

The Voltaic Solar Backpack: Is It Really Green?

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Introduction

Solar power is a viable source of renewable energy that has gained popularity in recent decades. As developments in photovoltaic (PV) technology produce higher levels of efficiency, the use of PV modules grows. One recent application of PV technology is the Voltaic Solar Backpack, a product made by Voltaic Systems, Inc. Although the company now offers a couple of other models (including a solar daypack and a solar messenger bag), the solar backpack is their most well-known product. The Voltaic backpack contains three PV panels that, given exposure to sunlight, can generate up to 4 watts of power. Owners easily access this power through an adapter that charges small electronic devices including cell phones, cameras, and mp3 players. The bag also includes a battery pack that stores surplus power for future use.¹



The Voltaic Solar Backpack contains three small PV modules that convert sunlight into energy that may be used to charge small electronic devices (source: www.voltaicsystems.com)

Voltaic markets the solar backpack as a green product. Many green product websites sell the bag and it won the 2005 Green Gadget award from HippyShopper, an online consumer group that promotes “ethical consumerism.”² The question is, is this product truly green? This paper seeks to answer just that. I will assess the sustainability of the Voltaic backpack by examining its lifecycle, focusing on the manufacture and end-of-life management of its two main materials. I will also evaluate the bag from a less technical perspective, discussing its practicality and economic viability. In the end, I will suggest a couple of improvements that might make the product more deserving of its “green” title.

Assessment: Lifecycle Analysis

In order to understand how the Voltaic backpack impacts the environment, I will first examine the materials it is made of, how they are manufactured, and what happens to them once the bag’s useful life is over.

¹ <http://www.voltaicsystems.com/index.shtml>

² <http://www.hippyshopper.com>

Nylon

The fabric used in the Voltaic backpack is nylon (ripstop 840D nylon),³ a material common in outdoor wear since it is lightweight and rain-resistant. Unfortunately, the production of nylon has negative impacts on the environment and it is not a sustainable process. First, nylon production results in the release of nitrous oxide due to one of its primary components – adipic acid. Despite efforts to minimize the release of nitrous oxide, the making of adipic acid contributes an estimated 5-8% to worldwide nitrous oxide emissions. Since nylon was created in the 1930s, millions of tons of nitrous oxide have been released in to the atmosphere as a result.⁴ Thus it seems that nylon, a main component of the Voltaic bag, has a negative impact on the environment by depleting the ozone and contributing to global warming.

The production of nylon detracts from sustainability in one other primary way – dependency on fossil fuels. Hexamethylenediamine, a chemical essential to nylon, is a petroleum derivative that can only be made through petroleum processing.⁵ This means that manufacturing nylon detracts from the globe's diminishing supply of fossil fuels. In turn, so does the Voltaic backpack. While the making of nylon is less than sustainable, the material does offer some promising results in terms of end-of-life management. Nylon is not biodegradable, but it is recyclable recent innovations may allow for some nylon fibers to be "repeat-recycled," a much better option than downcycling.⁶ Unfortunately, I was not able to determine whether the nylon used in the Voltaic backpack will benefit from these repeat-recycling technologies.

PV Solar Panels

Understanding the lifecycle of PV modules is even more important since the Voltaic backpack would not function as a "green" product without its solar energy capabilities. The PV panels used in the Voltaic backpack are mono-

³ <http://www.voltaicsystems.com/index.shtml>

⁴ Skinner, Geoffrey, "How Green is Your Gear? *The Environmental Impact of Nylon*," The Trail Companion, Spring 2006, <http://www.trailcenter.org/newsletter/2000/spring2000/spring2000-06.htm>

⁵ Ibid.

⁶ <http://www.greensage.com>

	Single Panel	3 Panels
Panel Dimensions	3½" x 7½" 184mm x 88mm	
Weight	4 ounces 120 grams	12 ounces 360 grams
Substrate Type	3mm Aluminum/Plastic	
Substrate Color	Silver	
Cell Type	Monocrystalline	
Cell Efficiency	17%	
Open Circuit Voltage	12.5 V	
Peak Voltage *	10.2 V	
Peak Current *	133 mA	400 mA
Peak Watt †	1.36 W	4.08 W

* Panel output is computed from cell manufacturer's data based on 0% reduction of cell efficiency after packaging of cell strings. Electrical output tolerance +/- 10%
† Under irradiance of 100 mW / sq. cm, spectrum of 1.5 air mass, at 25 degrees Celsius, as per cell manufacturer's specifications.

*This chart shows the specifications of the PV modules found in the Voltaic Solar Backpack.
(Source: <http://www.voltaicsystems.com/solarpanels.shtml>)*

crystalline modules.⁷ The production of crystalline PV modules is not entirely sustainable and has generated debate in the scientific field.⁸ One problem is the use of harsh chemicals during production, which may present health risks to workers. Another issue comes from the release of greenhouse gas emissions. These emissions vary in different countries, depending on the methods of material- and

⁷ Today, most PV technology relies on crystalline-silicon wafers, which may be mono-crystalline, multi-crystalline, or ribbon. Lower-cost, "thin-film" alternatives to the crystalline modules are a hot topic in the PV industry. These thin-film options are not as efficient as the crystalline modules, but they are cheaper to produce and the technology behind them is improving (see Malsch, Ienke, "Thin films Seek a Solar Future" *The Industrial Physicist*, April/May 2003, <http://www.tipmagazine.com/>). My analysis will focus on crystalline solar panels since they are the most efficient PV module available on the market, and thus the best module type for small surfaces such as a backpack.

⁸ The literature on life cycle assessment (LCA) of PV modules is extensive and varies greatly depending on the type of module. Some good references on this topic include Alsema et al (2006), Fthenakis and Kim (2006), Fthenakis et al (2005), and Fthenakis and Mokowitz (1991). See bibliography for complete references.

fuel-processing used,⁹ but are a problem in light of global warming and climate control.

Similar to nylon, the manufacture of solar panels requires some non-renewable fossil-fuels. Unlike nylon, however, PV cells will eventually pay off the energy needed to create them. Scientists measure this effect through energy payback time (EPBT), defined as the “time it takes for a PV system to generate energy equal to the amount of energy used in its production.”¹⁰ Mono-crystalline PV cells – as found in the Voltaic backpack – have an EPBT of about 2.7 years.¹¹ It is important to note that these estimates are for larger PV systems, usually used on building rooftops. It is possible that a small PV panel with intermittent exposure to the sun, like the ones in the Voltaic backpack, will have longer EPBTs.

Because PV technology receives a fair amount of attention in the energy debate, there have been efforts to improve the life cycle/environmental impact of PV production. For example, in 2005, the industry adopted a recycling measure that helps save materials used in the production of crystalline-silicon PV. One study estimates that this recycling technique will reduce the environmental impact of each module by 15%.¹² There are signs, then, that the life cycle of PV modules will continue to improve. It is important to note, however, that most life cycle analyses of PV panels assume that they will be used as large-scale alternative energy systems (large here meaning bigger than the size of a backpack). Thus quantitative studies often weigh the environmental impacts of PV against other energy sources, such as oil production. While PV has clear benefits as an alternative energy system, its advantages are not as clear in the context of extremely small panels used only to charge small digital devices, as is the case with the Voltaic backpack.

The final step in analyzing the lifecycle of the Voltaic backpack is to examine what will happen to the product once its useful life is over. PV modules

⁹ Fthenakis, Vasilis M. and Hyung Chul Kim, “CdTe Photovoltaics: Life Cycle Environmental Profile and Comparisons,” prepared for the *European Material Research Society Meeting*, Nice, France, June 2, 2006, http://www.nrel.gov/cdte/ref_res.html

¹⁰ Ibid.

¹¹ Ibid.

¹² Alsema, E.A., M.J. de Wild-Scholten, and V.M. Fthenakis, “Environmental Impacts of PV Electricity Generation – A Critical Comparison of Energy Supply Options,” presented at the *21st European Photovoltaic Solar Energy Conference*, Dresden, Germany, September 2006, http://www.nrel.gov/cdte/ref_res.html

like those found in the Voltaic backpack are estimated to last approximately 30 years. Currently (based on my research), there is no established system for recycling or reusing PV panels once their life time expires. One study proposes that a recycling system could be created, modeled after existing recycling programs for electronic/telecommunications devices and NiCd batteries.¹³ Even this proposal, however, focuses on recycling rather than salvaging parts for reuse. Most importantly, the recycling or reuse of expired modules is not a priority for Voltaic. Their website specifically states that new PV panels (\$30 each) may be ordered to replace broken/outdated panels, yet they provide no options for recycling or reusing the old panels.

In sum, the lifecycle of the Voltaic backpack suggests that the product may not be so deserving of its green title. The production of its two materials – nylon and PV modules – is fossil-fuel dependent and results in greenhouse materials. While PV modules can pay off their energy use, their application at such a small scale seems questionable. Even worse, it is not clear that this backpack offers better options for recycling or reuse than any other “regular” backpack on the market.

Assessment: Economics and Practicality

In many respects, the Voltaic solar backpack is a product of convenience, not sustainability. For people who live in a sunny climate and are outside carrying a bag regularly, it provides a chance to charge small electronic devices without worrying about access to an electric outlet. The total amount of power generated, however, is not even enough to charge a laptop. Thus it is unclear how much this product actually helps offset the use of electricity and other less green forms of energy.

It is also important to note the price tag -- \$239. Since most people can easily charge their cell phones, PDAs, mp3 players, etc. by using car adapters, it is unclear why they would be willing to spend so much on a backpack that offers a similar service. The high price of the product reflects the cost of making PV modules. Applied on a larger scale (i.e. powering a building), this cost seems

¹³Fthenakis, Vasilis M., “End-of-life Management and Recycling of PV Modules,” *Energy Policy*, 28, 2000, pp. 1051-1058.

worthwhile and is more likely to be paid off quickly. For three small modules on a backpack, however, the economics do not make as much sense.

Suggestions for Improvement

On the whole, the Voltaic backpack does not inherently support a sustainable way of living. In my opinion, it makes more sense for people to keep the backpacks they have and invest in larger-scale PV applications (like powering their home). However, there are a couple of options that might make the backpack greener. First, the manufacturer could find a biodegradable material to replace the nylon in the bag. If nylon is the best material for this type of product, there is technology for producing the material in a more sustainable manner. While no company that makes outdoor wear/bags (like Patagonia) has committed to using green nylon,¹⁴ Voltaic could be the first. A second possible improvement is a viable recycling/reuse of the PV modules once they expire. If Voltaic is truly committed to sustainability, they could fund research around PV salvaging/recycling and provide end-of-life options for the buyers of their bags.

¹⁴ Skinner, Geoffrey, "How Green is Your Gear? The Environmental Impact of Nylon," *The Trail Companion*, Spring 2006, <http://www.trailcenter.org/newsletter/2000/spring2000/spring2000-06.htm>

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Voltaic Systems, Inc: <http://www.voltaicsystems.com/index.shtml>

HippyShopper: <http://www.hippyshopper.com>