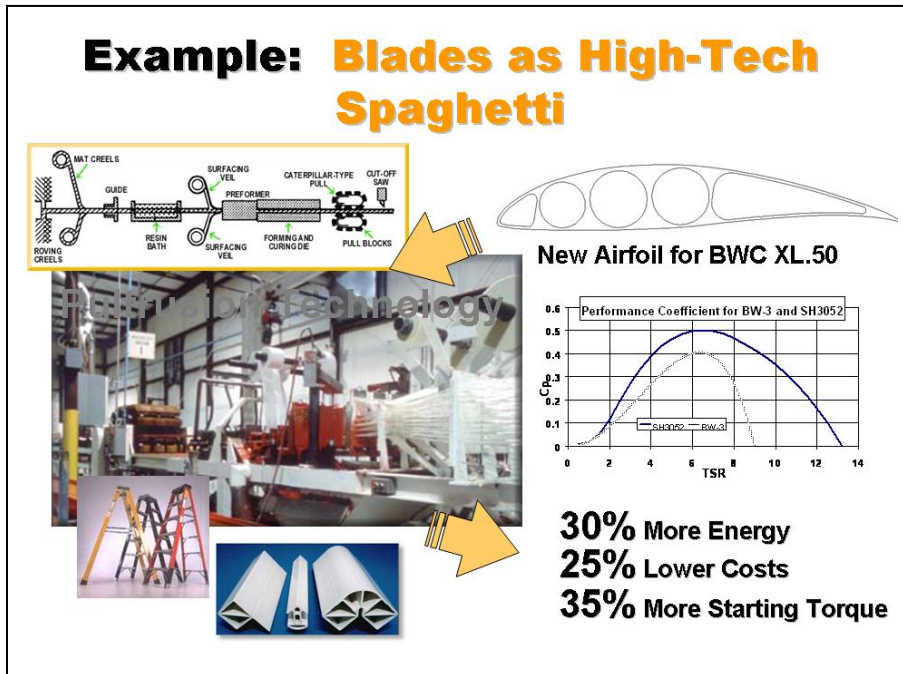


Hi Stew,

Yes, thanks for pointing out this slide (#16) in which Mike Bergey talks about one of his improved blades at a recent conference (KidWind).



Yes I agree there certainly seems to be some inconsistency here. The slide, of course, shows  $C_p$  vs TSR. I remember seeing TSR defined in an IEEE article by Knights & Peters Vol 20 2005 pp 459-466. So I looked it up:

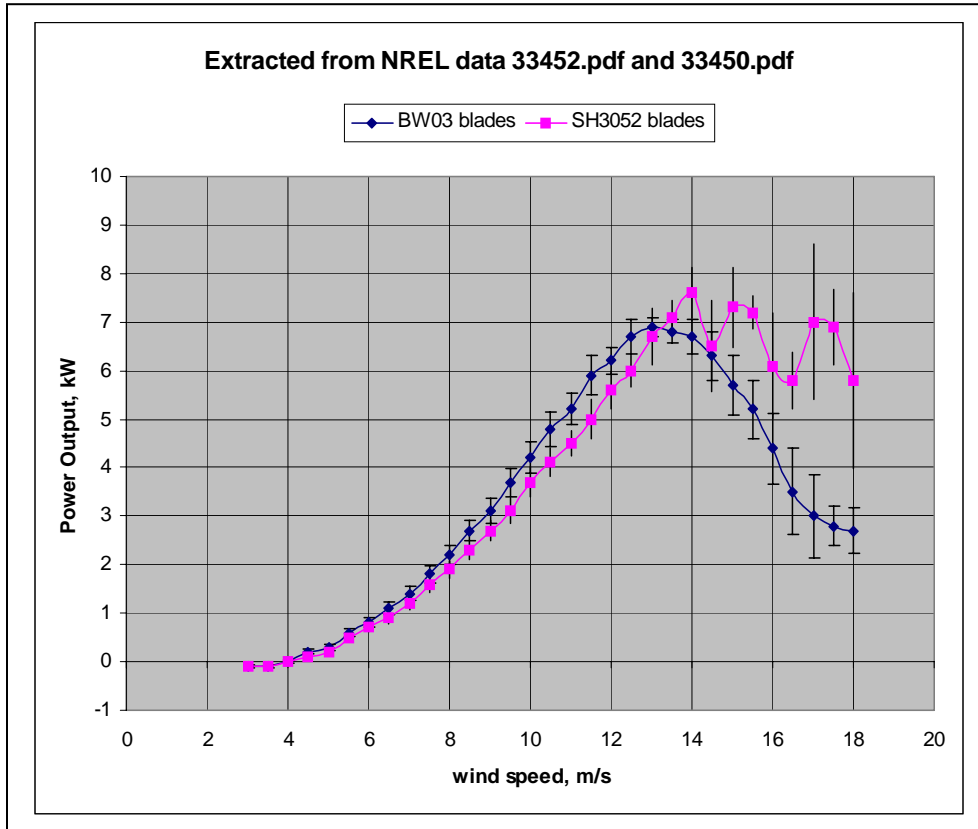
**TSR** = radius of blade \* rotational speed/wind speed.

A plot of  $C_p$  vs TSR usually shows a distinct maximum as in slide #16. In designing blades/turbines you want to match the airfoils and generator so that the turbine operates somewhere near the peak  $C_p$  over the expected productive wind speeds. Now, this slide compares two blades on, I presume, the same Bergey turbine. Well changing the blades might change the angular velocity at any given wind speed when the turbine is loaded at MPPT, right? So now the question I have is how much will the operational range of TSR change when you change blades but use the two sets of blades in the same wind environment and with the same turbine? I can't figure that out from Mike Bergey's slide #16; it seems we need more information. But total power production will be given by:

**power (kW)** = 0.5 x air density x swept blade area x  $C_p$  x (wind velocity)<sup>3</sup>.

So the issue here is: How do the two blades perform in the real world on the same turbine in the same wind environment? The NREL data you site and that I reference on my SWIEP site would seem to give the answer. The purpose of the two NREL publications was NOT to compare the SH3052 blade to the BW03 blade but one can take the two data sets + error bars, and plot them on the same graph. I have done this and will post it on my SWIEP site. The answer is interesting!

The SH3052 blades consistently underperform the WB03 blades until the peak power is reached (around 13-14 m/s). Then the power output of the SH3052 exceeds that of the WB03 as wind velocity increases; both power curves fall off with increasing wind but the SH3052 falls off slower.

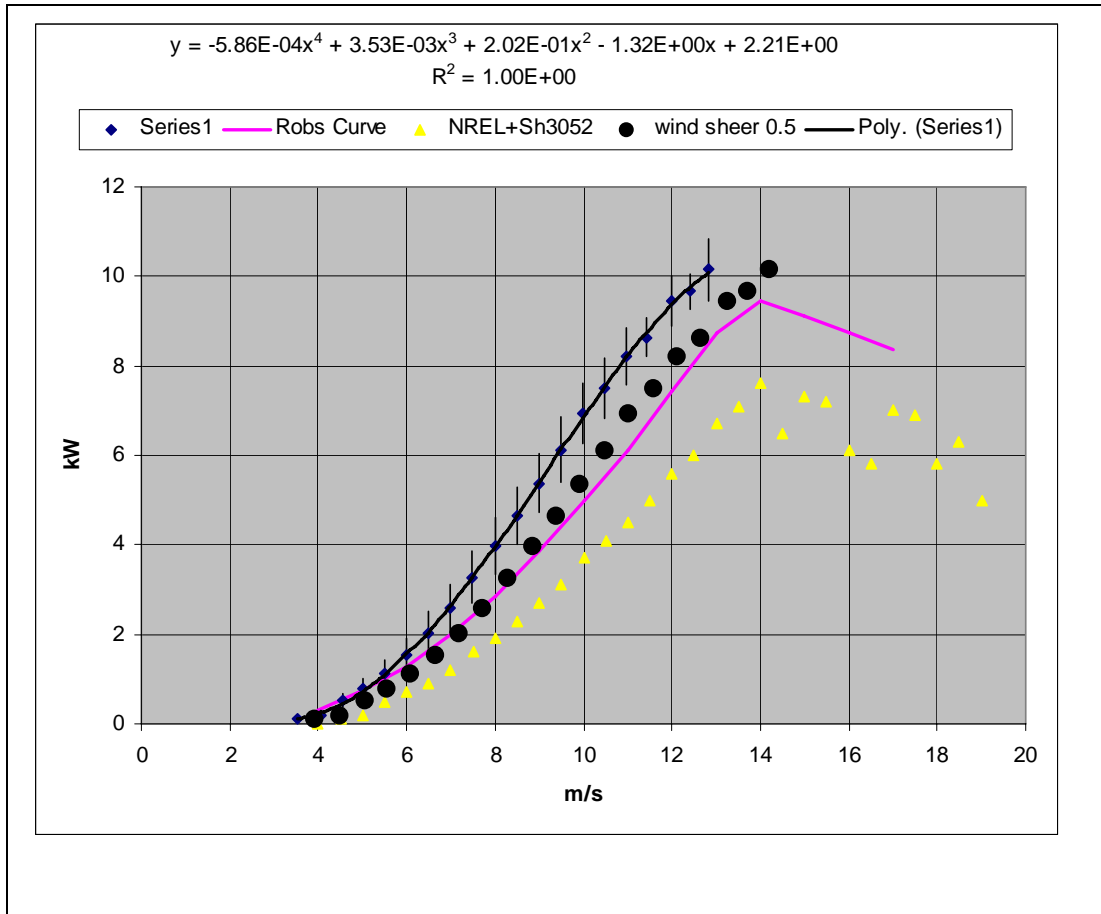


I think we have to keep in mind, that the power output is the function of three components working together, i.e., the blades + the turbine-generator + inverter. Any one of these components can limit the output of the other.

So the situation is complex but it clearly appears that Mike Bergey may be overstating the case regarding which blade is better. If Mike Bergey has his own data sets of better quality than NREL or even just as good as...well, he ought to 'publish' them, but we need materials, methods, results, statistics and analysis ... not just claims that his blades are the best in the industry.

#### **REVISION: Dec 7 2008**

However, there is another interpretation. Mike Bergey's PowerPoint slide might refer to the wrong blade number (SH3052 in his slide). I recently asked my installer (SED) to check what blades were put on my Bergey Excel-s two years ago. ANSWER: SH3055. So why would Mike be giving a PowerPoint talk about an OLD blade when he has a new one? So I dug a little more into power curves. I reproduce the power curve above with a new power curve transmitted by Bergey Windpower Company (BWC) to Rob Beckers.



In the above graph the yellow triangles are the NREL data on the SH3052 blades attached to the Bergey Excel-s and the pink line is the BWC-provided curve for the SH3055 blades attached to the same turbine. In both cases the inverter is the GridTek10. This does show a dramatic improvement. Is there an independent confirmation of this? NOT REALLY. But I do have something close that supports the BWC claim.

I am not collecting power curves on my Bergey Excel-s in Ellenburg, NY, yet. But I do have an NRG anemometer mounted on my Bergey tower at 100 ft (about 22 ft below the hub). This is a surplus anemometer taken from a met tower operated by SED to collect wind speed data for a commercial wind farm in my area. In the old days (2004), SED tells me that it was common practice to collect wind data for future wind-farms using NRG anemometers without independent calibration. So this NRG anemometer has never been calibrated by an independent agent. They assumed in the old days that the factory calibration was good enough.

I have used this to get what I call a 'power correlation curve' (PCC); a PCC is a correlation between measured power output versus wind speed near by (in this case 22 ft below hub-height where wind speeds are likely to be lower by a factor =  $(100/122)^\alpha$  where  $\alpha$  = the wind sheer coefficient. A PCC is fine for my use, which is to calculate how many kWh of energy is lost on a windy day when the GridTek10 inverter gets overloaded and shuts down (see SWIEP R#40).

In my location I have recorded a lower-than-expected turbulence intensity (TI = 0.15) hence I expect  $\alpha$  to be around 0.3 because  $\alpha$  and TI tend to increase together. The highest  $\alpha$  I could justify might be 0.5. It is not legitimate to do this but in the interest of fairness I will do it.

I have added my PCC to the real power curves on page 3. The small circles with error bars (SD = standard deviations) are the power produced at 122 ft versus the wind speed at 100 ft based on 1 min bins (I measured wind speed at 1 Hz so the means contain 60 readings). I save all 1-s readings so I can re-compute bins at any time-window. The results are unchanged for bins between 45 s and 90 s, i.e., the means are unchanged but SD does increase slightly as you go from 90 s to 45 s bins. If I correct for  $\alpha$  I can get something nearer a real power curve and this is represented by the large circles. CAUTION: this is still not a power curve in the usual sense because (1) I have not corrected for air density. I have data to do that and if I did the PCC would increase slightly, and (2) I have excluded periods of time when the GridTek10 is off-line because it tends to enter a power-overload state when wind speed exceeds about 16 m/s. A real power curve would NOT exclude those off-line periods, but the purpose of my PCC is to figure out how much power I would have if the GridTek10 does not go off-line, hence that is my reason for doing this in an unusual way.

Bottom line, I have a weak but independent confirmation of BWC's power curve and hence I feel that BWC's claim is justified. The SH3055 is an improvement over the SH3052 blade. In retrospect I am sorry I took Mike Bergey's PowerPoint slide as correct. I suspect now that the SH3052 label should have been SH3055. Mike, you might want to correct your slide. I am sorry I did not contact you to confirm!

--Mel

Prof Mel Tyree

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Disclaimer: I am not an expert on wind turbines. So I welcome comments from experts so that I can improve this and future summaries I might write. Email comments to [mtyree@ales.ualberta.ca](mailto:mtyree@ales.ualberta.ca)

Since posting this message, I have received an opinion from an expert in Japan who designs wind turbines (received late May 2008). I quote this below:

Dear Mel,

I read from some newsletter email your issue with the Bergey blades and their dramatically improved performance. I quite agree with you regarding too clandestine report about the efficiency of Bergey blades.

First issue is that BW03 blades are bigger than SH3052 blades so the rotor is 7m instead of 6.76m in later case. It doesn't seem to be much, but when you compare output you will find that BW03 would give 7.2% higher mechanical power than SH3052 rotor. This could explain difference in a power curve you presented on page 2 of your pdf paper.

Sudden brake down in power performance for higher wind speeds could be due the stalling effect of the BW03 blade that is yielding a very thin protruded airfoils in a tip region comparing to the thick ones ifor SH3052 airfoil case that are probably more resistant to aerodynamic twisting.

Best Regards,  
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