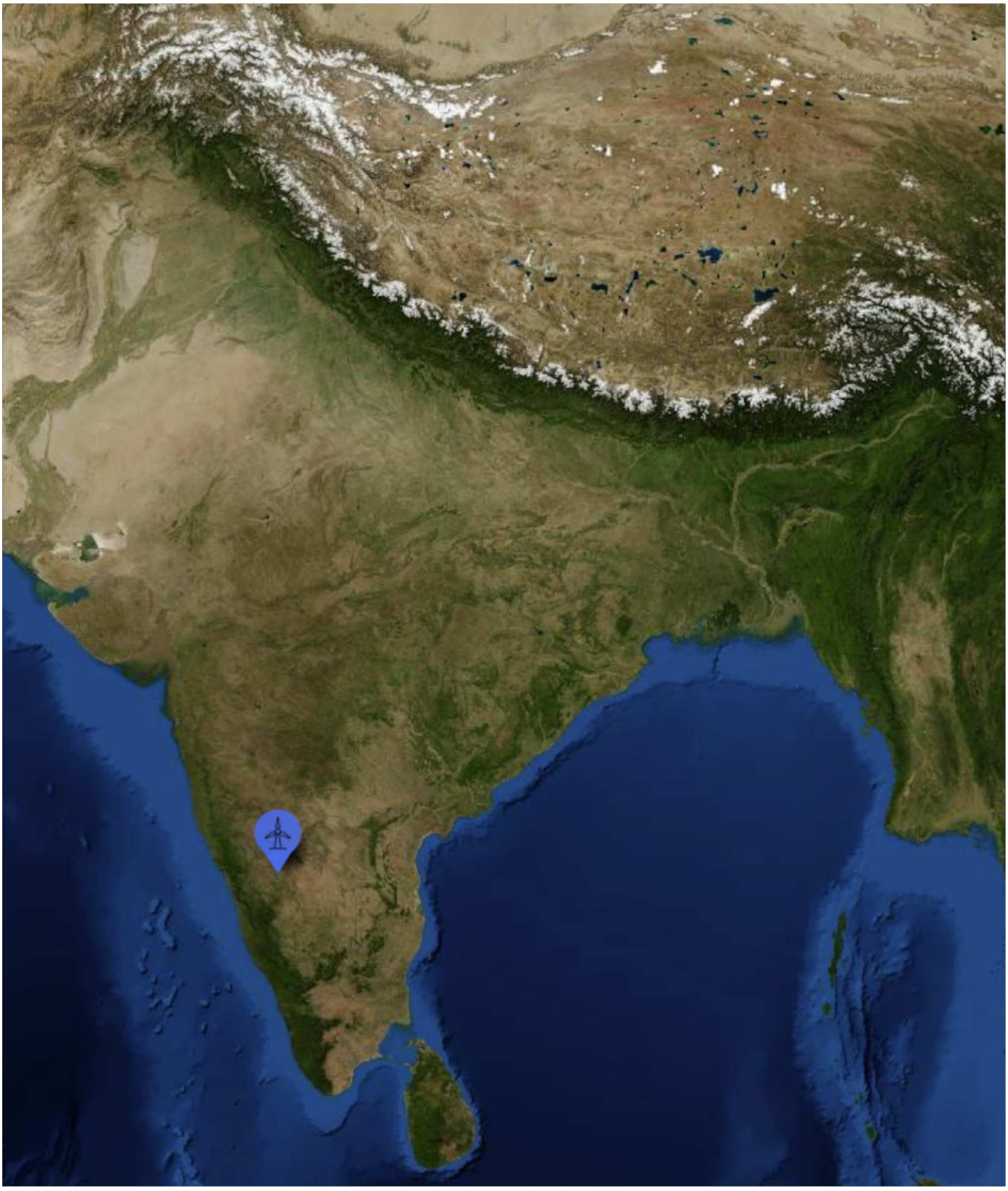
Yield Assessment - Harapanahalli, Karnataka



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Calculated:
27/2/2022 20:29/3.5.508

PARK - Main Result

Calculation: 22-459-009 Harapanahalli - Karnataka

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: 44
At the site centre the difference between grid north and true north is: -0,7°

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 !O! hub: 105,0 m (TOT: 180,0 m) dist: 750 m (5,0 RD

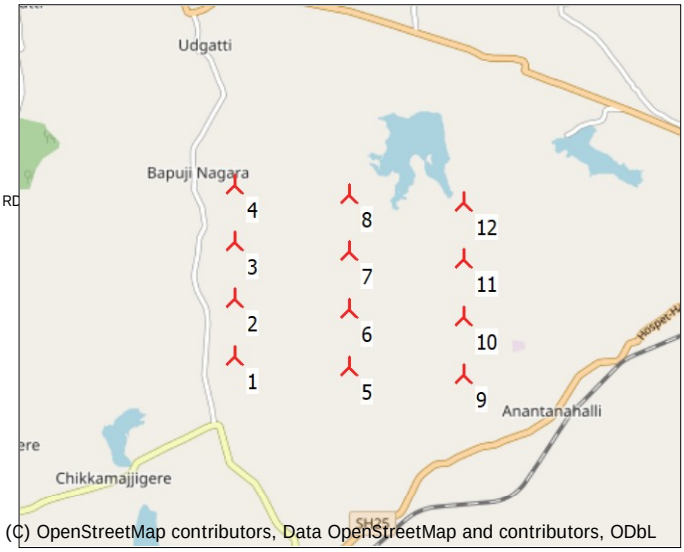
Scaler / wind data

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_N14.779_E075.910 - KA
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]	20,7	20,9	20,8			
From air density settings	[hPa]	931,0	934,0	932,3			
Resulting air density	[kg/m³]	1,104	1,107	1,105			
Relative to 15°C at sea level	[%]	90,1	90,3	90,2	-5,8	-5,8	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%	GROSS (no loss) Free WTGs	Wake loss	Specific results¤) Capacity factor	Mean WTG result	Full load hours	Wind speed free	wake reduced
	[MWh/y]	[MWh/y]	[MWh/y]	[%]	[%]	[MWh/y]	[Hours/year]	[m/s]	[m/s]
Wind farm	205.138,9	188.727,8	213.612,0	4,0	42,7	15.727,3	3.745	7,4	7,2

¤) 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 Result [MWh/y]	Result-8,0% [MWh/y]	Wake loss [%]	Wind speed 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 & PO1-0S - 08-2019	17.241,1	15.862	2,8	7,37	7,26
2	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	17.365,7	15.976	3,4	7,43	7,30
3	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	17.518,8	16.117	3,3	7,47	7,34
4	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	17.626,1	16.216	2,3	7,45	7,36
5	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	17.643,4	16.232	2,8	7,48	7,37
6	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.754,8	15.414	5,6	7,37	7,16
7	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.844,0	15.496	5,7	7,40	7,18
8	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.880,0	15.530	5,2	7,38	7,18
9	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	17.127,3	15.757	1,3	7,27	7,22
10	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.766,9	15.426	4,6	7,33	7,15
11	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.918,0	15.565	5,2	7,40	7,19
12	Yes	VESTAS	V150-4.2-4.200	4.200	150,0	105,0	EMD	Level 00 - Calculated - Modes PO1 & PO1-0S - 08-2019	16.453,0	15.137	5,2	7,27	7,07

WTG siting

		Geo [deg]-WGS84 Longitude	Latitude	Z [m]	Row data/Description	Calculation period Start	End
1	New	75,909691° E	14,772227° N	613,8	0,0°, 750,0 m	1/1/2002	1/1/2022
2	New	75,909691° E	14,779007° N	625,4		1/1/2002	1/1/2022
3	New	75,909691° E	14,785787° N	621,8		1/1/2002	1/1/2022
4	New	75,909691° E	14,792567° N	616,5		1/1/2002	1/1/2022
5	New	75,923666° E	14,770995° N	629,0	0,0°, 750,0 m	1/1/2002	1/1/2022
6	New	75,923666° E	14,777775° N	618,0		1/1/2002	1/1/2022
7	New	75,923666° E	14,784555° N	614,8		1/1/2002	1/1/2022
8	New	75,923666° E	14,791336° N	605,2		1/1/2002	1/1/2022
9	New	75,937642° E	14,770095° N	622,2	0,0°, 750,0 m	1/1/2002	1/1/2022
10	New	75,937642° E	14,776875° N	621,9		1/1/2002	1/1/2022
11	New	75,937642° E	14,783656° N	618,7		1/1/2002	1/1/2022
12	New	75,937642° E	14,790436° N	601,0		1/1/2002	1/1/2022

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PARK - Wind Data Analysis

Calculation: 22-459-009 Harapanahalli - KarnatakaWind 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: 0° (26); Hub height: 105,0

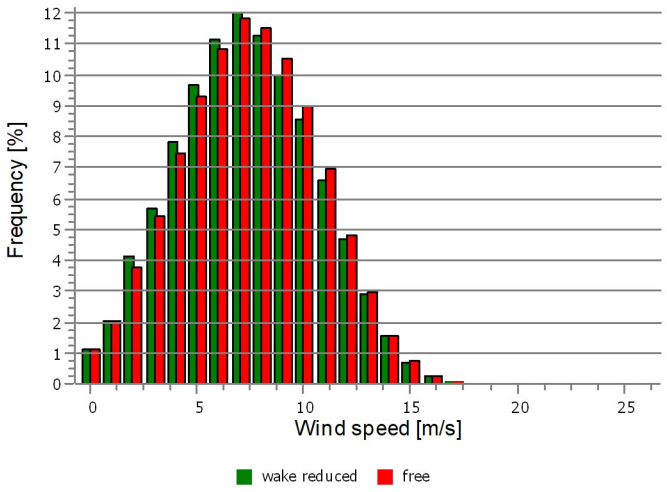
Site coordinates

Geo WGS84
East: 75,909691° E North: 14,772227° 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: 0° (26)
Masts used
Take nearest

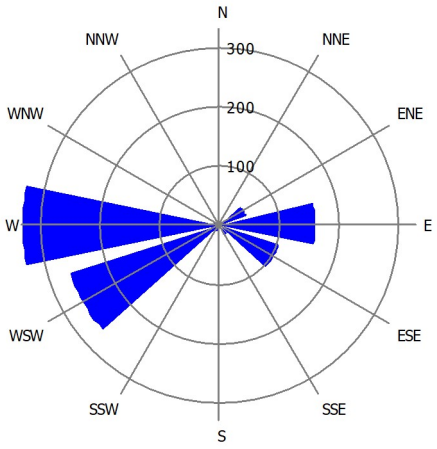
Winddata for site

Sector	Free mean wind speed [m/s]	Wake reduced mean wind speed [m/s]	Frequency [%]
0 N	3,6	3,1	1,2
1 NNE	4,8	4,7	2,2
2 ENE	6,4	5,9	7,5
3 E	7,6	7,2	16,9
4 ESE	8,1	8,1	8,9
5 SSE	6,1	6,1	2,6
6 S	4,4	4,4	1,4
7 SSW	5,1	5,1	2,3
8 WSW	8,0	8,0	23,4
9 W	8,0	8,0	29,4
10 WNW	4,6	4,6	3,0
11 NNW	3,5	3,5	1,2
All	7,4	7,3	100,0

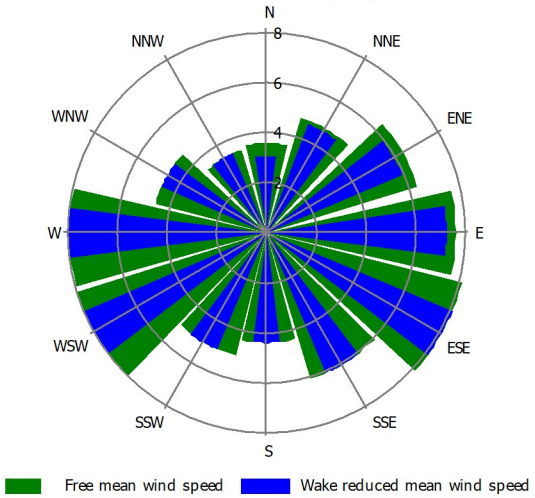
Wind distribution



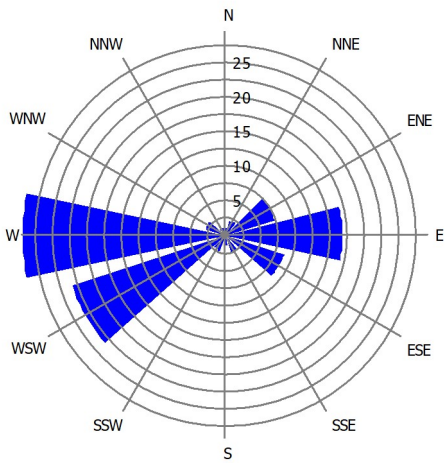
Energy Rose (WTG) (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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PARK - Time varying AEP

Calculation: 22-459-009 Harapanahalli - Karnataka

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	1.042	839	727	589	838	998	1.093	948	718	536	835	1.037	10.201
1	1.009	802	584	461	764	964	1.089	936	633	491	810	1.020	9.564
2	992	747	481	378	638	917	1.073	891	604	460	794	1.028	9.002
3	997	729	452	318	547	821	988	824	535	445	773	1.011	8.439
4	995	734	436	347	560	837	1.001	854	530	395	751	955	8.396
5	961	712	406	322	529	846	1.022	843	548	391	703	956	8.239
6	926	667	354	249	459	805	1.014	815	488	355	708	881	7.720
7	851	605	272	178	409	848	1.036	863	500	332	616	815	7.326
8	530	359	142	119	358	823	1.003	877	499	289	535	577	6.111
9	454	310	139	113	329	799	945	809	466	320	527	553	5.763
10	442	330	161	116	314	823	1.004	848	512	350	571	588	6.058
11	410	313	161	97	397	920	1.103	991	617	343	526	569	6.447
12	337	291	180	96	418	998	1.203	1.084	668	328	479	516	6.597
13	313	272	187	108	458	1.050	1.264	1.183	752	343	447	465	6.842
14	320	267	217	130	468	1.090	1.313	1.207	776	351	414	443	6.994
15	287	248	232	153	475	1.071	1.276	1.174	759	359	409	431	6.875
16	316	289	267	210	615	1.155	1.348	1.219	858	410	387	439	7.513
17	390	328	317	326	837	1.269	1.397	1.323	936	493	466	504	8.584
18	581	477	458	552	1.048	1.305	1.417	1.354	1.096	673	614	709	10.285
19	833	668	689	812	1.193	1.316	1.418	1.364	1.149	804	817	925	11.990
20	1.023	843	889	949	1.220	1.297	1.364	1.286	1.094	815	953	1.084	12.818
21	1.026	898	955	920	1.123	1.170	1.213	1.144	903	758	946	1.102	12.159
22	1.028	852	868	772	956	1.011	1.113	969	759	659	895	1.021	10.902
23	1.032	861	798	662	873	970	1.047	899	685	588	860	1.040	10.315
Grand Total	17.095	13.442	10.372	8.975	15.826	24.103	27.746	24.705	17.084	11.288	15.834	18.669	205.139

Hour/Month [MW]	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
0	33,6	30,0	23,5	19,6	27,0	33,3	35,3	30,6	23,9	17,3	27,8	33,4	27,9
1	32,5	28,6	18,8	15,4	24,6	32,1	35,1	30,2	21,1	15,8	27,0	32,9	26,2
2	32,0	26,7	15,5	12,6	20,6	30,6	34,6	28,7	20,1	14,9	26,5	33,1	24,7
3	32,2	26,0	14,6	10,6	17,6	27,4	31,9	26,6	17,8	14,4	25,8	32,6	23,1
4	32,1	26,2	14,1	11,6	18,0	27,9	32,3	27,6	17,7	12,7	25,0	30,8	23,0
5	31,0	25,4	13,1	10,7	17,1	28,2	33,0	27,2	18,3	12,6	23,4	30,8	22,6
6	29,9	23,8	11,4	8,3	14,8	26,8	32,7	26,3	16,3	11,5	23,6	28,4	21,2
7	27,5	21,6	8,8	5,9	13,2	28,3	33,4	27,8	16,7	10,7	20,5	26,3	20,1
8	17,1	12,8	4,6	4,0	11,5	27,4	32,4	28,3	16,6	9,3	17,8	18,6	16,7
9	14,7	11,1	4,5	3,8	10,6	26,6	30,5	26,1	15,5	10,3	17,6	17,9	15,8
10	14,2	11,8	5,2	3,9	10,1	27,4	32,4	27,4	17,1	11,3	19,0	19,0	16,6
11	13,2	11,2	5,2	3,2	12,8	30,7	35,6	32,0	20,6	11,1	17,5	18,4	17,7
12	10,9	10,4	5,8	3,2	13,5	33,3	38,8	35,0	22,3	10,6	16,0	16,6	18,1
13	10,1	9,7	6,0	3,6	14,8	35,0	40,8	38,2	25,1	11,1	14,9	15,0	18,7
14	10,3	9,5	7,0	4,3	15,1	36,3	42,4	38,9	25,9	11,3	13,8	14,3	19,2
15	9,2	8,9	7,5	5,1	15,3	35,7	41,2	37,9	25,3	11,6	13,6	13,9	18,8
16	10,2	10,3	8,6	7,0	19,9	38,5	43,5	39,3	28,6	13,2	12,9	14,2	20,6
17	12,6	11,7	10,2	10,9	27,0	42,3	45,1	42,7	31,2	15,9	15,5	16,3	23,5
18	18,8	17,0	14,8	18,4	33,8	43,5	45,7	43,7	36,5	21,7	20,5	22,9	28,2
19	26,9	23,9	22,2	27,1	38,5	43,9	45,7	44,0	38,3	25,9	27,2	29,9	32,8
20	33,0	30,1	28,7	31,6	39,3	43,2	44,0	41,5	36,5	26,3	31,8	35,0	35,1
21	33,1	32,1	30,8	30,7	36,2	39,0	39,1	36,9	30,1	24,5	31,5	35,6	33,3
22	33,2	30,4	28,0	25,7	30,8	33,7	35,9	31,2	25,3	21,2	29,8	32,9	29,9
23	33,3	30,8	25,7	22,1	28,2	32,3	33,8	29,0	22,8	19,0	28,7	33,5	28,3
Grand Total	23,0	20,0	13,9	12,5	21,3	33,5	37,3	33,2	23,7	15,2	22,0	25,1	23,4

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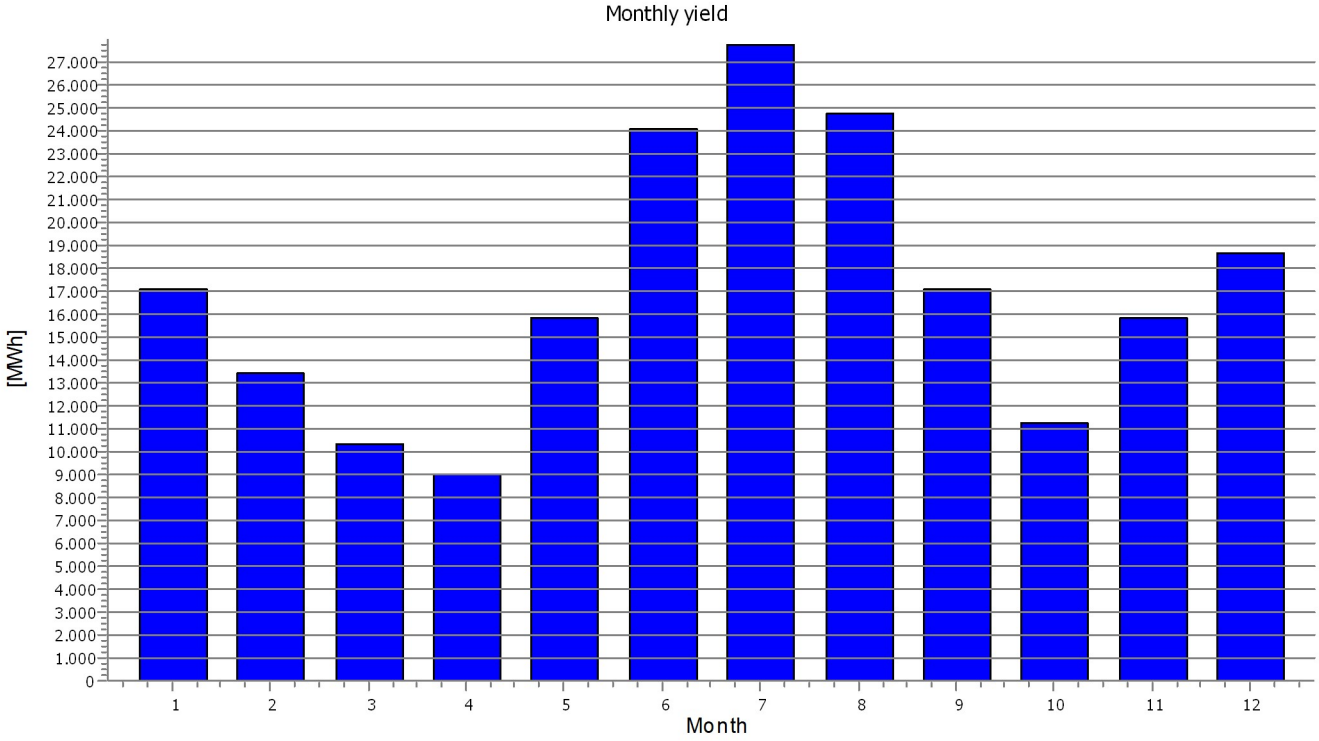
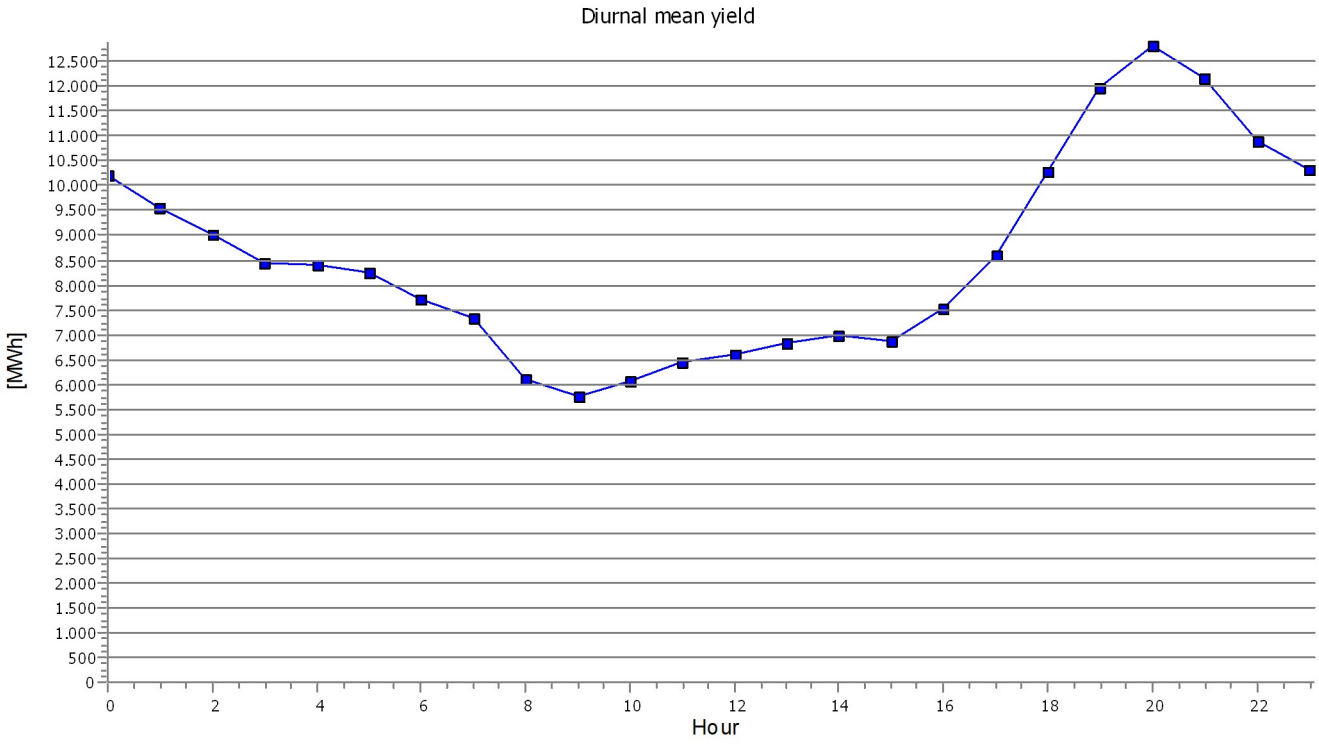
PARK - Time varying AEP

Calculation: 22-459-009 Harapanahalli - Karnataka

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.



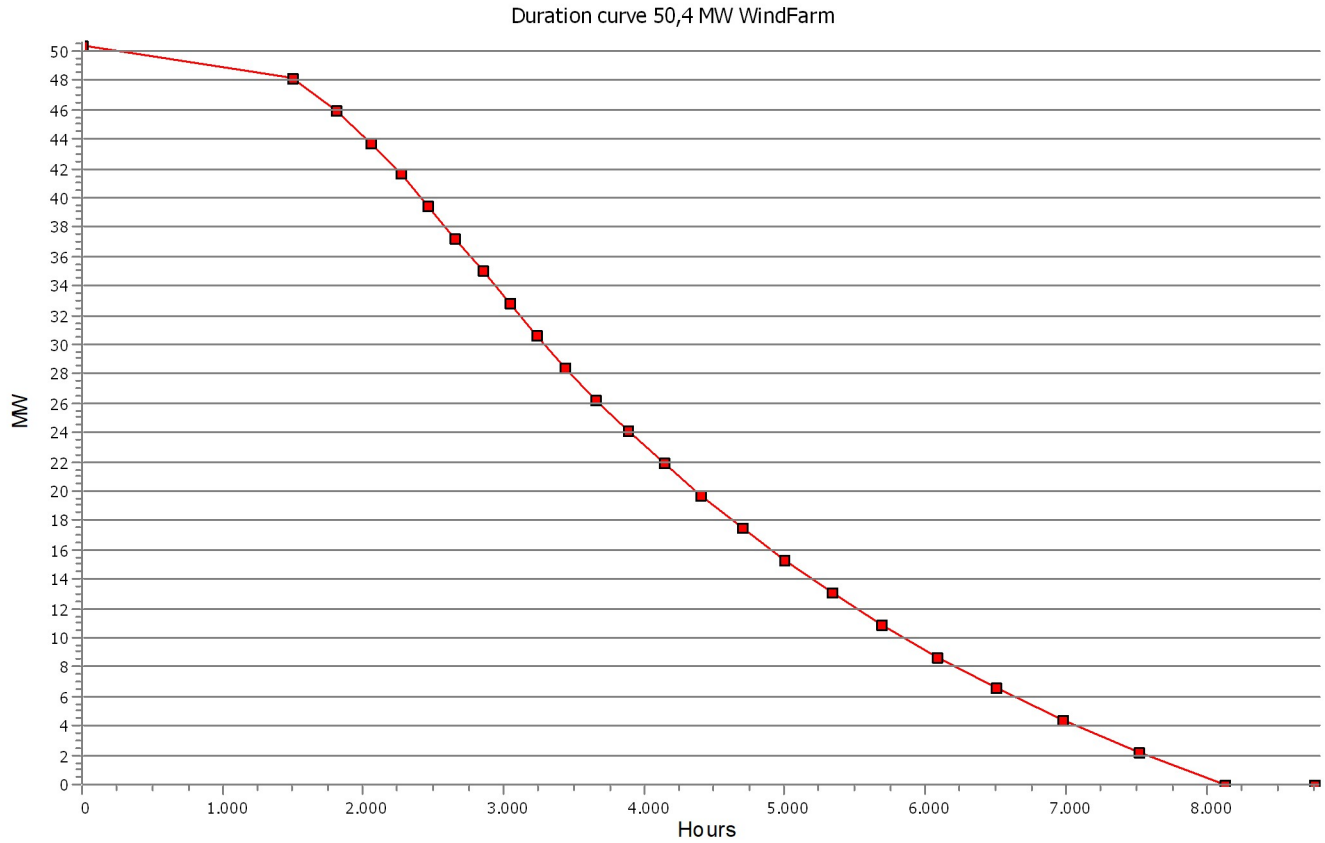


PARK - Time varying AEP

Calculation: 22-459-009 Harapanahalli - Karnataka

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
1490	17,0	1490	48,2 - 50,4	4,0 - 4,2
315	3,6	1805	46,0 - 48,2	3,8 - 4,0
244	2,8	2049	43,8 - 46,0	3,7 - 3,8
219	2,5	2268	41,6 - 43,8	3,5 - 3,7
194	2,2	2462	39,4 - 41,6	3,3 - 3,5
189	2,2	2651	37,3 - 39,4	3,1 - 3,3
192	2,2	2843	35,1 - 37,3	2,9 - 3,1
193	2,2	3035	32,9 - 35,1	2,7 - 2,9
199	2,3	3235	30,7 - 32,9	2,6 - 2,7
204	2,3	3439	28,5 - 30,7	2,4 - 2,6
215	2,5	3654	26,3 - 28,5	2,2 - 2,4
232	2,6	3886	24,1 - 26,3	2,0 - 2,2
251	2,9	4138	21,9 - 24,1	1,8 - 2,0
265	3,0	4402	19,7 - 21,9	1,6 - 1,8
286	3,3	4689	17,5 - 19,7	1,5 - 1,6
310	3,5	4998	15,3 - 17,5	1,3 - 1,5
333	3,8	5331	13,1 - 15,3	1,1 - 1,3
358	4,1	5689	11,0 - 13,1	0,9 - 1,1
385	4,4	6074	8,8 - 11,0	0,7 - 0,9
430	4,9	6503	6,6 - 8,8	0,5 - 0,7
476	5,4	6980	4,4 - 6,6	0,4 - 0,5
541	6,2	7521	2,2 - 4,4	0,2 - 0,4
605	6,9	8126	0,0 - 2,2	0,0 - 0,2
640	7,3	8766	0,0	0,0



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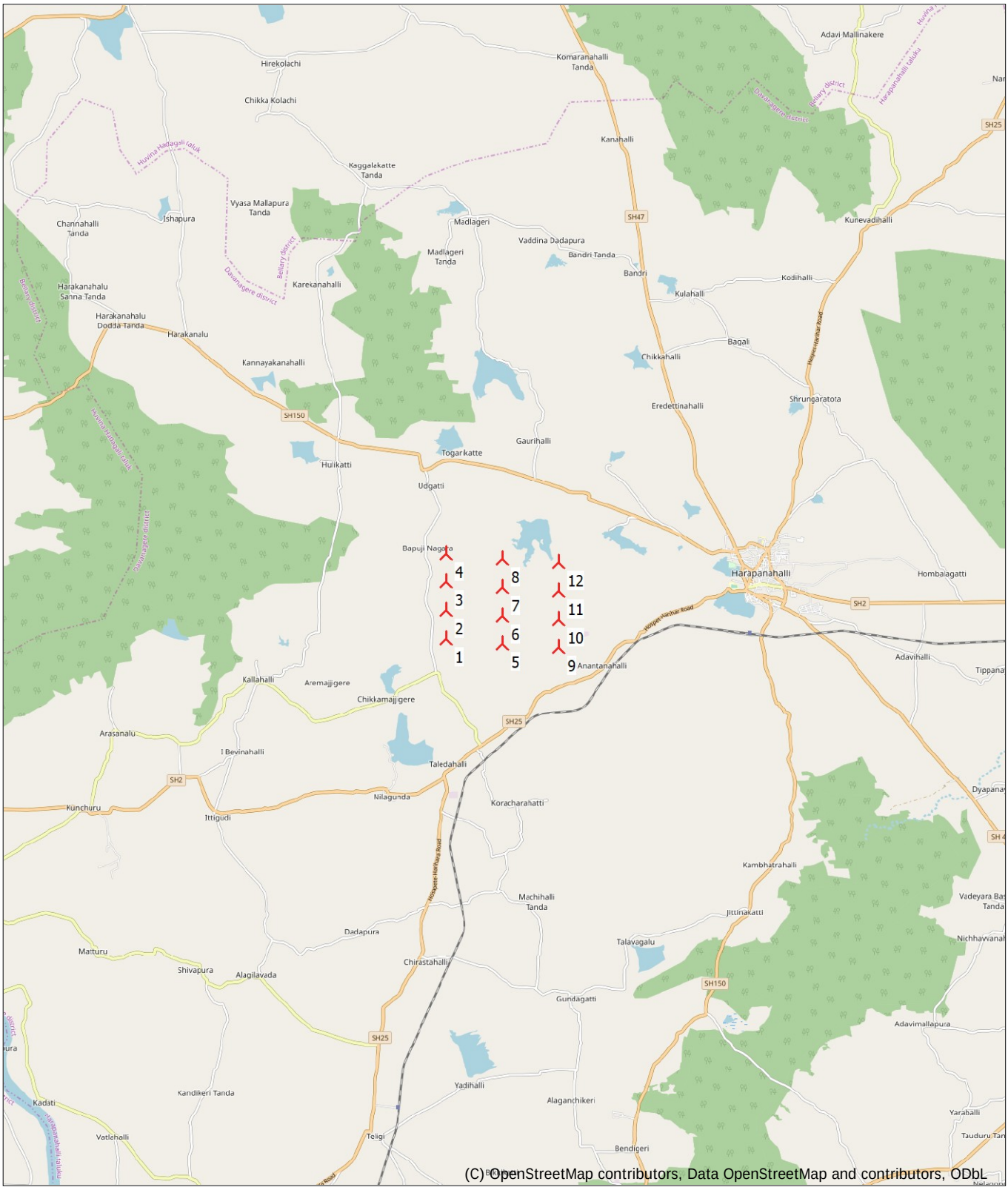
PARK - Map

Calculation: 22-459-009 Harapanahalli - Karnataka



0 2,5 5 7,5 10km

Map: EMD OpenStreetMap , Print scale 1:150.000, Map center Geo WGS84 East: 75,923666° E North: 14,781331° N

New WTG

Heat Maps - Harapanahalli, Karnataka

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	3,717	3,434	1,689	1,156	1,951	3,781	**15,727**
2	2,867	2,501	1,207	992	1,621	3,178	**12,366**
3	2,064	1,350	555	751	1,593	3,229	**9,542**
4	1,606	1,008	409	448	1,747	3,039	**8,257**
5	2,564	1,801	1,286	1,673	3,398	3,839	**14,560**
6	3,404	3,069	3,096	3,872	4,642	4,092	**22,175**
7	3,904	3,747	3,730	4,652	5,134	4,359	**25,526**
8	3,311	3,106	3,243	4,276	4,839	3,954	**22,729**
9	2,291	1,900	1,925	2,719	3,715	3,167	**15,718**
10	1,778	1,354	1,198	1,270	2,190	2,594	**10,385**
11	2,955	2,556	1,985	1,609	2,101	3,361	**14,567**
12	3,768	3,319	2,105	1,705	2,372	3,907	**17,176**
Total	**34,229**	**29,146**	**22,429**	**25,123**	**35,303**	**42,498**	**1,88,728**

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	59.5%	55.0%	27.0%	18.5%	31.2%	60.5%	**41.9%**
2	50.8%	44.3%	21.4%	17.6%	28.7%	56.3%	**36.5%**
3	33.0%	21.6%	8.9%	12.0%	25.5%	51.7%	**25.4%**
4	26.6%	16.7%	6.8%	7.4%	28.9%	50.2%	**22.8%**
5	41.0%	28.8%	20.6%	26.8%	54.4%	61.4%	**38.8%**
6	56.3%	50.8%	51.2%	64.0%	76.7%	67.7%	**61.1%**
7	62.5%	60.0%	59.7%	74.4%	82.2%	69.7%	**68.1%**
8	53.0%	49.7%	51.9%	68.4%	77.4%	63.3%	**60.6%**
9	37.9%	31.4%	31.8%	45.0%	61.4%	52.4%	**43.3%**
10	28.4%	21.7%	19.2%	20.3%	35.0%	41.5%	**27.7%**
11	48.9%	42.3%	32.8%	26.6%	34.7%	55.6%	**40.1%**
12	60.3%	53.1%	33.7%	27.3%	38.0%	62.5%	**45.8%**
Total	**46.5%**	**39.6%**	**30.5%**	**34.1%**	**48.0%**	**57.8%**	**42.7%**