ENERCON
ENERGY FOR THE WORLD

Wind Farm Engineering Report

Energy Yield Estimation and

Site Suitability Assessment

Wind Farm:

Pontinvrea_II (IT)

Layout C01

2 x E-138 EP3 E3 dep. 3MW with 110.2m hh

Publisher

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Checked by	Dimitrios Kompolias

Revisions

Revision	Date	Change
0	2021-10-11	Document created including Energy Yield Estimation and Site Suitability Assessment - Preliminary Results
1	2021-10-11	Document created including Energy Yield Estimation and Site Suitability Assessment

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a) any errors or shortcomings in the underlying wind data provided by the client,
b) any errors or shortcomings immanent in the applied software.
c) any errors or shortcomings immanent in applied power/ct curves and certified design limits of competitor turbines.

Special Notes:

The power curve is measured at the WEC reference point (at the 400V or 690V AC terminals behind the power cabinets). The net annual energy production (Net AEP) takes into account both the wake losses and the specific loss factors as shown in "2a) Yield Estimation Summary Table". If not expressly stated in the report, any other losses were not considered. For the definition of wind class the air density of the site has to be taken into account. This evaluation does not assess the impact of the site conditions on the power curve.

This evaluation is based, and highly dependent, on specific conditions and input data (including but not limited to the wind farm coordinates, wind turbine type and hub height, curtailments/shutdown/reduction strategies, operational mode). If any of these conditions are modified or any input data updated after completion of this report, the results of this report have to be reviewed.

This evaluation is affected by uncertainties (in the calculation model or in the information on landscape roughness and obstacles or due to inaccuracy of available maps). Therefore, it is strongly recommended to consider the uncertainty as stated in the report.

1a) Project Information

Turbine Type:

Quantity	**2**
Turbine type	**E-138 EP3 E3**
Rated power	3 MW
Hub Height	110.2 m
Rotor diameter	138.3 m
Design guideline	IEC 61400-1 {ed. 3}
Wind class	S
Design climate	Normal climate
Design lifetime	25 years
Tower version	E-138 EP3-RB-02
Blade version	HST-111-FB-C-01

Terrain:
The Pontinvrea_II wind farm is planned in medium complexity terrain. It is located in mountainous terrain. In the vicinity of the turbines, steep slopes can be found, which influence the flow at the site. The vegetation surrounding the wind farm consists of forests interrupted by open fields.

Wind data:
The performed calculations are based on wind data obtained by wind measurements. The data was cut to full years to avoid seasonal effects. For the energy yield estimation and the calculation of the annual average wind speed distribution the wind data was long term correlated by means of ERA5 reanalysis data (provided by EMD) covering a 15-year period (Node: ERA5_N44.543308_E008.250000).

Overview about long term correlation:
- WMM PONT_0721: Concurrent period: 82 months, Correlation: 0.571, Scaling factor: 1.013

Additionally, for the calculation of annual average wind speed distribution and extreme wind speed, the wind data was air density adjusted based on the weather station sestri v3 with a distance of about 33 km to the site.

The results of this investigation are subject to increased uncertainty because:
- Due to the level of terrain complexity, the highest measurement height should represent at least the planned hub height of the planned turbine type. In the present case it is only 36 % (WMM PONT_0721) of the required height.

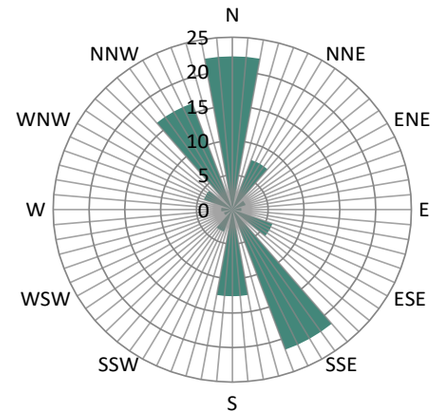
Wind modelling:
The modelled wind conditions of the WEC locations were extrapolated from measurement data both vertically using the matrix of shear coefficients and horizontally using E-Wind (ENERCON GmbH inhouse CFD software for wind assessment; Version: 20.1).

1b) Wind park layout and wind measurements information

Height [m]	Type	Measuring period		Total [years]	Availability [%]	Effective period [year]
		Start	End			
40	nrg	2011-09-01	2018-08-31	7.0	95.0%	6.7
20	nrg	2011-09-01	2018-08-31	7.0	95.0%	6.7

Measuring period and availability after cutting data into full years for WMM PONT_0721

Sector	A parameter [m/s]	k parameter []	frequency [%]	Mean wind speed [m/s]
Mean	5.92	1.74	100	5.27
N	5.36	2.02	22.2	4.75
NNE	4.90	1.92	7.7	4.35
ENE	3.46	1.64	2.0	3.10
E	2.59	1.21	1.3	2.43
ESE	7.38	2.08	6.0	6.54
SSE	8.08	2.21	21.6	7.16
S	6.79	1.99	12.6	6.01
SSW	5.12	1.60	3.4	4.59
WSW	3.23	1.26	1.2	3.00
W	3.45	1.18	1.5	3.26
WNW	3.68	1.38	4.2	3.36
NNW	4.91	1.79	16.4	4.37



Directional wind distribution (table and diagram) at the position of WMM PONT_0721 at 40 m height (For 84.1 months of measurement period)

2a) Yield Estimation Summary Table

The energy yield estimation results are shown in the following table. For turbine specific results please refer to section 2c). The considered yield losses are described in Annex A.

Wind Farm Capacity[1]	**6.00**	**[MW]**
Gross Energy Output	**19 244**	**[MWh/y]**
Total Losses[2]	**-1.8%**	
Wake Losses	**-1.8%**	Project specific
Internal Wake Losses	-0.7%	Project specific
External Wake Losses	-1.1%	Project specific
Net AEP (P50)	**18 898**	**[MWh/y]**
Full Load Hours[3]	**2 218**	**[h/y]**
Capacity Factor[3]	**25.3%**	

[1] Considering the capacity limit at the point of connection to the grid if needed

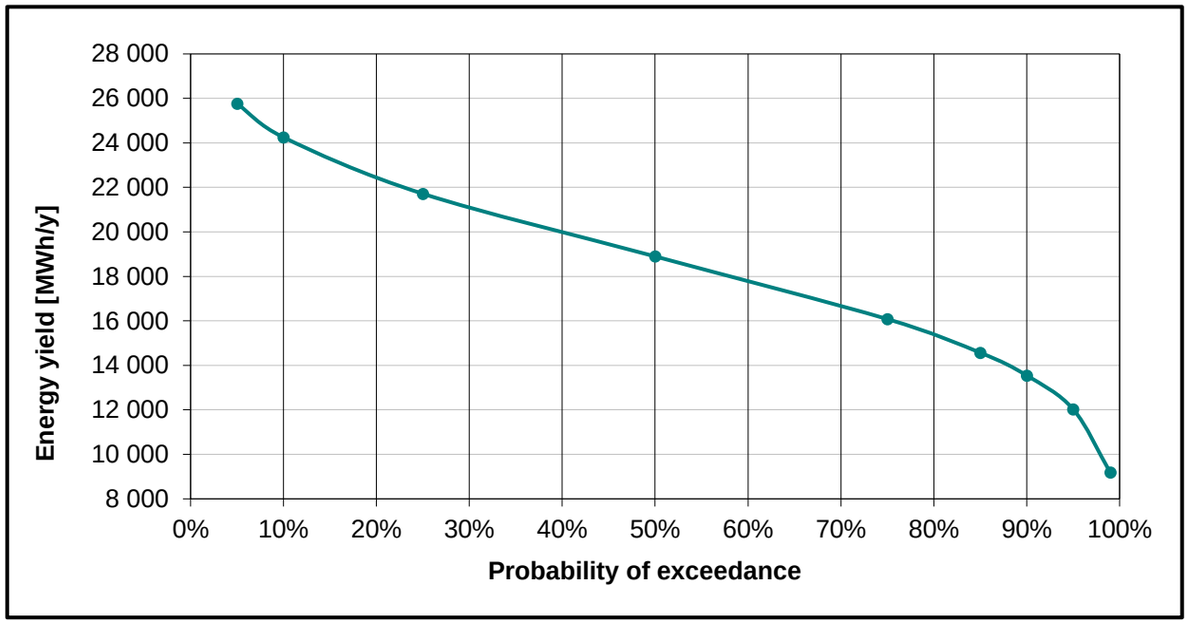
[2] Unless otherwise stated, losses are treated as independent and combined by multiplication of efficiencies

[3] In terms of P50 and wind farm capacity

2b) Energy Yield Uncertainty and P-Values

Net AEP	**18 898 [MWh/y]**
Uncertainty (25 Years)	**22.1%**

P-Values (Probability of exceedance)	**Energy yield** [MWh/y]
P99	9 182
P95	12 029
P90	13 546
P85	14 570
P75	16 081
P50	**18 898**
P25	21 715
P10	24 251
P05	25 768



2c) Yield Estimation Overview Table (YEOT)

Running WEC No.	WEC / Mast	Coordinate system: UTM (north)-WGS84 Zone: 32			Wind turbine type	Power [kW]	(Hub) Height [m]	IEC Wind Class	Min. WEC distance [RD of closest WEC]	Air density ρ [kg/m³]	Gross AEP [MWh/y]	Wake Loss [%]	Net AEP incl. wake loss [MWh/y]	Annual average wind speed V_{ave} [m/s]	Waked Annual average wind speed V_{ave} [m/s]
		X (East)	Y (North)	Z height asl [m]											
1	WMM PONT_0721	454931	4919169	730	-	-	40.0	-	-	1.135	-	-	-	5.2	-
1	WEC_02	455013	4919400	730	E-138 EP3 E3	3000	110.2	S	2.7	1.127	10012	1.8	9834	6.3	-
2	WEC_01	454823	4919080	719	E-138 EP3 E3	3000	110.2	S	2.7	1.129	9232	1.8	9065	6.0	-

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PARK - Main Result

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH

Wake Model N.O. Jensen (RISØ/EMD)

Calculation performed in UTM (north)-WGS84 Zone: 32
At the site centre the difference between grid north and true north is: -0.4°

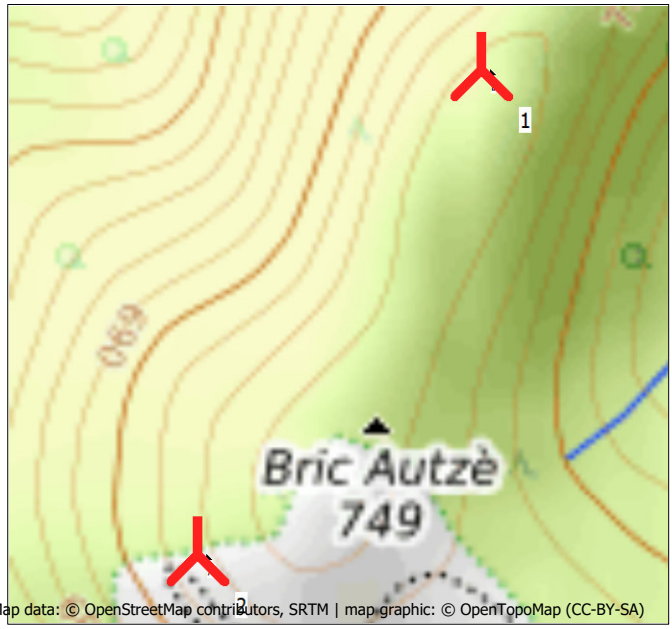
Power curve correction method
IEC 61400-12 method (only recommended for small corrections e.g. <5%)
Air density calculation method
Height dependent, temperature from climate station
Station: GENOVA/SESTRI V3 2014
Base temperature: 15.5 °C at 3.0 m
Base pressure: 1013.3 hPa at 0.0 m
Air density for Site center in key hub height: 730.0 m + 111.0 m = 1.127 kg/m³ -> 92.0 % of Std
Relative humidity: 0.0 %

Wake Model Parameters

From angle [°]	To angle [°]	Terrain type	Wake decay constant
345.0	15.0	User defined	0.045
15.0	45.0	User defined	0.049
45.0	75.0	User defined	0.049
75.0	105.0	User defined	0.060
105.0	135.0	User defined	0.071
135.0	165.0	User defined	0.071
165.0	195.0	User defined	0.066
195.0	225.0	User defined	0.061
225.0	255.0	User defined	0.069
255.0	285.0	User defined	0.056
285.0	315.0	User defined	0.041
315.0	345.0	User defined	0.039

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



Scale 1:5 000
New WTG
Meteorological Data

Key results for height 111.0 m above ground level

Terrain **UTM (north)-WGS84 Zone: 32**

	Easting	Northing	Name of wind distribution	Height [m]	Type	Wind energy [kWh/m²]	Mean wind speed [m/s]
A	454 823	4 919 080	T01 SF 1.01273885	110.2	MEASURE	2 270	6.0
B	455 013	4 919 400	T02 SF 1.01273885	110.2	MEASURE	2 724	6.3

Calculated Annual Energy for Wind Farm

				Specific results¤)			
WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Wake loss [%]	Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
Wind farm	18 898.4	19 243.9	1.8	25.3	9 449.2	3 149	6.1

¤) Based on wake reduced results and any curtailments.

Calculated Annual Energy for each of 2 new WTGs with total 8.5 MW rated power

	WTG type						Power curve		Annual Energy		
Links	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Creator	Name	Result [MWh/y]	Wake loss [%]	Free mean wind speed [m/s]
1 B	Yes	ENERCON GmbH	E-138 EP3 E3-4 260	3 000	138.3	110.2	USER	D02498114_0_SSPC_E-138_EP3 E3_3000_kW_OM0s_Pontivrea_Bric_Autze_calculated	9 833.8	1.8	6.31
2 A	Yes	ENERCON GmbH	E-138 EP3 E3-4 260	3 000	138.3	110.2	USER	D02498114_0_SSPC_E-138_EP3 E3_3000_kW_OM0s_Pontivrea_Bric_Autze_calculated	9 064.6	1.8	5.99

Annual Energy result includes shown losses. Additional losses and uncertainty must be considered for an investment decision.

WTG siting

UTM (north)-WGS84 Zone: 32

	Easting	Northing	Z [m]	Row data/Description
1 New	455 013	4 919 400	730.0	ENERCON GmbH E-138 EP3 E3 dep3MW 138.3 !O! hub: 110.2 m (TOT: 179.4 m) (52)
2 New	454 823	4 919 080	718.8	ENERCON GmbH E-138 EP3 E3 dep3MW 138.3 !O! hub: 110.2 m (TOT: 179.4 m) (52)

*) Included in wake losses is influence from 4 WTG(s) in the neighborhood, which has status as "Reference WTGs", see separate report to identify these.

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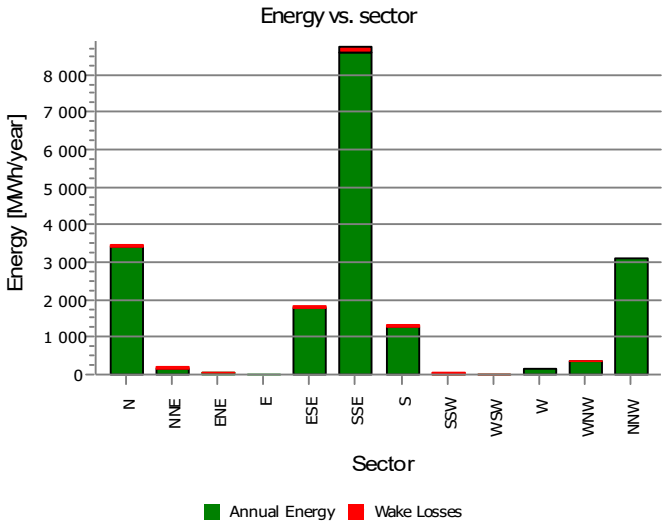
Calculated:
2021-10-11 16:28/3.4.415

PARK - Production Analysis

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH**WTG:** All new WTGs, Air density varies with WTG position 1.126 kg/m³ - 1.129 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]	3 437.0	228.4	34.2	24.9	1 820.9	8 755.1	1 304.1	34.9	21.6	146.0	356.8	3 080.1	19 243.9
-Decrease due to wake losses	[MWh]	46.8	70.2	0.8	0.0	35.6	168.1	13.8	9.7	0.6	0.0	0.0	0.0	345.6
Resulting energy	**[MWh]**	**3 390.2**	**158.2**	**33.5**	**24.9**	**1 785.3**	**8 587.0**	**1 290.4**	**25.2**	**20.9**	**146.0**	**356.8**	**3 080.1**	**18 898.4**
Specific energy	[kWh/m²]													629
Specific energy	[kWh/kW]													2 218
Decrease due to wake losses	[%]	1.4	30.7	2.2	0.0	2.0	1.9	1.1	27.8	3.0	0.0	0.0	0.0	1.80
Utilization	[%]	31.8	27.4	36.2	33.0	23.6	22.2	22.8	24.5	29.6	34.0	35.1	32.5	25.4
Full Load Equivalent	[Hours/year]	398	19	4	3	210	1 008	151	3	2	17	42	362	2 218



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PARK - Power Curve Analysis

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH**WTG:** 1 - ENERCON GmbH E-138 EP3 E3 4260 138.3 !O!, Hub height: 110.2 m

Name: D02498114_0_SSPC_E-138_EP3 E3_3000_kW_OM0s_Pontivrea_Bric_Autze_calculated
Source: D02498114_0

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m²
2021-10-07	USER	2021-10-08	2021-10-08	28.0	Pitch	User defined	Variable	0.28

D02498114_0_SSPC_E-138_EP3 E3_3000_kW_OM0s_Pontivrea_Bric_Autze_calculated
SVN_404_413

Power curve

Original data, Air density: 1.127 kg/m³

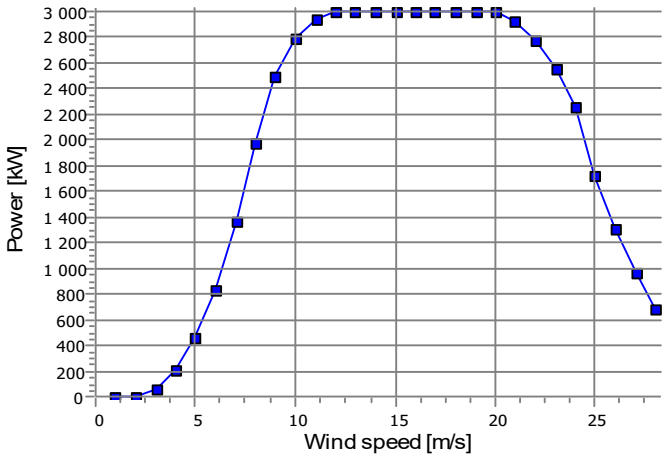
Wind speed [m/s]	Power [kW]	Cp	Wind speed [m/s]	Ct curve
2.0	1.0	0.01	2.0	0.77
2.5	14.0	0.11	2.5	1.10
3.0	52.0	0.23	3.0	1.04
3.5	118.0	0.33	3.5	0.96
4.0	205.0	0.38	4.0	0.91
4.5	317.0	0.41	4.5	0.89
5.0	459.0	0.43	5.0	0.88
5.5	631.0	0.45	5.5	0.88
6.0	836.0	0.46	6.0	0.88
6.5	1 081.0	0.47	6.5	0.87
7.0	1 361.0	0.47	7.0	0.86
7.5	1 670.0	0.47	7.5	0.84
8.0	1 981.0	0.46	8.0	0.80
8.5	2 262.0	0.44	8.5	0.75
9.0	2 496.0	0.40	9.0	0.68
9.5	2 667.0	0.37	9.5	0.60
10.0	2 791.0	0.33	10.0	0.52
10.5	2 885.0	0.29	10.5	0.46
11.0	2 937.0	0.26	11.0	0.40
11.5	2 976.0	0.23	11.5	0.35
12.0	2 998.0	0.20	12.0	0.30
12.5	3 000.0	0.18	12.5	0.27
13.0	3 000.0	0.16	13.0	0.24
13.5	3 000.0	0.14	13.5	0.21
14.0	3 000.0	0.13	14.0	0.19
14.5	3 000.0	0.12	14.5	0.17
15.0	3 000.0	0.11	15.0	0.15
15.5	3 000.0	0.10	15.5	0.14
16.0	3 000.0	0.09	16.0	0.13
16.5	3 000.0	0.08	16.5	0.11
17.0	3 000.0	0.07	17.0	0.11
17.5	3 000.0	0.07	17.5	0.10
18.0	3 000.0	0.06	18.0	0.09
18.5	3 000.0	0.06	18.5	0.08
19.0	3 000.0	0.05	19.0	0.08
19.5	3 000.0	0.05	19.5	0.07
20.0	2 995.0	0.04	20.0	0.07
20.5	2 965.0	0.04	20.5	0.06
21.0	2 921.0	0.04	21.0	0.06
21.5	2 861.0	0.03	21.5	0.05
22.0	2 780.0	0.03	22.0	0.05
22.5	2 677.0	0.03	22.5	0.05
23.0	2 555.0	0.02	23.0	0.04
23.5	2 426.0	0.02	23.5	0.04
24.0	2 262.0	0.02	24.0	0.03
24.5	2 097.0	0.02	24.5	0.03
25.0	1 730.0	0.01	25.0	0.03
25.5	1 502.0	0.01	25.5	0.02
26.0	1 314.0	0.01	26.0	0.02
26.5	1 134.0	0.01	26.5	0.02
27.0	969.0	0.01	27.0	0.01
27.5	818.0	0.00	27.5	0.01
28.0	679.0	0.00	28.0	0.01

Power, Efficiency and energy vs. wind speed

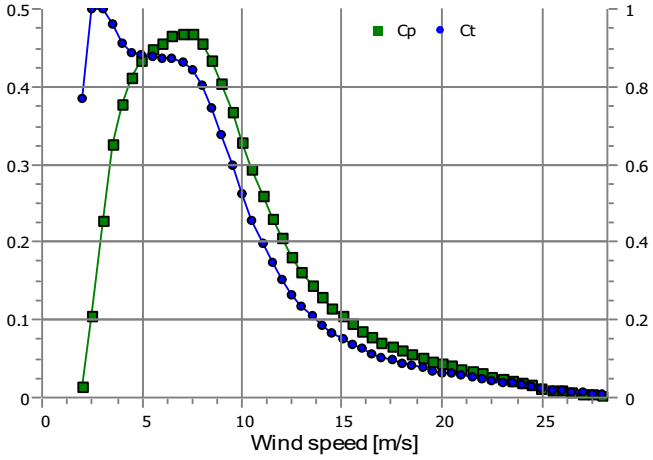
Data used in calculation, Air density: 1.127 kg/m³ IEC 61400-12 method (only recommended for small corrections e.g. <5%)

Wind speed [m/s]	Power [kW]	Cp	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	1.0	0.01	1.50- 2.50	4.5	4.5	0.0
3.0	52.0	0.23	2.50- 3.50	56.1	60.6	0.6
4.0	205.0	0.38	3.50- 4.50	214.2	274.8	2.8
5.0	459.0	0.43	4.50- 5.50	509.9	784.7	8.0
6.0	836.0	0.46	5.50- 6.50	856.0	1 640.7	16.7
7.0	1 361.0	0.47	6.50- 7.50	1 174.2	2 814.9	28.6
8.0	1 981.0	0.46	7.50- 8.50	1 350.6	4 165.5	42.4
9.0	2 496.0	0.40	8.50- 9.50	1 293.3	5 458.8	55.5
10.0	2 791.0	0.33	9.50-10.50	1 103.1	6 561.9	66.7
11.0	2 937.0	0.26	10.50-11.50	876.6	7 438.5	75.6
12.0	2 998.0	0.20	11.50-12.50	664.4	8 102.9	82.4
13.0	3 000.0	0.16	12.50-13.50	515.0	8 617.8	87.6
14.0	3 000.0	0.13	13.50-14.50	390.3	9 008.2	91.6
15.0	3 000.0	0.10	14.50-15.50	285.3	9 293.5	94.5
16.0	3 000.0	0.09	15.50-16.50	199.4	9 492.8	96.5
17.0	3 000.0	0.07	16.50-17.50	126.7	9 619.5	97.8
18.0	3 000.0	0.06	17.50-18.50	103.9	9 723.4	98.9
19.0	3 000.0	0.05	18.50-19.50	63.9	9 787.3	99.5
20.0	2 995.0	0.04	19.50-20.50	29.5	9 816.8	99.8
21.0	2 921.0	0.04	20.50-21.50	12.9	9 829.7	100.0
22.0	2 780.0	0.03	21.50-22.50	3.3	9 833.0	100.0
23.0	2 555.0	0.02	22.50-23.50	0.5	9 833.5	100.0
24.0	2 262.0	0.02	23.50-24.50	0.3	9 833.8	100.0
25.0	1 730.0	0.01	24.50-25.50	0.0	9 833.8	100.0
26.0	1 314.0	0.01	25.50-26.50	0.0	9 833.8	100.0
27.0	969.0	0.01	26.50-27.50	0.0	9 833.8	100.0
28.0	679.0	0.00	27.50-28.50	0.0	9 833.8	100.0

Power curve
For air density: 1.127 kg/m³ and reference climate data



Cp and Ct curve
For air density: 1.127 kg/m³ and reference climate data



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2021-10-11 16:28/3.4.415

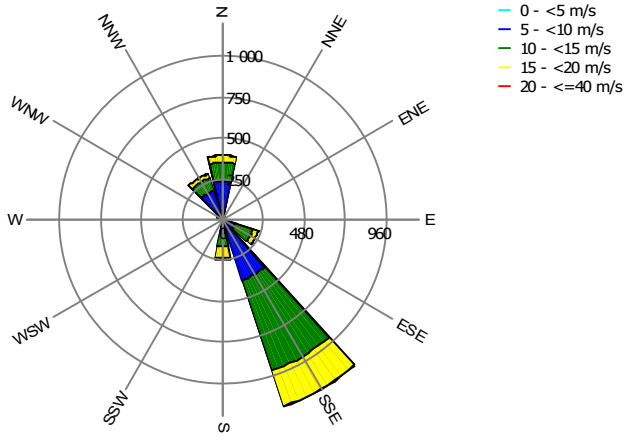
PARK - Wind Data Analysis

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH**Wind data:** A - T01 SF 1.01273885; Hub height: 110.2

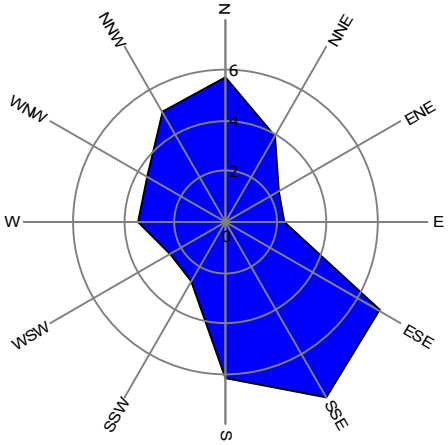
Site coordinates
UTM (north)-WGS84 Zone: 32
East: 454 823 North: 4 919 080
WEC_01 - ENERCON GmbH E-138 EP3 E3 dep3MW 138.3 !O! hub: 110.2 m
(TOT: 179.4 m) (52)

Sector	Wind gradient exponent	Sum	0.00 - 0.50	0.50 - 1.50	1.50 - 2.50	2.50 - 3.50	3.50 - 4.50	4.50 - 5.50	5.50 - 6.50	6.50 - 7.50	7.50 - 8.50	8.50 - 9.50	9.50 - 10.50	10.50 - 11.50	11.50 - 12.50	12.50 - 13.50	13.50 - 14.50	14.50 - 15.50	15.50 - 16.50	16.50 - 17.50	17.50 - 18.50	18.50 - 19.50	19.50 - 20.50	20.50 - 21.50	21.50 - 22.50	22.50 - 23.50	23.50 - 24.50
0 N	0.000	29907.00	184.00	720.00	1787.00	3066.00	4304.00	5386.00	4567.00	3410.00	2375.00	1574.00	952.00	621.00	346.00	225.00	134.00	61.00	70.00	62.00	32.00	20.00	8.00	2.00	1.00		
1 NNE	0.000	4609.00	149.00	446.00	668.00	836.00	846.00	787.00	427.00	196.00	103.00	69.00	53.00	21.00	6.00			2.00									
2 ENE	0.000	1558.00	125.00	384.00	485.00	276.00	135.00	65.00	37.00	11.00	13.00	20.00	6.00	1.00													
3 E	0.000	1360.00	123.00	382.00	411.00	216.00	98.00	42.00	30.00	28.00	9.00	8.00	5.00	4.00	4.00												
4 ESE	0.000	9193.00	133.00	372.00	483.00	631.00	794.00	926.00	1000.00	1075.00	843.00	755.00	608.00	491.00	377.00	253.00	190.00	109.00	69.00	57.00	21.00	5.00	1.00				
5 SSE	0.000	38577.00	190.00	473.00	782.00	1240.00	2373.00	3929.00	4957.00	5053.00	4523.00	3759.00	2994.00	2343.00	1859.00	1417.00	1027.00	665.00	481.00	319.00	127.00	57.00	7.00	1.00	1.00		
6 S	0.000	11830.00	137.00	420.00	721.00	1271.00	1692.00	1773.00	1592.00	1169.00	759.00	541.00	371.00	303.00	254.00	204.00	162.00	150.00	93.00	78.00	63.00	35.00	20.00	13.00	3.00	4.00	2.00
7 SSW	0.000	1704.00	142.00	351.00	394.00	380.00	233.00	91.00	55.00	23.00	12.00	5.00	9.00	3.00	2.00	1.00	2.00	1.00									
8 WSW	0.000	1078.00	97.00	266.00	273.00	213.00	112.00	49.00	23.00	18.00	9.00	6.00	5.00		1.00	2.00	2.00	1.00	1.00								
9 W	0.000	2476.00	161.00	448.00	519.00	455.00	255.00	186.00	94.00	85.00	100.00	86.00	46.00	21.00	10.00	8.00	2.00										
10 WNW	0.000	6851.00	224.00	804.00	1418.00	1481.00	1014.00	760.00	505.00	313.00	146.00	70.00	46.00	17.00	16.00	11.00	13.00	7.00	2.00	4.00							
11 NNW	0.000	29005.00	307.00	1306.00	2924.00	4389.00	4916.00	4402.00	3536.00	2737.00	1766.00	1000.00	636.00	387.00	246.00	156.00	104.00	85.00	36.00	32.00	21.00	17.00	2.00				
Sum		138148.00	1972.00	6372.00	10865.00	14454.00	16772.00	18396.00	16823.00	14118.00	10658.00	7893.00	5731.00	4212.00	3121.00	2277.00	1636.00	1081.00	752.00	552.00	264.00	134.00	38.00	16.00	5.00	4.00	2.00

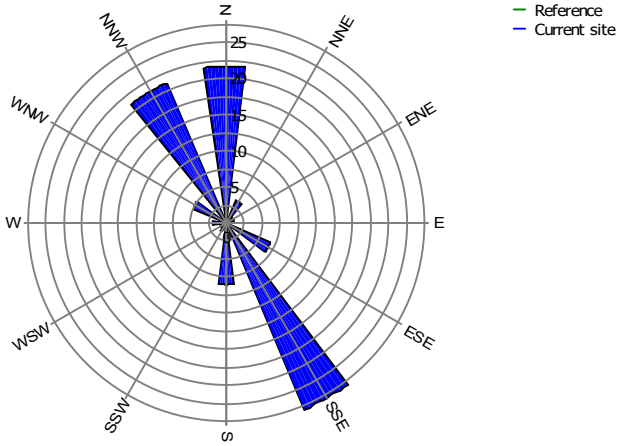
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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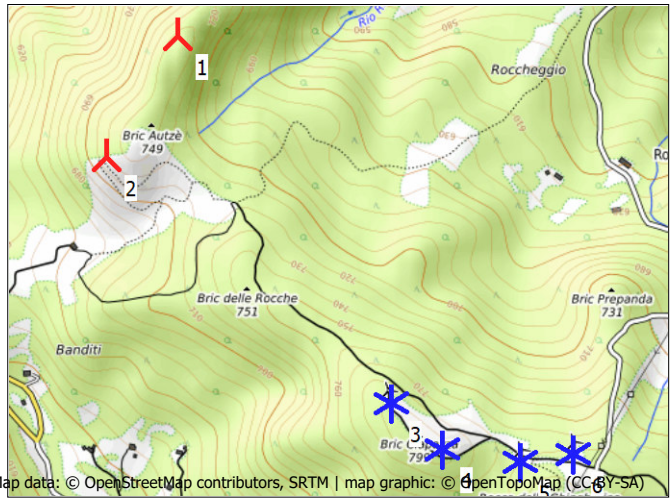
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PARK - WTG distances

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH

WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters
	[m]		[m]	[m]	
1	730.0	2	718.8	372	2.7
2	718.8	1	730.0	372	2.7
3	790.0	4	790.0	182	3.4
4	790.0	3	790.0	182	3.4
5	770.0	6	770.9	141	2.7
6	770.9	5	770.0	141	2.7
Min	**718.8**		**718.8**	**141**	**2.7**
Max	**790.0**		**790.0**	**372**	**3.4**



Scale 1:20 000

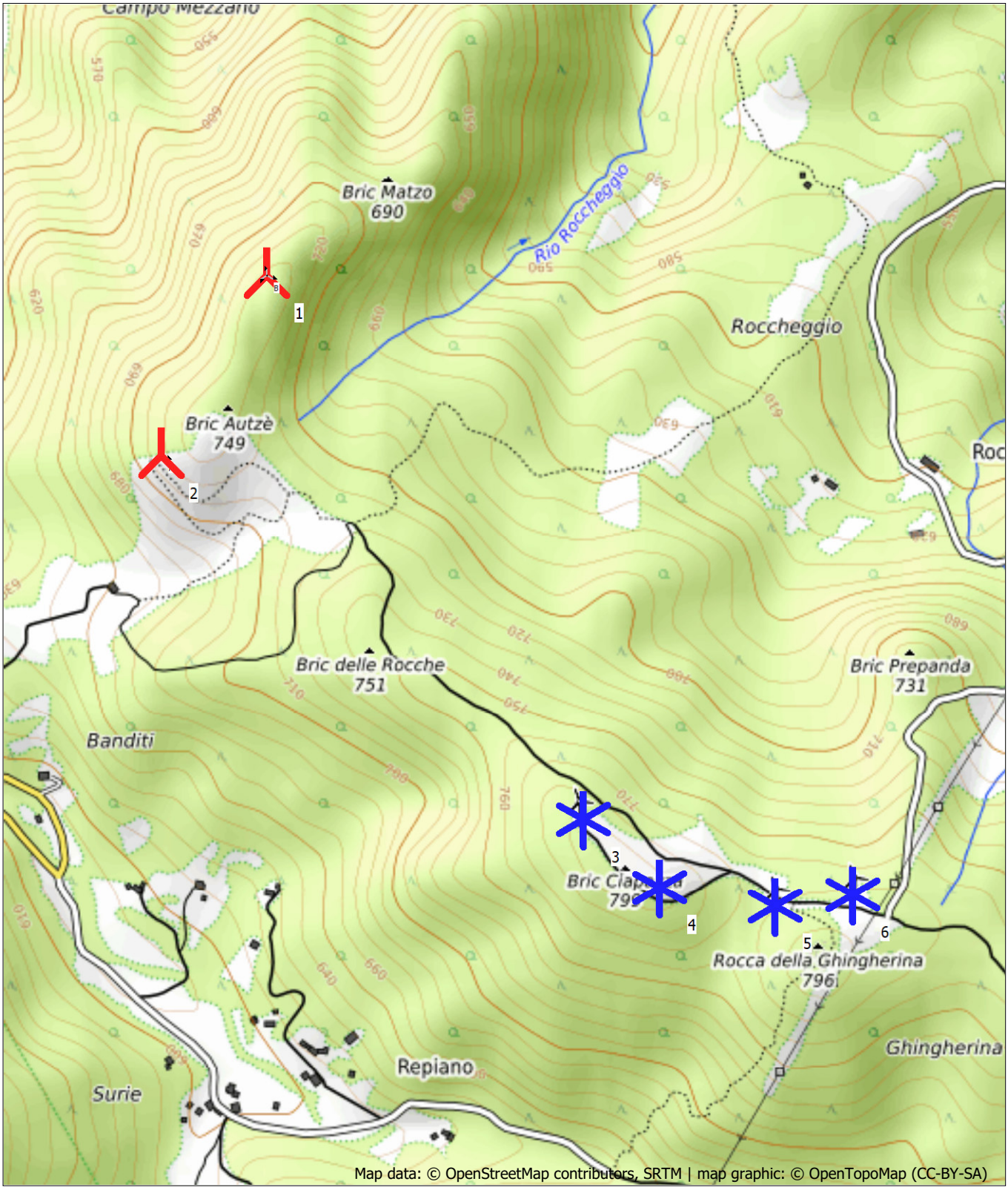
New WTG Existing WTG

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PARK - Map

Calculation: Energy Yield Estimation: 2xE-138 EP3 E3 dep3MW with 111mHH



0 100 200 300 400 m

Map: OpenTopoMap.org , Print scale 1:10 000, Map center UTM (north)-WGS84 Zone: 32 East: 455 439 North: 4 918 834

New WTG Existing WTG Meteorological Data

3a) Site Suitability Summary

The site suitability assessment presents the results of an evaluation of the site wind data in relation to the design parameter of the referring turbine type according to the guideline IEC 61400-1. The table below shows an overview of the results of the site suitability assessment. For turbine and parameter specific results please refer to "3b) Parameter Overview Table (POT)".

The investigated parameters are:

- Annual average wind speed distribution,
- Extreme 10 min average wind speed within 50 years,
- Extreme gust wind speed within 50 years,
- Ambient representative turbulence intensity,
- Effective turbulence intensity,
- Average wind shear exponent,
- Average flow inclination.

The following parameters are not investigated: Ultimate turbulence intensity, extreme wind direction change, extreme operation gust and extreme direction change with coherent gust.

Running WEC No.	Turbine type	Power [kW]	Hub Height [m]	IEC Wind Class	Sector manage-ment required	Site Suitability Results
1, 2	E-138 EP3 E3	3000	110.2	S	No	No concerns

Assuming that
- the data provided by the client are correct and duly reflect the wind conditions prevailing at the site,
- the final layout of the WECs at the site corresponds to the layout currently proposed by the client and analysed in this report,
- the load simulation model and related assumed load limits will not change, and
- in case of sector management the proposed sector management strategy is applied,

we confirm that in terms of wind-related site suitability for the design lifetime of 25 years, we have no concerns in respect of the installation and operation of the WECs at the site.

The methodology used for the site suitability assessment is shortly described in Annex B. The limits for investigated wind parameters are presented in Annex C.

3b) Parameter Overview Table (POT)

Running WEC No.	WEC / Mast	Coordinate system: UTM (north)-WGS84 Zone: 32			Wind turbine type	Power [kW]	(Hub) Height [m]	IEC Wind Class	Min. WEC distance [RD of closest WEC]	Air density ρ [kg/m³]	Normalized wind speed threshold [m/s]	Annual average wind speed V_{ave} [m/s]		Extreme 10 min average wind speed V_{50} [m/s]		Extreme gust wind speed V_{e50} [m/s]		Ambient characteristic/ representative turbulence: I_{char}/I_{rep}	Effective turbulence including wake: I_{eff}	Wind shear exponent α [-]		Flow inclination angle FI [°]		Result
		X (East)	Y (North)	Z height asl [m]																			For details please refer to "3c)"
	E-138 EP3 E3	Design limit of certain WEC type:					110.2	S						37.5		52.5		1 - 3		0.2		-8 < FI < 8		
1	WMM PONT_0721	454931	4919169	730	-	-	40.0	-	-	1.135	-	5.2		26.5		35.2		4	-	0.08		n.s.		-
1	WEC_02	455013	4919400	730	E-138 EP3 E3	3000	110.2	S	2.7	1.127	7.5	6.1		30.9		41.1		3	3	0.10		-0.3		[A][C]
2	WEC_01	454823	4919080	719	E-138 EP3 E3	3000	110.2	S	2.7	1.129	7.5	5.8		29.4		39.1		4	4	0.13		-0.7		[B][C]

n.s. = not specified

Please note that the colours adjacent to parameter values indicate the relation to the design value, see Annex C for a detailed explanation. Fields in the "Result"-column marked with yellow indicate that the investigation for such items has not been finalised. Accordingly, the results in this report may be subject to further adjustments.

3c) Results related to the POT

Results	
[A]	All investigated wind parameters are within the design limits of the WEC.
[B]	**Effective turbulence** exceeds IEC-turbulence-design limits.
[C]	The **Pseudo Equivalent Load Ratio model (PEqLR+)** has shown that the site suitability can be assured for this turbine position. The site wind conditions met the requirements of the PEqLR+ model.The parameters included in the PEqLR+ model are: i) the annual distribution of wind speed (histogram), ii) average air density and iii) effective turbulence intensity at this WEC location.

Annex A: Yield Estimation Losses

Wake Losses

The wake effect is the aggregated influence on the energy production of the wind farm which results from the changes in wind speed caused by the impact of the turbines on each other. The wake effect is calculated by means of N.O. Jensen Wake model.

Internal Wake Losses

Wake effects internal to the wind farm and generated by wind turbines (i.e. planned wind farm and, in case of wind farm extension, the existing wind farm which is going to be extended) as part of energy prediction analysis and which will have impact on the wind farm's energy production.

External Wake Losses

Wake effects generated externally to the wind farm area but which will have an impact on the wind farm's energy production.

Annex B: Site Suitability Assessment

In this annex the methods of the site suitability assessment are described for each evaluated parameter. Depending on the certification of the referring turbine types an extended design range is used for the evaluation of some parameters.

1. Annual Average Wind Speed Distribution V_{ave}

The annual average wind speed is measured at mast position and extrapolated to each turbine position at hub height. The values are long term and air density adjusted. For evaluation it is compared to the "normalized wind speed threshold" which is the design wind speed reduced by a certain value depending on the site-specific Weibull distribution. In case the "normalized wind speed threshold" wasn't applied, the average wind speed distribution between V_{ave} and 2 V_{ave} is compared to the design wind speed distribution of the WEC type.

2. Extreme Wind Speeds V_{50}/V_{e50}

The extreme 10 min average wind speed V_{50} is calculated by the "method of independent storms" based on the measurement data (10 min average wind speed). As no gust wind speed was recorded, the extreme gust wind speed V_{e50} at mast positions is calculated by estimating a gust factor for high wind speeds applying the Wieringa formula based on measured turbulence intensity. The values are air density adjusted and extrapolated to each turbine position using the ratio of average wind speeds at mast and turbine positions and compared to the design values.

3. Ambient Turbulence Intensity I_{char}/I_{rep}

The ambient turbulence intensity is measured at mast position and extrapolated to each turbine position using the wind speed ratio. Depending on the IEC design guideline used for certification the characteristic (IEC 61400-1 {ed. 2}) I_{char} or representative (IEC 61400-1 {ed. 3/4}) I_{rep} turbulence intensity is used for the evaluation and compared to the design turbulence category for all required wind bins.

4. Effective Turbulence Intensity I_{eff}

The effective turbulence intensity is calculated for each turbine position using WAT (Version: 4.1) based on the ambient turbulence intensity and frequency data and compared to the design turbulence category for all required wind bins.

5. Wind Shear Exponent α

The energy weighted average wind shear exponent is calculated using the power law. At mast positions it is based on the measurements at all applicable heights and at turbine position it is based on wind speeds at upper and lower tip heights.

6. Flow Inclination FI

The energy weighted average flow inclination is calculated for each turbine position based on E-Wind simulations.

Annex C: Evaluation Limits related to the POT

The limits used for the evaluation depend on the WEC type design according to IEC 61400-1.

Annual average wind speed V_{ave}

	V_{ave}	>	Site spec. normalized wind speed threshold*
	V_{ave}	≤	Site spec. normalized wind speed threshold*

*The site specific threshold values are stated in "3b)" (POT) for each turbine position.

Extreme 10 min ave. wind speed V_{50}

WC-I	V_{50} > 50	m/s
	V_{50} ≤ 50	m/s
WC-II	V_{50} > 42.5	m/s
	V_{50} ≤ 42.5	m/s
WC-III	V_{50} > 37.5	m/s
	V_{50} ≤ 37.5	m/s
WC-S	V_{50} > x	m/s
	V_{50} ≤ x	

Extreme wind speed V_{e50}

WC-I	V_{e50} > 70	m/s
	V_{e50} ≤ 70	m/s
WC-II	V_{e50} > 59.5	m/s
	V_{e50} ≤ 59.5	m/s
WC-III	V_{e50} > 52.5	m/s
	V_{e50} ≤ 52.5	m/s
WC-S	V_{e50} > x	m/s
	V_{e50} ≤ x	m/s

Turbulence

4	= problematic
3	= possibly problematic
2	= increased but o.k.
1	= o.k.

Wind shear exponent α

WEC type design: α = 0.2

α > 0.25 or α < 0.05
0.05 ≤ α ≤ 0.25

WEC type design: α = 0.28

α > 0.32 or α < 0.00
0.25 < α ≤ 0.32 or 0.00 ≤ α < 0.05
0.05 ≤ α ≤ 0.25

WEC type design: α = 0.0, 0.2

α > 0.25 or α < 0.00
0.00 ≤ α < 0.05
0.05 ≤ α ≤ 0.25

WEC type design: α = 0.0, 0.2, 0.3

α > 0.35 or α < 0.00
0.25 < α ≤ 0.35 or 0.00 ≤ α < 0.05
0.05 ≤ α ≤ 0.25

WEC type design: α = 0.0, 0.2, 0.4

α > 0.45 or α < 0.00
0.25 < α ≤ 0.45 or 0.00 ≤ α < 0.05
0.05 ≤ α ≤ 0.25

Flow Inclination angle FI

-8° > FI or FI > 8°
-8° ≤ FI ≤ 8°

WEC / Result

= Layout changes required or cancelation
= Investigation has not been finalized
= No concerns