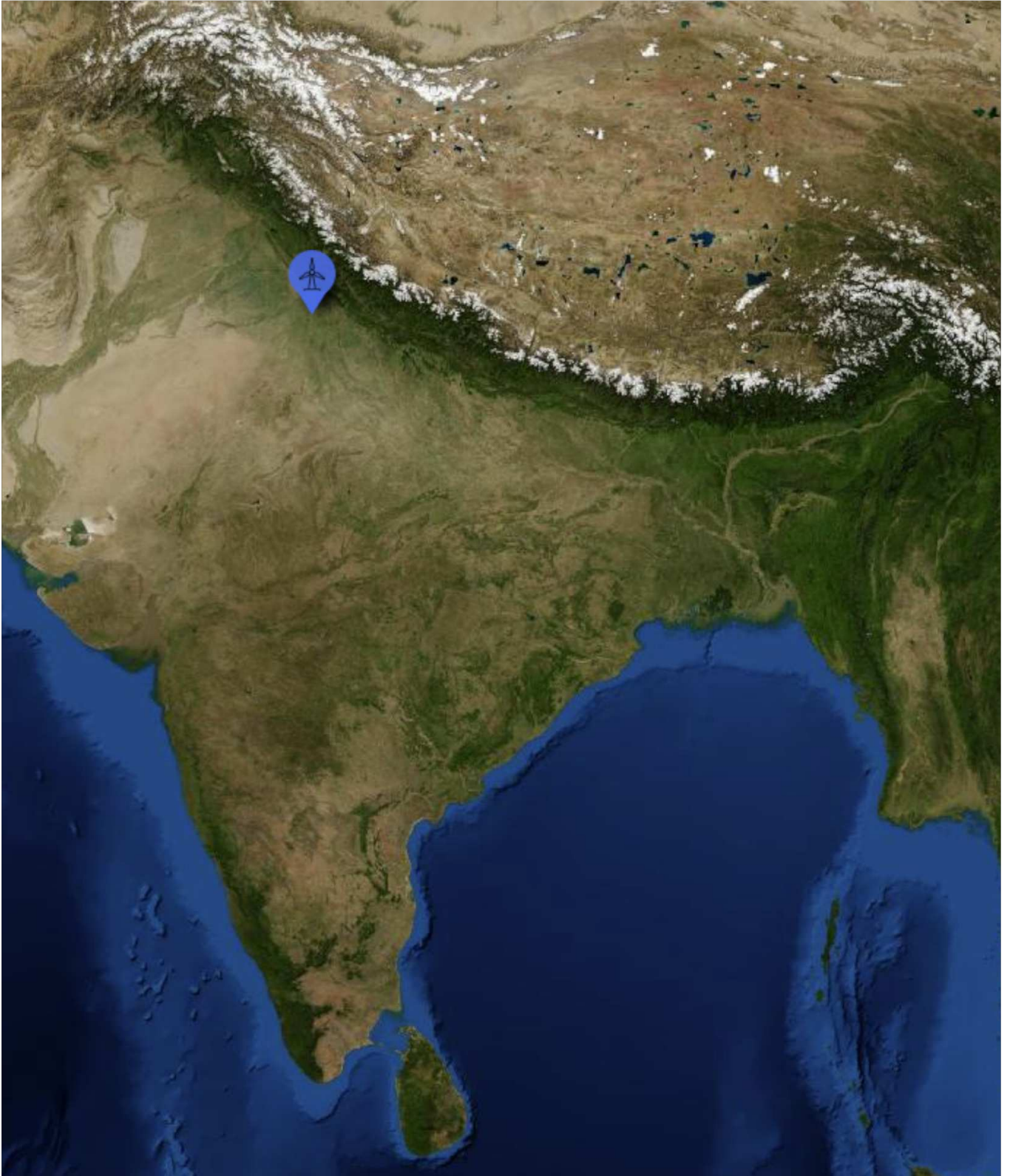


Yield Assessment - Saharanpur, Uttar Pradesh



Project:

Site Analysis contract 81274134

Description:

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

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Mathias Thamhain / mth@emd.dk

Calculated:

23/2/2022 23:21/3.5.508

PARK - Main Result

Calculation: 22-459-004 Saharanpur UP

Setup

AEP scaled to a full year based on number of samples
Scaling factor from 22,0 years to 1 year: 0,045

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 1/1/2000 05:30:00 - 1/1/2022 04:30:00

Meteo object(s) ERA5 (Gaussian Grid)_N29,929732_E077,1875 (UP), 100,00m -

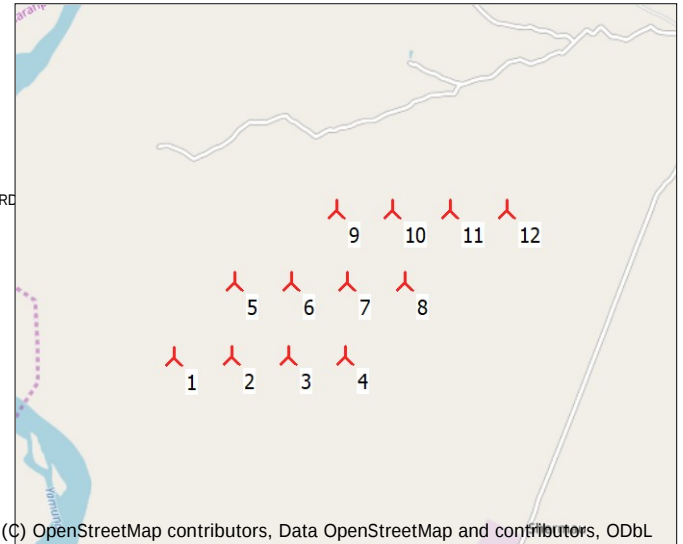
Displacement height Omnidirectional from objects

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]	23,1	23,1	23,1		
From air density settings	[hPa]	971,9	972,2	972,0		
Resulting air density	[kg/m³]	1,143	1,143	1,143		
Relative to 15°C at sea level	[%]	93,3	93,3	93,3	-5,4	-5,4
						0,0



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

Scale 1:100.000

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 ^{a)}		Full load hours [Hours/year]	Wind speed	
					Capacity factor [%]	Mean WTG result [MWh/y]		free [m/s]	wake reduced [m/s]
Wind farm	112.564,7	103.559,5	117.510,5	4,2	23,4	8.630,0	2.055	5,3	5,2

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		9.545,3	8.782	2,7	5,31	5,24
2 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.411,4	8.658	3,8	5,30	5,20
3 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.199,7	8.464	6,0	5,31	5,15
4 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		8.942,9	8.228	8,2	5,29	5,11
5 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.356,3	8.608	4,5	5,31	5,19
6 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.374,7	8.625	4,3	5,31	5,18
7 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.360,8	8.612	4,0	5,30	5,18
8 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.172,9	8.439	6,0	5,30	5,16
9 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.535,7	8.773	3,3	5,32	5,23
10 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.522,8	8.761	3,3	5,32	5,22
11 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.481,0	8.723	3,0	5,30	5,22
12 Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-OS - 08-2019		9.661,2	8.888	1,4	5,31	5,26

WTG siting

	Geo [deg]-WGS84		Z [m]	Row data/Description	Calculation period	
	Longitude	Latitude			Start	End
1 New	77,220240° E	29,873471° N	255,4	90,0°, 750,0 m	1/1/2000	1/1/2022
2 New	77,228002° E	29,873471° N	255,4		1/1/2000	1/1/2022
3 New	77,235764° E	29,873471° N	256,1		1/1/2000	1/1/2022
4 New	77,243525° E	29,873471° N	256,0		1/1/2000	1/1/2022
5 New	77,228400° E	29,882321° N	256,0	90,0°, 750,0 m	1/1/2000	1/1/2022
6 New	77,236163° E	29,882321° N	256,0		1/1/2000	1/1/2022
7 New	77,243926° E	29,882321° N	256,0		1/1/2000	1/1/2022
8 New	77,251688° E	29,882321° N	257,0		1/1/2000	1/1/2022
9 New	77,242312° E	29,890946° N	258,1	90,0°, 750,0 m	1/1/2000	1/1/2022
10 New	77,250075° E	29,890946° N	257,4		1/1/2000	1/1/2022
11 New	77,257838° E	29,890946° N	256,9		1/1/2000	1/1/2022
12 New	77,265602° E	29,890946° N	257,6		1/1/2000	1/1/2022

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Calculated:

23/2/2022 23:21/3.5.508

PARK - Wind Data Analysis

Calculation: 22-459-004 Saharanpur UPWind 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° (11); Hub height: 105,0

Site coordinates

Geo WGS84

East: 77,220240° E North: 29,873471° N

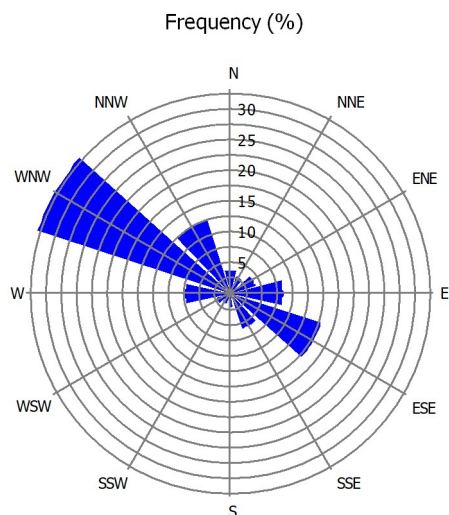
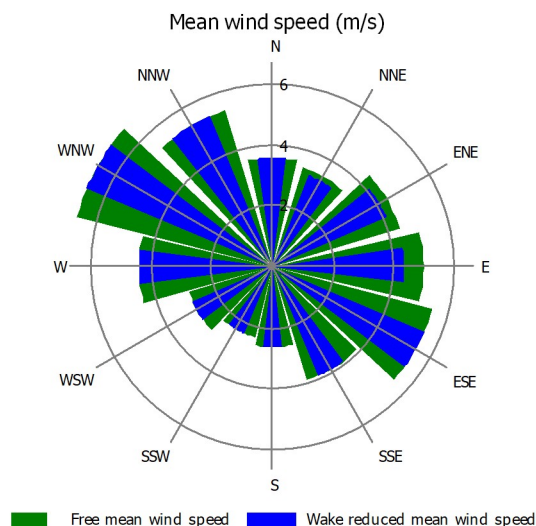
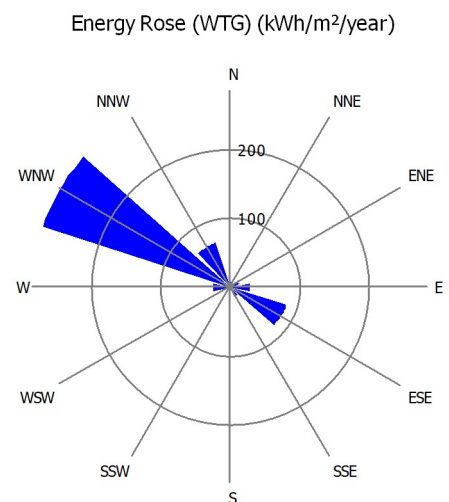
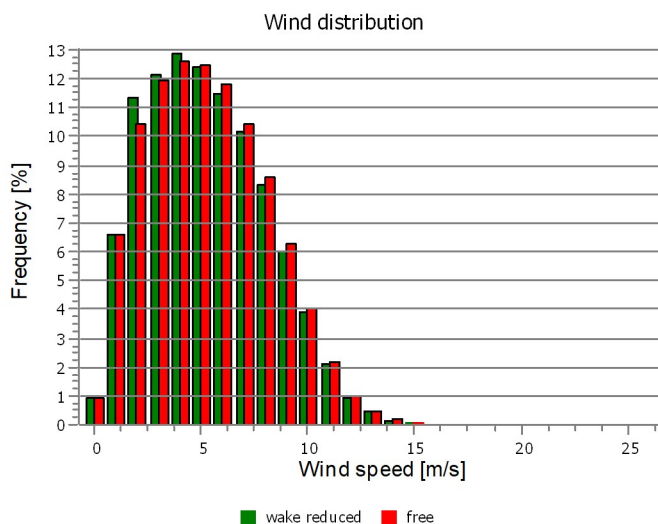
4*VESTAS V150-4.2 4200 150.0 !O! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD) angle: 90° (11)

Masts used

Take nearest

Winddata for site

Sector	Free mean wind speed [m/s]	Wake reduced mean wind speed [m/s]	Frequency [%]
0 N	3,6	3,6	3,8
1 NNE	3,4	3,3	2,9
2 ENE	4,4	4,1	4,2
3 E	5,0	4,4	8,6
4 ESE	5,5	5,5	15,5
5 SSE	3,9	3,9	6,0
6 S	2,7	2,7	2,2
7 SSW	2,4	2,4	1,7
8 WSW	2,9	2,9	2,4
9 W	4,4	4,4	7,3
10 WNW	6,7	6,7	33,0
11 NNW	5,4	5,4	12,5
All	5,3	5,2	100,0



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Calculated:
23/2/2022 23:21/3.5.508

PARK - Time varying AEP

Calculation: 22-459-004 Saharanpur UP

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	610	636	748	705	651	517	325	240	271	303	441	558	6.003
1	595	617	702	662	619	501	316	231	251	272	419	549	5.735
2	589	604	672	637	582	491	316	227	239	249	404	545	5.555
3	541	552	597	587	519	444	290	201	210	216	361	488	5.006
4	521	524	580	565	521	416	293	205	197	194	334	457	4.805
5	507	510	565	546	533	409	292	202	185	181	322	446	4.698
6	505	509	544	519	508	378	282	202	188	175	315	439	4.564
7	495	497	504	407	370	301	237	171	159	154	300	430	4.026
8	424	407	338	254	334	299	234	158	109	78	196	352	3.185
9	240	240	253	268	349	300	250	181	120	54	103	181	2.539
10	201	225	281	312	335	289	247	190	136	65	113	159	2.552
11	219	258	331	334	306	272	239	191	147	85	141	179	2.701
12	256	294	379	356	296	266	229	180	163	112	174	208	2.913
13	295	338	433	392	316	264	221	171	185	150	209	242	3.216
14	334	384	488	449	362	276	216	173	216	188	250	276	3.612
15	370	417	545	494	403	296	196	164	238	231	282	305	3.941
16	384	429	574	533	459	325	186	156	232	227	277	316	4.097
17	481	473	590	573	500	340	180	145	251	283	368	441	4.624
18	636	615	729	652	554	347	181	158	310	385	485	575	5.627
19	715	701	844	790	645	428	227	192	355	441	543	635	6.516
20	727	721	886	845	709	482	283	221	373	443	556	643	6.889
21	702	707	876	835	714	508	325	241	366	415	531	615	6.835
22	666	683	842	804	707	520	342	250	342	374	501	585	6.617
23	635	655	796	757	678	520	344	246	310	332	474	563	6.309
Grand Total	11.648	11.997	14.094	13.276	11.970	9.188	6.250	4.695	5.553	5.607	8.098	10.188	112.565

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	19,7	22,7	24,1	23,5	21,0	17,2	10,5	7,8	9,0	9,8	14,7	18,0	16,4
1	19,2	22,0	22,6	22,1	20,0	16,7	10,2	7,5	8,4	8,8	14,0	17,7	15,7
2	19,0	21,6	21,7	21,2	18,8	16,4	10,2	7,3	8,0	8,0	13,5	17,6	15,2
3	17,4	19,7	19,3	19,6	16,7	14,8	9,4	6,5	7,0	7,0	12,0	15,8	13,7
4	16,8	18,7	18,7	18,8	16,8	13,9	9,5	6,6	6,6	6,2	11,1	14,7	13,2
5	16,4	18,2	18,2	18,2	17,2	13,6	9,4	6,5	6,2	5,8	10,7	14,4	12,9
6	16,3	18,2	17,5	17,3	16,4	12,6	9,1	6,5	6,3	5,7	10,5	14,2	12,5
7	16,0	17,8	16,3	13,6	11,9	10,0	7,7	5,5	5,3	5,0	10,0	13,9	11,0
8	13,7	14,6	10,9	8,5	10,8	10,0	7,6	5,1	3,6	2,5	6,5	11,4	8,7
9	7,8	8,6	8,1	8,9	11,3	10,0	8,1	5,8	4,0	1,7	3,4	5,8	7,0
10	6,5	8,0	9,1	10,4	10,8	9,6	8,0	6,1	4,5	2,1	3,8	5,1	7,0
11	7,1	9,2	10,7	11,1	9,9	9,1	7,7	6,2	4,9	2,7	4,7	5,8	7,4
12	8,3	10,5	12,2	11,9	9,5	8,9	7,4	5,8	5,4	3,6	5,8	6,7	8,0
13	9,5	12,1	14,0	13,1	10,2	8,8	7,1	5,5	6,2	4,8	7,0	7,8	8,8
14	10,8	13,7	15,7	15,0	11,7	9,2	7,0	5,6	7,2	6,1	8,3	8,9	9,9
15	11,9	14,9	17,6	16,5	13,0	9,9	6,3	5,3	7,9	7,4	9,4	9,8	10,8
16	12,4	15,3	18,5	17,8	14,8	10,8	6,0	5,0	7,7	7,3	9,2	10,2	11,2
17	15,5	16,9	19,0	19,1	16,1	11,3	5,8	4,7	8,4	9,1	12,3	14,2	12,7
18	20,5	22,0	23,5	21,7	17,9	11,6	5,9	5,1	10,3	12,4	16,2	18,5	15,4
19	23,1	25,0	27,2	26,3	20,8	14,3	7,3	6,2	11,8	14,2	18,1	20,5	17,9
20	23,4	25,7	28,6	28,2	22,9	16,1	9,1	7,1	12,4	14,3	18,5	20,7	18,9
21	22,7	25,3	28,2	27,8	23,0	16,9	10,5	7,8	12,2	13,4	17,7	19,8	18,7
22	21,5	24,4	27,1	26,8	22,8	17,3	11,0	8,1	11,4	12,1	16,7	18,9	18,1
23	20,5	23,4	25,7	25,2	21,9	17,3	11,1	7,9	10,3	10,7	15,8	18,2	17,3
Grand Total	15,7	17,9	18,9	18,4	16,1	12,8	8,4	6,3	7,7	7,5	11,2	13,7	12,8

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PARK - Time varying AEP

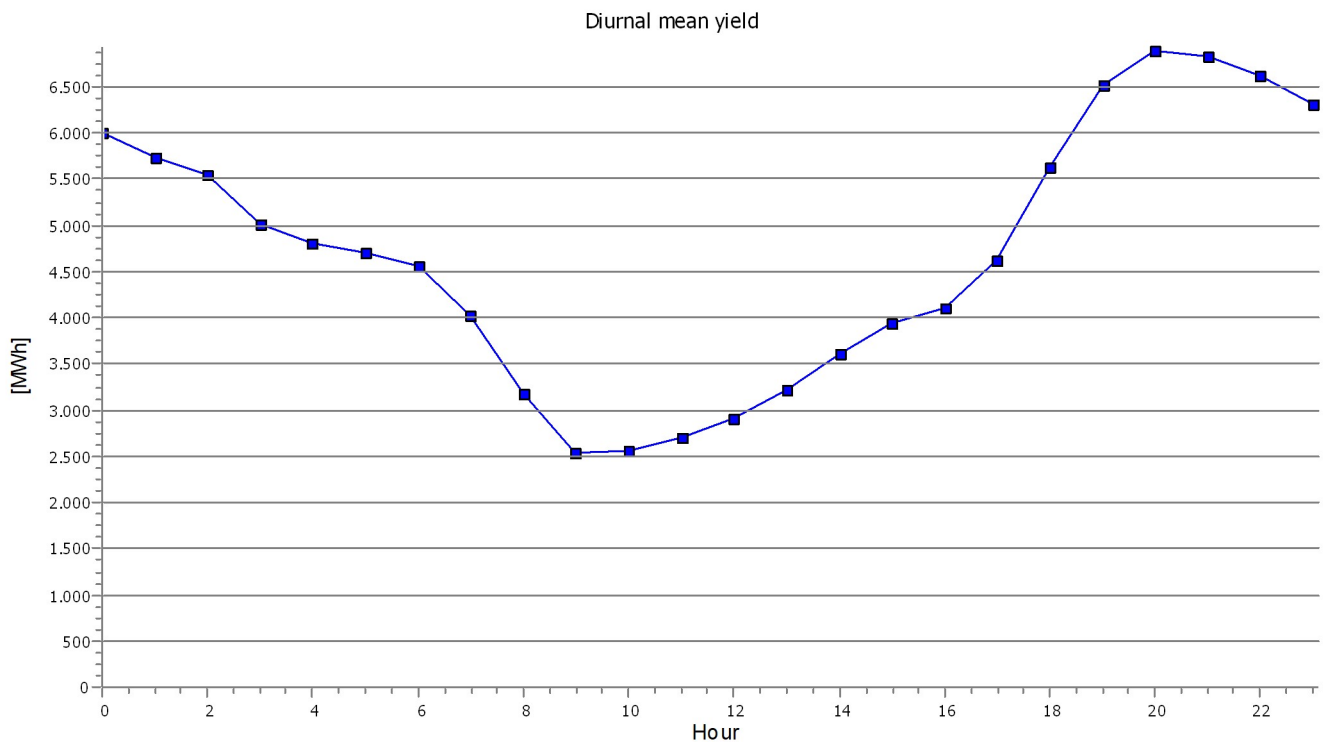
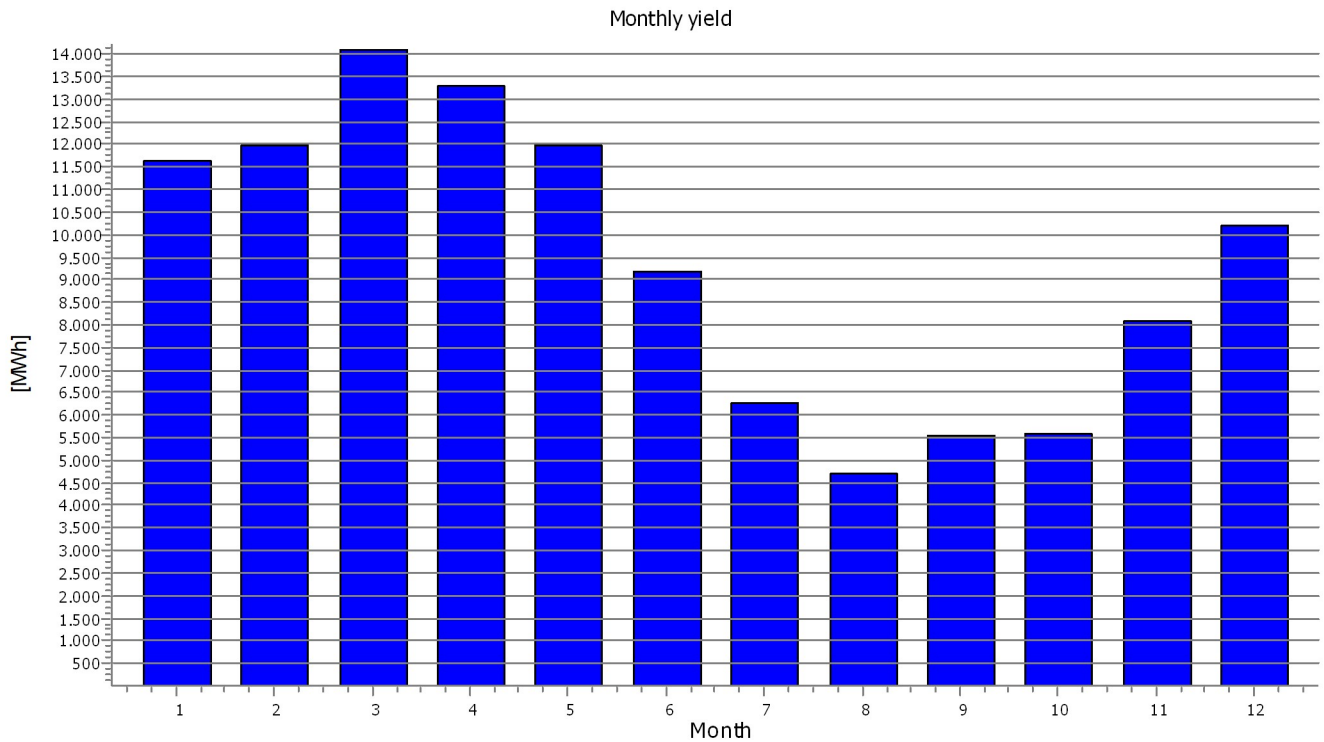
Calculation: 22-459-004 Saharanpur UP

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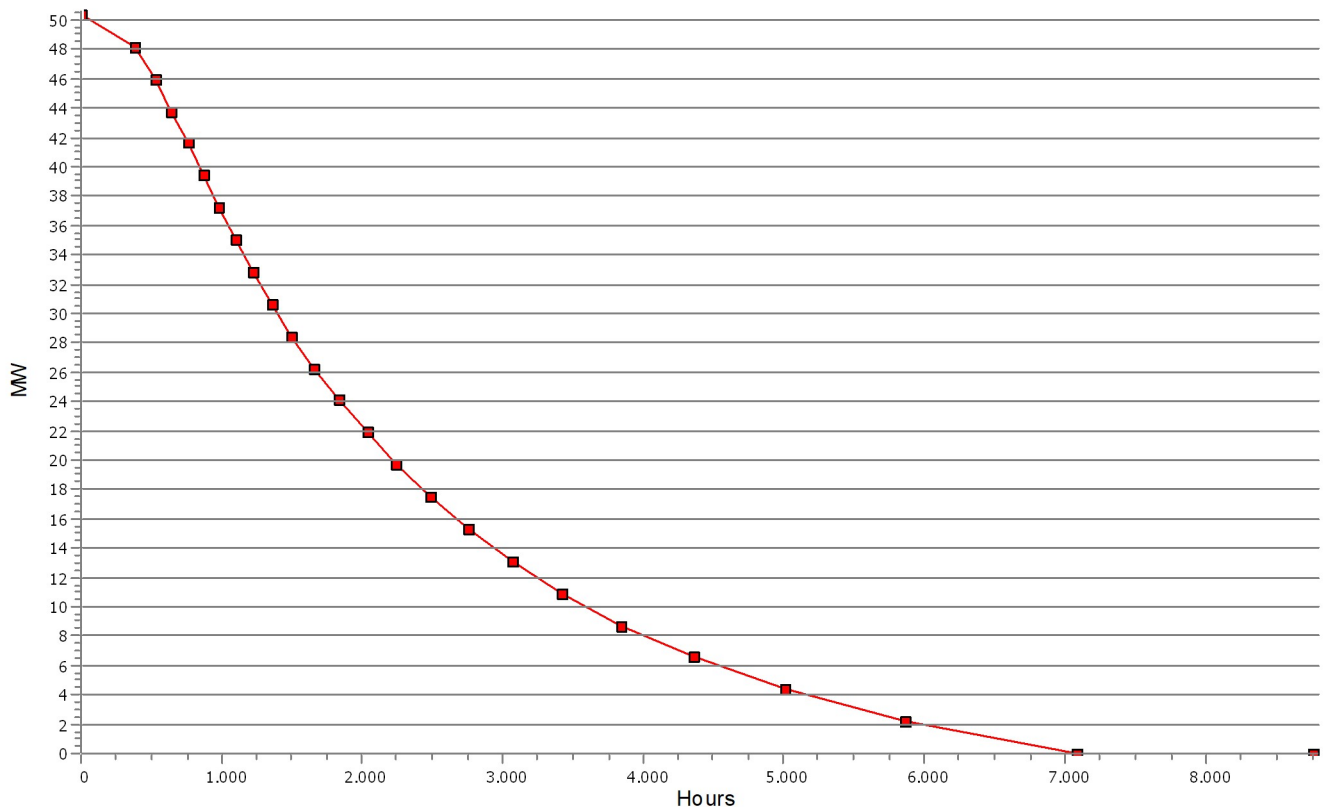
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Windfarm: 50,4 MW based on 12 turbines of type VESTAS V150-4.2 4200 150.0 !O!.

Selection: All new WTGs

Hours	Hours [%]	Hours accumulated	Power [MW]	Power (MW/WTG)
0	0,0	0	50,4	4,2
386	4,4	386	48,2 - 50,4	4,0 - 4,2
137	1,6	523	46,0 - 48,2	3,8 - 4,0
119	1,4	642	43,8 - 46,0	3,7 - 3,8
114	1,3	756	41,6 - 43,8	3,5 - 3,7
112	1,3	868	39,4 - 41,6	3,3 - 3,5
110	1,3	978	37,3 - 39,4	3,1 - 3,3
119	1,4	1097	35,1 - 37,3	2,9 - 3,1
128	1,5	1225	32,9 - 35,1	2,7 - 2,9
132	1,5	1357	30,7 - 32,9	2,6 - 2,7
141	1,6	1498	28,5 - 30,7	2,4 - 2,6
160	1,8	1658	26,3 - 28,5	2,2 - 2,4
174	2,0	1832	24,1 - 26,3	2,0 - 2,2
197	2,2	2029	21,9 - 24,1	1,8 - 2,0
214	2,4	2243	19,7 - 21,9	1,6 - 1,8
243	2,8	2486	17,5 - 19,7	1,5 - 1,6
270	3,1	2756	15,3 - 17,5	1,3 - 1,5
306	3,5	3062	13,1 - 15,3	1,1 - 1,3
353	4,0	3416	11,0 - 13,1	0,9 - 1,1
428	4,9	3844	8,8 - 11,0	0,7 - 0,9
512	5,8	4355	6,6 - 8,8	0,5 - 0,7
648	7,4	5003	4,4 - 6,6	0,4 - 0,5
860	9,8	5863	2,2 - 4,4	0,2 - 0,4
1225	14,0	7087	0,0 - 2,2	0,0 - 0,2
1679	19,2	8766	0,0	0,0

Duration curve 50,4 MW WindFarm



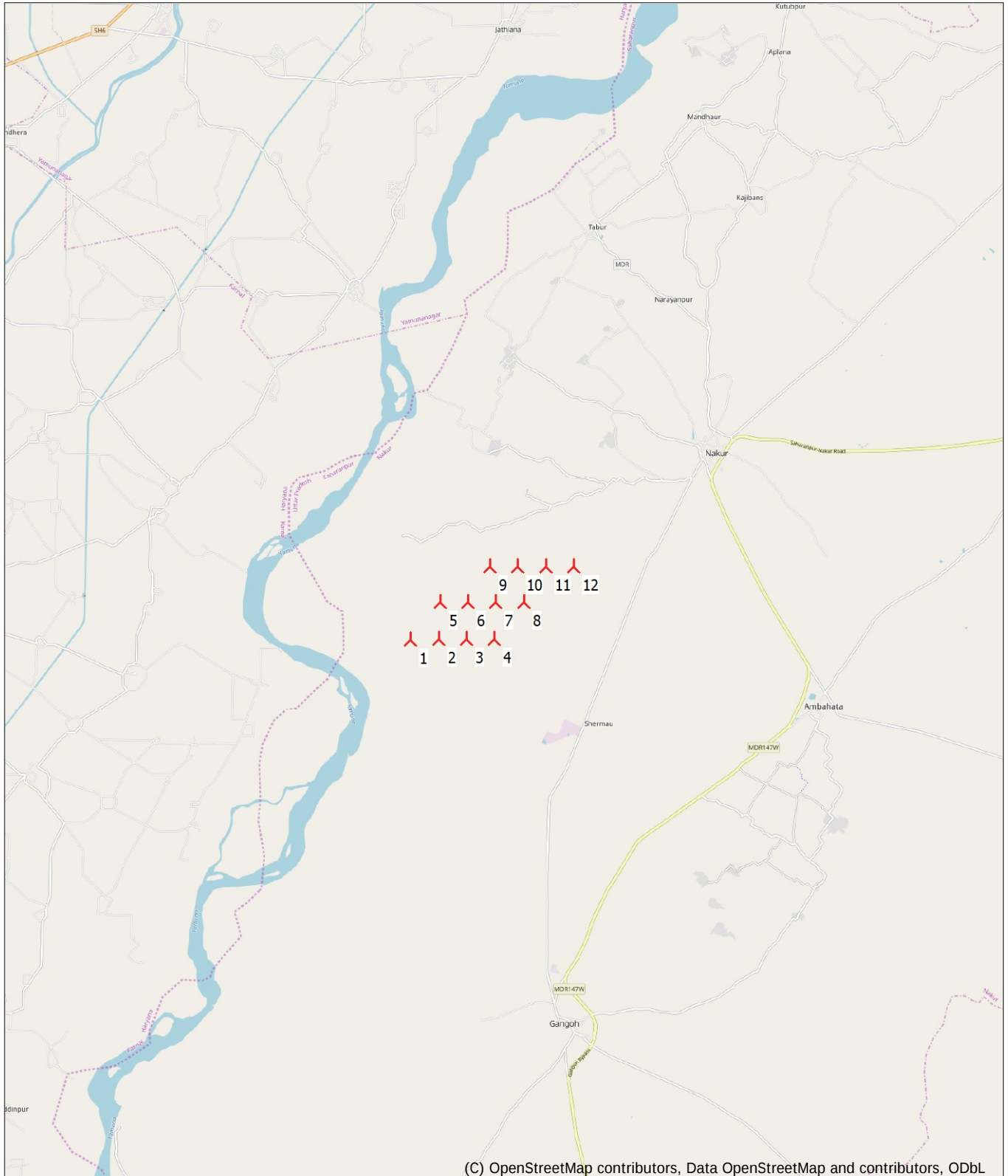
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Calculated:
23/2/2022 23:21/3.5.508

PARK - Map

Calculation: 22-459-004 Saharanpur UP



0 2,5 5 7,5 10km

Map: EMD OpenStreetMap , Print scale 1:150.000, Map center Geo WGS84 East: 77,242921° E North: 29,882209° N

New WTG

Heat Maps - Saharanpur, Uttar Pradesh

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	2,169	1,875	985	1,148	2,037	2,528	10,741
2	2,235	1,902	1,040	1,318	2,034	2,541	11,069
3	2,481	1,998	1,072	1,654	2,483	3,104	12,793
4	2,350	1,881	1,090	1,559	2,318	2,927	12,125
5	2,185	1,786	1,227	1,279	2,001	2,603	11,080
6	1,823	1,414	1,112	1,042	1,353	1,912	8,656
7	1,125	996	883	794	720	1,186	5,703
8	818	712	656	620	593	876	4,275
9	903	671	476	751	1,069	1,302	5,172
10	922	644	257	619	1,181	1,362	4,986
11	1,487	1,184	523	865	1,554	1,887	7,500
12	1,985	1,650	821	978	1,812	2,214	9,460
Total	20,483	16,712	10,141	12,626	19,155	24,442	1,03,560

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	34.7%	30.0%	15.8%	18.4%	32.6%	40.5%	28.6%
2	39.6%	33.7%	18.4%	23.4%	36.0%	45.0%	32.7%
3	39.7%	32.0%	17.2%	26.5%	39.7%	49.7%	34.1%
4	38.9%	31.1%	18.0%	25.8%	38.3%	48.4%	33.4%
5	35.0%	28.6%	19.6%	20.5%	32.0%	41.6%	29.5%
6	30.1%	23.4%	18.4%	17.2%	22.4%	31.6%	23.9%
7	18.0%	15.9%	14.1%	12.7%	11.5%	19.0%	15.2%
8	13.1%	11.4%	10.5%	9.9%	9.5%	14.0%	11.4%
9	14.9%	11.1%	7.9%	12.4%	17.7%	21.5%	14.3%
10	14.8%	10.3%	4.1%	9.9%	18.9%	21.8%	13.3%
11	24.6%	19.6%	8.7%	14.3%	25.7%	31.2%	20.7%
12	31.8%	26.4%	13.1%	15.7%	29.0%	35.4%	25.2%
Total	27.8%	22.7%	13.8%	17.2%	26.0%	33.2%	23.5%