Project:
715082

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Calculated:
26-10-2016 17:23/3.1.582

PARK - Main Result

Calculation: 10MW (8MW) 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	1,232 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

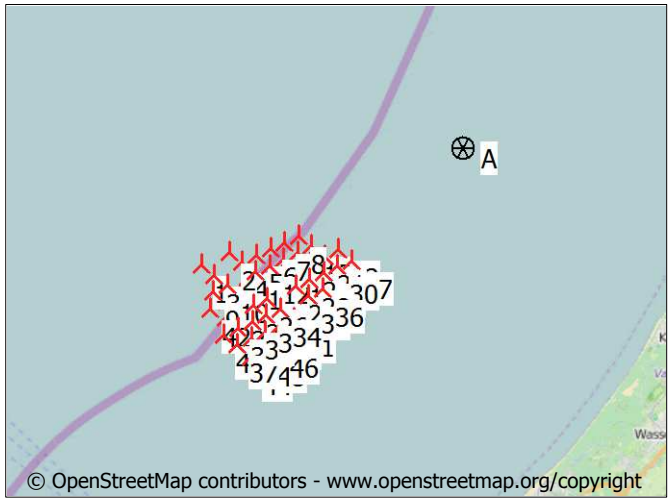
Displacement heights from objects

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

					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	1.452.351,3	1.628.107,0	89,2	44,1	30.901,1	3.863	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 [kW]	Rotor diameter [m]	Hub height [m]	Creator	Name	Result [MWh]	Efficiency [%]	Capacity factor [%]	Free mean wind speed [m/s]
1 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	33.363,5	96,52	47,6	8,88
2 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.630,7	94,17	46,5	8,90
3 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.449,7	93,82	46,3	8,88
4 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.495,8	90,86	44,9	8,90
5 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.049,7	89,49	44,3	8,91
6 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.927,8	89,07	44,1	8,91
7 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.024,9	89,29	44,2	8,92
8 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.475,8	90,54	44,9	8,93
9 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.083,2	92,83	45,7	8,88
10 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.142,0	90,00	44,4	8,89
11 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.726,8	88,62	43,8	8,90
12 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.153,4	86,89	43,0	8,91
13 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.948,9	86,25	42,7	8,92
14 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.082,2	86,58	42,9	8,92
15 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.732,6	88,42	43,8	8,93
16 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.926,8	89,44	44,1	8,88
17 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.323,4	87,60	43,2	8,89
18 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.211,4	87,07	43,1	8,91
19 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.821,0	85,89	42,5	8,92
20 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.882,7	86,02	42,6	8,92
21 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.489,0	87,73	43,5	8,93
22 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.452,6	90,49	44,9	8,93

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PARK - Main Result

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

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	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	31.449,3	91,04	44,8	8,87
24 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.164,1	87,23	43,0	8,88
25 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.774,5	86,02	42,5	8,89
26 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.945,9	86,43	42,7	8,90
27 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.188,6	87,02	43,0	8,91
28 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.960,2	86,32	42,7	8,92
29 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.272,3	87,19	43,2	8,92
30 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.928,1	89,04	44,1	8,92
31 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.707,0	88,89	43,8	8,87
32 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.900,6	86,47	42,6	8,88
33 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.620,4	85,58	42,2	8,89
34 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	29.943,4	86,46	42,7	8,90
35 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.820,0	88,87	43,9	8,91
36 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.008,4	89,38	44,2	8,91
37 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.817,7	92,25	45,4	8,86
38 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.646,0	88,75	43,7	8,87
39 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.109,8	87,10	42,9	8,88
40 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.087,1	86,96	42,9	8,89
41 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	30.810,7	89,00	43,9	8,89
42 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.467,1	94,03	46,3	8,87
43 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.182,8	93,29	45,9	8,86
44 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.459,6	94,18	46,3	8,86
45 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.447,3	91,11	44,8	8,87
46 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	31.164,9	90,19	44,4	8,88
47 A	Yes	VESTAS	V164-8.0-8.000	8.000	164,0	125,0	USER	Mode 0 - 10-2015	32.081,5	92,35	45,7	8,93

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	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (900)
2 New	566.623	5.789.229	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (901)
3 New	565.647	5.787.676	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (902)
4 New	567.499	5.788.569	0,0	64,9°, 1.028,0 m
5 New	568.424	5.789.016	0,0	
6 New	569.350	5.789.463	0,0	
7 New	570.276	5.789.911	0,0	
8 New	571.201	5.790.358	0,0	
9 New	565.597	5.786.570	0,0	64,9°, 1.028,0 m
10 New	566.523	5.787.016	0,0	
11 New	568.374	5.787.910	0,0	64,9°, 1.028,0 m
12 New	569.300	5.788.357	0,0	
13 New	570.226	5.788.804	0,0	
14 New	571.151	5.789.252	0,0	
15 New	572.076	5.789.699	0,0	
16 New	566.473	5.785.910	0,0	64,9°, 1.028,0 m
17 New	567.398	5.786.357	0,0	
18 New	570.175	5.787.698	0,0	64,9°, 1.028,0 m
19 New	571.101	5.788.145	0,0	
20 New	572.026	5.788.593	0,0	
21 New	572.952	5.789.040	0,0	
22 New	573.877	5.789.488	0,0	
23 New	566.422	5.784.803	0,0	64,9°, 1.028,0 m
24 New	567.348	5.785.250	0,0	
25 New	568.274	5.785.697	0,0	
26 New	569.200	5.786.144	0,0	
27 New	571.051	5.787.038	0,0	64,9°, 1.028,0 m
28 New	571.976	5.787.486	0,0	

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PARK - Main Result

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

...continued from previous page

		UTM (north)-ETRS89 Zone: 31			
		Easting	Northing	Z [m]	Row data/Description
29	New	572.902	5.787.934	0,0	
30	New	573.827	5.788.382	0,0	
31	New	567.298	5.784.143	0,0	64,9°, 1.028,0 m
32	New	568.224	5.784.590	0,0	
33	New	569.150	5.785.037	0,0	
34	New	570.075	5.785.485	0,0	
35	New	571.926	5.786.379	0,0	64,9°, 1.028,0 m
36	New	572.852	5.786.827	0,0	
37	New	567.248	5.783.037	0,0	64,9°, 1.028,0 m
38	New	568.174	5.783.484	0,0	
39	New	569.099	5.783.931	0,0	
40	New	570.025	5.784.378	0,0	
41	New	570.951	5.784.825	0,0	
42	New	565.391	5.785.381	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (913)
43	New	566.305	5.783.648	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (914)
44	New	568.124	5.782.188	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (915)
45	New	569.111	5.782.799	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (916)
46	New	569.936	5.783.421	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (917)
47	New	574.772	5.788.724	0,0	VESTAS V164-8.0 8000 164.0 !O! hub: 125,0 m (TOT: 207,0 m) (918)

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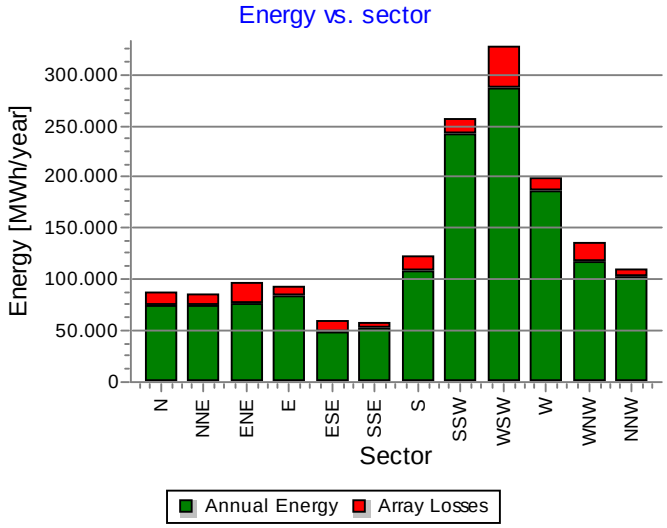
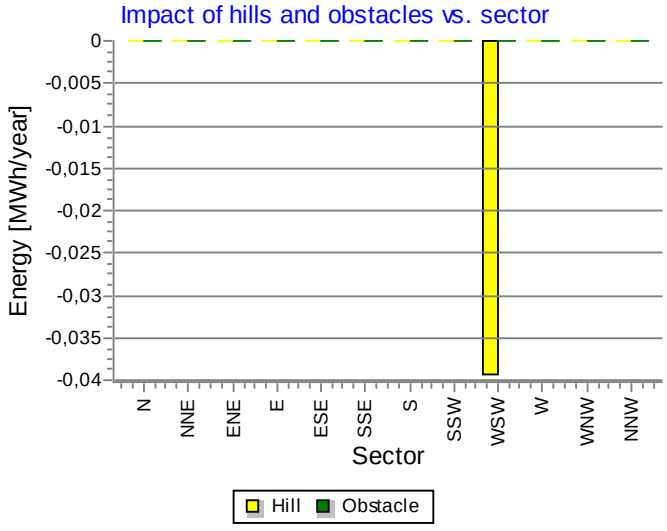
PARK - Production Analysis

Calculation: 10MW (8MW) alternatief: Kavel III**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]	87.803,7	84.599,5	95.797,0	92.470,2	58.923,6	57.420,4	122.042,6	257.362,3	327.182,5	199.090,0	135.519,8	109.895,6	1.628.106,9
-Decrease due to array losses	[MWh]	13.056,5	9.706,5	18.868,1	9.366,6	11.178,6	4.439,9	13.486,1	16.135,2	40.097,0	13.693,4	18.530,6	7.197,2	175.755,8
Resulting energy	**[MWh]**	**74.747,2**	**74.893,0**	**76.928,9**	**83.103,6**	**47.745,0**	**52.980,4**	**108.556,5**	**241.227,1**	**287.085,4**	**185.396,7**	**116.989,2**	**102.698,4**	**1.452.351,0**
Specific energy	[kWh/m²]													1.463
Specific energy	[kWh/kW]													3.863
Decrease due to array losses	[%]	14,9	11,5	19,7	10,1	19,0	7,7	11,1	6,3	12,3	6,9	13,7	6,5	10,80
Utilization	[%]	27,2	30,1	26,5	29,7	28,1	29,4	21,1	18,8	17,4	19,8	20,9	25,3	21,4
Operational	[Hours/year]	554	532	537	528	393	375	584	1.021	1.319	925	710	624	8.103
Full Load Equivalent	[Hours/year]	199	199	205	221	127	141	289	642	764	493	311	273	3.863





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PARK - Power Curve Analysis

Calculation: 10MW (8MW) alternatief: Kavel III**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

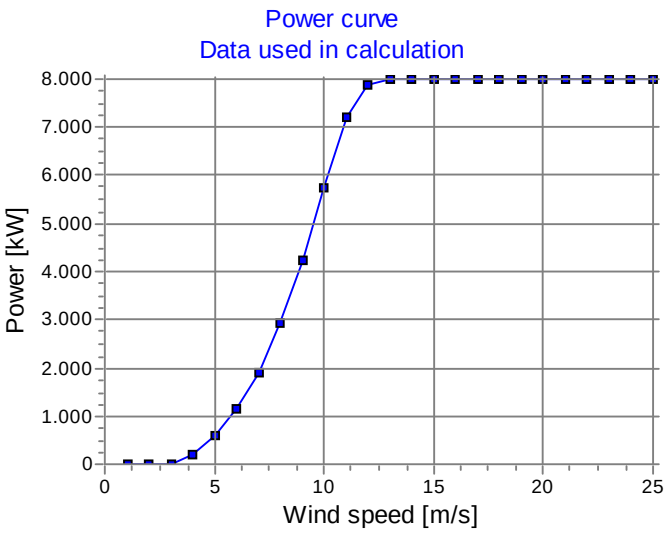
Original data, Air density: 1,225 kg/m³

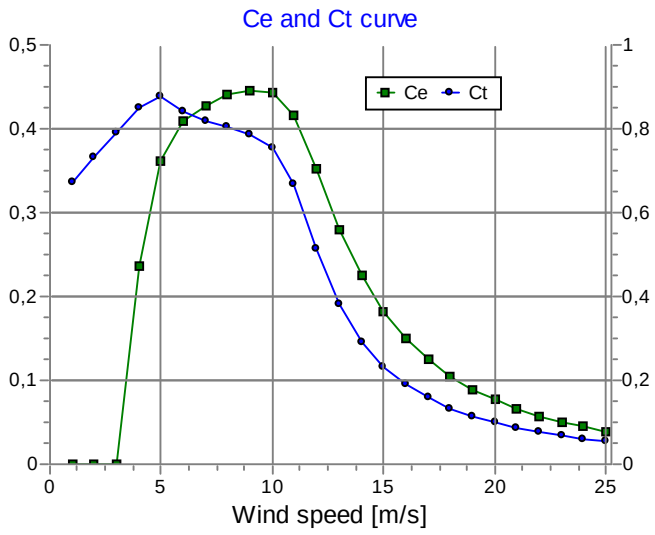
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
4,0	194,0	0,23	4,0	0,85
4,5	369,0	0,31	4,5	0,88
5,0	583,0	0,36	5,0	0,88
5,5	843,0	0,39	5,5	0,86
6,0	1.141,0	0,41	6,0	0,84
6,5	1.489,0	0,42	6,5	0,83
7,0	1.899,0	0,43	7,0	0,82
7,5	2.372,0	0,43	7,5	0,81
8,0	2.912,0	0,44	8,0	0,81
8,5	3.520,0	0,44	8,5	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	5,1	5,1	0,0
4,0	196,4	0,24	3,50- 4,50	118,9	124,0	0,4
5,0	587,5	0,36	4,50- 5,50	414,5	538,5	1,6
6,0	1.148,2	0,41	5,50- 6,50	876,0	1.414,4	4,2
7,0	1.910,5	0,43	6,50- 7,50	1.512,2	2.926,6	8,8
8,0	2.929,0	0,44	7,50- 8,50	2.289,1	5.215,7	15,6
9,0	4.222,1	0,45	8,50- 9,50	3.116,2	8.331,8	25,0
10,0	5.756,9	0,44	9,50-10,50	3.833,0	12.164,9	36,5
11,0	7.211,1	0,42	10,50-11,50	4.155,1	16.320,0	48,9
12,0	7.893,3	0,35	11,50-12,50	3.888,0	20.207,9	60,6
13,0	7.997,2	0,28	12,50-13,50	3.259,8	23.467,7	70,3
14,0	8.000,0	0,22	13,50-14,50	2.603,1	26.070,8	78,1
15,0	8.000,0	0,18	14,50-15,50	2.024,0	28.094,8	84,2
16,0	8.000,0	0,15	15,50-16,50	1.539,1	29.633,9	88,8
17,0	8.000,0	0,13	16,50-17,50	1.146,7	30.780,6	92,3
18,0	8.000,0	0,11	17,50-18,50	837,7	31.618,3	94,8
19,0	8.000,0	0,09	18,50-19,50	600,1	32.218,5	96,6
20,0	8.000,0	0,08	19,50-20,50	421,2	32.639,7	97,8
21,0	8.000,0	0,07	20,50-21,50	289,4	32.929,0	98,7
22,0	8.000,0	0,06	21,50-22,50	194,3	33.123,3	99,3
23,0	8.000,0	0,05	22,50-23,50	127,3	33.250,6	99,7
24,0	8.000,0	0,04	23,50-24,50	81,4	33.332,0	99,9
25,0	8.000,0	0,04	24,50-25,50	31,4	33.363,5	100,0





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Calculated:
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PARK - Terrain

Calculation: 10MW (8MW) 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:
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PARK - Wind Data Analysis

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

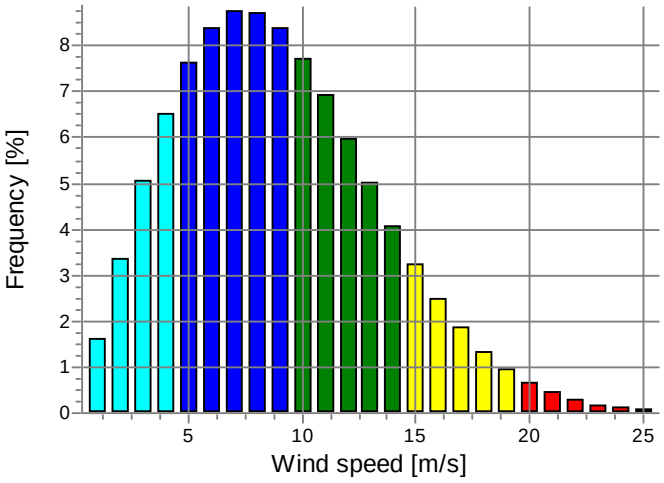
Site coordinates
UTM (north)-ETRS89 Zone: 31
East: 582.068 North: 5.796.386

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

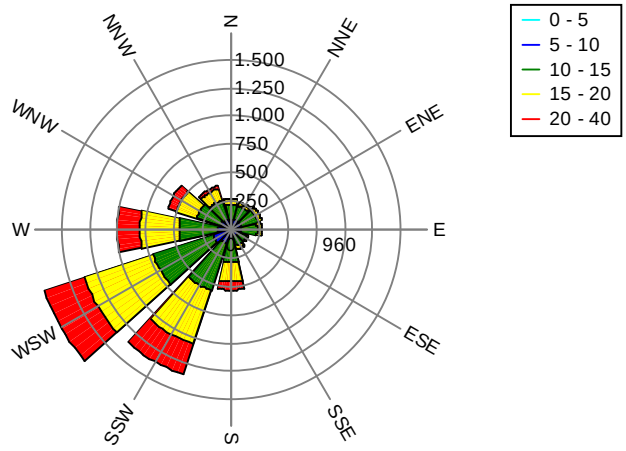
Weibull Data

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

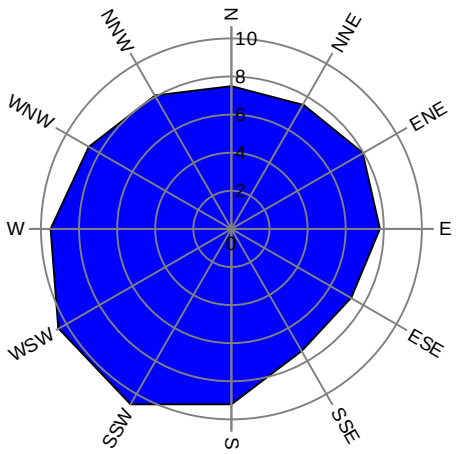
Weibull Distribution



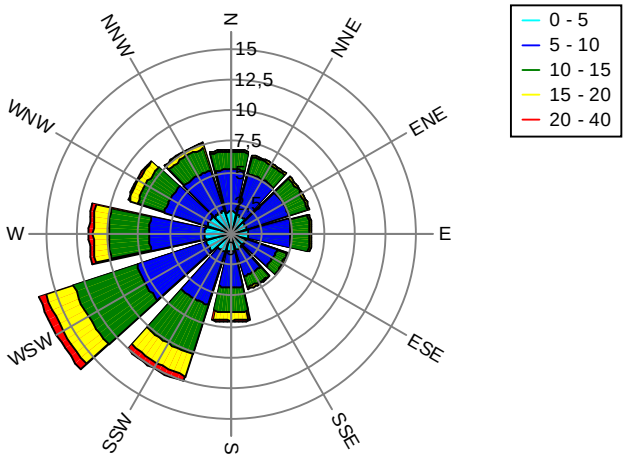
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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Calculated:
26-10-2016 17:23/3.1.582

PARK - Wind Data Analysis

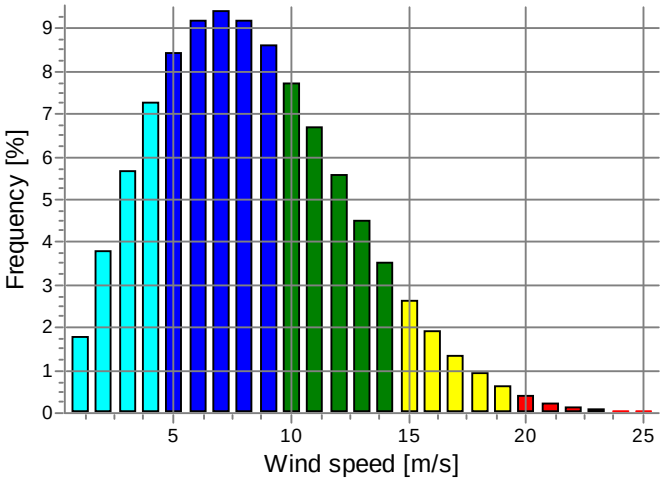
Calculation: 10MW (8MW) alternatief: Kavel III**Wind data:** A - Site data: Hollandse Kust Zuid; Hub height: 100,0

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

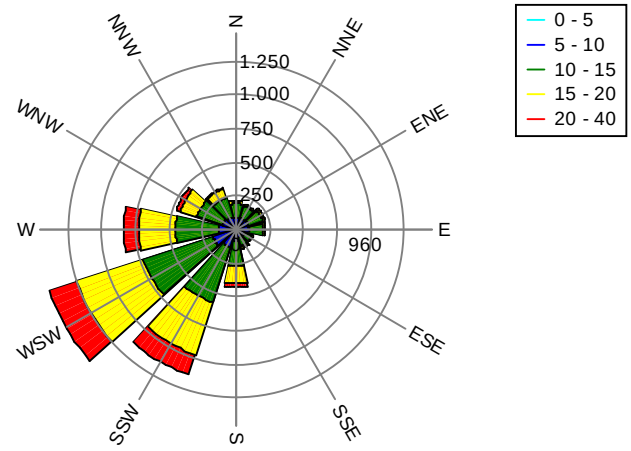
Weibull Data

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

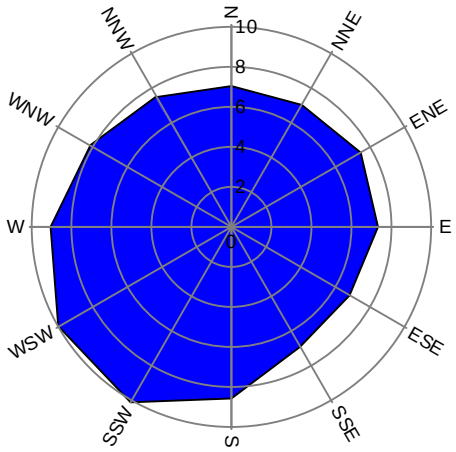
Weibull Distribution



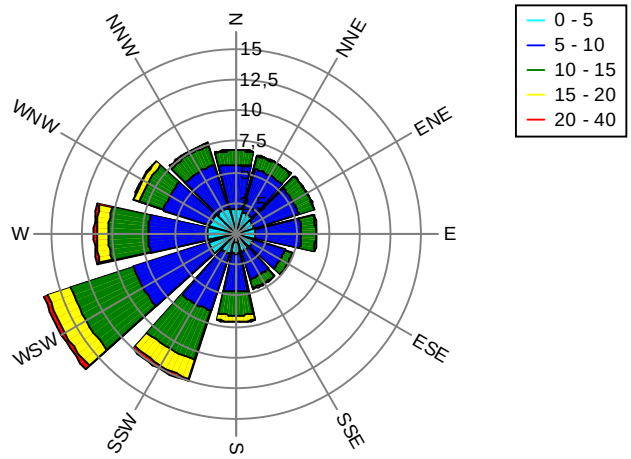
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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Calculated:
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PARK - Park power curve

Calculation: 10MW (8MW) 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3,5	993	380	390	391	281	420	366	507	395	398	283	397	367	499
4,5	17.500	11.432	11.135	12.190	9.662	12.492	10.241	13.630	11.111	12.218	9.703	12.440	10.244	13.624
5,5	39.887	29.063	28.405	30.823	25.302	31.395	26.635	33.336	28.410	30.874	25.350	31.287	26.637	33.322
6,5	70.416	54.014	52.937	56.870	48.041	57.721	50.209	60.671	52.917	56.946	48.126	57.567	50.212	60.654
7,5	112.143	87.609	86.080	91.852	78.657	93.120	81.982	97.495	86.041	91.970	78.817	92.883	81.985	97.469
8,5	166.410	131.640	129.476	137.650	118.932	139.464	123.667	145.679	129.431	137.817	119.161	139.125	123.672	145.634
9,5	233.610	187.273	184.230	195.545	169.979	197.978	176.402	206.314	184.162	195.761	170.274	197.523	176.408	206.247
10,5	307.212	253.351	249.129	264.326	231.311	267.207	239.521	277.047	249.043	264.540	231.654	266.690	239.532	276.961
11,5	360.517	318.370	312.883	331.620	294.724	333.864	303.709	341.685	312.843	331.701	294.913	333.487	303.734	341.578
12,5	374.763	357.367	353.575	368.572	339.528	369.160	347.519	371.398	353.798	368.564	339.325	369.044	347.528	371.365
13,5	376.000	371.667	372.155	375.739	364.260	375.764	369.050	375.880	372.501	375.737	363.813	375.757	369.050	375.878
14,5	376.000	375.750	375.920	376.000	375.254	376.000	375.644	376.000	375.939	376.000	375.120	376.000	375.654	376.000
15,5	376.000	375.999	376.000	376.000	375.999	376.000	376.000	376.000	376.000	376.000	375.999	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.

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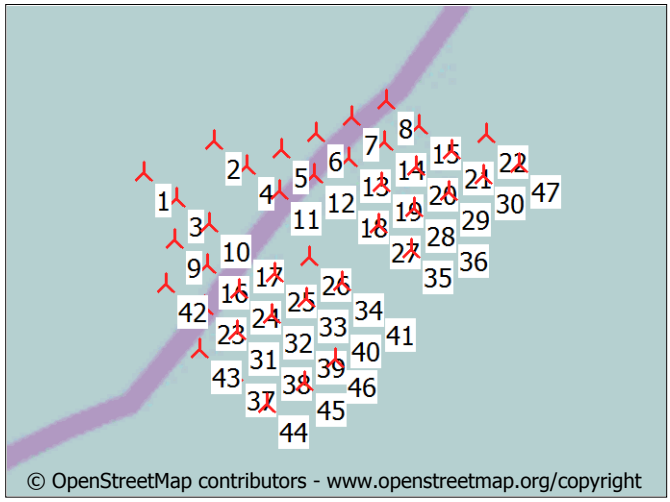
PARK - WTG distances

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

WTG distances

	Z [m]	Nearest WTG	Z [m]	Horizontal distance [m]	Distance in rotor diameters
1	0,0	3	0,0	1.097	6,7
2	0,0	4	0,0	1.096	6,7
3	0,0	10	0,0	1.097	6,7
4	0,0	5	0,0	1.028	6,3
5	0,0	4	0,0	1.028	6,3
6	0,0	5	0,0	1.028	6,3
7	0,0	6	0,0	1.028	6,3
8	0,0	7	0,0	1.028	6,3
9	0,0	10	0,0	1.028	6,3
10	0,0	9	0,0	1.028	6,3
11	0,0	12	0,0	1.028	6,3
12	0,0	11	0,0	1.028	6,3
13	0,0	12	0,0	1.028	6,3
14	0,0	13	0,0	1.028	6,3
15	0,0	14	0,0	1.028	6,3
16	0,0	17	0,0	1.028	6,3
17	0,0	16	0,0	1.028	6,3
18	0,0	19	0,0	1.028	6,3
19	0,0	18	0,0	1.028	6,3
20	0,0	19	0,0	1.028	6,3
21	0,0	20	0,0	1.028	6,3
22	0,0	21	0,0	1.028	6,3
23	0,0	24	0,0	1.028	6,3
24	0,0	23	0,0	1.028	6,3
25	0,0	24	0,0	1.028	6,3
26	0,0	25	0,0	1.028	6,3
27	0,0	28	0,0	1.028	6,3
28	0,0	27	0,0	1.028	6,3
29	0,0	28	0,0	1.028	6,3
30	0,0	47	0,0	1.005	6,1
31	0,0	32	0,0	1.028	6,3
32	0,0	31	0,0	1.028	6,3
33	0,0	32	0,0	1.028	6,3
34	0,0	33	0,0	1.028	6,3
35	0,0	36	0,0	1.028	6,3
36	0,0	35	0,0	1.028	6,3
37	0,0	38	0,0	1.028	6,3
38	0,0	37	0,0	1.028	6,3
39	0,0	46	0,0	980	6,0
40	0,0	46	0,0	961	5,9
41	0,0	40	0,0	1.028	6,3
42	0,0	23	0,0	1.182	7,2
43	0,0	31	0,0	1.110	6,8
44	0,0	45	0,0	1.162	7,1
45	0,0	46	0,0	1.033	6,3
46	0,0	40	0,0	961	5,9
47	0,0	30	0,0	1.005	6,1
Min	**0,0**		**0,0**	**961**	**5,9**
Max	**0,0**		**0,0**	**1.182**	**7,2**



Scale 1:200.000

New WTG

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Calculated:
26-10-2016 17:23/3.1.582

PARK - Wind statistics info

Calculation: 10MW (8MW) 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:
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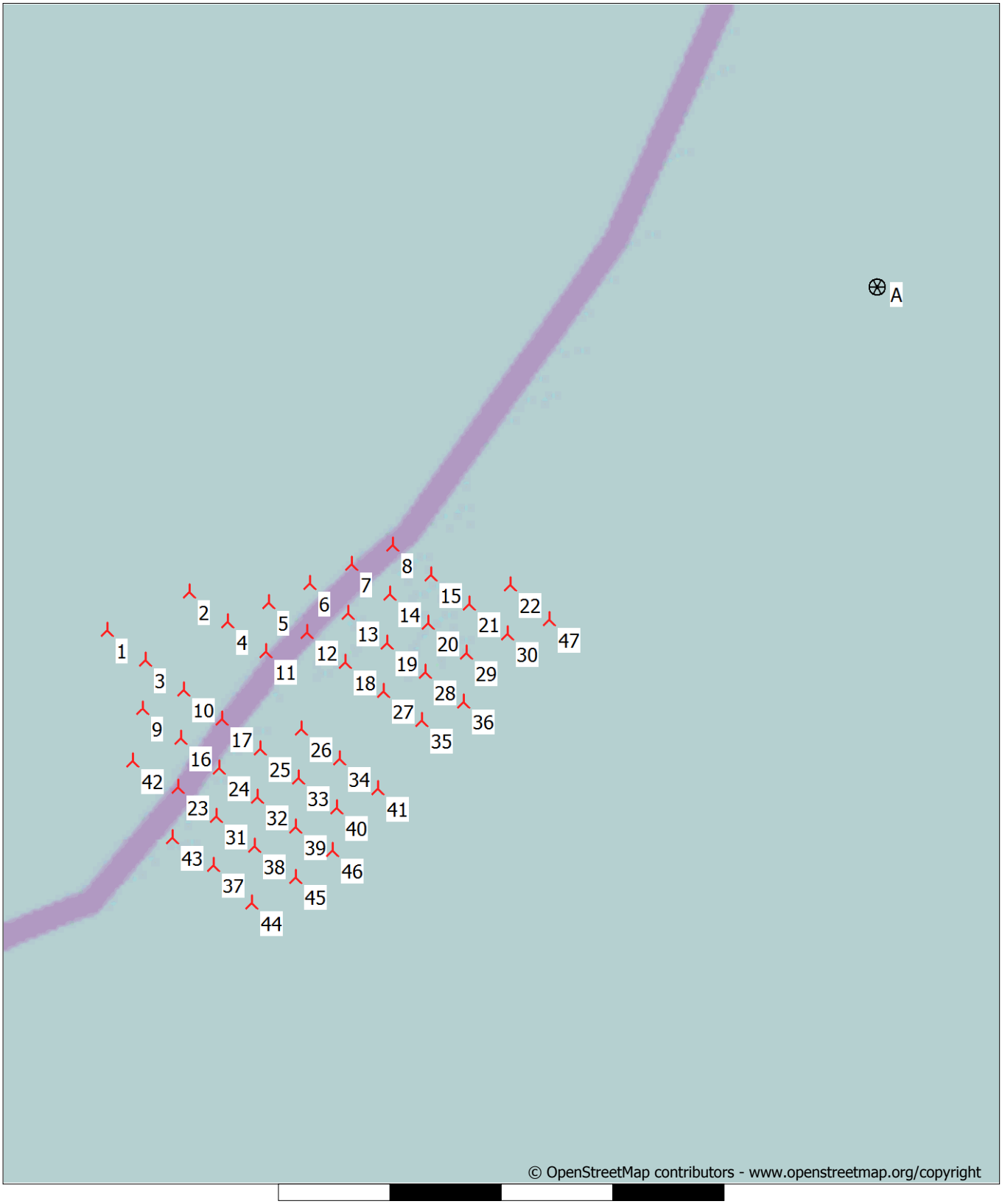
PARK - Map

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



Map: Open Street Map 001 , Print scale 1:125.000, Map center UTM (north)-ETRS89 Zone: 31 East: 573.420 North: 5.789.287

New WTG Site Data