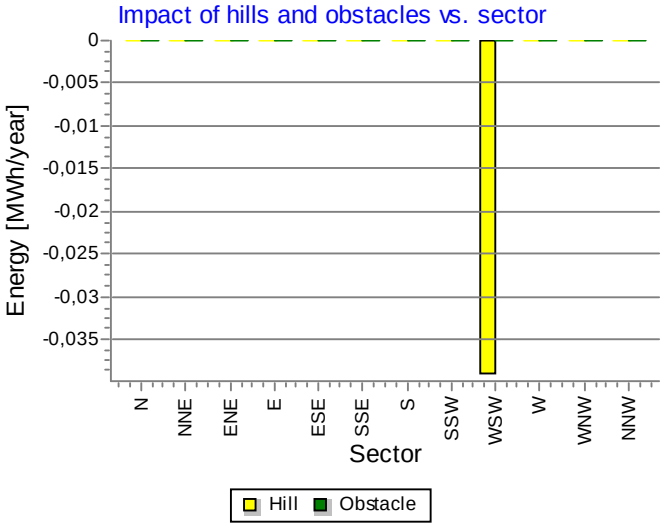
PARK - Production Analysis

Calculation: 6MW alternatief: Kavel III**WTG:** 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]	85.426,9	82.028,1	92.825,8	89.766,6	57.310,2	56.052,7	120.827,7	258.372,1	328.636,6	199.752,7	133.381,8	107.449,6	1.611.830,6
-Decrease due to array losses	[MWh]	9.910,9	17.259,4	17.553,6	13.995,3	12.522,8	6.608,9	10.095,5	32.043,6	37.499,4	21.067,9	21.599,7	10.806,4	210.963,4
Resulting energy	**[MWh]**	**75.516,0**	**64.768,8**	**75.272,2**	**75.771,4**	**44.787,3**	**49.443,8**	**110.732,2**	**226.328,5**	**291.137,2**	**178.684,8**	**111.782,1**	**96.643,1**	**1.400.867,1**
Specific energy	[kWh/m²]													1.194
Specific energy	[kWh/kW]													3.706
Decrease due to array losses	[%]	11,6	21,0	18,9	15,6	21,9	11,8	8,4	12,4	11,4	10,5	16,2	10,1	13,09
Utilization	[%]	28,7	27,2	27,1	28,2	27,3	28,5	22,0	17,4	17,4	19,0	20,7	24,9	20,8
Operational	[Hours/year]	578	555	560	550	410	391	609	1.065	1.375	965	740	651	8.447
Full Load Equivalent	[Hours/year]	200	171	199	200	118	131	293	599	770	473	296	256	3.706





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Calculated:
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PARK - Power Curve Analysis

Calculation: 6MW alternatief: Kavel III**WTG:** 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/m²
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/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

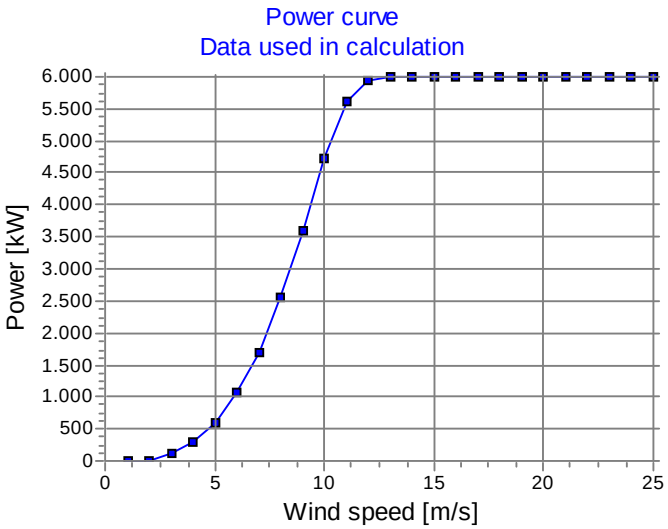
Original data, Air density: 1,225 kg/m³

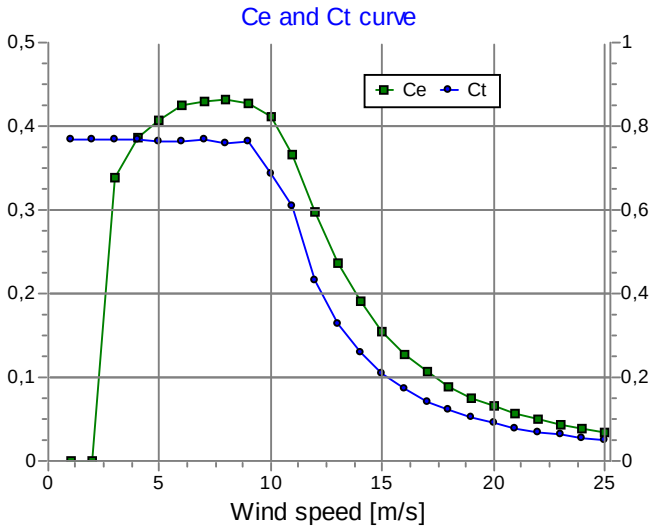
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3,0	104,0	0,34	3,0	0,77
4,0	281,0	0,38	4,0	0,77
5,0	580,0	0,41	5,0	0,76
6,0	1.048,0	0,43	6,0	0,76
7,0	1.677,0	0,43	7,0	0,77
8,0	2.527,0	0,43	8,0	0,76
9,0	3.562,0	0,43	9,0	0,76
10,0	4.695,0	0,41	10,0	0,69
11,0	5.594,0	0,37	11,0	0,61
12,0	5.929,0	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	3,1	3,1	0,0
3,0	105,3	0,34	2,50- 3,50	55,1	58,2	0,2
4,0	283,9	0,39	3,50- 4,50	199,0	257,2	1,0
5,0	585,7	0,41	4,50- 5,50	466,4	723,6	2,9
6,0	1.057,3	0,43	5,50- 6,50	889,7	1.613,3	6,6
7,0	1.691,6	0,43	6,50- 7,50	1.451,7	3.065,0	12,5
8,0	2.547,6	0,43	7,50- 8,50	2.090,7	5.155,7	21,0
9,0	3.589,2	0,43	8,50- 9,50	2.686,9	7.842,6	31,9
10,0	4.722,0	0,41	9,50-10,50	3.061,8	10.904,3	44,4
11,0	5.606,7	0,37	10,50-11,50	3.048,2	13.952,6	56,8
12,0	5.931,8	0,30	11,50-12,50	2.673,3	16.625,9	67,7
13,0	5.992,3	0,24	12,50-13,50	2.153,4	18.779,3	76,5
14,0	5.999,1	0,19	13,50-14,50	1.658,9	20.438,2	83,3
15,0	6.000,0	0,15	14,50-15,50	1.243,6	21.681,8	88,3
16,0	6.000,0	0,13	15,50-16,50	911,5	22.593,4	92,0
17,0	6.000,0	0,11	16,50-17,50	653,9	23.247,3	94,7
18,0	6.000,0	0,09	17,50-18,50	458,9	23.706,2	96,6
19,0	6.000,0	0,08	18,50-19,50	314,5	24.020,7	97,8
20,0	6.000,0	0,07	19,50-20,50	210,2	24.230,9	98,7
21,0	6.000,0	0,06	20,50-21,50	136,7	24.367,6	99,3
22,0	6.000,0	0,05	21,50-22,50	86,4	24.454,0	99,6
23,0	6.000,0	0,04	22,50-23,50	53,0	24.507,0	99,8
24,0	6.000,0	0,04	23,50-24,50	31,5	24.538,6	100,0
25,0	6.000,0	0,03	24,50-25,50	11,6	24.550,2	100,0





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PARK - Terrain

Calculation: 6MW alternatief: Kavel III**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

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Calculated:
26-10-2016 17:22/3.1.582

PARK - Wind Data Analysis

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

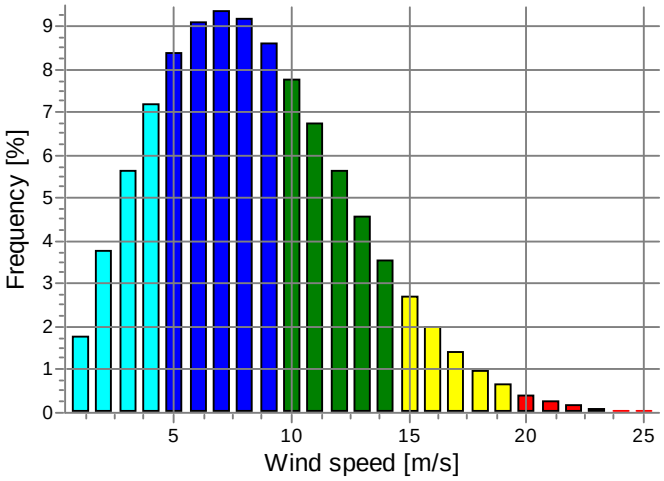
Site coordinates
UTM (north)-ETRS89 Zone: 31
East: 582.068 North: 5.796.386
Wind statistics
NL EmdERA_N52.281_E004.218 (3), 86-15 - 100,00 m.wws

Weibull Data

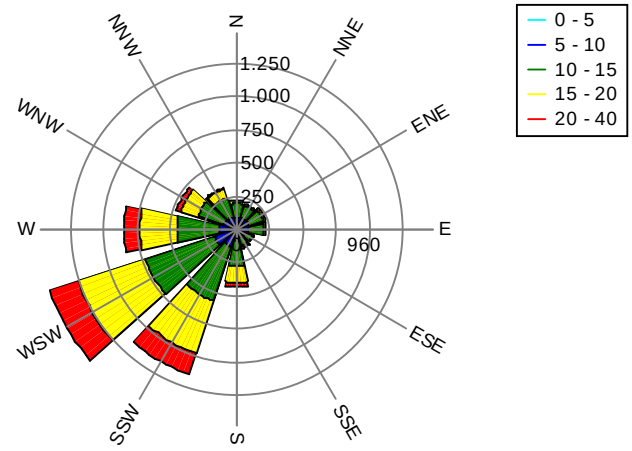
Current site

Sector	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
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

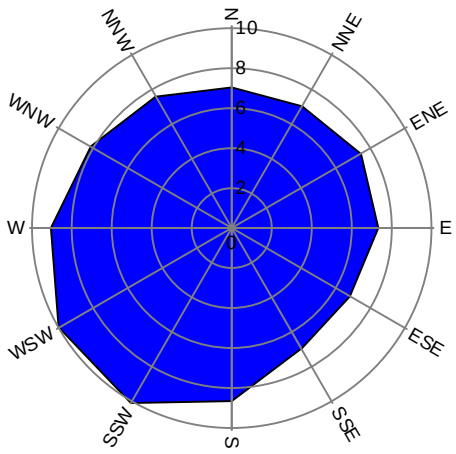
Weibull Distribution



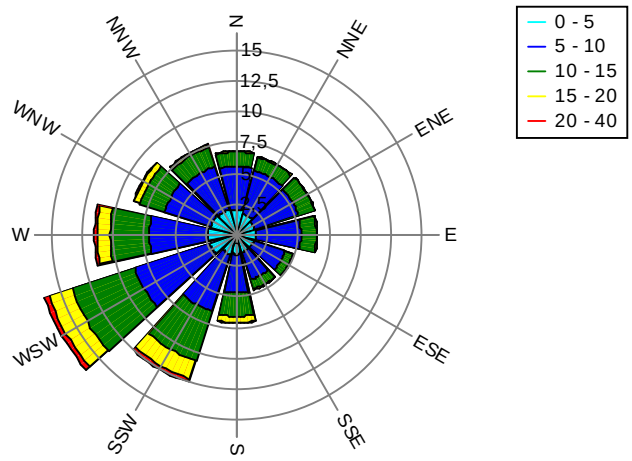
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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PARK - Wind Data Analysis

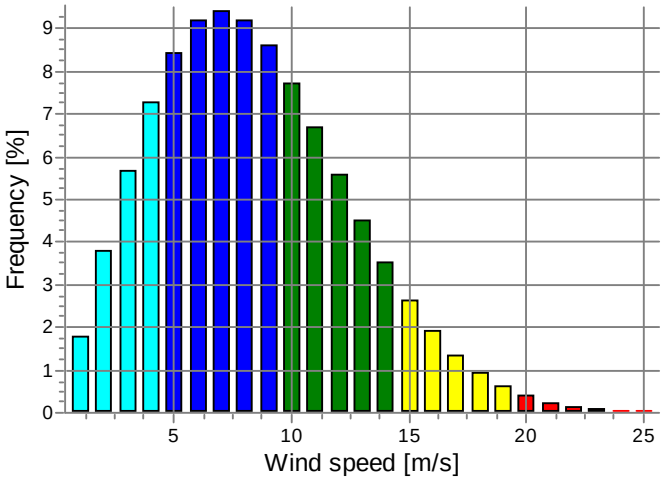
Calculation: 6MW alternatief: Kavel III**Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 100,0

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

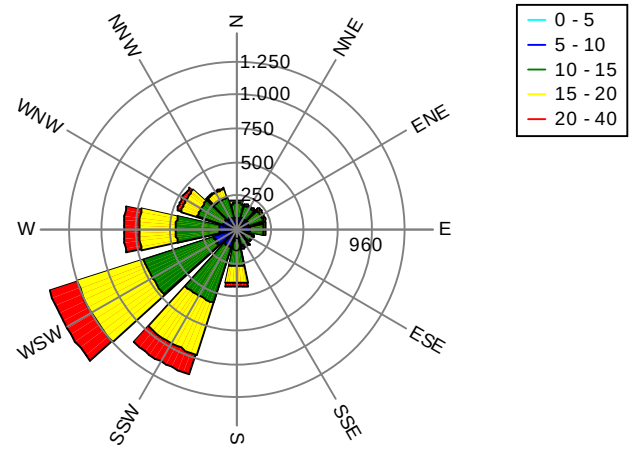
Weibull Data

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

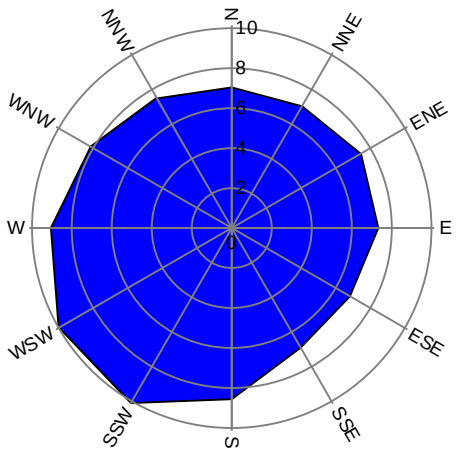
Weibull Distribution



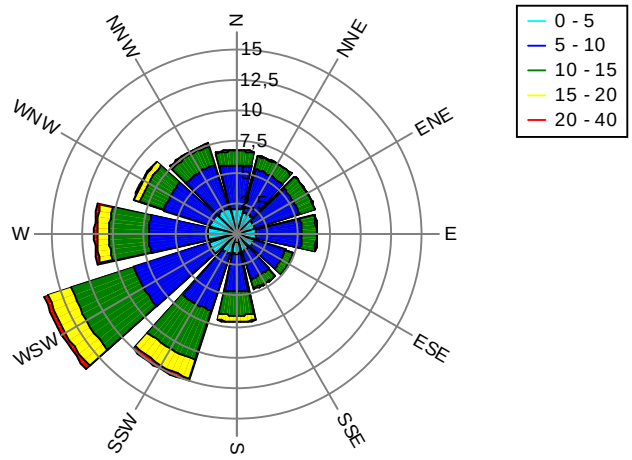
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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PARK - Park power curve

Calculation: 6MW alternatief: Kavel III

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	346	422	305	287	350	340	440	444	309	280	332	346	440
3,5	12.223	8.477	9.590	7.870	8.012	8.729	7.723	9.541	9.616	7.824	8.007	8.710	7.708	9.555
4,5	27.330	20.134	22.065	18.987	19.314	20.537	18.935	21.989	22.134	18.942	19.307	20.494	18.954	22.039
5,5	51.680	38.410	41.914	36.401	36.861	39.119	36.259	41.796	42.051	36.311	36.853	39.039	36.271	41.878
6,5	86.470	64.993	70.817	61.666	62.476	66.212	61.320	70.570	71.040	61.500	62.462	66.089	61.340	70.679
7,5	133.418	100.736	109.590	95.662	96.884	102.591	95.196	109.257	109.953	95.448	96.848	102.370	95.211	109.406
8,5	193.231	147.054	159.783	139.814	141.595	149.689	139.022	159.211	160.257	139.454	141.532	149.407	139.073	159.464
9,5	262.022	203.948	220.847	194.101	196.849	207.785	193.078	220.266	221.395	193.642	196.779	207.344	192.972	220.353
10,5	326.027	267.809	287.527	255.824	260.084	272.908	254.330	286.777	287.860	255.272	260.064	272.602	253.856	286.812
11,5	363.853	325.452	342.938	312.908	319.963	331.608	311.596	343.059	343.053	312.629	319.938	331.323	310.575	342.660
12,5	375.700	360.328	370.286	350.256	358.735	365.131	351.169	371.185	370.461	350.451	358.713	364.924	350.527	371.060
13,5	377.739	374.104	377.072	369.524	374.429	375.880	371.317	377.334	377.167	370.012	374.360	375.726	371.439	377.321
14,5	377.972	377.714	377.930	377.155	377.795	377.870	377.476	377.942	377.936	377.425	377.784	377.857	377.521	377.941
15,5	378.000	377.990	377.998	377.972	377.991	377.995	377.980	377.999	377.998	377.980	377.991	377.995	377.981	377.999
16,5	378.000	378.000	378.000	377.999	378.000	378.000	378.000	378.000	378.000	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:

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.

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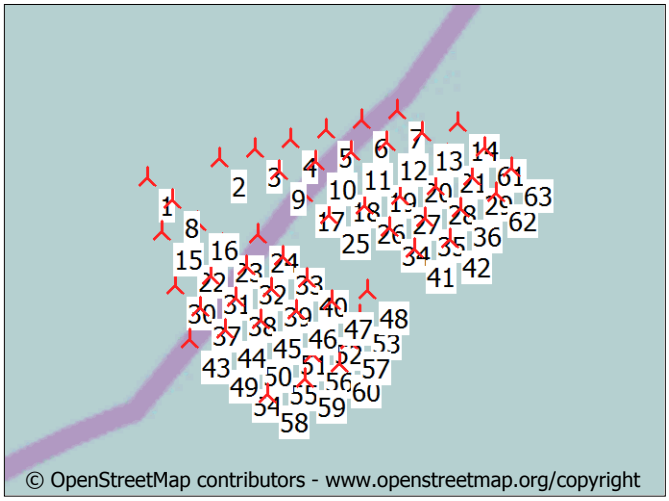
Calculated:
26-10-2016 17:22/3.1.582

PARK - WTG distances

Calculation: 6MW alternatief: Kavel III

WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters
	[m]		[m]	[m]	
1	0,0	8	0,0	884	5,7
2	0,0	3	0,0	987	6,4
3	0,0	9	0,0	884	5,7
4	0,0	10	0,0	884	5,7
5	0,0	11	0,0	884	5,7
6	0,0	12	0,0	884	5,7
7	0,0	13	0,0	883	5,7
8	0,0	16	0,0	884	5,7
9	0,0	17	0,0	884	5,7
10	0,0	18	0,0	884	5,7
11	0,0	19	0,0	884	5,7
12	0,0	20	0,0	884	5,7
13	0,0	21	0,0	883	5,7
14	0,0	21	0,0	895	5,8
15	0,0	22	0,0	884	5,7
16	0,0	23	0,0	884	5,7
17	0,0	25	0,0	884	5,7
18	0,0	26	0,0	884	5,7
19	0,0	27	0,0	884	5,7
20	0,0	28	0,0	883	5,7
21	0,0	29	0,0	883	5,7
22	0,0	31	0,0	884	5,7
23	0,0	32	0,0	884	5,7
24	0,0	33	0,0	884	5,7
25	0,0	17	0,0	884	5,7
26	0,0	34	0,0	884	5,7
27	0,0	35	0,0	884	5,7
28	0,0	36	0,0	883	5,7
29	0,0	62	0,0	796	5,2
30	0,0	37	0,0	884	5,7
31	0,0	38	0,0	884	5,7
32	0,0	39	0,0	884	5,7
33	0,0	40	0,0	884	5,7
34	0,0	41	0,0	884	5,7
35	0,0	42	0,0	883	5,7
36	0,0	28	0,0	883	5,7
37	0,0	44	0,0	884	5,7
38	0,0	45	0,0	884	5,7
39	0,0	46	0,0	884	5,7
40	0,0	47	0,0	884	5,7
41	0,0	34	0,0	884	5,7
42	0,0	35	0,0	883	5,7
43	0,0	37	0,0	895	5,8
44	0,0	49	0,0	811	5,3
45	0,0	50	0,0	802	5,2
46	0,0	51	0,0	730	4,7
47	0,0	52	0,0	724	4,7
48	0,0	53	0,0	685	4,4
49	0,0	54	0,0	807	5,2
50	0,0	45	0,0	802	5,2
51	0,0	46	0,0	730	4,7
52	0,0	47	0,0	724	4,7
53	0,0	48	0,0	685	4,4
54	0,0	49	0,0	807	5,2
55	0,0	58	0,0	773	5,0
56	0,0	59	0,0	701	4,6
57	0,0	60	0,0	682	4,4
58	0,0	55	0,0	773	5,0
59	0,0	56	0,0	701	4,6
60	0,0	57	0,0	682	4,4
61	0,0	29	0,0	827	5,4
62	0,0	63	0,0	773	5,0
63	0,0	62	0,0	773	5,0
Min	**0,0**		**0,0**	**682**	**4,4**
Max	**0,0**		**0,0**	**987**	**6,4**



Scale 1:200.000

New WTG

Licensed user:
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Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:22/3.1.582

PARK - Wind statistics info

Calculation: 6MW alternatief: Kavel III

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.wws
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.

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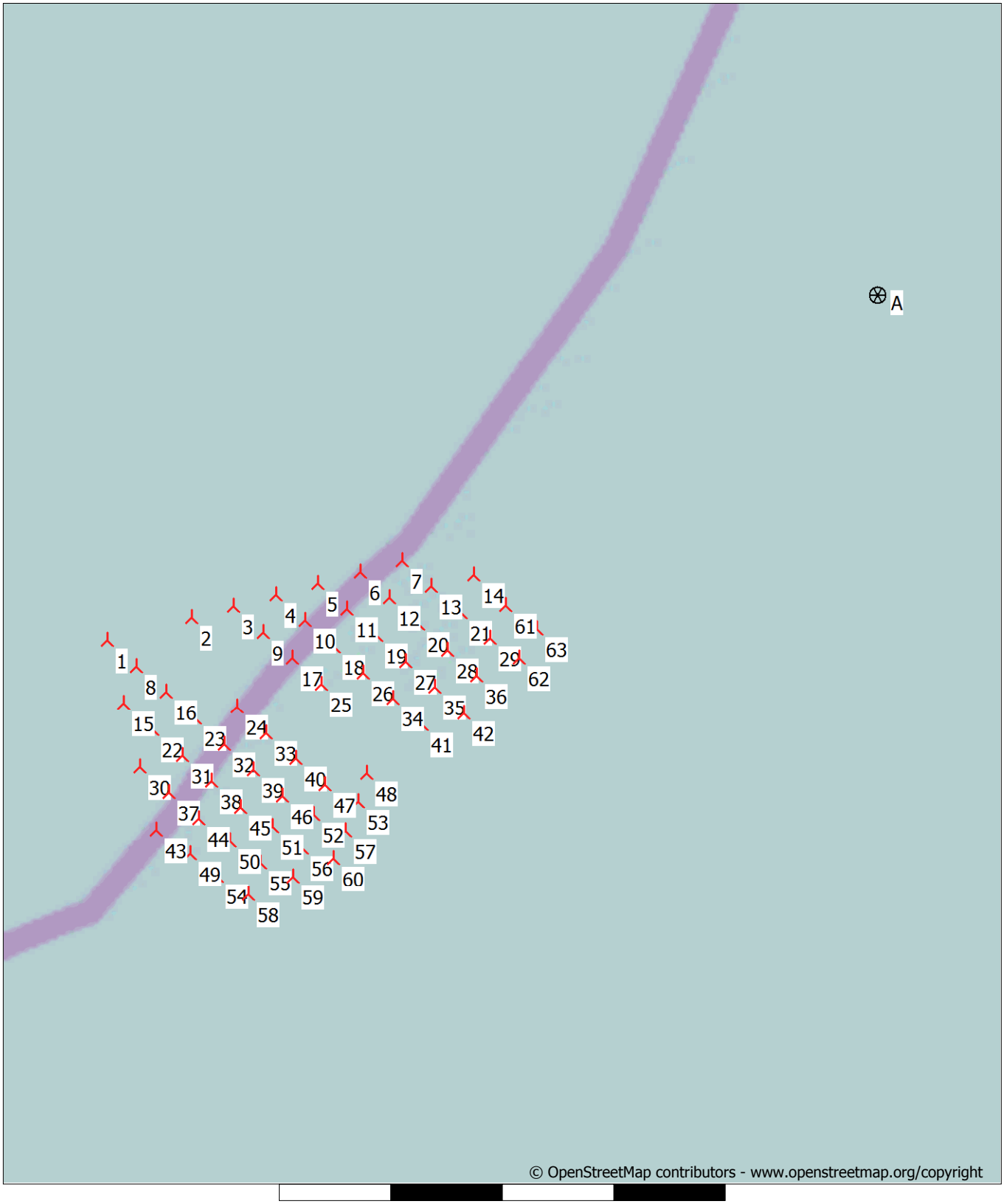
Calculated:
26-10-2016 17:22/3.1.582

PARK - Map

Calculation: 6MW alternatief: Kavel III



Map: Open Street Map 001 , Print scale 1:125.000, Map center UTM (north)-ETRS89 Zone: 31 East: 573.420 North: 5.789.502

New WTG Site Data