

TEST SUMMARY REPORT

Manufacturer

Wish Energy Solutions Pvt. Ltd.

Wind Turbine

WINDISTAR 4500, Off- grid, 48 V DC

Test Report Number

PT14-PP-40, August 2016
PT14-SFT-41, August 2016
PT14-DT-42, August 2016



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(ISO 9001:2008)

1. Introduction: The report summarises the Power Performance measurement, Duration Test and Safety & Function test carried out on WINDISTAR 4500, in accordance with the international standard of IEC 61400-12-1 for “Power Performance Measurements of electricity producing wind turbines” and IEC 61400-2 for “Design Requirements for Small Wind Turbine”. The WINDISTAR 4500 is a three bladed, upwind variable speed turbine. The rotor swept area of the turbine is 16.6 m². The turbine was tested in the battery charger configuration with a charge controller voltage of 48 V DC. The measurements were carried out at Wind Turbine Research Station, Kayathar during the period 19 May 2015 to 02 August 2016.

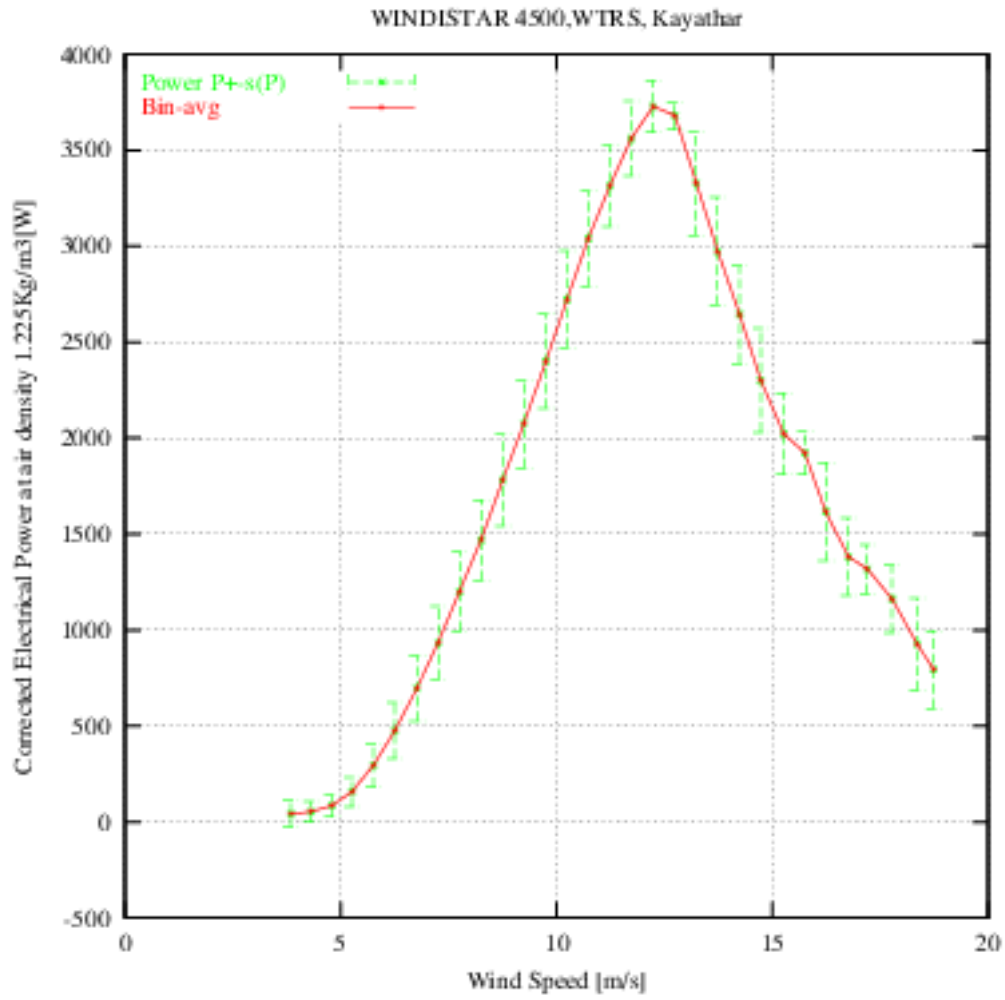
2. TURBINE RATING BASED ON TEST MEASUREMENT:

Reference Annual Energy	4296 kWh @ Annual average wind speed 5 m/s
Reference Power	3200 W @ 11 m/s
Peak Power	3730 W @ 12.2 m/s

3. Annual Energy Production (At Sea Level Air Density 1.225 kg/ m³)

Mean Wind Speed (m/s)	AEP Measured (kWh)			AEP Extrapolated (kWh)		
	AEP	Std. Dev	%	AEP	Std. Dev	%
4	1931	614	31.80	1931	614	31.80
5	4296	873	20.32	4296	873	20.32
6	7036	1079	15.34	7040	1080	15.34
7	9520	1226	12.88	9545	1227	12.85
8	11380	1314	11.55	11470	1320	11.51
9	12538	1353	10.79	12752	1367	10.72
10	13080	1352	10.34	13469	1377	10.22
11	13154	1321	10.04	13744	1360	9.90

4. Power Curve with combined uncertainty (data corrected for standard dry air density of 1.225 kg/m³)



5. Power Curve with Uncertainty Budget

A: Bin no. []

B: Wind speed [m/s]

C: Electrical power, adjusted for density variations [W]

D: Slope of power curve $\Delta P/\Delta v$ [W/(m/s)]

E: $\Delta P/\Delta t$ [W/(degK)]

F: $\Delta P/\Delta B$ [W/(mBar)]

G: Cp []

H: Category A uncertainty [W]

I: Category B uncertainty [W]

J: Total uncertainty [W]

K: Counts []

A	B	C	D	E	F	G	H	I	J	K
1	2.74	-23.4	-340.38	-0.08	-0.02	0.00	0	0	0	40
2	3.36	-19.9	5.68	-0.07	-0.02	0.00	1.7	51.8	51.9	82
3	3.84	40.1	124.94	0.14	0.04	0.07	13.2	69.8	71.1	59
4	4.32	53.7	28.31	0.19	0.05	0.07	4.4	52.9	53	534
5	4.79	84.2	64.83	0.29	0.08	0.08	2.5	57.2	57.3	2024
6	5.26	156.5	154	0.54	0.15	0.11	2.4	77.6	77.6	3781
7	5.76	295.2	277.26	1.02	0.29	0.15	3	116.2	116.2	4820
8	6.25	474.8	366.63	1.65	0.47	0.19	3.6	146.9	147	5736
9	6.76	695.3	432.33	2.41	0.69	0.22	4.1	170.2	170.3	6605
10	7.2	933.6	486.27	3.24	0.92	0.24	4.6	189.6	189.6	7382
11	7.75	1199.8	532.54	4.17	1.18	0.25	5.1	206.3	206.4	8038
12	8.25	1469.9	540.14	5.1	1.45	0.26	5.7	209.1	209.2	8378
13	8.75	1780.4	621	6.18	1.76	0.26	6.4	238.6	238.7	8463
14	9.24	2073.9	599.04	7.2	2.05	0.26	7.3	230.6	230.7	7980
15	9.75	2399.6	638.61	8.33	2.37	0.25	8.6	245.1	245.2	7139
16	10.24	2722.2	658.29	9.45	2.69	0.25	10.2	252.3	252.5	5955
17	10.73	3038.5	645.51	10.55	3	0.24	12.5	247.7	248	4537
18	11.23	3313.7	550.36	11.51	3.27	0.23	15.9	212.9	213.5	3118
19	11.73	3561.1	494.88	12.36	3.52	0.22	20.6	192.9	194	2034
20	12.24	3728.2	327.57	12.95	3.68	0.20	26.5	133.6	136.2	1340
21	12.74	3679.6	-97.16	12.78	3.63	0.17	32.7	64	71.8	952
22	13.24	3328.1	-703.02	11.56	3.29	0.14	36.8	268.8	271.3	803
23	13.73	2973.8	-722.94	10.33	2.94	0.11	44.8	276.1	279.7	550
24	14.24	2642.5	-649.63	9.18	2.61	0.09	45.3	249.1	253.2	497
25	14.73	2300.6	-697.9	7.99	2.27	0.07	48.5	266.8	271.2	367
26	15.26	2021.6	-526.36	7.02	2	0.06	54.6	204.1	211.3	219
27	15.75	1922.2	-202.76	6.67	1.9	0.05	64.6	92.1	112.5	159
28	16.23	1615.6	-638.92	5.61	1.59	0.04	77.5	245.2	257.1	79
29	16.76	1381.1	-442.34	4.8	1.36	0.03	102.3	173.8	201.7	53
30	17.20	1316.6	-146.66	4.57	1.3	0.03	104	75.6	128.6	39
31	17.77	1161.1	-272.79	4.03	1.15	0.02	134.1	114.7	176.5	20
32	18.35	925.8	-405.78	3.21	0.91	0.01	180.2	160.8	241.5	11
33	18.74	793	-340.38	2.75	0.78	0.01	147.5	137.8	201.9	14

6. Duration Testing: The turbine has successfully completed the duration test for an IEC Class III turbine during the test period. An operational time fraction of 95.82 % was achieved. The average turbulence intensity recorded at 15 m/s during the test period was 11.81%.

7. Safety & Function Testing: The turbine successfully completed the tests for Loss of Load and Emergency Stop under normal operation. The turbine performance with respect to power & speed control, over speed protection, battery overvoltage protection and yaw system control were observed to be within manufacturer specified limits.

8. Manufacturer supplied Turbine Specification

General Configuration	Make, Model	WISH Energy Solutions Pvt Ltd, WINDISTAR 4500
	Rotation Axis	Horizontal
	Orientation	Upwind
	Number of blades	3
	Rotor diameter (m)	4.6
	Hub height (m)	18
Performance	Rated Electrical Power (W)	4500
	Rated wind speed (m/s)	12.5
	Cut-in wind speed(m/s)	3
Rotor	Swept area (m ²)	16.62
	Rotational Speed (rpm)	600
	Direction of rotation	Clockwise
	Over-speed control	Furling tail, Dump Load
Yaw System	Wind Direction Sensor	Furling tail
	Yaw control method	Free yaw
Tower	Type	Guyed Steel Tubular
	Height (m)	18

Battery Charger	Model	WINDISTAR 4500
	Manufacturer	WISH Energy Solutions Pvt Ltd
	Nominal Battery Voltage (V) DC	48
	Maximum output power (W)	5000
	Maximum Output Current (A)	100 A