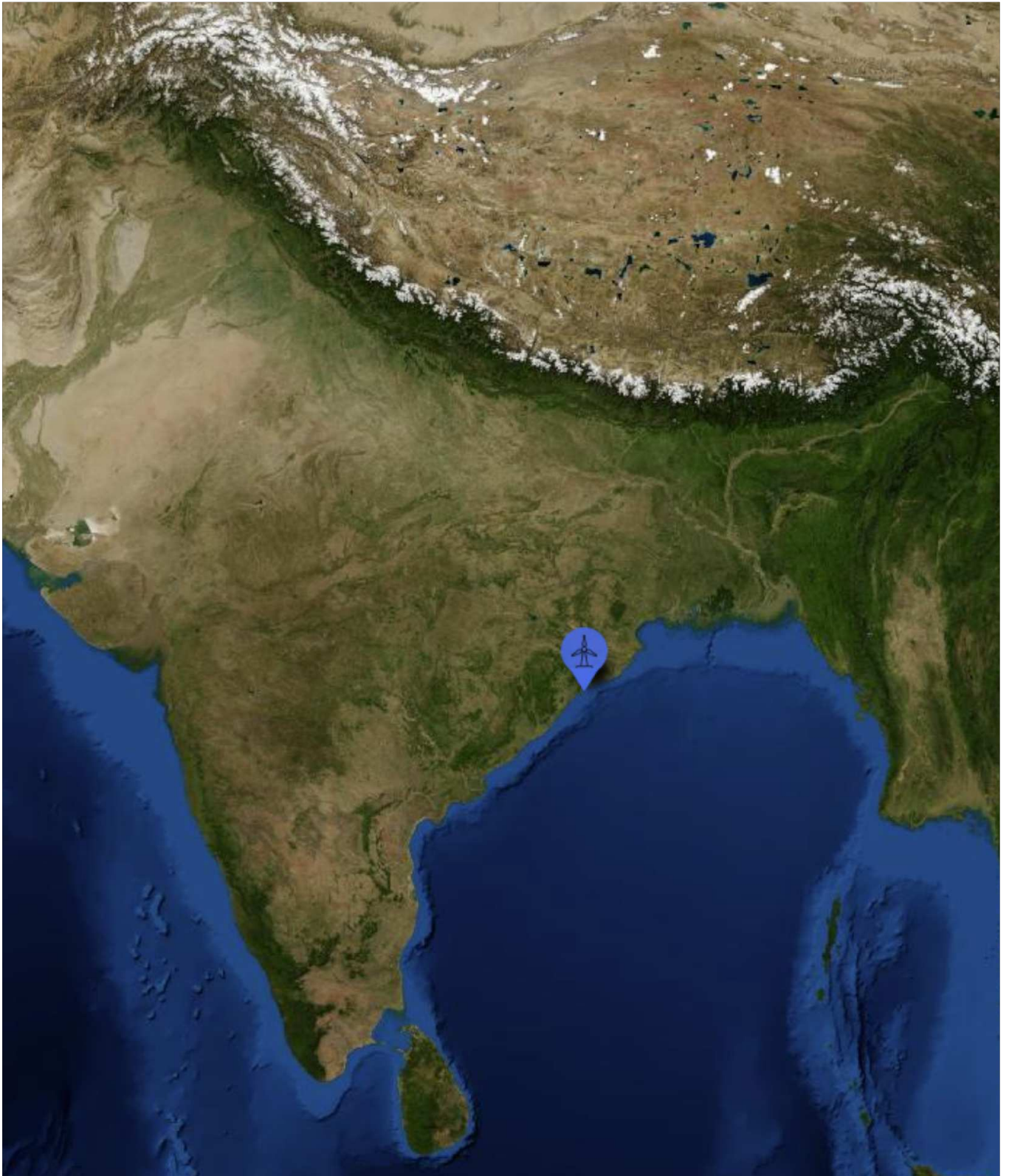


Yield Assessment - Chilika, Orissa



Project:

Site Analysis contract 81274134

Description:

Preliminary energy yield assessment based on meso-scale data. Consult with expert prior to investment decision. This report extract is subject to confidentiality and liability limitation clause of the main report.

Licensed user:

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Mathias Thamhain / mth@emd.dk
Calculated:
21/2/2022 09:08/3.5.508

PARK - Main Result

Calculation: 22-459-002 Chilika - Orissa

Setup

AEP scaled to a full year based on number of samples
Scaling factor from 20,0 years to 1 year: 0,050

Calculation performed in UTM (north)-WGS84 Zone: 43

At the site centre the difference between grid north and true north is: -0,8°

Wake

Wake Model: N.O. Jensen (RISØ/EMD)

Wake decay constant

Reference WTG: 4*VESTAS V150-4.2 4200 150.0 IO! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD

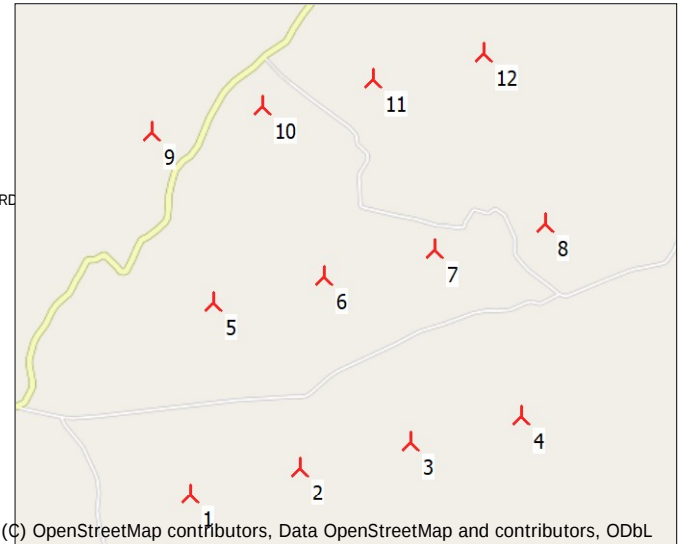
Scaler/wind data

Name EMD Default Measurement Mast Scaler
Terrain scaling Measured Data Scaling (WASP Stability / A-Parameter)
Micro terrain flow model WASP IBZ from Site Data
Used period 1/1/2002 04:30:00 - 1/1/2022 04:30:00
Meteo object(s) EmdWrf_N19.632_E085.363 - Chilika
Displacement height Omnidirectional from objects
WASP version WASP 11 Version 11.06.0028

Power correction

Power curve correction (adjusted IEC method, improved to match turbine control)

	Min	Max	Avg	Corr.	Neg. corr.	Pos. corr.
				[%]	[%]	[%]
Air density						
From air density settings	[°C]	24,7	24,8	24,8		
From air density settings	[hPa]	1000,0	1001,0	1000,7		
Resulting air density	[kg/m³]	1,170	1,170	1,170		
Relative to 15°C at sea level	[%]	95,5	95,5	95,5	-2,9	-2,9
						0,0



(C) OpenStreetMap contributors, Data OpenStreetMap and contributors, ODbL

Scale 1:50.000

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK	Result-8,0% [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Wake loss [%]	Specific results ^{a)}		Full load hours [Hours/year]	Wind speed	
					Capacity factor [%]	Mean WTG result [MWh/y]		free [m/s]	wake reduced [m/s]
Wind farm	151.192,9	139.097,5	159.069,1	5,0	31,5	11.591,5	2.760	6,2	6,0

a) Based on Result-8,0%

Calculated Annual Energy for each of 12 new WTGs with total 50,4 MW rated power

WTG type	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Power curve Creator	Name	Annual Energy		Wake loss [%]	Wind speed	
									Result	Result-8,0%		free	reduced
									[MWh/y]	[MWh/y]		[m/s]	[m/s]
1 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		13.586,0	12.499	1,5	6,30	6,24
2 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		13.256,2	12.196	2,2	6,23	6,15
3 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		13.499,0	12.419	2,1	6,30	6,22
4 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		13.582,5	12.496	1,3	6,29	6,24
5 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.639,8	11.629	4,1	6,13	5,99
6 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.073,7	11.108	7,3	6,09	5,86
7 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.211,6	11.235	7,9	6,15	5,91
8 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.494,3	11.495	7,0	6,20	5,99
9 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.424,8	11.431	2,3	6,01	5,93
10 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		12.067,4	11.102	6,0	6,04	5,85
11 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		11.675,8	10.742	8,9	6,04	5,78
12 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		11.681,8	10.747	9,4	6,06	5,80

WTG siting

	Geo [deg]-WGS84			Z [m]	Row data/Description	Calculation period	
	Longitude	Latitude				Start	End
1 New	85,353470° E	19,618173° N	9,7	76,6°, 750,0 m		1/1/2002	1/1/2022
2 New	85,360428° E	19,619734° N	2,0			1/1/2002	1/1/2022
3 New	85,367386° E	19,621294° N	5,0			1/1/2002	1/1/2022
4 New	85,374344° E	19,622855° N	2,6			1/1/2002	1/1/2022
5 New	85,354939° E	19,629562° N	7,8	76,6°, 750,0 m		1/1/2002	1/1/2022
6 New	85,361897° E	19,631122° N	2,0			1/1/2002	1/1/2022
7 New	85,368856° E	19,632683° N	4,7			1/1/2002	1/1/2022
8 New	85,375814° E	19,634243° N	5,8			1/1/2002	1/1/2022
9 New	85,351086° E	19,639656° N	1,6	76,6°, 750,0 m		1/1/2002	1/1/2022
10 New	85,358045° E	19,641217° N	2,0			1/1/2002	1/1/2022
11 New	85,365004° E	19,642777° N	2,0			1/1/2002	1/1/2022
12 New	85,371963° E	19,644337° N	3,0			1/1/2002	1/1/2022

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Calculated:
21/2/2022 09:08/3.5.508

PARK - Wind Data Analysis

Calculation: 22-459-002 Chilika - Orissa Wind data: 1 - 4*VESTAS V150-4.2 4200 150.0 !O! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD) angle: 77° (5); Hub height: 105,0

Site coordinates

Geo WGS84

East: 85,353470° E North: 19,618173° N

4*VESTAS V150-4.2 4200 150.0 !O! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD) angle: 77° (5)

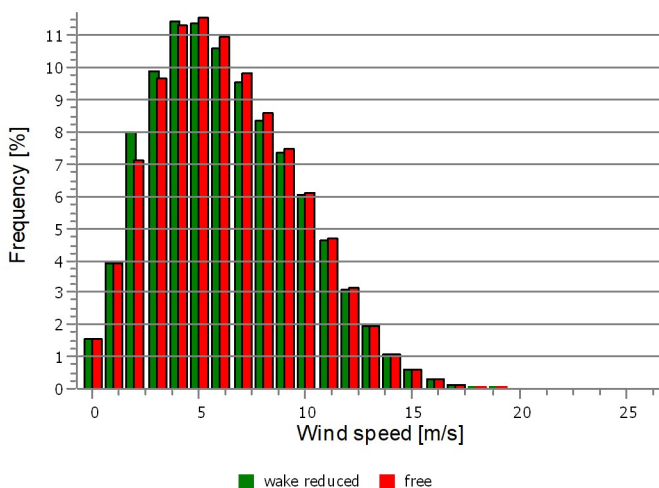
Masts used

Take nearest

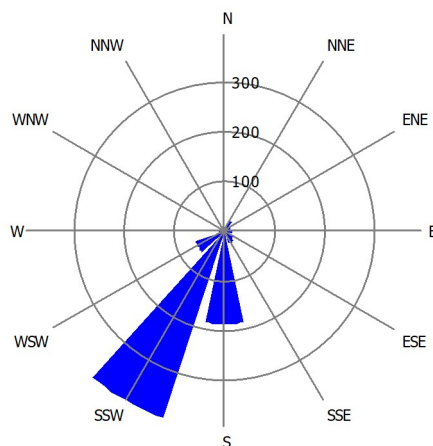
Winddata for site

Sector	Free mean wind speed [m/s]	Wake reduced mean wind speed [m/s]	Frequency [%]
0 N	3,8	3,5	3,5
1 NNE	4,7	4,4	7,2
2 ENE	4,4	4,0	4,5
3 E	4,6	4,3	4,5
4 ESE	4,5	4,5	6,1
5 SSE	4,8	4,8	7,0
6 S	7,6	7,6	17,7
7 SSW	8,3	8,3	32,0
8 WSW	5,7	5,7	9,7
9 W	3,8	3,8	4,1
10 WNW	3,0	3,0	2,0
11 NNW	3,2	3,2	1,6
All	6,3	6,2	100,0

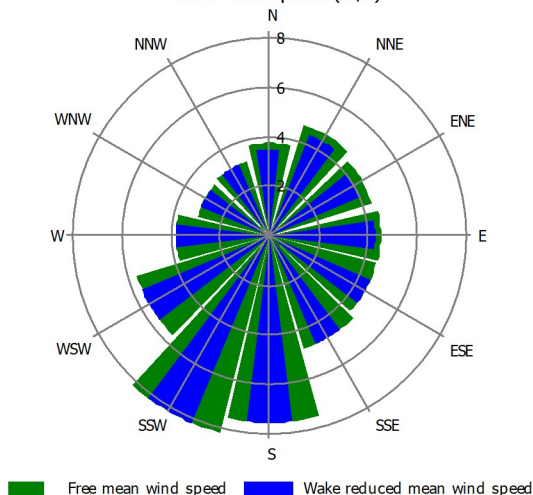
Wind distribution



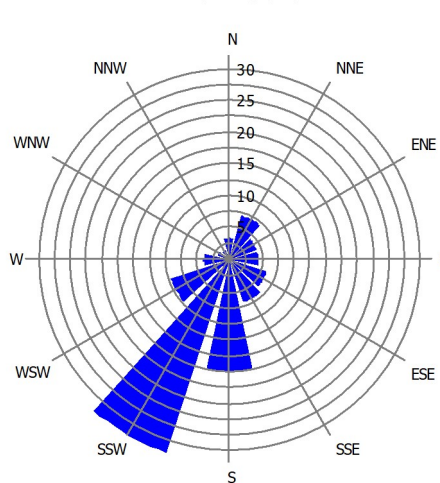
Energy Rose (WTG) (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



Project:

Site Analysis contract 81274134

Description:

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Mathias Thamhain / mth@emd.dk

Calculated:

21/2/2022 09:08/3.5.508

PARK - Time varying AEP

Calculation: 22-459-002 Chilika - Orissa

Windfarm: 50,4 MW based on 12 turbines of type VESTAS V150-4.2 4200 150.0 !O!.

Selection: All new WTGs

Calculated mean yield per month and hour [MWh]. The result includes wake losses and any curtailment losses.

Values are scaled to a full year, see correction factors at main result page.

Hour/Month [MWh]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	132	261	630	952	958	844	718	570	419	193	129	128	5.932
1	113	226	579	935	961	805	696	550	388	204	130	132	5.721
2	122	198	552	906	943	758	686	527	386	210	146	144	5.577
3	138	194	524	842	860	664	582	462	344	213	154	155	5.131
4	151	183	491	840	843	667	585	457	331	218	151	166	5.084
5	145	164	465	819	825	677	586	461	342	220	167	186	5.058
6	142	163	422	761	815	641	611	458	324	217	178	177	4.909
7	156	156	393	726	791	623	580	445	326	227	192	197	4.812
8	150	148	385	682	787	629	606	452	320	222	187	203	4.772
9	148	156	367	709	837	629	582	446	334	214	152	174	4.748
10	117	159	412	809	859	649	602	458	344	207	135	149	4.901
11	109	185	454	872	985	712	628	494	373	201	121	115	5.249
12	125	258	604	1.016	1.088	799	707	552	413	213	126	118	6.020
13	200	369	753	1.132	1.176	902	808	690	523	289	154	141	7.136
14	281	501	902	1.210	1.259	1.008	929	832	637	373	213	204	8.347
15	351	562	946	1.226	1.231	1.044	966	887	642	412	271	262	8.800
16	382	582	933	1.174	1.191	1.049	1.008	892	713	426	290	290	8.929
17	373	542	881	1.107	1.119	998	976	912	654	404	299	285	8.550
18	353	522	866	1.085	1.069	949	887	793	616	373	258	268	8.040
19	328	479	848	1.077	1.053	913	820	759	543	320	241	242	7.623
20	275	436	785	1.031	1.001	921	794	692	498	260	204	223	7.121
21	209	393	745	992	950	865	724	639	412	240	172	198	6.538
22	174	320	694	967	945	835	750	616	395	215	147	157	6.215
23	135	294	661	950	970	833	717	573	385	196	130	139	5.982
Grand Total	4.809	7.449	15.291	22.818	23.517	19.413	17.549	14.619	10.663	6.266	4.347	4.453	151.193

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	4,2	9,3	20,3	31,7	30,9	28,1	23,2	18,4	14,0	6,2	4,3	4,1	16,3
1	3,7	8,1	18,7	31,2	31,0	26,8	22,5	17,7	12,9	6,6	4,3	4,3	15,7
2	3,9	7,1	17,8	30,2	30,4	25,3	22,1	17,0	12,9	6,8	4,9	4,7	15,3
3	4,4	6,9	16,9	28,1	27,7	22,1	18,8	14,9	11,5	6,9	5,1	5,0	14,1
4	4,9	6,5	15,8	28,0	27,2	22,2	18,9	14,7	11,0	7,0	5,0	5,3	13,9
5	4,7	5,9	15,0	27,3	26,6	22,6	18,9	14,9	11,4	7,1	5,6	6,0	13,9
6	4,6	5,8	13,6	25,4	26,3	21,4	19,7	14,8	10,8	7,0	5,9	5,7	13,4
7	5,0	5,6	12,7	24,2	25,5	20,8	18,7	14,4	10,9	7,3	6,4	6,3	13,2
8	4,8	5,3	12,4	22,7	25,4	21,0	19,6	14,6	10,7	7,2	6,2	6,6	13,1
9	4,8	5,6	11,8	23,6	27,0	21,0	18,8	14,4	11,1	6,9	5,1	5,6	13,0
10	3,8	5,7	13,3	27,0	27,7	21,6	19,4	14,8	11,5	6,7	4,5	4,8	13,4
11	3,5	6,6	14,6	29,1	31,8	23,7	20,3	16,0	12,4	6,5	4,0	3,7	14,4
12	4,0	9,2	19,5	33,9	35,1	26,6	22,8	17,8	13,8	6,9	4,2	3,8	16,5
13	6,5	13,2	24,3	37,7	37,9	30,1	26,1	22,3	17,4	9,3	5,1	4,5	19,5
14	9,1	17,9	29,1	40,3	40,6	33,6	30,0	26,8	21,2	12,0	7,1	6,6	22,9
15	11,3	20,1	30,5	40,9	39,7	34,8	31,2	28,6	21,4	13,3	9,0	8,5	24,1
16	12,3	20,8	30,1	39,1	38,4	35,0	32,5	28,8	23,8	13,8	9,7	9,3	24,5
17	12,0	19,3	28,4	36,9	36,1	33,3	31,5	29,4	21,8	13,0	10,0	9,2	23,4
18	11,4	18,6	27,9	36,2	34,5	31,6	28,6	25,6	20,5	12,0	8,6	8,6	22,0
19	10,6	17,1	27,3	35,9	34,0	30,4	26,4	24,5	18,1	10,3	8,0	7,8	20,9
20	8,9	15,6	25,3	34,4	32,3	30,7	25,6	22,3	16,6	8,4	6,8	7,2	19,5
21	6,7	14,0	24,0	33,1	30,7	28,8	23,3	20,6	13,7	7,7	5,7	6,4	17,9
22	5,6	11,4	22,4	32,2	30,5	27,8	24,2	19,9	13,2	6,9	4,9	5,1	17,0
23	4,4	10,5	21,3	31,7	31,3	27,8	23,1	18,5	12,8	6,3	4,3	4,5	16,4
Grand Total	6,5	11,1	20,6	31,7	31,6	27,0	23,6	19,6	14,8	8,4	6,0	6,0	17,3

PARK - Time varying AEP

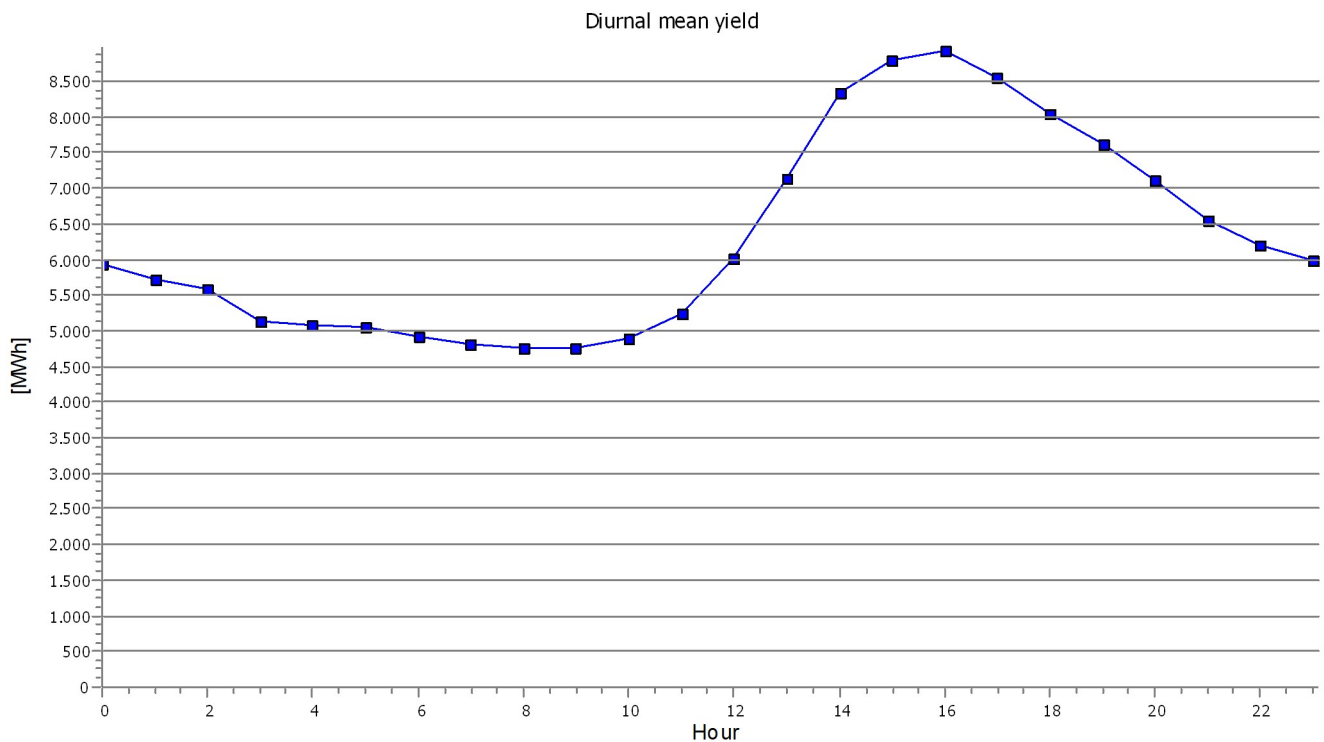
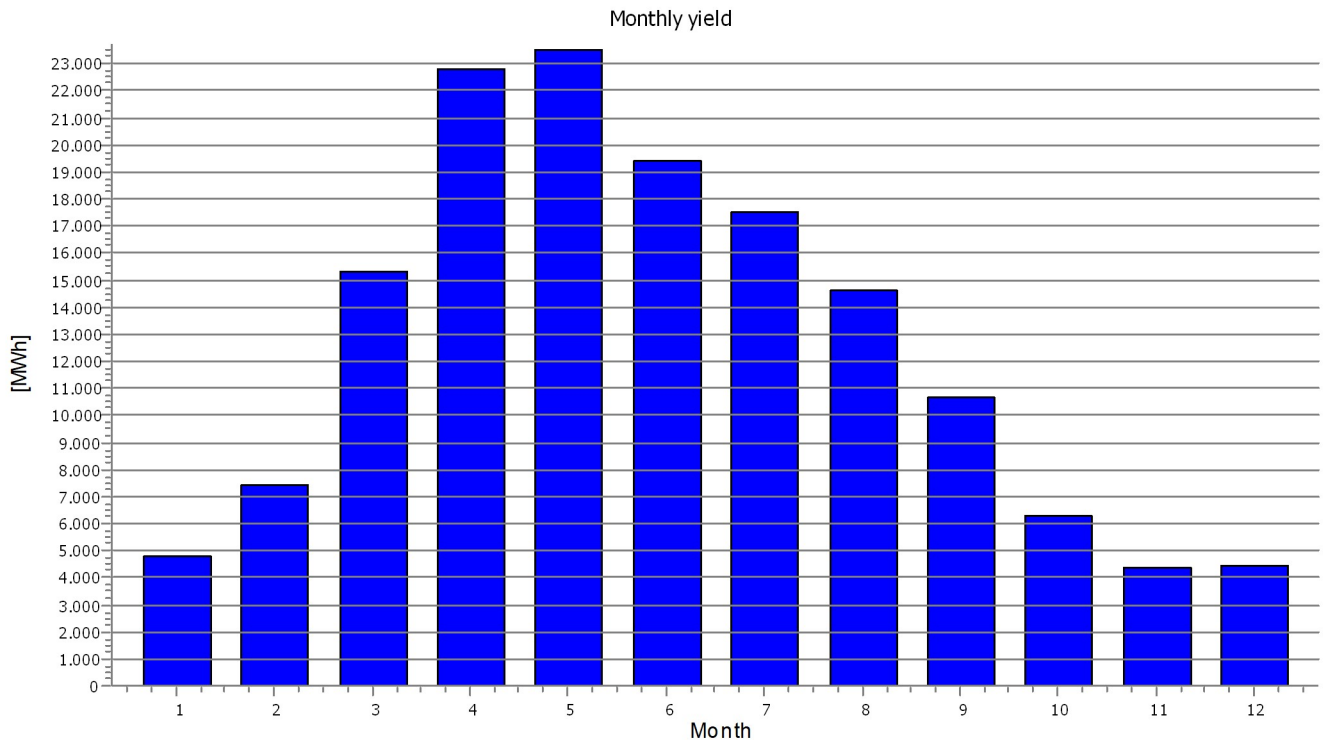
Calculation: 22-459-002 Chilika - Orissa

Windfarm: 50,4 MW based on 12 turbines of type VESTAS V150-4.2 4200 150.0 !O!.

Selection: All new WTGs

Calculated mean yield per month and hour [MWh]. The result includes wake losses and any curtailment losses.

Values are scaled to a full year, see correction factors at main result page.



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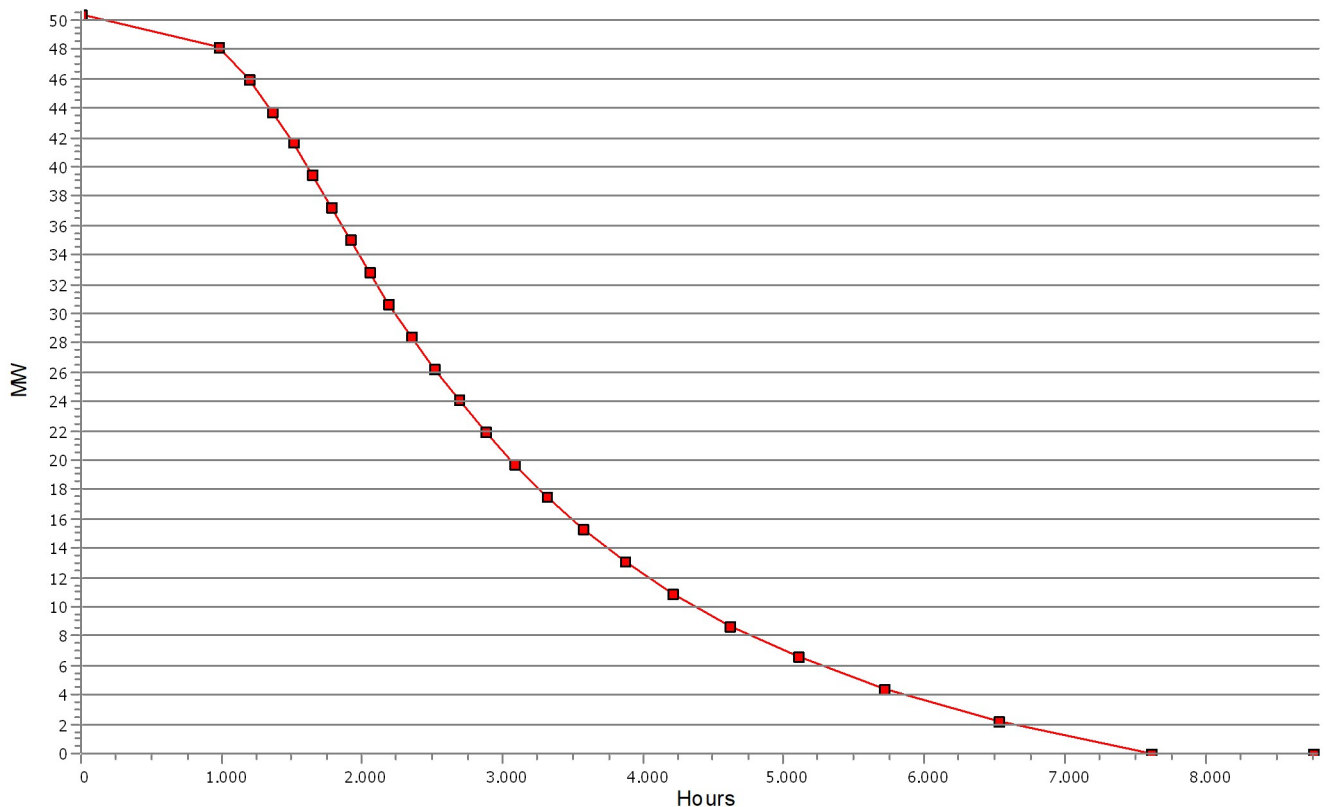
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Windfarm: 50,4 MW based on 12 turbines of type VESTAS V150-4.2 4200 150.0 !O!.

Selection: All new WTGs

Hours	Hours [%]	Hours accumulated	Power [MW]	Power (MW/WTG)
0	0,0	0	50,4	4,2
971	11,1	971	48,2 - 50,4	4,0 - 4,2
222	2,5	1193	46,0 - 48,2	3,8 - 4,0
167	1,9	1359	43,8 - 46,0	3,7 - 3,8
145	1,7	1504	41,6 - 43,8	3,5 - 3,7
138	1,6	1642	39,4 - 41,6	3,3 - 3,5
139	1,6	1780	37,3 - 39,4	3,1 - 3,3
135	1,5	1915	35,1 - 37,3	2,9 - 3,1
136	1,6	2051	32,9 - 35,1	2,7 - 2,9
140	1,6	2191	30,7 - 32,9	2,6 - 2,7
155	1,8	2346	28,5 - 30,7	2,4 - 2,6
166	1,9	2512	26,3 - 28,5	2,2 - 2,4
176	2,0	2688	24,1 - 26,3	2,0 - 2,2
190	2,2	2878	21,9 - 24,1	1,8 - 2,0
205	2,3	3083	19,7 - 21,9	1,6 - 1,8
228	2,6	3312	17,5 - 19,7	1,5 - 1,6
254	2,9	3566	15,3 - 17,5	1,3 - 1,5
300	3,4	3865	13,1 - 15,3	1,1 - 1,3
343	3,9	4209	11,0 - 13,1	0,9 - 1,1
402	4,6	4611	8,8 - 11,0	0,7 - 0,9
489	5,6	5100	6,6 - 8,8	0,5 - 0,7
615	7,0	5715	4,4 - 6,6	0,4 - 0,5
808	9,2	6523	2,2 - 4,4	0,2 - 0,4
1088	12,4	7611	0,0 - 2,2	0,0 - 0,2
1155	13,2	8766	0,0	0,0

Duration curve 50,4 MW WindFarm



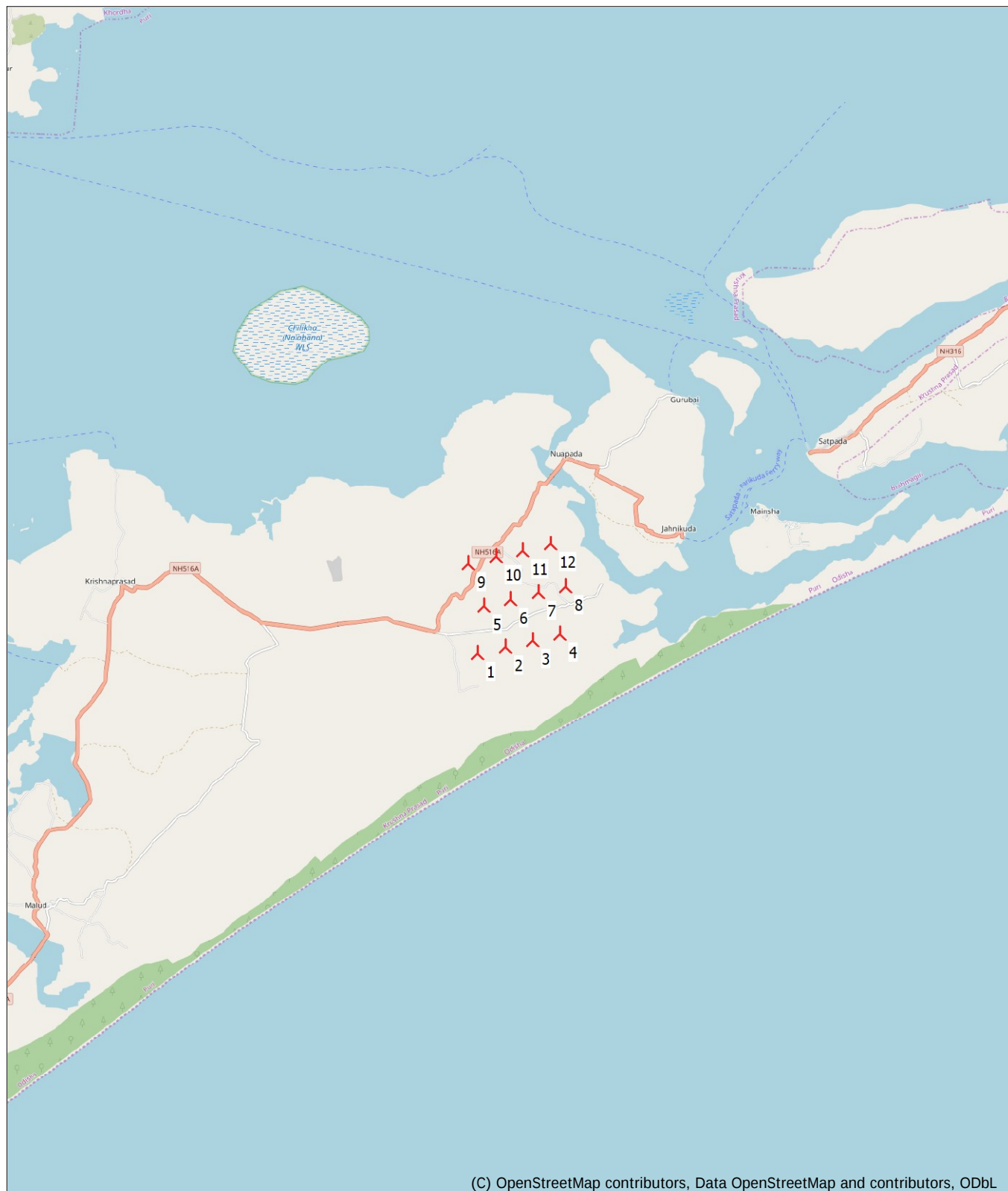
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Calculated:
21/2/2022 09:08/3.5.508

PARK - Map

Calculation: 22-459-002 Chilika - Orissa



New WTG

Map: EMD OpenStreetMap , Print scale 1:150.000, Map center Geo WGS84 East: 85,363450° E North: 19,631255° N

Heat Maps - Chilika, Orissa

AEP [MWh]							
Hour/Month	00:00 - 04:00	04:00 - 08:00	08:00 - 12:00	12:00 - 16:00	16:00 - 20:00	20:00 - 00:00	TOTAL
1	464	547	482	880	1,322	730	4,424
2	808	612	597	1,554	1,954	1,327	6,853
3	2,103	1,629	1,488	2,948	3,245	2,655	14,068
4	3,345	2,894	2,826	4,217	4,088	3,624	20,993
5	3,424	3,013	3,191	4,373	4,078	3,558	21,635
6	2,825	2,399	2,409	3,454	3,596	3,178	17,860
7	2,467	2,174	2,225	3,137	3,396	2,746	16,145
8	1,940	1,676	1,702	2,725	3,088	2,318	13,450
9	1,414	1,218	1,261	2,037	2,324	1,555	9,810
10	754	812	776	1,184	1,401	838	5,764
11	514	633	548	702	1,001	600	3,999
12	514	667	590	667	998	660	4,097
Total	20,572	18,274	18,095	27,879	30,491	23,787	1,39,098

Capacity factor [Per cent]							
Hour/Month	00:00 - 04:00	04:00 - 08:00	08:00 - 12:00	12:00 - 16:00	16:00 - 20:00	20:00 - 00:00	TOTAL
1	7.4%	8.7%	7.7%	14.1%	21.2%	11.7%	11.8%
2	14.3%	10.8%	10.6%	27.5%	34.6%	23.5%	20.2%
3	33.7%	26.1%	23.8%	47.2%	51.9%	42.5%	37.5%
4	55.3%	47.8%	46.7%	69.7%	67.6%	59.9%	57.9%
5	54.8%	48.2%	51.1%	70.0%	65.2%	56.9%	57.7%
6	46.7%	39.7%	39.8%	57.1%	59.5%	52.5%	49.2%
7	39.5%	34.8%	35.6%	50.2%	54.3%	43.9%	43.1%
8	31.0%	26.8%	27.2%	43.6%	49.4%	37.1%	35.9%
9	23.4%	20.1%	20.9%	33.7%	38.4%	25.7%	27.0%
10	12.1%	13.0%	12.4%	18.9%	22.4%	13.4%	15.4%
11	8.5%	10.5%	9.1%	11.6%	16.6%	9.9%	11.0%
12	8.2%	10.7%	9.4%	10.7%	16.0%	10.6%	10.9%
Total	28.0%	24.8%	24.6%	37.9%	41.4%	32.3%	31.5%