Solar Urban Legends
by Lee H Goldberg 7/28/2007

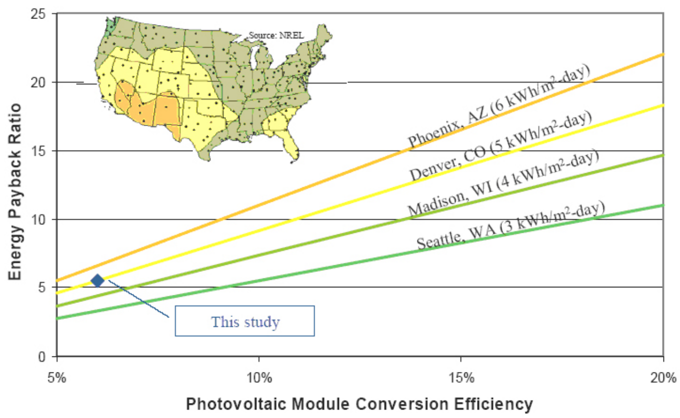
The tremendous popularity renewable energy is enjoying both within the engineering and financial communities is a mixed blessing because it's also helped generate a dense cloud of disinformation around the topic. Whether it's overstating the benefits of corn-derived ethanol, or knocking hybrid cars as less eco-friendly than a Hummer[1], the less-than-whole truths and urban legends being slung about by green tech proponents, and opponents, are making it difficult to make rational choices about how best to develop the technologies we'll need build the kind of future we'd be proud to turn over to our grandkids.

One of the most common urban legends I've been bumping into of late is the notion that solar-electric panels and wind generators take more energy to manufacture than they ever produce. In fact, I'd heard this rumor so many times that I began to wonder if there was any truth to it and decided to do a little research.

It turns out that it's fairly easy to calculate the so-called *embedded energy* that goes into a solar system by taking the energy required to refine, crystallize, slice and process the silicon that goes into a solar cell and add that to the energy needed to refine, form, and assemble the glass, aluminum, copper and other materials required to build a complete solar panel and its mounting hardware. When you take the embedded energy and divide it by the average number of watt-hours the panel produces per year[2] you get the *energy payback period*, an important but often-overlooked figure that tells you how long an energy source takes to generate the energy consumed in its manufacture.

A study conducted by Siemens Solar in 2000 showed that the energy payback period for their 75 W SP75 monocrystalline panel was about 3.3 years. A 2004 study published by the National Renewable Energy Laboratory (NREL) for multicrystalline solar panels with an assumed efficiency of 12% yielded a payback period of a bit over 3.5 years. In both cases, the energy required for refining and processing the silicon accounted for about ⅔ of the embedded energy in a solar panel. Since these studies were published, typical efficiencies of silicon PV cells has improved from about 12% to 14% - 16%, with some high-performance products delivering as much as 21%. Between this higher efficiency and the use of thinner cells (less material means less embedded energy), it's likely that the payback periods for today's solar panels is 2.5 years or less. Given the 20 - 30-year service life of a typical solar panel, it's apparent that it will produce much more power than was used to make it.

Another useful way to look at this data is to calculate a solar-electric system *net energy gain*. Simply put, this is the difference between the energy required to manufacture, transport, and install a solar panel versus the amount of energy it produces during its active service life. A study conducted by the University of Wisconsin in 2002 shows that the conversion efficiency of a solar panel, and where it's located, are the primary factors that affect how many times the panel embedded energy (see the figure) is repaid. While the graph was developed for panels using thin film amorphous silicon fabrication technology, all available data shows that mono- and polysilicon panels follow very similar, and even more productive, patterns.



Even counting for the somewhat higher embedded energy of crystalline cells, they should, depending on where they are installed, have an overall net energy gain of 7x to 15x, and as high as 20x for some of the new ultra-high-efficiency products just coming onto the market. This compares very favorably with the corn-based Ethanol (1.3x - 2x) and soy-based biodiesel (around 3x) technologies that are getting so much attention today[3].

Regardless of whether you look at solar panel energy payback period or their net energy gain, it's pretty apparent that the only way to keep them from quickly returning the energy it took to make them would be to keep them locked in a dark closet. Hopefully the analysis presented here has convinced you that it's better to put those panels on the roof and then put some of the weird urban legends about solar back in that closet where they won't cause any more mischief.

Comments? Questions? Thoughts on renewable energy payback or interesting urban legends you'd like to share? Write me at: **lhg at en-genius.net**, or post

Footnotes

1. Weird as it may sound, there is a scholarly-seeming study published by CNW Marketing Research that's making the rounds which uses some rather creative analytical techniques to prove that a 12-mpg Hummer overall environmental footprint is smaller than a 40-mpg Toyota Prius hybrid car. I'm in the middle of digesting it, and several other critiques of the study. If I find anything new, I'll post my thoughts on it here.
2. The US average solar insolation is 1825 kW-h/m^2/yr (5 full sun hours per day). A common mid-range number used in the literature is 1700 kW-h/m^2/yr (4.7 full sun hours per day).

3. I tried to find about the net energy gain of fossil- and nuclear-powered electric plants but little seems been have been written about it to date. Nevertheless I'm very curious about this and am in the process of locating some raw data about the embedded energy of power plants and the refining process of the fuels they use. I'm hoping I can turn what I learn into a future editorial.

References

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- *PV FAQs - What is the Energy Ppayback for PV?* The National Renewable Energy Laboratory (NREL), 2004
- *Life Cycle Assessment of Electricity Generation Systems and Applications for Climate Change Policy Analysis*, P J Meier, University of Wisconsin, 2002 (image source)
- *Annual Energy Outlook 2007 with Projections to 2030*, US Energy Information Administration, Report #:DOE/EIA-0383(2007)