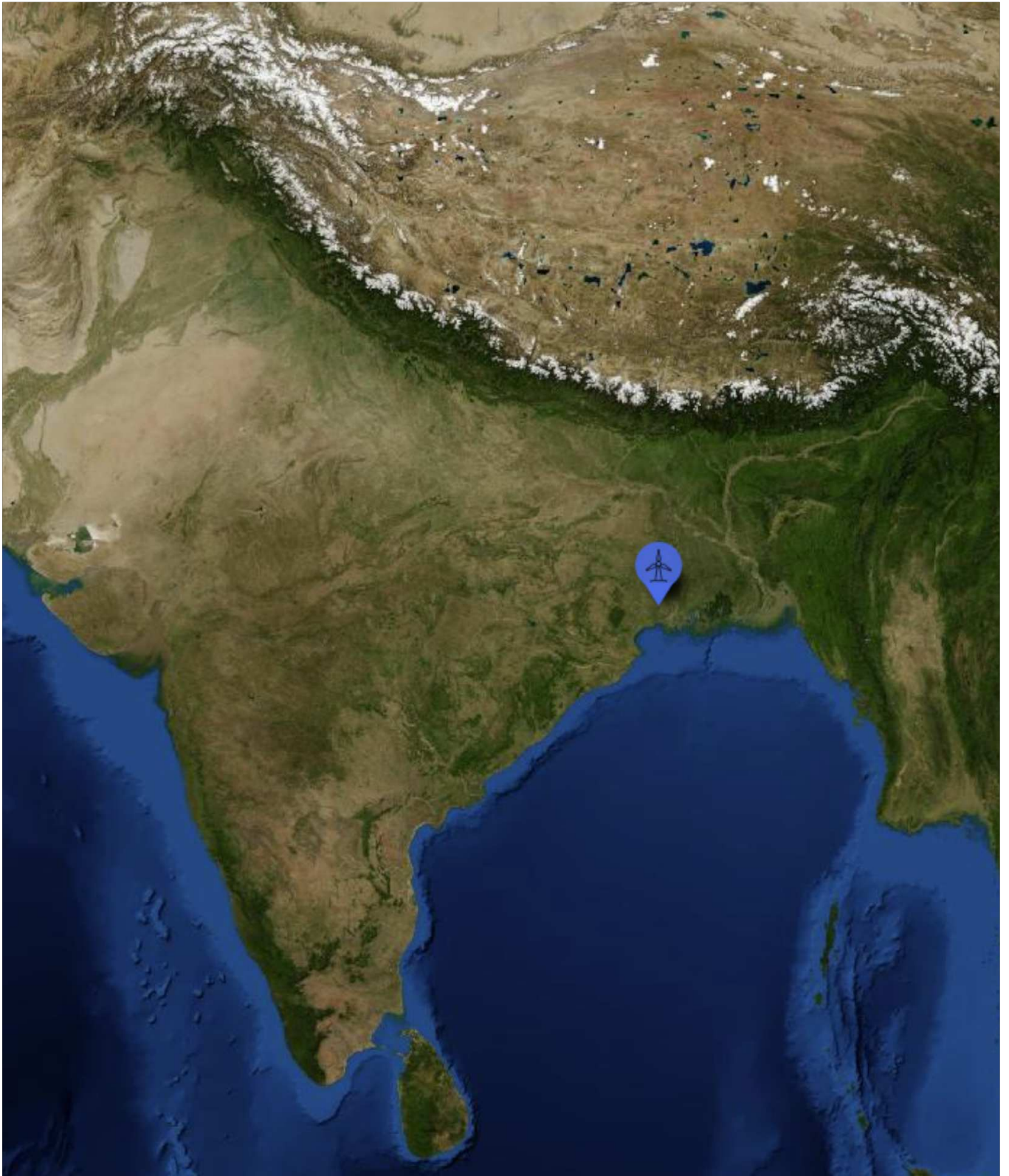


Yield Assessment - Kharagpur, West Bengal



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 09:51/3.5.508

PARK - Main Result

Calculation: 22-459-003 Kharagpur WB

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:

Wake decay constant: 0,075 DTU default onshore

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_N22.143_E087.653 - WB

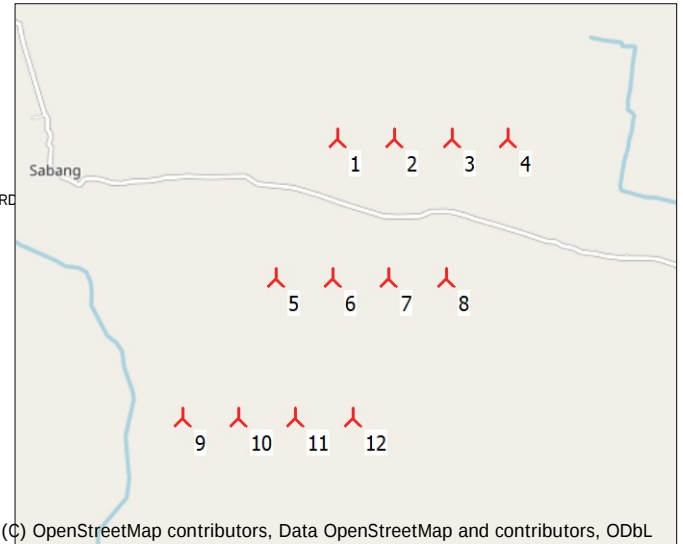
Displacement height: Omnidirectional from objects

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	24,7			
From air density settings [hPa]	1000,1	1000,7	1000,3			
Resulting air density [kg/m³]	1,170	1,170	1,170			
Relative to 15°C at sea level [%]	95,5	95,5	95,5	-4,0	-4,0	0,0



New WTG

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		Full load hours [Hours/year]	Wind speed		
					Capacity factor [%]	Mean WTG result [MWh/y]		free [m/s]	wake [m/s]	reduced [m/s]
Wind farm	98.760,1	90.859,3	104.641,5	5,6	20,6	7.571,6	1.803	5,1		4,9

*) 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 [MWh/y]	Result-8,0% [MWh/y]		free [m/s]	reduced [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		7.984,8	7.346	8,1	5,06	4,91
2 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		7.999,0	7.359	9,1	5,08	4,91
3 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		7.918,2	7.285	8,2	5,04	4,89
4 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.354,4	7.686	4,9	5,08	4,99
5 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.116,5	7.467	7,7	5,08	4,93
6 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.057,9	7.413	8,7	5,09	4,91
7 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.008,8	7.368	7,8	5,05	4,89
8 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.439,8	7.765	4,2	5,09	4,99
9 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.540,1	7.857	1,4	5,05	5,01
10 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.508,6	7.828	2,3	5,06	5,00
11 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.324,1	7.658	2,7	5,03	4,95
12 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.508,0	7.827	2,2	5,06	5,00

WTG siting

	Geo [deg]-WGS84			Z [m]	Row data/Description	Calculation period	
	Longitude	Latitude				Start	End
1 New	87,630730° E	22,181047° N	8,4	90,0°, 750,0 m		1/1/2002	1/1/2022
2 New	87,638005° E	22,181047° N	9,0			1/1/2002	1/1/2022
3 New	87,645279° E	22,181047° N	4,8			1/1/2002	1/1/2022
4 New	87,652554° E	22,181047° N	9,2			1/1/2002	1/1/2022
5 New	87,622773° E	22,164569° N	9,5	90,0°, 750,0 m		1/1/2002	1/1/2022
6 New	87,630047° E	22,164569° N	8,9			1/1/2002	1/1/2022
7 New	87,637322° E	22,164569° N	4,0			1/1/2002	1/1/2022
8 New	87,644596° E	22,164569° N	8,7			1/1/2002	1/1/2022
9 New	87,610757° E	22,148034° N	4,1	90,0°, 750,0 m		1/1/2002	1/1/2022
10 New	87,618030° E	22,148034° N	7,4			1/1/2002	1/1/2022
11 New	87,625304° E	22,148034° N	3,9			1/1/2002	1/1/2022
12 New	87,632577° E	22,148034° N	4,9			1/1/2002	1/1/2022

Project:

Site Analysis contract 81274134

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Mathias Thamhain / mth@emd.dk
Calculated:
21/2/2022 09:51/3.5.508

PARK - Wind Data Analysis

Calculation: 22-459-003 Kharagpur WBWind 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: 90° (8); Hub height: 105,0

Site coordinates

Geo WGS84

East: 87,630730° E North: 22,181047° N

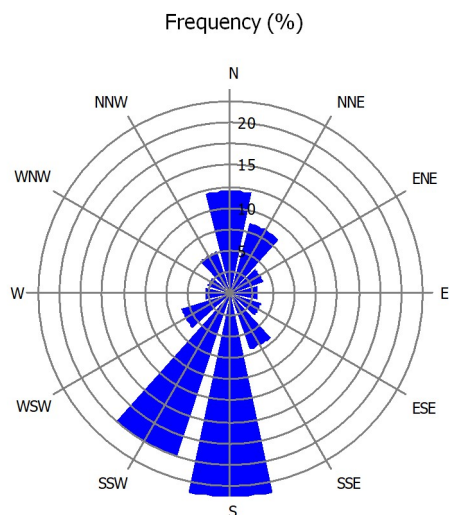
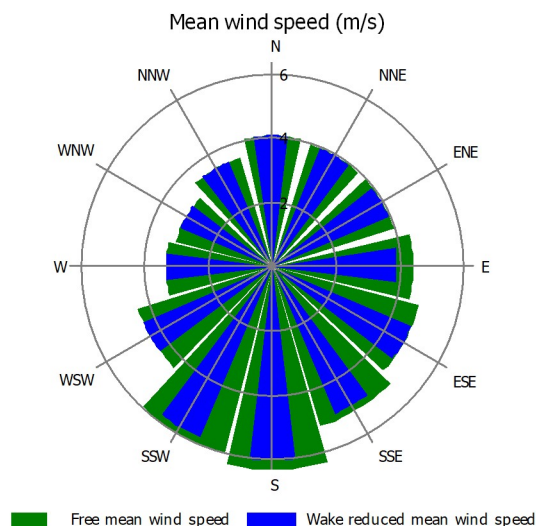
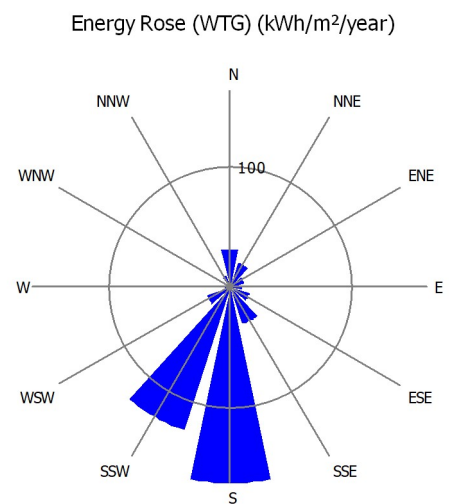
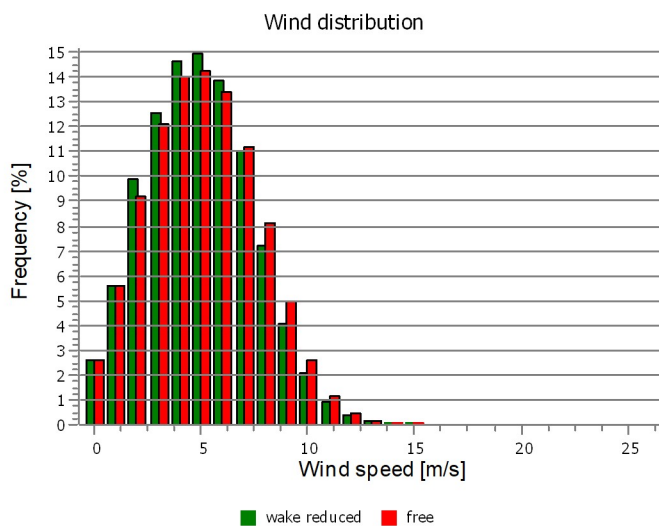
4*VESTAS V150-4.2 4200 150.0 !O! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD) angle: 90° (8)

Masts used

Take nearest

Winddata for site

Sector	Free mean wind speed [m/s]	Wake reduced mean wind speed [m/s]	Frequency [%]
0 N	4,1	4,1	12,1
1 NNE	4,0	4,0	8,6
2 ENE	4,0	4,0	4,1
3 E	4,4	3,9	3,2
4 ESE	4,8	4,7	3,8
5 SSE	5,2	5,0	7,0
6 S	6,3	6,0	23,9
7 SSW	6,0	5,8	20,2
8 WSW	4,4	4,4	6,1
9 W	3,4	3,4	3,0
10 WNW	3,1	3,1	2,8
11 NNW	3,6	3,6	5,2
All	5,1	4,9	100,0



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Mathias Thamhain / mth@emd.dk

Calculated:

21/2/2022 09:51/3.5.508

PARK - Time varying AEP

Calculation: 22-459-003 Kharagpur WB

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	226	254	458	652	659	594	502	411	337	168	164	194	4.619
1	223	239	439	658	674	596	501	421	318	186	173	214	4.641
2	262	237	431	641	638	570	499	407	326	185	201	255	4.653
3	289	251	409	537	537	490	427	357	281	188	222	267	4.254
4	308	261	381	537	513	473	415	345	266	191	238	275	4.203
5	297	236	329	482	471	440	393	319	275	196	240	305	3.983
6	266	201	268	396	457	374	367	293	248	178	227	255	3.530
7	204	133	194	369	419	344	323	266	219	124	131	182	2.909
8	92	70	148	288	381	330	330	265	223	113	74	84	2.397
9	95	72	126	243	352	325	303	271	229	132	67	82	2.296
10	111	77	132	236	309	330	352	298	244	140	89	115	2.435
11	106	80	112	219	368	350	390	327	268	126	88	111	2.546
12	95	73	135	272	407	388	435	343	272	126	82	106	2.734
13	101	80	164	347	490	482	504	434	329	137	72	94	3.234
14	109	99	234	515	655	596	620	527	400	151	70	98	4.073
15	99	123	327	632	721	602	568	513	401	159	76	100	4.321
16	136	193	435	753	833	673	639	537	466	174	88	122	5.050
17	218	300	566	800	847	712	651	627	462	209	143	175	5.708
18	279	378	636	791	806	691	631	569	471	234	158	221	5.867
19	295	377	611	757	732	626	597	573	444	227	177	238	5.654
20	289	335	547	703	709	643	576	522	449	210	164	232	5.378
21	265	305	532	664	640	590	522	481	380	199	168	231	4.978
22	251	272	495	652	637	570	532	449	351	185	158	205	4.758
23	220	264	462	647	662	557	485	403	312	172	155	197	4.537
Grand Total	4.838	4.912	8.571	12.792	13.917	12.347	11.562	9.958	7.969	4.109	3.427	4.360	98.760

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	7,3	9,1	14,8	21,7	21,2	19,8	16,2	13,3	11,2	5,4	5,5	6,3	12,7
1	7,2	8,5	14,2	21,9	21,7	19,9	16,2	13,6	10,6	6,0	5,8	6,9	12,7
2	8,5	8,5	13,9	21,4	20,6	19,0	16,1	13,1	10,9	6,0	6,7	8,2	12,7
3	9,3	8,9	13,2	17,9	17,3	16,3	13,8	11,5	9,4	6,1	7,4	8,6	11,7
4	9,9	9,3	12,3	17,9	16,5	15,8	13,4	11,1	8,9	6,2	7,9	8,9	11,5
5	9,6	8,4	10,6	16,1	15,2	14,7	12,7	10,3	9,2	6,3	8,0	9,8	10,9
6	8,6	7,2	8,6	13,2	14,7	12,5	11,8	9,5	8,3	5,7	7,6	8,2	9,7
7	6,6	4,8	6,3	12,3	13,5	11,5	10,4	8,6	7,3	4,0	4,4	5,9	8,0
8	3,0	2,5	4,8	9,6	12,3	11,0	10,6	8,6	7,4	3,6	2,5	2,7	6,6
9	3,1	2,6	4,1	8,1	11,3	10,8	9,8	8,7	7,6	4,3	2,2	2,7	6,3
10	3,6	2,8	4,3	7,9	10,0	11,0	11,3	9,6	8,1	4,5	3,0	3,7	6,7
11	3,4	2,9	3,6	7,3	11,9	11,7	12,6	10,6	8,9	4,1	2,9	3,6	7,0
12	3,1	2,6	4,3	9,1	13,1	12,9	14,0	11,1	9,1	4,1	2,7	3,4	7,5
13	3,2	2,9	5,3	11,6	15,8	16,1	16,2	14,0	11,0	4,4	2,4	3,0	8,9
14	3,5	3,5	7,6	17,2	21,1	19,9	20,0	17,0	13,3	4,9	2,3	3,2	11,2
15	3,2	4,4	10,5	21,1	23,3	20,1	18,3	16,6	13,4	5,1	2,5	3,2	11,8
16	4,4	6,9	14,0	25,1	26,9	22,4	20,6	17,3	15,5	5,6	2,9	3,9	13,8
17	7,0	10,7	18,2	26,7	27,3	23,7	21,0	20,2	15,4	6,7	4,8	5,7	15,6
18	9,0	13,5	20,5	26,4	26,0	23,0	20,4	18,4	15,7	7,5	5,3	7,1	16,1
19	9,5	13,4	19,7	25,2	23,6	20,9	19,3	18,5	14,8	7,3	5,9	7,7	15,5
20	9,3	12,0	17,6	23,4	22,9	21,4	18,6	16,8	15,0	6,8	5,5	7,5	14,7
21	8,6	10,9	17,2	22,1	20,6	19,7	16,8	15,5	12,7	6,4	5,6	7,5	13,6
22	8,1	9,7	16,0	21,7	20,6	19,0	17,2	14,5	11,7	6,0	5,3	6,6	13,0
23	7,1	9,4	14,9	21,6	21,4	18,6	15,7	13,0	10,4	5,5	5,2	6,3	12,4
Grand Total	6,5	7,3	11,5	17,8	18,7	17,1	15,5	13,4	11,1	5,5	4,8	5,9	11,3

PARK - Time varying AEP

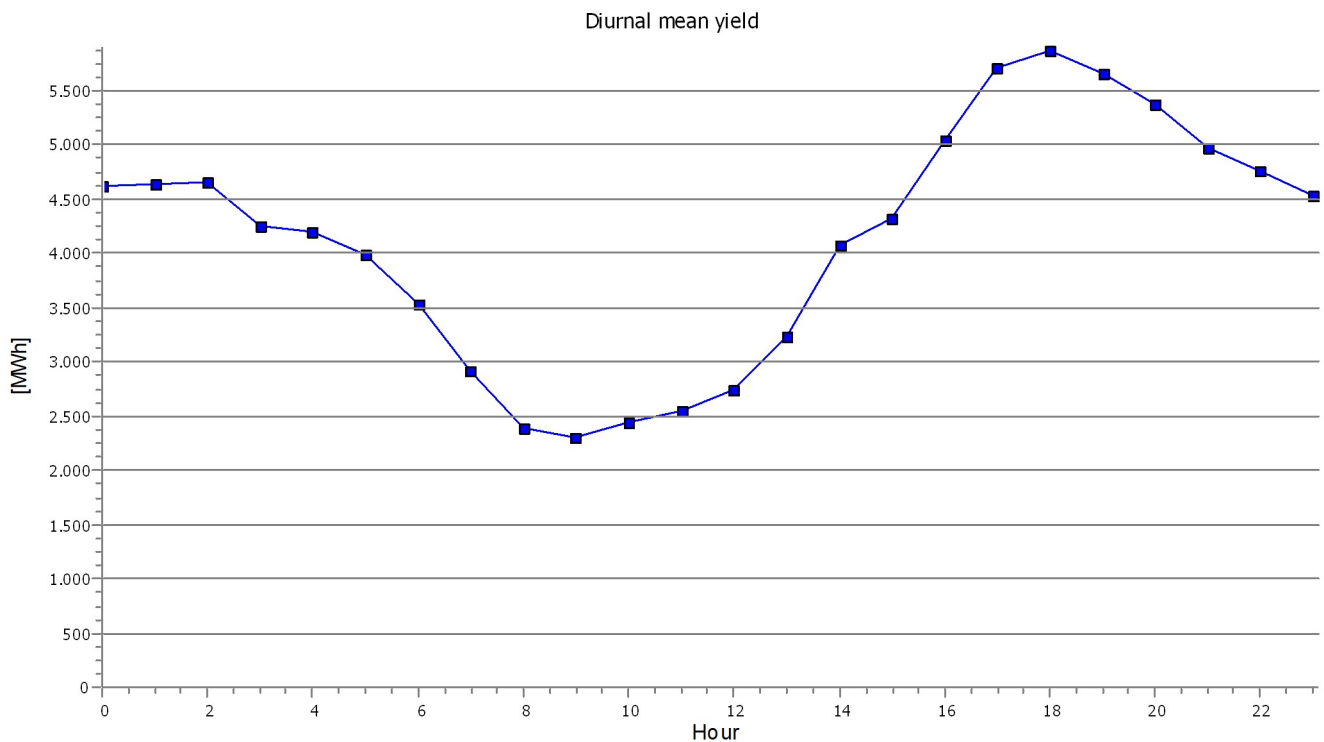
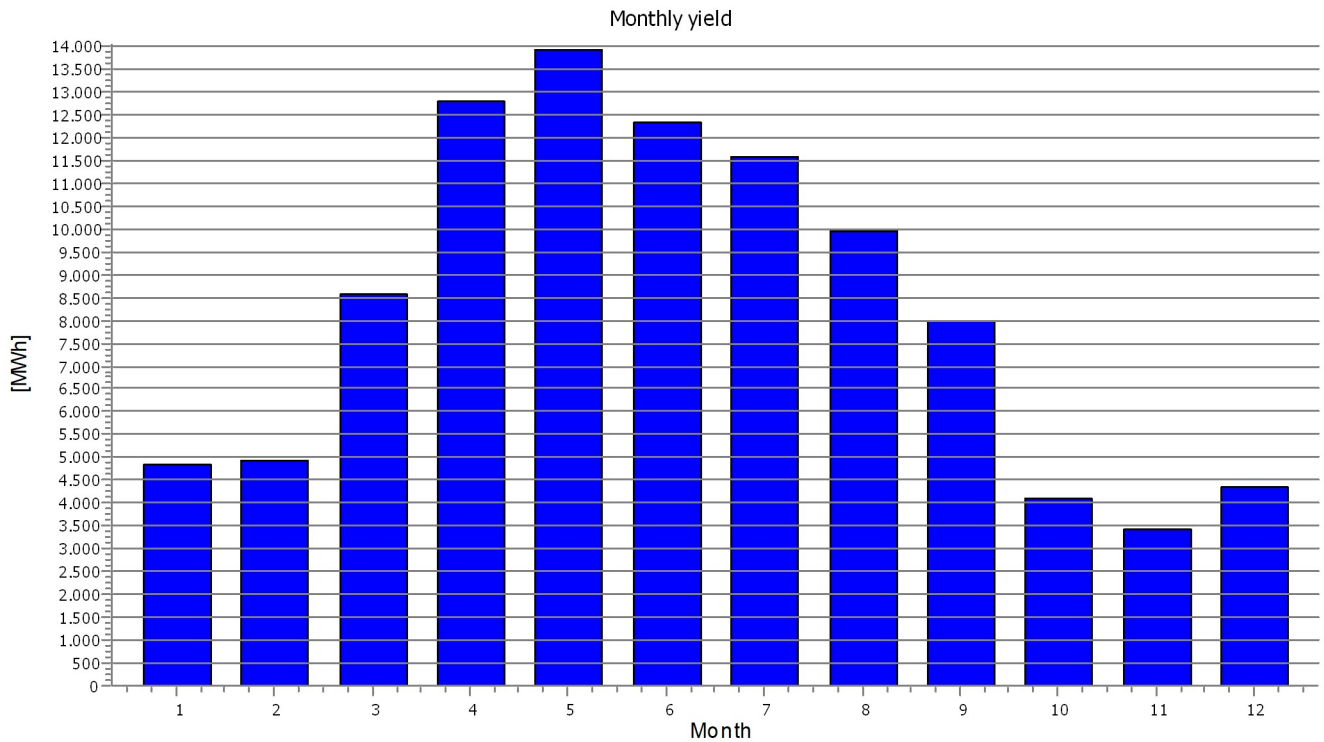
Calculation: 22-459-003 Kharagpur WB

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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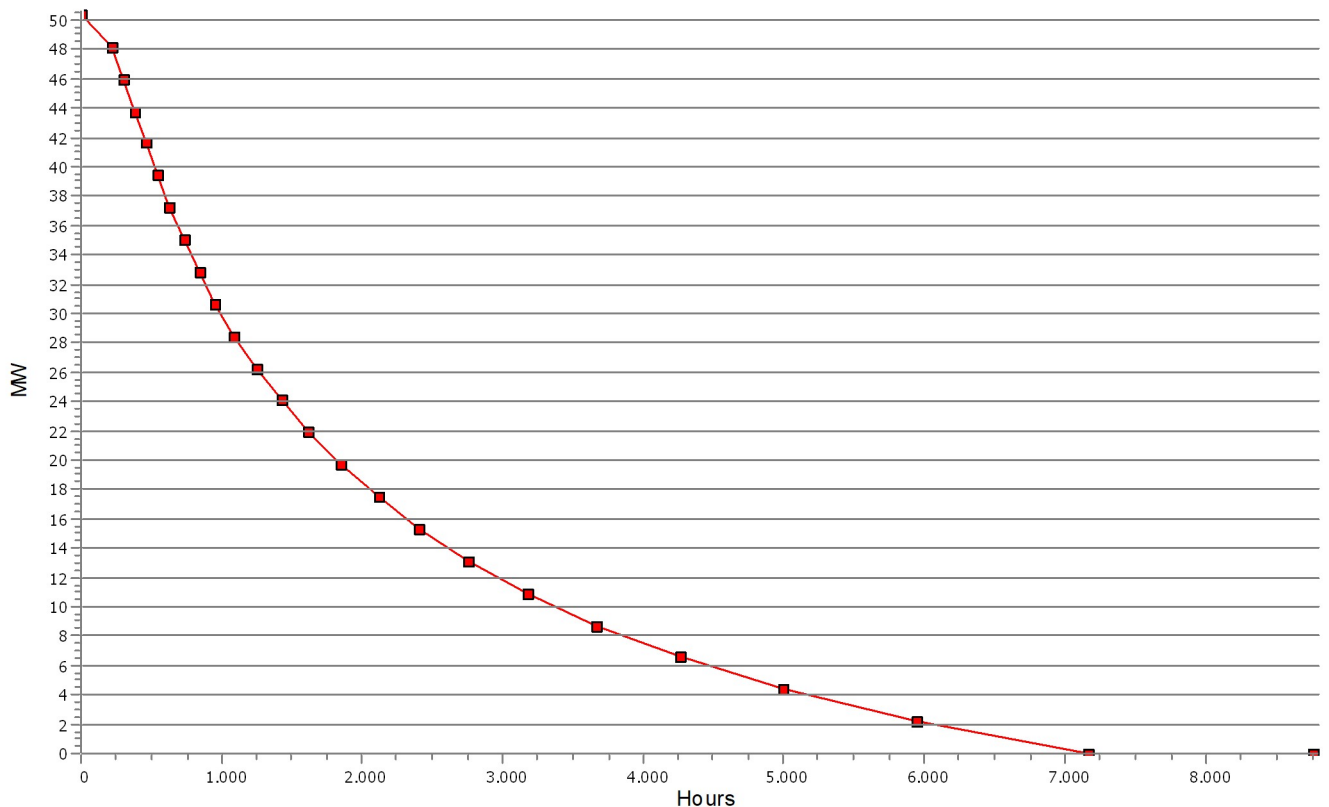
Calculation: 22-459-003 Kharagpur WB

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
211	2,4	211	48,2 - 50,4	4,0 - 4,2
86	1,0	297	46,0 - 48,2	3,8 - 4,0
82	0,9	379	43,8 - 46,0	3,7 - 3,8
77	0,9	455	41,6 - 43,8	3,5 - 3,7
86	1,0	541	39,4 - 41,6	3,3 - 3,5
87	1,0	629	37,3 - 39,4	3,1 - 3,3
101	1,1	729	35,1 - 37,3	2,9 - 3,1
107	1,2	836	32,9 - 35,1	2,7 - 2,9
118	1,3	954	30,7 - 32,9	2,6 - 2,7
135	1,5	1089	28,5 - 30,7	2,4 - 2,6
156	1,8	1245	26,3 - 28,5	2,2 - 2,4
174	2,0	1418	24,1 - 26,3	2,0 - 2,2
200	2,3	1619	21,9 - 24,1	1,8 - 2,0
223	2,5	1842	19,7 - 21,9	1,6 - 1,8
268	3,1	2110	17,5 - 19,7	1,5 - 1,6
297	3,4	2408	15,3 - 17,5	1,3 - 1,5
349	4,0	2757	13,1 - 15,3	1,1 - 1,3
419	4,8	3175	11,0 - 13,1	0,9 - 1,1
489	5,6	3664	8,8 - 11,0	0,7 - 0,9
591	6,7	4255	6,6 - 8,8	0,5 - 0,7
738	8,4	4993	4,4 - 6,6	0,4 - 0,5
956	10,9	5949	2,2 - 4,4	0,2 - 0,4
1221	13,9	7169	0,0 - 2,2	0,0 - 0,2
1597	18,2	8766	0,0	0,0

Duration curve 50,4 MW WindFarm



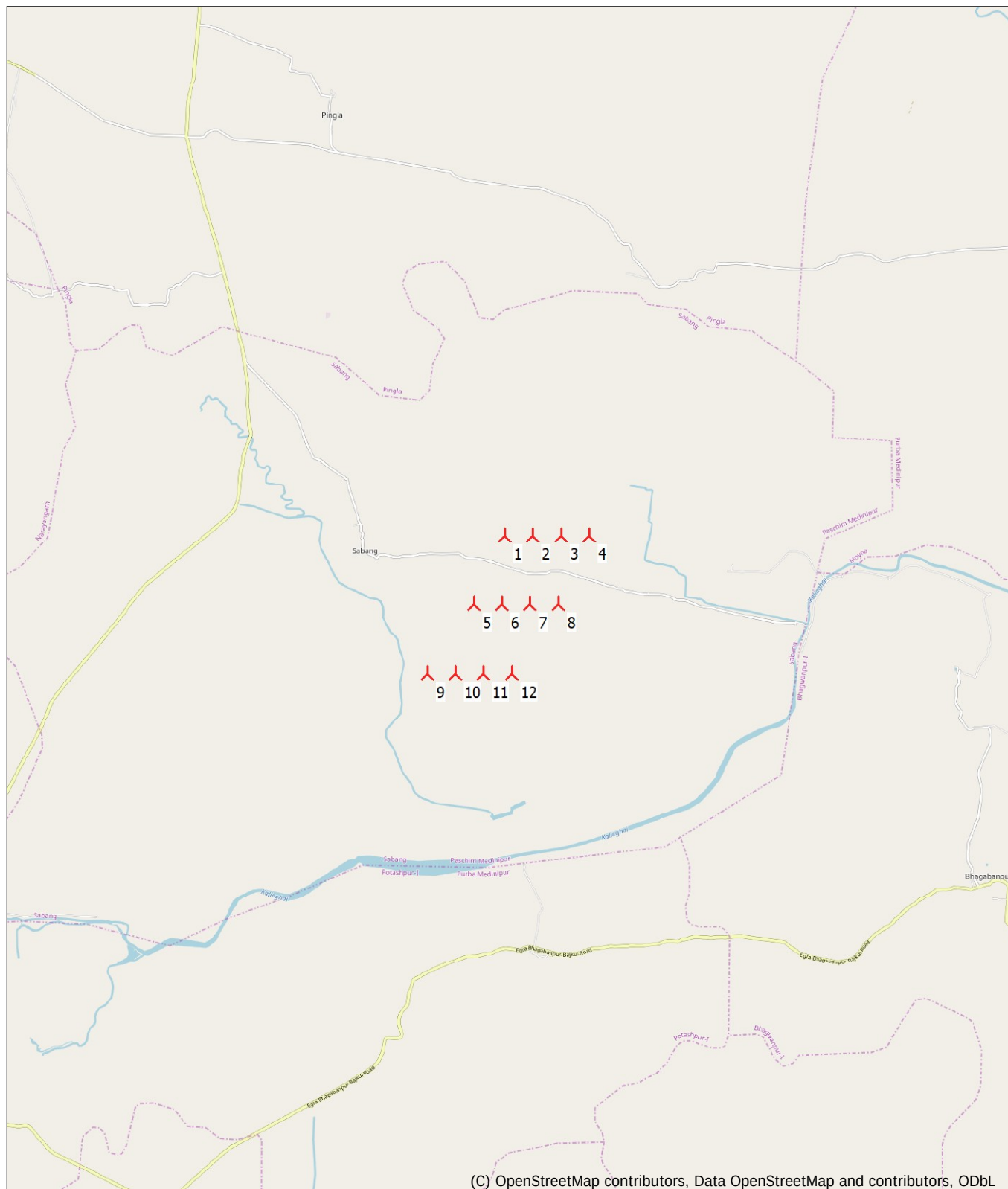
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Calculated:
21/2/2022 09:51/3.5.508

PARK - Map

Calculation: 22-459-003 Kharagpur WB



0 2,5 5 7,5 10km

Map: EMD OpenStreetMap , Print scale 1:150.000, Map center Geo WGS84 East: 87,631656° E North: 22,164540° N

 New WTG

Heat Maps - Kharagpur, West Bengal

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	920	989	372	372	855	944	4,451
2	902	764	276	345	1,149	1,083	4,519
3	1,598	1,078	477	791	2,068	1,873	7,885
4	2,289	1,641	908	1,625	2,852	2,453	11,768
5	2,306	1,711	1,297	2,092	2,961	2,436	12,803
6	2,071	1,501	1,228	1,902	2,486	2,171	11,360
7	1,775	1,379	1,264	1,956	2,317	1,946	10,637
8	1,469	1,125	1,068	1,672	2,121	1,707	9,161
9	1,160	927	887	1,290	1,695	1,373	7,331
10	669	635	470	527	776	704	3,780
11	700	769	292	276	522	594	3,152
12	856	937	361	365	697	795	4,011
Total	16,715	13,455	8,901	13,213	20,496	18,080	90,859

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	14.7%	15.8%	5.9%	5.9%	13.7%	15.1%	11.9%
2	16.0%	13.5%	4.9%	6.1%	20.3%	19.2%	13.3%
3	25.6%	17.3%	7.6%	12.7%	33.1%	30.0%	21.0%
4	37.8%	27.1%	15.0%	26.9%	47.2%	40.6%	32.4%
5	36.9%	27.4%	20.8%	33.5%	47.4%	39.0%	34.1%
6	34.2%	24.8%	20.3%	31.5%	41.1%	35.9%	31.3%
7	28.4%	22.1%	20.2%	31.3%	37.1%	31.1%	28.4%
8	23.5%	18.0%	17.1%	26.8%	33.9%	27.3%	24.4%
9	19.2%	15.3%	14.7%	21.3%	28.0%	22.7%	20.2%
10	10.7%	10.2%	7.5%	8.4%	12.4%	11.3%	10.1%
11	11.6%	12.7%	4.8%	4.6%	8.6%	9.8%	8.7%
12	13.7%	15.0%	5.8%	5.8%	11.1%	12.7%	10.7%
Total	22.7%	18.3%	12.1%	18.0%	27.9%	24.6%	20.6%