

Small-scale Vertical Axis Wind Turbines: Wind tunnel testing results

Cleanfield's first prototype small-scale Vertical Axis Wind Turbine (VAWT) has been tested in the wind tunnel at National Resources Canada's laboratory in Ottawa.



Figure 1. NRCan 9m Wind Tunnel

The targeted nominal power for this turbine was 2.5kW at 250rpm. Changes of the conceptual design during detailed design and prototype build have allowed increasing the expected output power within the same size and wind parameters to 3.5kW.

The tests in the wind tunnel had two main objectives:

1. Experimental determination of the power curves (power surface)
 - Dimensional – power vs. rotational speed for different wind speeds
 - Dimensionless: Power coefficient (C_p) vs Tip speed ratio λ
 - Power coefficient: ratio of produced power to power available in the wind
 - Tip speed ratio λ : ratio of blade speed to wind speed
2. Determination of additional improvements to the design for increased output power and structural integrity

The tests were conducted in the 9m low speed wind tunnel under ideal wind conditions: flat velocity profile, low turbulence, highly controlled wind speed.

Measured values:

- Tunnel conditions: V_∞ , P, T
- Total drag, Yawing moment from tunnel balance
- RPM, Torque, Vibrations from turbine instrument package

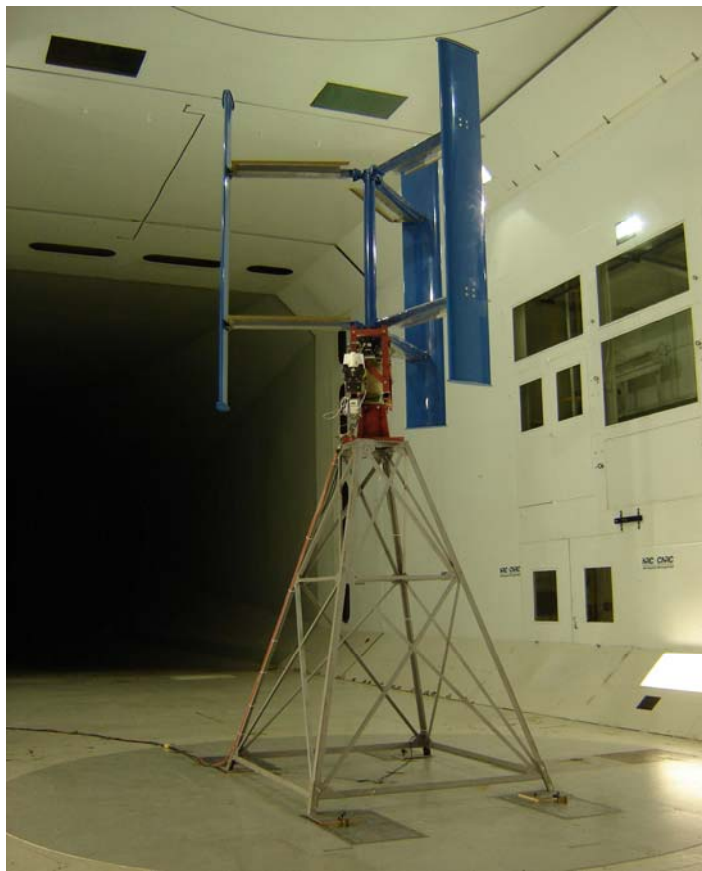


Figure 2. Assembled test setup in NRCan wind tunnel



Figure 3. Detail of instrumentation and control installation

Power curves measurements have been done under the following conditions:

- Wind speeds: 6,8,10,12,14,16 m/s
- Vary rotary speed by 5 RPM from first self-sustaining RPM to maximum RPM (unless high vibration exists).
- 120/60 second averaging to account for pulsating nature of torque signal
- Control of the rpm using a closed loop mechanical system (for optimum performance usually done by power electronics controlling the generator – under development at the time of the tests).

Test Results:

Figure 4 shows the experimental turbine's power curves:

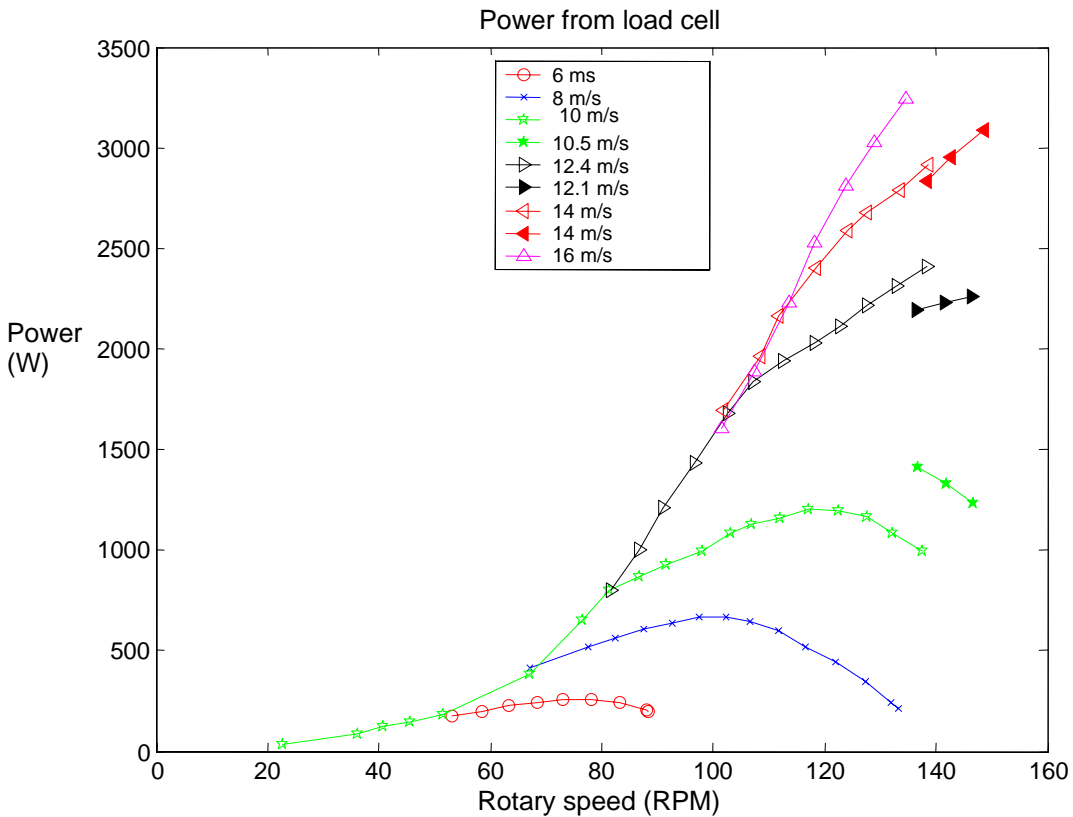


Figure 4. Experimental Power Curves

The 2.5kW is obtained at of about 140rpm and wind speed of 12m/sec.

At higher wind speeds the output power can increase up to 3.5kW, without increasing the rotational speed significantly. The effect is higher power at low rpm reducing even further the audible noise typically anyway low for this type of turbine.

The expected vibrations detected at a number of rotational speeds have been recorded and will be avoided through the electronic control of the generator.

The information gathered during the tests and following analysis has been considered and implemented in the VAWT pilot production's documentation.