TEST SUMMARY REPORT

Manufacturer	**Spitzen Energy Solutions (India)Pvt. Ltd.**
Wind Turbine	**Montana, Off- grid, 48 V DC**
Test Report Number	**PT11-PP-31, August 2015** **PT11-SFT-32, August 2015** **PT11- DT- 33, August 2015**

1. **Introduction:** The report summarises the Power Performance measurement, Duration Test and Safety & Function test carried out on Montana, 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 Montana is a three bladed, upwind variable speed turbine. The rotor swept area of the turbine is 19.63 m^2. 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 May 26, 2013 to March 9, 2015.

2. **TURBINE RATING BASED ON TEST MEASUREMENT:**

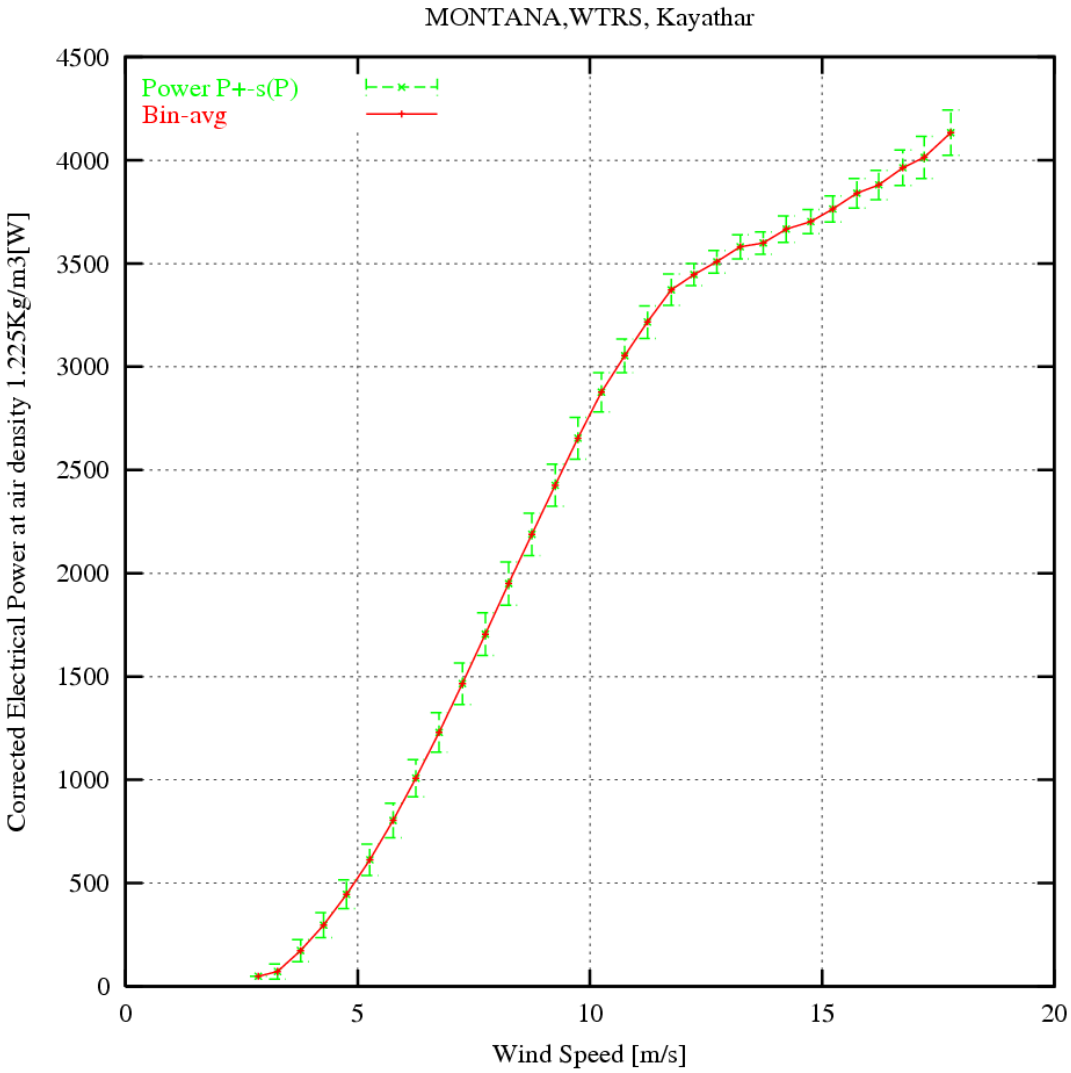
Reference Annual Energy	6634 kWh @ Annual average wind speed 5 m/s
Reference Power	3100 W @ 11 m/s
Peak Power	4130 W @ 17.8 m/s

3. **Annual Energy Production (At Sea Level Air Density 1.225 kg/ m^3)**

Mean Wind Speed (m/s)	**AEP Measured (kWh)**			**AEP Extrapolated (kWh)**		
	AEP	Std. Dev	%	AEP	Std. Dev	%
4	3807	424	11.14	3807	424	11.14
5	6634	529	7.97	6634	529	7.97
6	9627	586	6.09	9664	586	6.06
7	12375	606	4.90	12604	608	4.82
8	14561	602	4.13	15296	609	3.98
9*	16038	583	3.64	17649	597	3.38
10*	16826	554	3.29	19592	579	2.96
11*	17045	520	3.05	21084	557	2.64

* In-complete as per IEC 61400-12-1 (As per IEC 61400-12-1, estimations of AEP –measured shall be labelled as "incomplete" when calculations show that the AEP-measured is less than 95 % of the AEP- extrapolated.)

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	2.86	49.2	211.2	0.17	0.05	0.17	0	0	0	90
2	3.27	72.1	55.41	0.25	0.07	0.17	2.5	36.8	36.9	488
3	3.77	173.1	205.26	0.6	0.17	0.27	3.4	54	54.1	610
4	4.26	296.7	249.13	1.03	0.29	0.32	4.2	61	61.1	769
5	4.76	446.2	298.97	1.55	0.44	0.34	4.5	69.4	69.5	1087
6	5.26	612.9	335.9	2.13	0.6	0.35	4.8	75.8	76	1360
7	5.76	803.4	383.27	2.79	0.79	0.35	5.4	84.4	84.5	1614
8	6.25	1007.9	414.88	3.5	1	0.34	6.1	90.2	90.4	1722
9	6.75	1230.6	444.17	4.27	1.21	0.33	6.7	95.6	95.9	1849
10	7.25	1465.3	469.94	5.09	1.45	0.32	8	100.5	100.8	1577
11	7.75	1705.8	482.57	5.92	1.68	0.31	9.3	102.9	103.3	1452
12	8.25	1950.6	490.65	6.77	1.93	0.29	10.4	104.4	105	1451
13	8.75	2189.2	478.2	7.6	2.16	0.27	11.8	102.2	102.8	1341
14	9.25	2426.8	473.49	8.43	2.4	0.26	12.4	101.3	102.1	1356
15	9.74	2654.8	465.8	9.22	2.62	0.24	13.7	100	100.9	1297
16	10.25	2877	433.18	9.99	2.84	0.22	15.3	94	95.2	1165
17	10.75	3053.1	354.25	10.6	3.01	0.2	17.6	79.8	81.7	875
18	11.24	3216.4	331.25	11.17	3.18	0.19	19.6	75.8	78.3	766
19	11.75	3373	309.07	11.71	3.33	0.17	22.2	72	75.4	594
20	12.24	3445.7	146.1	11.96	3.4	0.16	24.7	47.2	53.2	496
21	12.73	3508.3	129.69	12.18	3.46	0.14	30.9	45.3	54.8	331
22	13.24	3581.5	142.25	12.44	3.54	0.13	34.8	46.8	58.4	263
23	13.73	3598.9	35.47	12.5	3.55	0.12	38.8	37.9	54.3	226
24	14.23	3666.5	134.45	12.73	3.62	0.11	43.7	46	63.5	179
25	14.76	3703.2	70.4	12.86	3.66	0.1	42.9	39.9	58.6	176
26	15.23	3764	127	13.07	3.72	0.09	44.7	45.2	63.6	160
27	15.75	3839.9	148.11	13.33	3.79	0.08	53.3	47.8	71.5	102
28	16.22	3880.7	85.73	13.47	3.83	0.08	57.8	41.3	71	87
29	16.74	3963.5	161.02	13.76	3.91	0.07	69.8	49.5	85.6	57
30	17.2	4013.4	108.06	13.94	3.96	0.07	92.2	43.5	101.9	27
31	17.77	4133.7	211.2	14.35	4.08	0.06	93.3	56.7	109.2	23

6. **Duration Testing:** The turbine has successfully completed the duration test for an IEC Class II turbine during the test period. An operational time fraction of 95.93 % was achieved. The average turbulence intensity recorded at 15 m/s during the test period was 11.08%. The maximum instantaneous wind speed recorded was 20.4 m/s in August 2013.

7. **Safety & Function Testing:** The turbine has 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	Spitzen Energy Solutions (India) Pvt Ltd, MONTANA
	Rotation Axis	Horizontal
	Orientation	Upwind
	Number of blades	3
	Rotor diameter (m)	5
	Hub height (m)	18
Performance	Rated Electrical Power (W)	5000
	Rated wind speed (m/s)	14
	Cut-in wind speed(m/s)	2.5
	Furling wind speed (m/s)	14
Rotor	Swept area (m^2)	19.63
	Rotational Speed (rpm)	300
	Direction of rotation	Clockwise
	Over-speed control	Furling tail
Yaw System	Wind Direction Sensor	Furling tail
	Yaw control method	Free yaw
Tower	Type	Guyed Steel Tubular
	Height (m)	18

Battery Charger	Model	MONTANA
	Manufacturer	Spitzen Energy Solutions (India) Pvt Ltd
	Nominal Battery Voltage (V) DC	48
	Maximum output power (W)	5600
	Maximum Output Current (A)	150 A