

# WIND POWER BLADE EFFICIENCY UPGRADE

Benton F. Baugh, Ph.D., P.E.

## EXECUTIVE SUMMARY:

The presentation of substantial efficiency upgrades to wind energy devices, i.e. quadrupling the output, and small scale test results.

The photograph on the opposite column shows a wind farm in Hawaii, probably the only state in the union which has to import 100% of its fossil fuels. As you can see, they are not generating power and are in need of repair. It is not clear what the situation is, however, it would tend to teach that wind energy is not actually economic—except as a venture based on government grants. Once the grant money runs out, they are abandoned.

The development of substantially more efficient wind energy can be a key component in U.S. energy independence and a greener environment. The same would apply for all the world. Fossil fuels are now and will continue to be critical to civilization as we know it. Literally when fossil fuels are gone, planes will no longer fly.

Conventional wisdom says to make wind turbines with 2 or 3 blades. If you want more power you simply make the blades longer. Blades are now being designed to be as long as a football field. This increases capacities, but with the following unintended consequences:

1. Substantial cost increases on the blades and the taller towers to support them.
2. The tip speed of the blades is so fast that birds cannot see them, and when in bird migration paths can have a substantial bird kill.
3. It is hard to imagine that you can accelerate the tips of the blades to a speed which makes them invisible and still harvest net energy. You would get some energy from the tips and you would spend energy to push the tips at great speeds.

Figure 1 at the right shows the conventional 3 blades such as would be used on a wind farm. Occasionally there will be only two blades. This is what will be considered as the base case. Upgrades will be compared to this.



Photo by Marc Moskowski

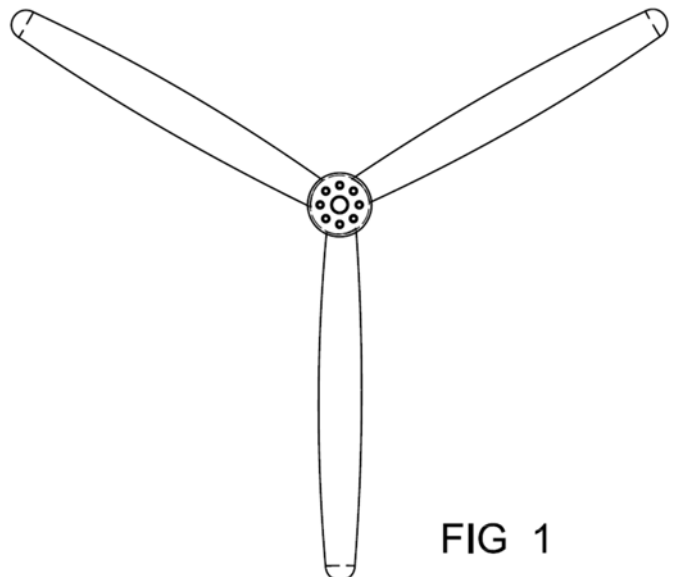


FIG 1

# WIND POWER BLADE EFFICIENCY UPGRADE

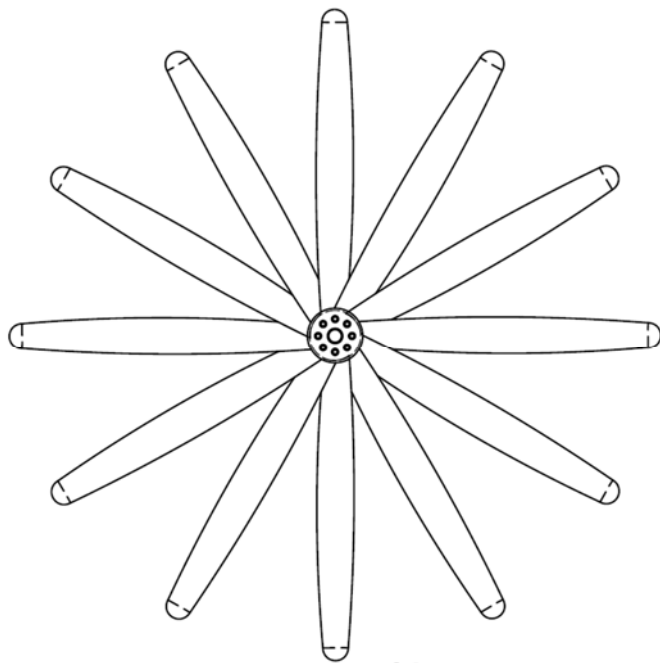
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## UPGRADE DESIGN #1:

Figure #2 as shown will increase the capacity to harvest energy from the wind by an extra 300%. That's it. Add 9 more blades.

Staying with the same tower and the same blade length it becomes 4 times as efficient. The pipe to make the tower may need to have a slightly thicker wall, but it will not be significant. Most of the work of the tower is to hold itself up.

This change is so simple that a small child can understand it. Who it is not clear to is industry experts. I have personally proposed this to a past Chair of the ASME Wind Energy Division several years ago, and only received a blank stare. I have shown this to hundreds of individuals over the years and have had no one disagree with me. I finally had a college professor who at least could tell me a reason. He said that all the formulas were set up for 2 or 3 blades so what could he do?



I suspect that the problem stems from propeller designers drawing on blade designs based on powered propellers such as aircraft propulsion.

In an airplane you may be putting hundreds of horsepower into blades plowing into the wind. In this case if you have too many blades, one will be in the wake of the preceding blade giving it bad flow characteristics.

When the wind is powering the blades the dynamics are very different. You are much less likely to have the wake of one blade interfering with the next blade. The wake will be moving away from the blades at the speed of the wind.

The challenge I regularly make is for a person to go to a farmer who has 12 blades on this windmill and tell him he will get more power if he removes 9 of his blades. I have gotten no takers.

## UPGRADE DESIGN #2

Upgrade design #2 was manufactured and tested against the professionally design propeller of the Sterling engine shown below. The "crankshaft" was removed and replaced with a 0.062" Tig wire so that we would have a straight shaft for the propeller to drive. The propeller is 7.990" long.



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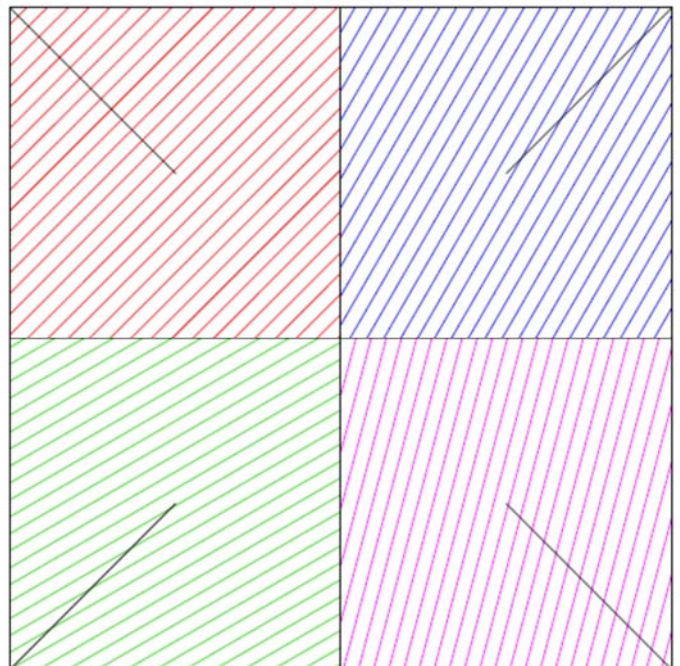
The Sterling engine was mounted as shown and a nylon thread of 0.008" diameter was glued to the axle, giving a moment arm of 0.035" to the centerline of the thread as seen in the following photograph.



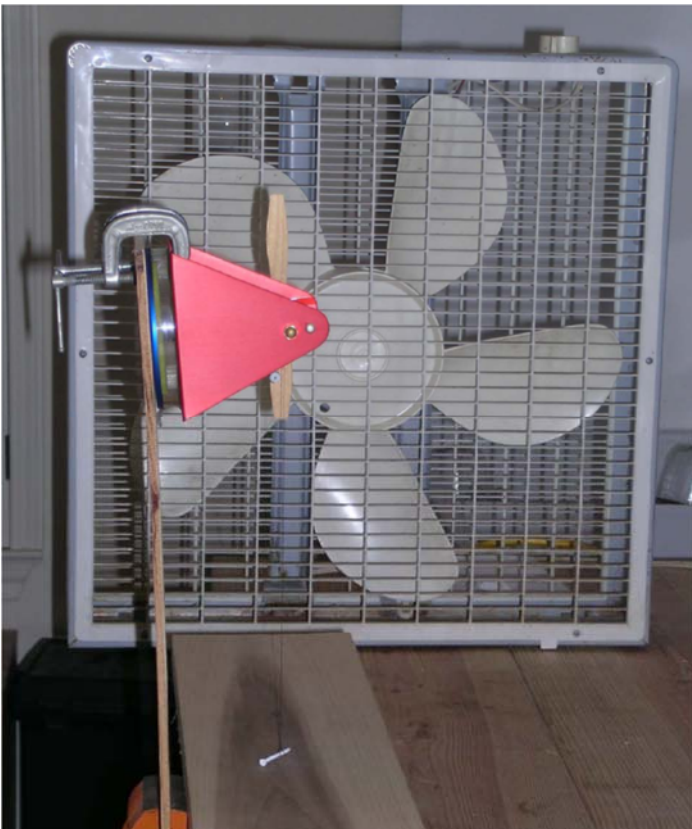
The Sterling engine was mounted on a board and a single nail weighing 0.0165 oz. was tied to the thread. A 3-speed Galaxy box fan with 5—18" blades was placed in front of it and moved until the commercial propeller barely would pick up the single nail on high speed and would not pick it up on medium speed. This is shown on the photo on the lower left. The resultant distance between the fan blade and commercial propeller was 27.5". The torque produced by the propeller in this condition was  $0.035 \times 0.0165 = 0.0005775$  oz-in, or  $3.008 \times 10^{-6}$  ft-lbs.

The fan speed on the low setting was 4.2 mph, the fan speed on the medium setting was 4.8 mph, and the fan speed on the high speed setting was 5.5 mph.

The design of upgrade #2 was found in the internet at <http://www.wikihow.com/Make-a-Pinwheel> and is as follows:



Scaling the drawing to being 7.990" corner to corner, it fits in the same space as the commercial propeller.





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The photo following shows the pinwheel which is taped to the front of the propeller for a mounting.



The results of testing with the fan in the same position was:

Fan on low speed	28 nails lifted
Fan on medium speed	42 nails lifted
Fan on high speed	60 nails lifted

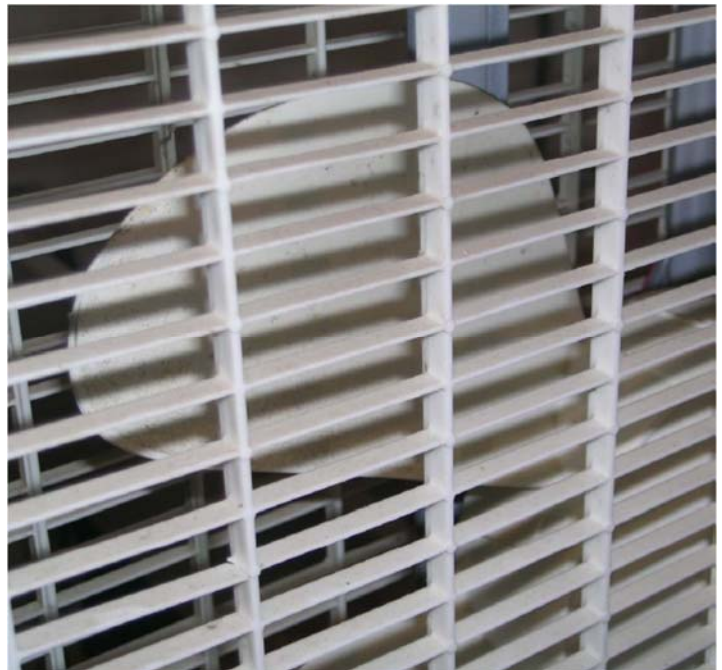
With the pinwheel installed with no modifications it outperformed the commercial blade by a factor of 60/1. In all fairness, commercial wind farms usually use 3 blades rather than the 2 blades on the Sterling engine, so it really only outperformed by a factor of 40/1.

There were 2 additional observations made in this study. In the <http://www.wikihow.com/Make-a-Pinwheel> website there was a picture of a

small boy with a pinwheel. It is seen below and indicates shows the use of construction with 8 blades rather than the 4 uses in the testing. Would using a double pinwheel it would be 80 times as efficient?



Secondly, the blades on the Galaxy box fan had a scooping profile or a curved surface rather than the flat surface of the farmer's windmills. It may be interesting to see how much this adds to the efficiency of wind energy harvesting.



May be time to get a new formula.

**OTC-29470-MS**

**Substantially Improved Wind Power Performance**

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See the Offshore Technology Conference paper OTC-29470-MS "Substantially Improved Wind Power Performance" for additional formal testing.