



## TEST SUMMARY REPORT

Manufacturer **Spitzen Energy Solutions (India )Pvt. Ltd.**

Wind Turbine **Passaat, Off- grid, 48 V DC**

Test Report Number **PT4-PP-10, August 2012**  
**PT4-SFT-11, August 2012**  
**PT4-DT-12, December 2012**

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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 Passaat, 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 Passaat is a three bladed, upwind variable speed turbine. The rotor swept area of the turbine is 7.65 m<sup>2</sup>. 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 December 6, 2010 to October 31, 2012.

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

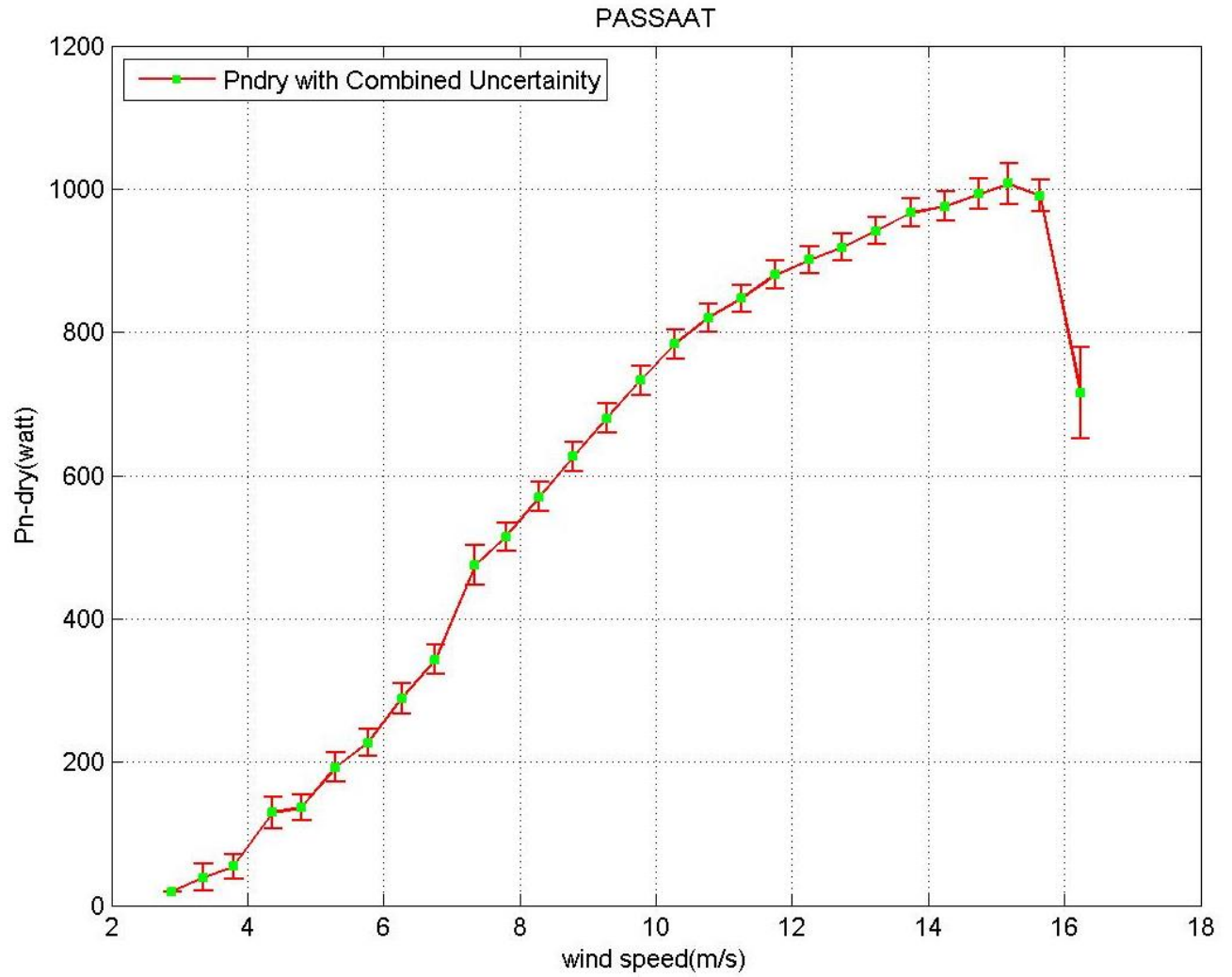
<b>Reference Annual Energy</b>	1810 kWh @ Annual average wind speed 5 m/s
<b>Reference Power</b>	845 W @ 11 m/s
<b>Peak Power</b>	925 W @ 14.74 m/s

### 3. Annual Energy Production (At Sea Level Air Density 1.225 kg/ m<sup>3</sup>)

Mean wind speed (m/s)	AEP Measured (kWh)			AEP Extrapolated (kWh)		
	AEP	Std. Dev	%	AEP	Std. Dev	%
4	1076	116	10.781	1076	116	10.781
5	1810	136	7.514	1812	136	7.506
6	2545	147	5.776	2563	148	5.774
7	3163	153	4.837	3248	155	4.772
8*	3595	154	4.284	3822	160	4.186
9*	3831	151	3.942	4271	162	3.793
10*	3904	145	3.714	4597	164	3.568
11*	3856	138	3.579	4810	163	3.389

\* 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/m<sup>3</sup>)



## 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	2.89	19.12	-437.15	0.06	0.02	159.093	0	0	0	19
2	3.35	39.06	40.69	0.13	0.04	208.5	2.7	18	18.2	91
3	3.8	54.00	31.75	0.18	0.05	198.592	1.3	17.8	17.9	462
4	4.37	129.56	123.38	0.42	0.12	311.613	4	21.5	21.8	125
5	4.79	136.40	15.68	0.45	0.13	249.392	1.6	17.6	17.7	848
6	5.29	192.75	105.44	0.63	0.18	261.117	1.8	20.5	20.6	1029
7	5.76	226.77	68.36	0.74	0.21	238.116	1.4	18.8	18.9	2158
8	6.27	289.13	117.25	0.95	0.27	236.409	1.5	21.1	21.2	2465
9	6.76	343.23	103.37	1.12	0.32	223.574	1.6	20.4	20.5	2736
10	7.34	474.14	210.98	1.55	0.44	240.693	4.4	27.5	27.8	507
11	7.8	514.77	83.12	1.68	0.48	217.702	3.2	19.5	19.7	1022
12	8.29	570.16	105.59	1.86	0.53	200.75	3	20.5	20.7	1212
13	8.78	626.18	105.34	2.04	0.58	185.063	2.9	20.5	20.7	1251
14	9.27	679.82	101.92	2.21	0.63	170.616	3.1	20.3	20.6	1082
15	9.77	732.53	98.54	2.39	0.68	157.046	3.4	20.2	20.5	829
16	10.28	783.52	92.14	2.55	0.72	144.108	3.6	19.9	20.2	652
17	10.77	820.07	68.92	2.66	0.76	131.145	3.5	18.9	19.3	638
18	11.25	846.96	49.97	2.75	0.78	118.528	3.5	18.3	18.7	574
19	11.75	880.11	62.1	2.86	0.81	108.225	3.7	18.7	19.1	434
20	12.25	900.94	37.82	2.92	0.83	97.602	4	18.1	18.5	325
21	12.73	918.76	34.01	2.98	0.85	88.674	4.7	18	18.6	209
22	13.24	941.25	41.69	3.05	0.87	80.83	5.2	18.1	18.9	140
23	13.74	966.98	46.91	3.13	0.89	74.231	6.9	18.3	19.5	63
24	14.25	975.80	14.61	3.16	0.9	67.102	8.9	17.7	19.9	32
25	14.74	992.59	31.41	3.21	0.91	61.682	11.5	17.9	21.3	20
26	15.18	1007.10	38.72	3.27	0.93	57.508	21.4	18.1	28	15
27	15.64	990.56	-39.12	3.21	0.91	51.528	12	18.1	21.7	13
28	16.23	715.14	-437.15	2.31	0.66	33.24	42.9	47.1	63.8	11

**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 90.08 % was achieved. The average turbulence intensity recorded at 15 m/s during the test period was 7.07%. The maximum instantaneous wind speed recorded was 18.5m/s on 18.7.2011.

**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	Spitzen Energy Solution (I) Pvt. Ltd., PASSAAT
	Rotation Axis	Horizontal
	Orientation	Upwind
	Number of blades	3
	Rotor diameter (m)	3.12
	Hub height (m)	20
Performance	Rated Electrical Power (W)	1400
	Rated wind speed (m/s)	15
	Cut-in wind speed(m/s)	3
	Cut-out wind speed (m/s)	25
Rotor	Swept area (m <sup>2</sup> )	7.65
	Rotational Speed (rpm)	0 - 800
	Direction of rotation	Clockwise
	Over-speed control	Yawing and Dump Load
Yaw System	Wind Direction Sensor	Furling tail
	Yaw control method	Free yaw
Tower	Type	Tilt-up tubular tower
	Height (m)	20

Battery Charger	Model	PASSAAT
	Manufacturer	Spitzen Energy Solution (I) Pvt. Ltd.
	Nominal Battery Voltage (V) DC	48
	Maximum output power (W)	1400