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 17:23/3.1.582

PARK - Main Result

Calculation: 10MW (8MW) 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	1,232 kg/m³
Air density relative to standard	100,5 %
Hub altitude above sea level (asl)	125,0 m
Annual mean temperature at hub alt.	9,2 °C
Pressure at WTGs	998,1 hPa

Wake Model Parameters

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

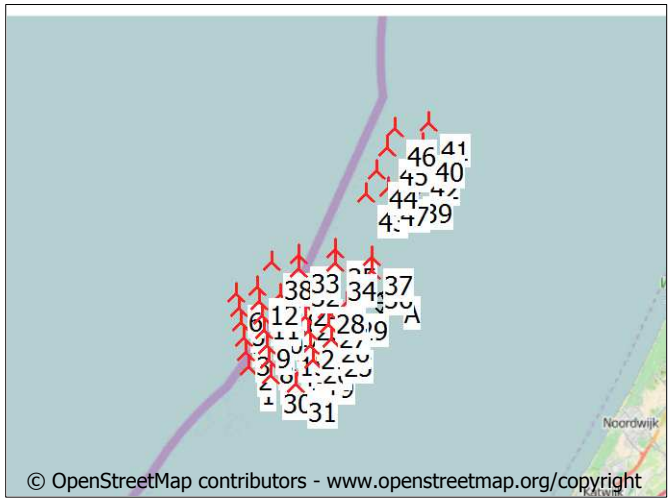
Displacement heights from objects

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

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Capacity factor [%]	Specific results¤) Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
Wind farm	1.516.121,2	1.635.014,6	92,7	46,0	32.257,9	4.032	8,9

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

Calculated Annual Energy for each of 47 new WTGs with total 376,0 MW rated power

	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]
1 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.021,7	94,89	47,1	8,94
2 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.582,8	93,60	46,5	8,94
3 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.485,7	93,30	46,3	8,94
4 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.518,7	93,38	46,4	8,94
5 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.700,0	93,90	46,6	8,94
6 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.200,0	95,34	47,3	8,94
7 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.822,4	91,42	45,4	8,94
8 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.429,0	90,27	44,8	8,94
9 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.270,2	89,79	44,6	8,94
10 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.346,0	89,99	44,7	8,95
11 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.637,4	90,83	45,1	8,95
12 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.338,5	92,84	46,1	8,95
13 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.991,2	91,94	45,6	8,94
14 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.327,4	90,00	44,7	8,94
15 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.897,9	88,73	44,1	8,95
16 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.824,9	88,50	44,0	8,95
17 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.946,0	88,84	44,1	8,95
18 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.380,7	90,08	44,7	8,95
19 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.079,4	92,21	45,7	8,94
20 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.266,4	89,84	44,6	8,94
21 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.896,6	88,74	44,1	8,95
22 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.790,3	88,41	43,9	8,95

To be continued on next page...

Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Main Result

Calculation: 10MW (8MW) alternatief: Kavel IV

...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	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.974,9	88,93	44,2	8,95
24 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.493,8	90,41	44,9	8,95
25 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.901,2	91,70	45,5	8,94
26 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.319,2	89,98	44,7	8,95
27 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.121,6	89,39	44,4	8,95
28 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.468,2	90,37	44,9	8,95
29 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.166,8	92,44	45,9	8,95
30 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.786,9	94,24	46,8	8,94
31 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.189,3	95,45	47,3	8,94
32 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.252,2	92,58	46,0	8,95
33 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.833,8	94,25	46,8	8,95
34 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.522,7	93,41	46,4	8,95
35 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.975,4	94,72	47,0	8,95
36 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.040,2	95,00	47,1	8,95
37 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.045,2	95,01	47,1	8,95
38 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.198,2	95,30	47,3	8,95
39 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.472,9	96,49	47,7	8,94
40 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.259,7	96,07	47,4	8,93
41 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.590,6	97,18	47,9	8,92
42 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.269,8	96,01	47,4	8,93
43 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.622,8	96,73	47,9	8,94
44 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.523,3	96,55	47,8	8,94
45 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.511,9	96,64	47,8	8,93
46 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.658,5	97,20	48,0	8,93
47 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.169,1	95,51	47,3	8,94

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	572.953	5.791.985	0,0	-9,1°, 985,4 m
2 New	572.782	5.792.956	0,0	
3 New	572.611	5.793.926	0,0	
4 New	572.440	5.794.897	0,0	
5 New	572.269	5.795.867	0,0	
6 New	572.098	5.796.838	0,0	
7 New	574.328	5.792.470	0,0	-9,1°, 985,4 m
8 New	574.157	5.793.441	0,0	
9 New	573.986	5.794.411	0,0	
10 New	573.815	5.795.382	0,0	
11 New	573.643	5.796.352	0,0	
12 New	573.472	5.797.323	0,0	
13 New	575.875	5.791.985	0,0	-9,1°, 985,4 m
14 New	575.703	5.792.956	0,0	
15 New	575.532	5.793.926	0,0	
16 New	575.360	5.794.896	0,0	
17 New	575.189	5.795.867	0,0	
18 New	575.017	5.796.837	0,0	
19 New	577.250	5.792.470	0,0	-9,1°, 985,4 m
20 New	577.078	5.793.441	0,0	
21 New	576.906	5.794.411	0,0	
22 New	576.735	5.795.381	0,0	
23 New	576.563	5.796.352	0,0	
24 New	576.391	5.797.322	0,0	
25 New	578.453	5.793.926	0,0	-9,1°, 985,4 m
26 New	578.281	5.794.896	0,0	
27 New	578.109	5.795.866	0,0	
28 New	577.936	5.796.837	0,0	

To be continued on next page...

Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Main Result

Calculation: 10MW (8MW) alternatief: Kavel IV

...continued from previous page

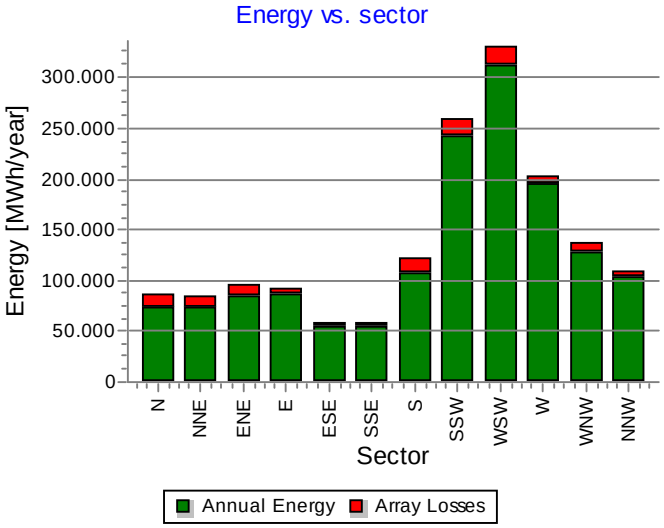
		UTM (north)-ETRS89 Zone: 31			
		Easting	Northing	Z [m]	Row data/Description
29	New	579.482	5.796.351	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (930)
30	New	574.488	5.791.426	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (931)
31	New	576.137	5.790.887	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (932)
32	New	576.220	5.798.604	0,0	0,9°, 900,6 m
33	New	576.221	5.799.504	0,0	
34	New	578.659	5.799.014	0,0	0,9°, 900,6 m
35	New	578.660	5.799.914	0,0	
36	New	581.098	5.798.523	0,0	0,9°, 900,6 m
37	New	581.098	5.799.424	0,0	
38	New	574.408	5.798.981	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (936)
39	New	583.606	5.804.256	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (943)
40	New	584.343	5.807.061	0,0	15,7°, 1.450,0 m
41	New	584.712	5.808.463	0,0	
42	New	584.032	5.805.928	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (945)
43	New	580.646	5.803.664	0,0	24,0°, 1.700,0 m
44	New	581.314	5.805.227	0,0	
45	New	581.981	5.806.790	0,0	
46	New	582.496	5.808.064	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (947)
47	New	582.080	5.804.060	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (948)

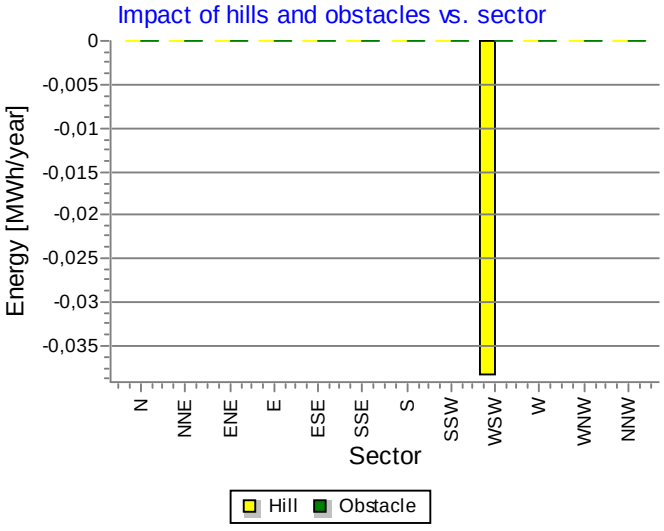
Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Production Analysis

Calculation: 10MW (8MW) alternatief: Kavel IV**WTG:** All new WTGs, Air density 1,232 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]	86.318,0	83.678,9	94.988,8	91.541,9	58.973,3	57.840,7	122.298,0	259.002,6	330.855,2	203.152,4	137.400,6	108.964,3	1.635.015,6
-Decrease due to array losses	[MWh]	13.805,5	9.666,9	9.664,7	5.811,6	5.368,0	2.951,7	14.312,3	15.975,0	19.532,8	8.310,5	8.682,3	4.812,2	118.893,4
Resulting energy	**[MWh]**	**72.512,6**	**74.012,0**	**85.324,1**	**85.730,3**	**53.605,3**	**54.889,0**	**107.985,7**	**243.027,6**	**311.322,3**	**194.842,0**	**128.718,3**	**104.152,0**	**1.516.121,5**
Specific energy	[kWh/m²]													1.527
Specific energy	[kWh/kW]													4.032
Decrease due to array losses	[%]	16,0	11,6	10,2	6,3	9,1	5,1	11,7	6,2	5,9	4,1	6,3	4,4	7,27
Utilization	[%]	27,2	30,3	29,9	31,2	31,5	30,0	20,4	18,2	18,3	19,9	22,3	26,2	21,8
Operational	[Hours/year]	554	532	538	527	393	374	576	1.015	1.322	930	712	624	8.097
Full Load Equivalent	[Hours/year]	193	197	227	228	143	146	287	646	828	518	342	277	4.032





Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Power Curve Analysis

Calculation: 10MW (8MW) alternatief: Kavel IV**WTG:** 1 - VESTAS V164-8.0 8000 164.0 !O! Mode 0 - 10-2015, Hub height: 125,0 m

Name: Mode 0 - 10-2015
Source: General specification V164-8.0 MW 50 Hz Offshore

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m²
14-10-2015	USER	26-1-2016	26-1-2016	25,0	Pitch	User defined	Variable	0,38

Doc nr 011-5675 V12

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]	10.946	17.266	23.695	29.658	34.849	39.116
VESTAS V164-8.0 8000 164.0 !O! Mode 0 - 10-2015	[MWh]	10.479	16.907	23.474	29.548	34.797	39.060
Check value	[%]	4	2	1	0	0	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^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

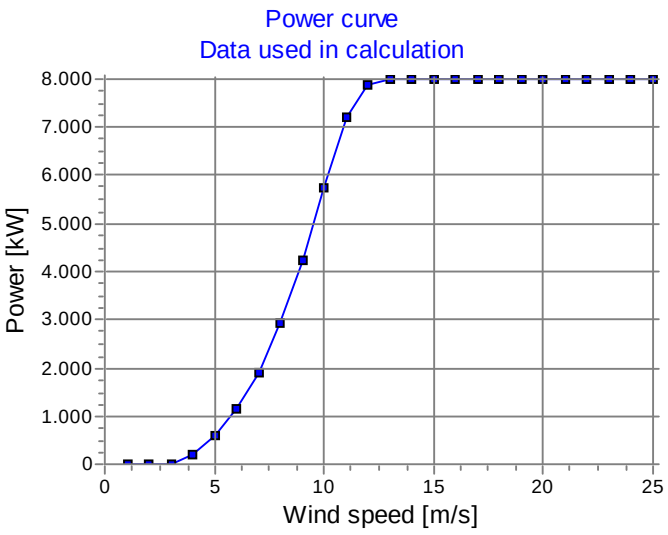
Original data, Air density: 1,225 kg/m³

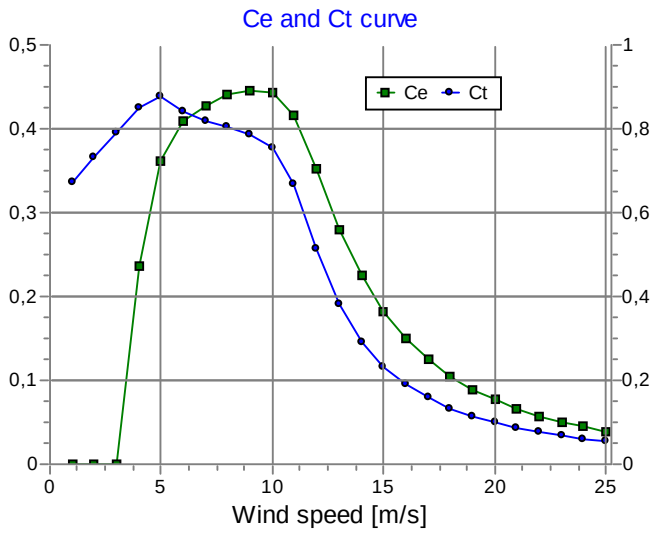
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
4,0	194,0	0,23	4,0	0,85
4,5	369,0	0,31	4,5	0,88
5,0	583,0	0,36	5,0	0,88
5,5	843,0	0,39	5,5	0,86
6,0	1.141,0	0,41	6,0	0,84
6,5	1.489,0	0,42	6,5	0,83
7,0	1.899,0	0,43	7,0	0,82
7,5	2.372,0	0,43	7,5	0,81
8,0	2.912,0	0,44	8,0	0,81
8,5	3.520,0	0,44	8,5	0,80
9,0	4.197,0	0,44	9,0	0,79
9,5	4.941,0	0,45	9,5	0,77
10,0	5.724,0	0,44	10,0	0,75
10,5	6.504,0	0,43	10,5	0,72
11,0	7.186,0	0,42	11,0	0,67
11,5	7.657,0	0,39	11,5	0,60
12,0	7.888,0	0,35	12,0	0,51
12,5	7.972,0	0,32	12,5	0,44
13,0	7.997,0	0,28	13,0	0,38
13,5	8.000,0	0,25	13,5	0,33
14,0	8.000,0	0,23	14,0	0,29
14,5	8.000,0	0,20	14,5	0,26
15,0	8.000,0	0,18	15,0	0,23
15,5	8.000,0	0,17	15,5	0,21
16,0	8.000,0	0,15	16,0	0,19
16,5	8.000,0	0,14	16,5	0,17
17,0	8.000,0	0,13	17,0	0,16
17,5	8.000,0	0,12	17,5	0,14
18,0	8.000,0	0,11	18,0	0,13
18,5	8.000,0	0,10	18,5	0,12
19,0	8.000,0	0,09	19,0	0,11
19,5	8.000,0	0,08	19,5	0,11
20,0	8.000,0	0,08	20,0	0,10
20,5	8.000,0	0,07	20,5	0,09
21,0	8.000,0	0,07	21,0	0,09
21,5	8.000,0	0,06	21,5	0,08
22,0	8.000,0	0,06	22,0	0,08
22,5	8.000,0	0,05	22,5	0,07
23,0	8.000,0	0,05	23,0	0,07
23,5	8.000,0	0,05	23,5	0,06
24,0	8.000,0	0,04	24,0	0,06
24,5	8.000,0	0,04	24,5	0,06

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,232 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	0,0	0,0	0,0
3,0	0,0	0,00	2,50- 3,50	5,0	5,0	0,0
4,0	196,4	0,24	3,50- 4,50	115,9	120,9	0,4
5,0	587,5	0,36	4,50- 5,50	404,5	525,4	1,6
6,0	1.148,2	0,41	5,50- 6,50	855,1	1.380,6	4,2
7,0	1.910,5	0,43	6,50- 7,50	1.476,8	2.857,3	8,7
8,0	2.929,0	0,44	7,50- 8,50	2.236,6	5.093,9	15,4
9,0	4.222,1	0,45	8,50- 9,50	3.046,8	8.140,7	24,7
10,0	5.756,9	0,44	9,50-10,50	3.751,7	11.892,4	36,0
11,0	7.211,1	0,42	10,50-11,50	4.073,6	15.966,0	48,3
12,0	7.893,3	0,35	11,50-12,50	3.821,0	19.787,0	59,9
13,0	7.997,2	0,28	12,50-13,50	3.215,0	23.002,0	69,7
14,0	8.000,0	0,22	13,50-14,50	2.580,1	25.582,0	77,5
15,0	8.000,0	0,18	14,50-15,50	2.019,0	27.601,0	83,6
16,0	8.000,0	0,15	15,50-16,50	1.547,5	29.148,5	88,3
17,0	8.000,0	0,13	16,50-17,50	1.163,8	30.312,3	91,8
18,0	8.000,0	0,11	17,50-18,50	859,4	31.171,6	94,4
19,0	8.000,0	0,09	18,50-19,50	622,9	31.794,5	96,3
20,0	8.000,0	0,08	19,50-20,50	442,8	32.237,3	97,6
21,0	8.000,0	0,07	20,50-21,50	308,4	32.545,7	98,6
22,0	8.000,0	0,06	21,50-22,50	210,0	32.755,7	99,2
23,0	8.000,0	0,05	22,50-23,50	139,8	32.895,5	99,6
24,0	8.000,0	0,04	23,50-24,50	90,8	32.986,3	99,9
25,0	8.000,0	0,04	24,50-25,50	35,4	33.021,7	100,0





Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Terrain

Calculation: 10MW (8MW) 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

Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Wind Data Analysis

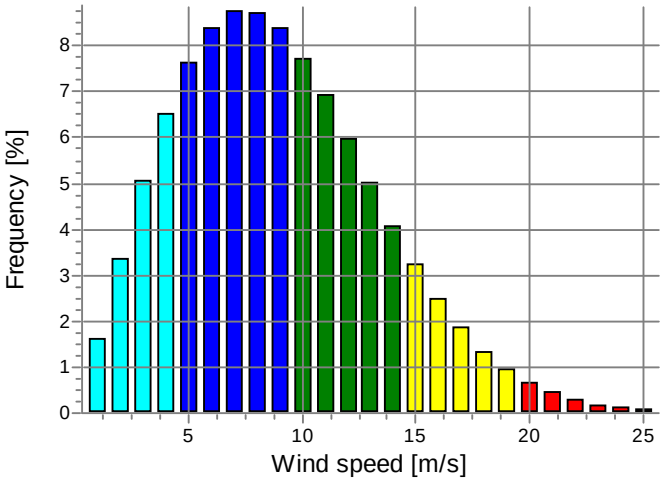
Calculation: 10MW (8MW) alternatief: Kavel IV**Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 125,0

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

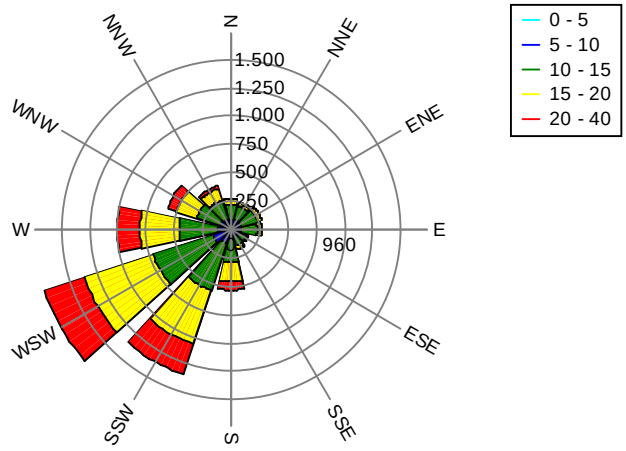
Weibull Data

Sector	Current site A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	8,51	7,54	2,244	6,8
1 NNE	8,53	7,57	2,436	6,6
2 ENE	8,98	7,98	2,564	6,6
3 E	8,85	7,86	2,529	6,5
4 ESE	8,19	7,26	2,396	4,8
5 SSE	8,40	7,44	2,178	4,6
6 S	10,37	9,19	2,150	7,1
7 SSW	12,00	10,63	2,346	12,5
8 WSW	11,88	10,53	2,295	16,3
9 W	10,80	9,57	2,064	11,5
10 WNW	9,80	8,69	2,018	8,8
11 NNW	9,12	8,07	2,068	7,7
All	10,09	8,94	2,104	100,0

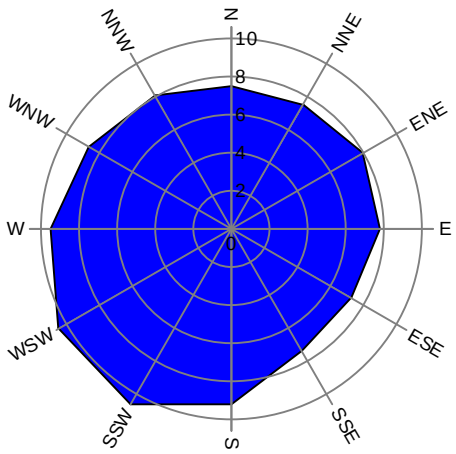
Weibull Distribution



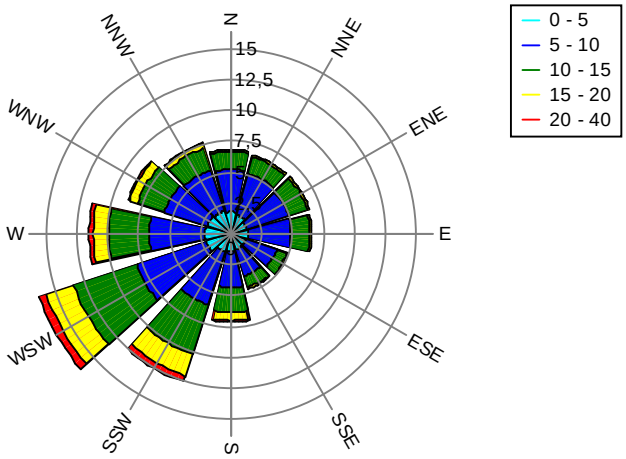
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Wind Data Analysis

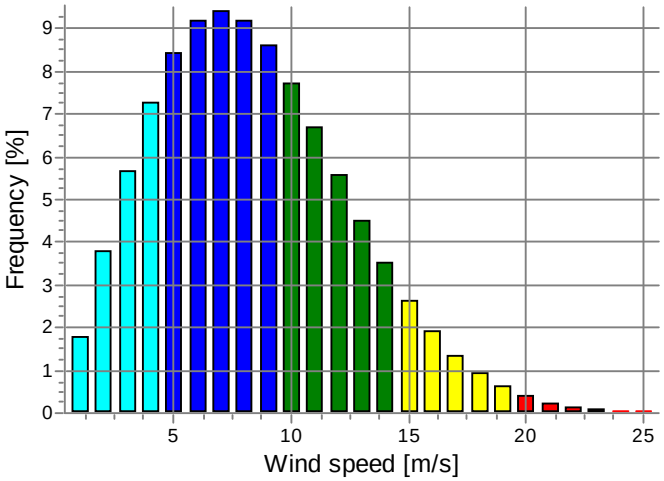
Calculation: 10MW (8MW) alternatief: Kavel IV**Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 100,0

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

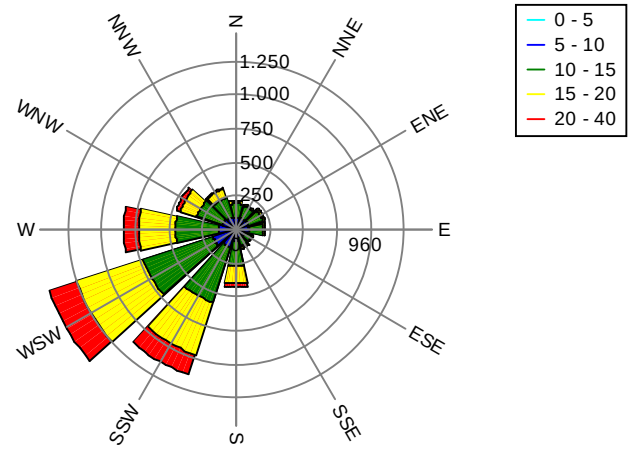
Weibull Data

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

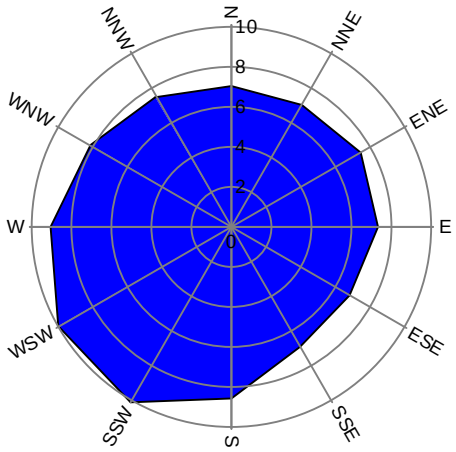
Weibull Distribution



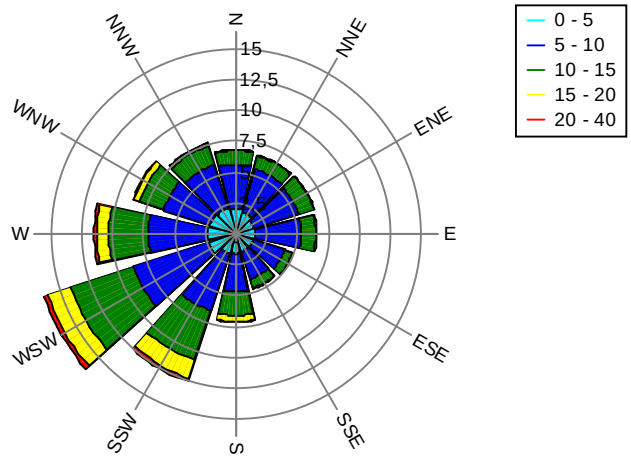
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Park power curve

Calculation: 10MW (8MW) 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3,5	993	470	437	302	414	536	562	614	447	317	441	543	560	606
4,5	17.500	13.172	11.559	12.309	12.780	14.355	13.472	14.981	11.576	12.282	12.818	14.364	13.467	14.964
5,5	39.887	32.302	28.556	30.930	31.771	34.494	33.119	35.542	28.583	30.848	31.836	34.511	33.113	35.510
6,5	70.416	58.940	52.859	56.996	58.105	62.397	60.200	63.937	52.903	56.874	58.196	62.422	60.189	63.892
7,5	112.143	94.965	85.857	92.054	93.767	100.068	96.895	102.405	85.920	91.870	93.914	100.105	96.878	102.332
8,5	166.410	142.061	129.092	137.929	140.364	149.321	144.781	152.649	129.177	137.672	140.577	149.377	144.758	152.544
9,5	233.610	201.266	183.548	195.843	198.979	211.122	204.909	215.484	183.649	195.520	199.265	211.194	204.878	215.349
10,5	307.212	270.221	247.193	264.508	267.580	282.518	274.488	287.252	247.243	264.242	267.883	282.590	274.457	287.122
11,5	360.517	333.325	306.981	331.246	331.223	345.458	337.090	348.104	306.794	331.376	331.428	345.492	337.081	348.048
12,5	374.763	365.041	342.974	368.041	364.549	372.141	368.338	372.204	342.684	368.132	364.664	372.143	368.347	372.165
13,5	376.000	373.765	362.666	375.688	374.955	375.906	375.613	375.893	362.780	375.678	374.965	375.906	375.613	375.877
14,5	376.000	375.728	374.000	376.000	375.992	376.000	375.999	376.000	374.128	375.999	375.992	376.000	375.999	376.000
15,5	376.000	375.999	375.991	376.000	376.000	376.000	376.000	376.000	375.992	376.000	376.000	376.000	376.000	376.000
16,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
17,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
18,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
19,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
20,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
21,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
22,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
23,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
24,5	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000	376.000
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.

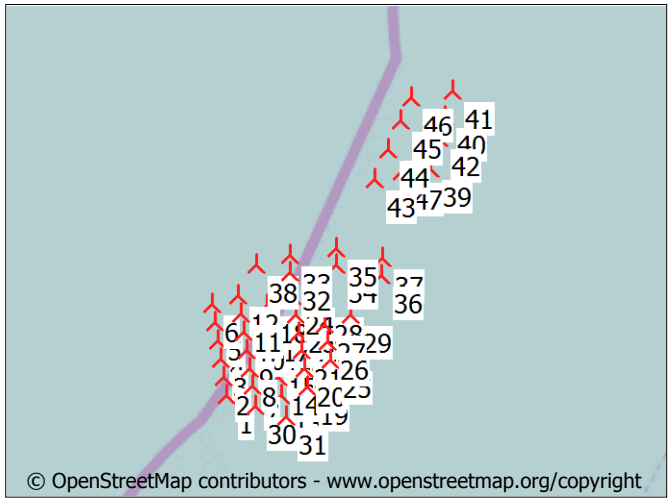
Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - WTG distances

Calculation: 10MW (8MW) alternatief: Kavel IV

WTG distances

	Z [m]	Nearest WTG	Z [m]	Horizontal distance [m]	Distance in rotor diameters
1	0,0	2	0,0	985	6,0
2	0,0	1	0,0	985	6,0
3	0,0	4	0,0	985	6,0
4	0,0	5	0,0	985	6,0
5	0,0	4	0,0	985	6,0
6	0,0	5	0,0	985	6,0
7	0,0	8	0,0	985	6,0
8	0,0	7	0,0	985	6,0
9	0,0	10	0,0	985	6,0
10	0,0	9	0,0	985	6,0
11	0,0	10	0,0	985	6,0
12	0,0	11	0,0	985	6,0
13	0,0	14	0,0	985	6,0
14	0,0	13	0,0	985	6,0
15	0,0	14	0,0	985	6,0
16	0,0	15	0,0	985	6,0
17	0,0	16	0,0	985	6,0
18	0,0	17	0,0	985	6,0
19	0,0	20	0,0	985	6,0
20	0,0	19	0,0	985	6,0
21	0,0	22	0,0	985	6,0
22	0,0	21	0,0	985	6,0
23	0,0	22	0,0	985	6,0
24	0,0	23	0,0	985	6,0
25	0,0	26	0,0	985	6,0
26	0,0	25	0,0	985	6,0
27	0,0	26	0,0	985	6,0
28	0,0	27	0,0	985	6,0
29	0,0	27	0,0	1.457	8,9
30	0,0	7	0,0	1.056	6,4
31	0,0	13	0,0	1.129	6,9
32	0,0	33	0,0	901	5,5
33	0,0	32	0,0	901	5,5
34	0,0	35	0,0	901	5,5
35	0,0	34	0,0	901	5,5
36	0,0	37	0,0	901	5,5
37	0,0	36	0,0	901	5,5
38	0,0	32	0,0	1.851	11,3
39	0,0	47	0,0	1.539	9,4
40	0,0	42	0,0	1.175	7,2
41	0,0	40	0,0	1.450	8,8
42	0,0	40	0,0	1.175	7,2
43	0,0	47	0,0	1.488	9,1
44	0,0	47	0,0	1.397	8,5
45	0,0	46	0,0	1.373	8,4
46	0,0	45	0,0	1.373	8,4
47	0,0	44	0,0	1.397	8,5
Min	**0,0**		**0,0**	**901**	**5,5**
Max	**0,0**		**0,0**	**1.851**	**11,3**



Scale 1:400.000

New WTG

Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Wind statistics info

Calculation: 10MW (8MW) 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.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

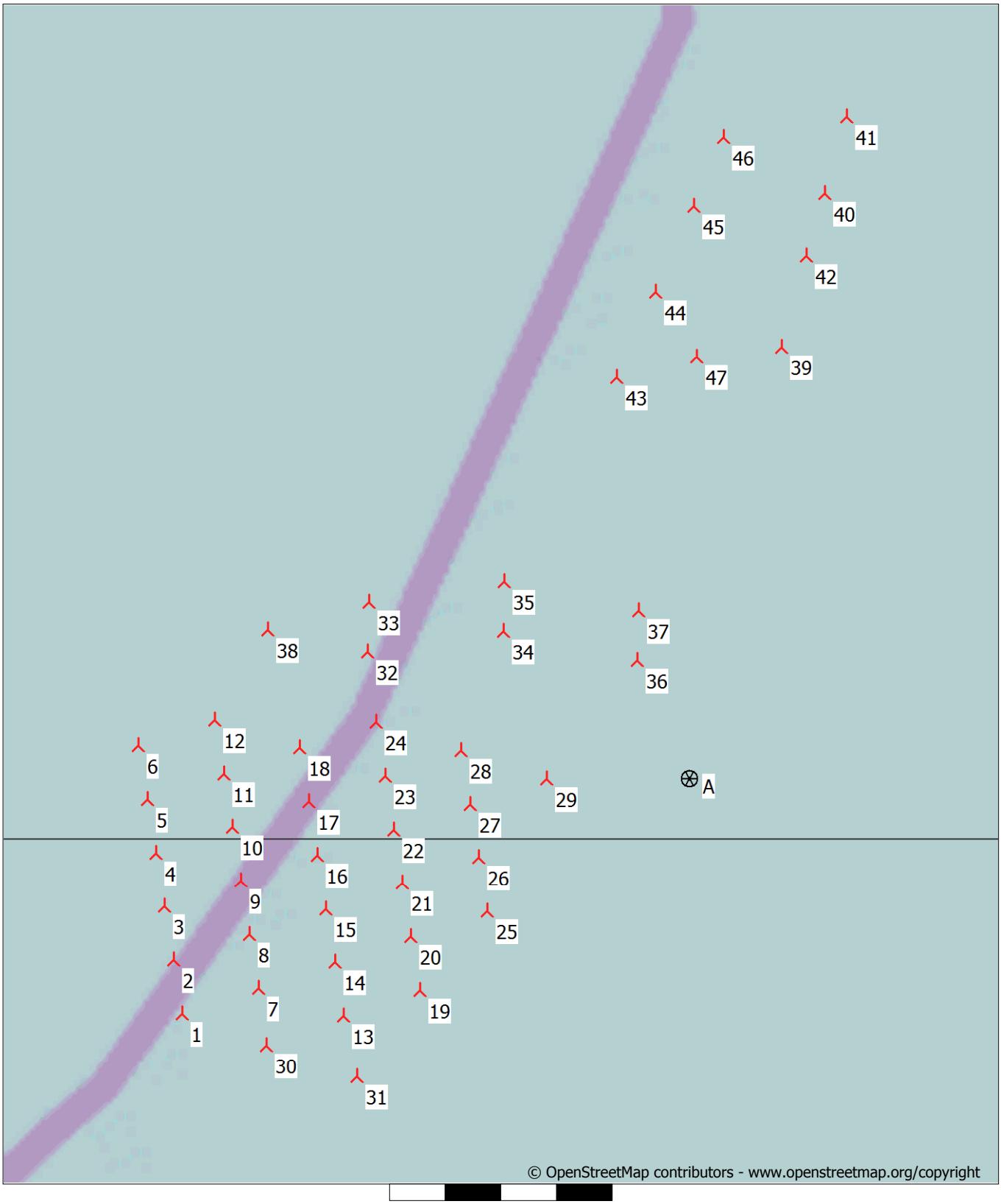
Note

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.

Licensed user:
Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940
Andrew Beltau / a.beltau@ponderaconsult.com
Calculated:
26-10-2016 17:23/3.1.582

PARK - Map

Calculation: 10MW (8MW) alternatief: Kavel IV



Map: Open Street Map 001 , Print scale 1:100.000, Map center UTM (north)-ETRS89 Zone: 31 East: 578.405 North: 5.799.675

New WTG Site Data