Solar Wind Hybrids

By Daniel Moholia

Background

The inconvenient truths of fossil fuel depletion and a looming climate crisis have lead many countries into joining the alternative energy race to save world economies before fossil fuels leaves us stranded. Development of many different energy sources has become popular, while solar and wind as alternatives remain among the most promising. What if there is a way to combine them?

Purpose

The purpose of this experiment is to determine whether it is possible to harmonize the electrical potential of solar and wind alternative energy sources into an efficient Solar Wind Hybrid design.

Hypothesis

If thin, polycrystalline solar cells were added on the blades of a functional wind turbine; both wind and solar energy sources can be efficiently harnessed by assuring that the turbine design benefits both, while minimizing the negative effects.

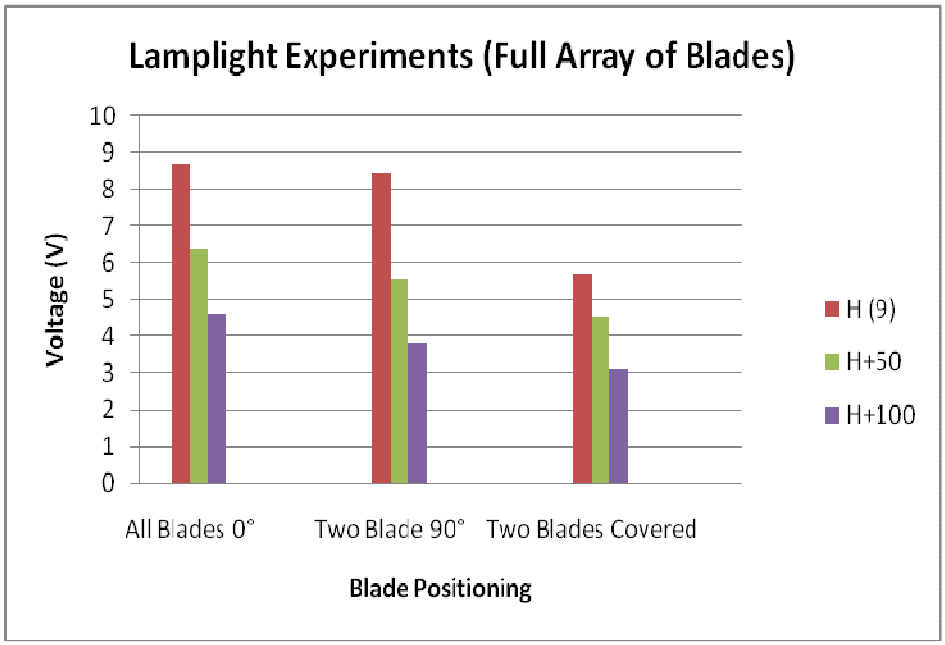
Procedure

By constructing a vertical, six blade wind turbine with three polycrystalline 3” × 3” solar cells on each blade connected in series, a prototype solar wind turbine was build for testing. The effect of light intensity and the angle of incidence on the solar cells was tested using an array of lights consisting of nine 23W and two 13W fluorescent light bulbs. This light fixture was hung at different distances above the blades and voltage measurements were taken. The full array of blades was horizontally oriented in the first

round of experiments. In the second round, two of the six blades were tilted at a 90° angle to simulate the situation that would occur during rotation in the wind. Finally, in the third round, two of the six blades were covered completely so that voltage readings could be compared to the second round and therefore measure the miniscule inefficiency of two blades at 90° angles during wind operation.

In subsequent experimentation, a single blade with three solar cells was tested at different angles, beginning with 0° (horizontal) and increasing by 15° after each voltage reading to a maximum of 90°. This was done with an array of three fluorescent light bulbs, while first being suspended at 9cm (the clearance required for the blades to fully rotate) to test all of the angles, and then increased by 50cm, at which the angles were retested. This was repeated a third time at a distance of 109cm from the blades.

Results

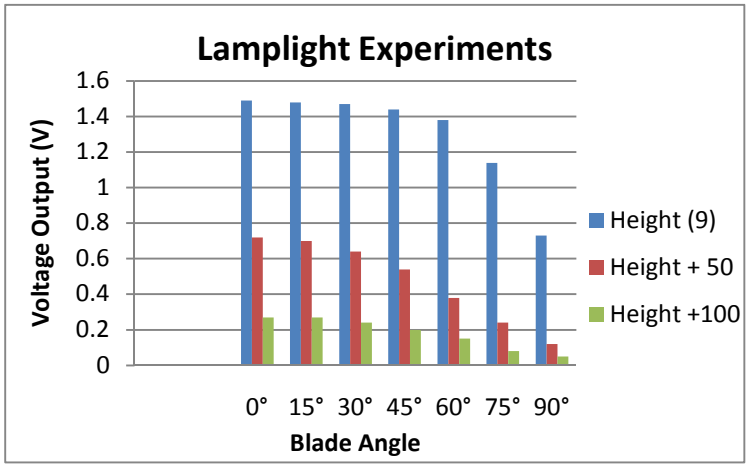


When the full array of blades were all placed at a horizontal angle and tested at a distance of 9cm from the light source, the maximum voltage reading was 8.68V. At a distance of 109cm at the same angle, the reading decreased to 4.61V. This is a nearly 50% decrease in voltage, resulting from the decrease in light

intensity, which was used to demonstrate the effect of different weather factors such as water vapour or air pollution.

When two of the six blades were vertically positioned at a 9cm distance from the light source, the voltage decreased by as much as 190mV, demonstrating that a 90° angle is not as inefficient as might be thought. Each of the blades account for approximately 1.09V in this experiment, therefore 190mV is not a significant loss compared to the gain that would result from harnessing the wind energy.

The result of completely covering two of the blades at a distance of 9cm from the light source is a 3V decrease in voltage, fifteen times less efficient than positioning these blades at 90° angles. At a distance of 109cm from the source, the voltage difference decreased to 1.5V. This is due to the resistance build-up in the cells that are not producing, but instead using electricity and therefore generating heat. This could be prevented using bypass diodes. Nonetheless the inefficiency would still be greater than at 90° since the blades are not contributing to the net electricity output.



In testing a single blade at different angles and with different light intensities, the voltage reading decreased quickly, indicating that the degree of incidence, which is the angle at which the light hits the solar cells, made a great difference. During operation, the blades in a vertical or near vertical position remain so for a very short period of time, to catch the wind energy more

efficiently. These blades are tilted horizontally afterwards and the voltage quickly rises back to its peak. This is evident in measurements at all three distances from the light source.

Conclusions

Testing under different weather conditions would be a necessary consideration if a large-scale Solar Wind Hybrid were to be constructed. Although the efficiency of the solar cells would decrease during cloudy weather, this would usually occur along with stronger winds, thus the hybrid is still benefiting from the wind.

The factors that need to be adjusted in order for the hybrid to harness the wind efficiently are much harder to accommodate compared to the factors for the solar energy. This is why the implementation of rotating blades to benefit from the wind was risky and could have affected the solar cells negatively. Experimentation was necessary to show that the loss in efficiency of the solar cells due to the blades rotating in order to catch the wind was miniscule when compared to the gain.

Another factor that was tested was the movement of the blades from a horizontal to a vertical position and vice versa during rotation. The data that was observed showed that these transitional movements did not affect the efficiency greatly, since the difference in voltage for a 0° to a 45° angle is approximately 0.05V. Only from a 75° to a 90° angle does the voltage make the largest jump from 1.14V to 0.73V. A concern that this observation could potential solve is the problem when the turbine is not rotating but rather just gathering solar energy. The single blade at 90° of the six would not lose a great deal of efficiency, but two other blades are also in the transition stage form a horizontal to a vertical or vice versa. The data observed would benefit them much more

than it would the vertical blade, and depending on the position of the sun in the sky, could increase or decrease the degree of incidence.

Earlier Work

An earlier project studied the factors of composition, angle, and length of blades and how they affected the efficiency of wind turbines. Based on the results, a Solar Wind Turbine was designed and constructed for this project so as to benefit both harnessing the wind and solar energy.

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Reference

"Diodes in Solar Arrays." ABS Alaskan, Inc. 2001. Web. 2 April 2010. <http://www.absak.com/tech/diodes.pdf>.

"Solar Cell Wind Turbine." Green Living Tips. 22 Oct 2007. Michael Bloch. Web. 31 Dec 2009. <http://www.greenlivingtips.com/blogs/154/Solar-cell-wind-turbine.html>.

Nelson, Jenny. *The Physics of Solar Cells.* Westminster, London: Imperial College Press, 2004, Print

"Types of Solar Cells." Solar Power - DIY and News. 5 January. 2010. Web. 5 April 2010. <http://nature-log.blogspot.com/2010/01/types-of-solar-cells.html>.

Bibliography

DeGunther, Rik. *Alternative Energy for Dummies.* Indianapolis, Indiana: Wiley Publishing, Inc., 2009, Print

"A Walk Through Time." pvresources.com. 2001. Denis Lenardic. Web. 17 Oct 2009. <http://www.pvresources.com/en/history.php>.

"Breakthrough in Solar Power Technology: Price Falls to 1$ per Watt." Solar Power - DIY and News. 6 January. 2010. Web. 5 April 2010. <http://nature-log.blogspot.com/2010/01/breakthrough-in-solar-power-technology.html>.

Salkever, Alex. "California Gives Green Light to Space-based Solar Power Project." DailyFinance. 4 December. 2009. Web. 5 April. <http://www.dailyfinance.com/story/company-news/california-gives-green-light-to-space-based-solar-power-project/19266073/>.

Schor, Elana. "Green Energy Blooms in the Desert." guardian.co.uk. 24 June. 2008. Web. 5 April 2010. <http://www.guardian.co.uk/environment/2008/jun/24/energy.energyefficiency>.

"How Do Solar Panels Work?" wiseGEEK. Last Updated 03 Jan. 2010. Web. 29 Dec 2009. <http://www.wisegeek.com/how-do-solar-panels-work.htm>.

Edwards, Lin. "Huge Solar Powered Plane Takes to the Air (w/Video)." PHYSORG.com. 1 April. 2010. Web. 5 April 2010. <http://www.physorg.com/news189322240.html>.

"New Flexible Plastic Solar Panels Are Inexpensive And Easy To Make." ScienceDaily.com. 19 July. 2007. Web. 31 Dec 2009. <http://www.sciencedaily.com/releases/2007/07/070719011151.htm>.

"Solar Powered Antro Solo Prototype Readying to Zoom in 2012." Ecofriend. 20 January. 2010. Web. 5 April 2010.<http://www.ecofriend.org/entry/solar-powered-antro-solo-prototype-readying-to-zoom-in-2012/>.

"Solar Revolution." cbc.ca. 2006-2009. Web.19 Dec 2009. <http://www.cbc.ca/toronto/features/solar/internet.html>.

"Space Solar Power: Limitless Clean energy From Space." National Space Society. October. 2007. Web. 5 April 2010. <http://www.nss.org/settlement/ssp/>.

LaMonica, Martin. "The Final Frontier: Solar Power From Space" cnet news. 14 April. 2009. Web. 5 April 2010. <http://news.cnet.com/8301-11128_3-10218788-54.html>.

UCtelevision (University of California). "The Power of the Sun - The Science of the Silicon Solar Cell." YouTube. 13 March. 2008. Web. 2 April 2010. <http://www.youtube.com/watch?v=u0hckM8TKY0&NR=1>