Blank Power & Light

SOLAR ELECTRICITY SHINES IN MILWAUKEE

by Curt Blank

Unlike a lot of solar enthusiasts, Curt Blank's concerns were not environmental when he first considered having a solar-electric system installed at his home in Milwaukee, Wisconsin. His primary motivation? Dollars and cents, plain and simple.

In the summer of 2005, I was channel-surfing and landed on an HGTV program called "I Want That." The particular episode was showcasing a solar-electric (photovoltaic; PV) system. As a self-proclaimed techhead—my house is full of computers, I write code and push local weather data up to the Web—I always have an eye out for cutting-edge electronics. The thought of having a roof covered with electricity-producing silicon made me put down the remote. I decided on the spot to do some more research and give PV technology a closer look.

Delving into the Details

Real-world data has shown that solar-electric modules will typically produce energy for 25 years and then some. Practically speaking, investing money in a system now is the same as buying your electricity decades in advance. The clincher is, as utility rates rise, the cost of the electricity I generate using solar energy will be locked in for a *minimum* of ten years under my current arrangement with the utility. This is a good idea if you live in a state where electric rates are on the rise—and that's pretty much all of them. Average Wisconsin residential electric rates have increased 24 percent, just in the past six years! Besides insuring myself against rate hikes, I'm protecting my financial future. Even though it's still on the horizon, retirement is eventually headed my way. Fixing my cost for electricity will be a handy feature, since my income will one day be "fixed" too.

During my initial Web research, I discovered that my local utility, We Energies, offered financial incentives for residential PV systems through Wisconsin's Focus on Energy program. On top of that, I was hearing rumblings that a new federal solar tax credit was going to become available in 2006. I'd assumed that a PV system would be expensive, and up-front they are. But the possibility of using incentives to offset the initial cost really caught my attention, and was the motivation I needed.

To receive the maximum amount from the Focus on Energy incentive program, my system installer had to be certified by the North American Board of Certified Energy Practitioners (NABCEP), a nationwide organization that tests and certifies solar installers. I started to shop around for electrical contractors with PV system installation experience and NABCEP certification, but I came up empty handed—none were available locally. So I expanded my search and located Andrew Bangert, from H&H Solar Energy Services in Madison. He made the 90-mile trip to Milwaukee to evaluate my site, and put a bid together.

Getting the Site Right

Once his boots were on the ground, or actually up on the roof, Andrew quickly determined that the four 40-foot-tall pine trees, to the south and southwest of the house, would need to come down. Another complicating factor was the dormer that was smack in the middle of my south-facing roof. Without it, I would have had about 600 square feet of clear, south-facing roof. But the dormer reduced the available space to two roof surfaces of about 200 square feet each. With this constraint, Andy's initial inspection indicated that about 3,300 watts was the best I could do with the 187-watt Kyocera modules I had specified—without hanging panels left, right, and upside down.

The remaining task before we could install the system was to reshingle the roof, although this was strictly by my choice. The existing composition roofing still had about five years of life left before it would need replacing, but it didn't make sense to me to install the array, which I didn't plan on moving for 25 years or more, only to remove and reinstall it a handful of years later. The roofing added an additional $4,500 to the bottom line, although it's an expense I would have eventually faced, regardless.

Household Electrical Loads & Efficiency

One of the first steps in any home-scale solar-electric project is doing what you can to make your household as energy efficient as possible. Every watt-hour you save is one that your PV system doesn't have to generate, leading to a less expensive system. All the lightbulbs in my house are energy-saving compact fluorescents, and it's been that way for fifteen years or so. Over the past five years, I've upgraded all my major appliances with the most energy efficient ones I could buy. I even undertook the expensive project of replacing the old single-paned windows in my house with tight, well-insulated double-paned units a few years back.

Even with these measures in place, I still use a lot of electricity—about 1,400 kilowatt-hours per month, on average, which sets me back between $100 and $160. While I do my best to conserve energy, I have three computer servers, and three DirecTV receivers with TiVo running 24 hours a day. This equipment uses a lot of electricity day in and day out, and accounts for the majority of my electricity use. But for the time being, it allows me to work from home for my employment with the Information and Media Technology Department at University of Wisconsin at Milwaukee, and for my own personal Web and programming work. I also enjoy woodworking as a hobby, and the 2 to 3 hp electric motors in my shop guzzle electrons whenever the woodchips are flying.

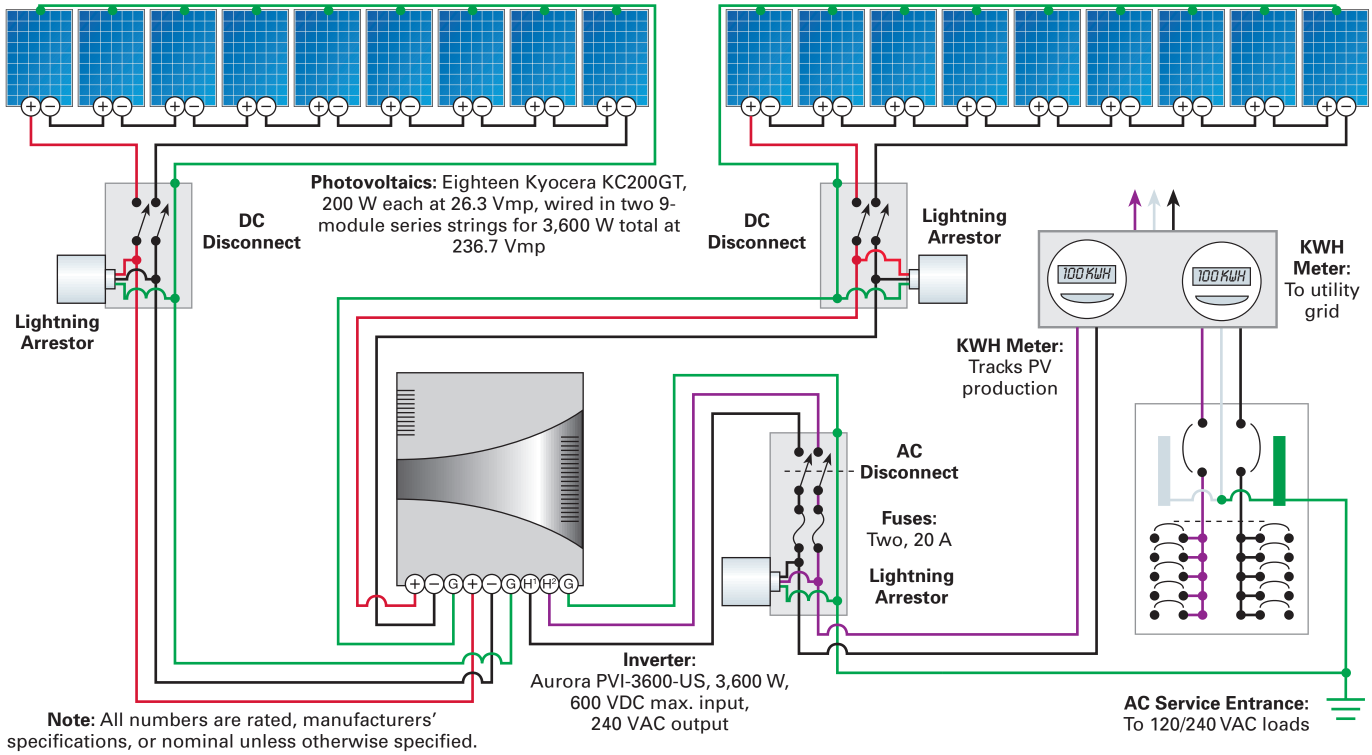
Sizing Up the System

After surveying the site for solar access and shading, and getting a handle on my electrical use, Andrew put together a bid for a PV system that was within my budget, and would offset about one-third of my present electricity use. His quote of $21,500 (before incentives) was higher than I'd anticipated, but it wasn't out of the ballpark. Even so, I ended up hemming and hawing for several months over the initial cash outlay before I signed the contract in December 2005. We tentatively scheduled installation for the coming spring.

A little delay was a good thing: That spring, Kyocera increased the output of the modules we selected from 187 watts to 190 watts each, raising my array's total DC output to 3,420 watts. But the modules were in short supply at that time because of a silicon shortage, which has since eased. As a result, Andrew pushed the installation date into midsummer. And again, our patience was rewarded—before my modules shipped, Kyocera upped the module output to 200 watts each, increasing the array output to 3,600 watts. Who says procrastination's a bad thing?

Top: The roof is reshingled in preparation for the PV installation. Bottom: Andrew Bangert and Chad Silverthorn of H&H Solar Energy Services begin assembling the PV arrays.

Blank Grid-Tied PV System



Ready, Set, Install

In June, the trees came down and the PV system went up. Andrew and his associate Chad Silverthorn made quick work of the installation, and I'd recommend them to anyone looking for pro solar installers in southern Wisconsin. A 1,800-watt array was mounted on each side of the dormer and separate wiring from each array was run in conduit down to the inverter. One of the nice features of the Aurora inverter that was specified for the system is that it can independently track and optimize the power outputs of two separate series

L to R: The solar array's AC disconnect, PV production meter, and utility meter.

Tech Specs

Overview

System type: Batteryless, grid-tie solar-electric

Location: Milwaukee, Wisconsin

Solar resource: 4.5 average daily peak sun-hours

Production: 358 AC KWH per month (first 11 months of operation)

Utility electricity offset: 29 percent

Photovoltaics

Modules: 18 Kyocera KC200GT, 200 W STC, 26.3 Vmp

Array: Two 9-module series strings, 3,600 W STC total, 236.7 Vmp

Array installation: UniRac mounts installed on south-facing roof, 40-degree tilt

Balance of System

Inverter: Power-One (formerly Magnetek) Aurora PVI-3600-US, 600 VDC maximum input voltage, 90–530 VDC MPPT voltage window, 240 VAC output

System performance metering: PC-based inverter monitoring with custom code for Linux operating system

PV System Costs

Item	Cost
18 Kyocera KC200GT PV modules, 200 W	$16,027
Aurora PVI-3600-US inverter, 3.6 KW	2,187
Labor	1,856
Miscellaneous electrical	1,023
UniRac PV mounts	900
Tax	825
Shipping	60
Total*	$22,878
Focus on Energy rebate	-$8,007
Federal tax credit	-2,000
Grand Total	$12,871

*Total cost slightly higher than initial quote due to additional equipment installed to participate in We Energies buy-back program

One thing I immediately noticed after reviewing some of the early system output data was that the modules were often operating below their rated output during the summer. After talking with Andrew from H&H, and the folks at Magnetek (Power-One has since purchased the Aurora line of inverters), I learned that the higher the ambient temperature is, the lower the voltage produced by the PV modules will be. Despite long, sunshine-filled summertime days, the array experiences a higher peak array output during the shorter, colder days of late fall, winter, and early spring. My best single generation day to date was April 5, when the system cranked out 24 AC KWH. But the bottom line is that cumulative energy is what I'm after. While peak power or the energy produced on a given day is often higher during the colder months, the long days and mostly clear weather during the summer is when the system generates the most energy.

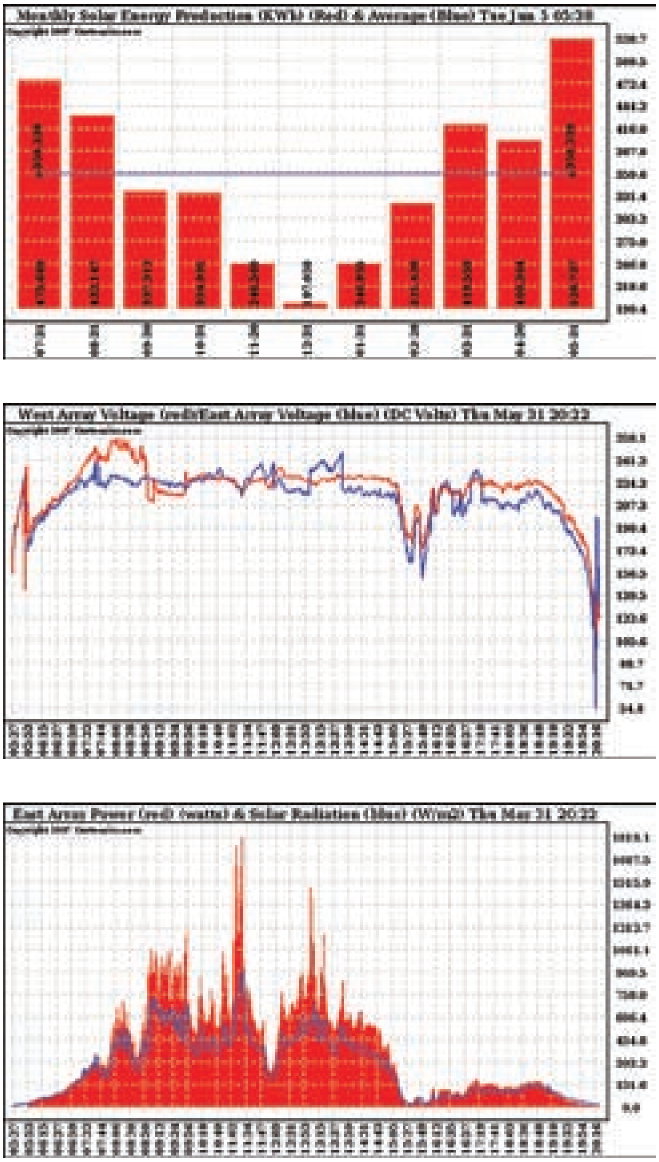
strings of PV modules. In my case, this was a worthy feature, since trees to the east and west of the house, along with the dormer and chimney, cast some shadows on one array or the other in the early morning or late in the afternoon when the sun is low on the horizon.

The inverter will also function down to 90 VDC. So except during extremely hot summer conditions, when the modules' operating voltage is low, I can essentially lose the output of five of the nine modules in a string to shading and the Aurora will still produce energy. Since these shading conditions only exist at the beginning and end of each day, this low operating voltage capability doesn't add all that much additional energy to my system's total production. But I figured that it made sense to optimize my PV system's performance in every way possible, which would also optimize my financial investment.

We had to delay the final commissioning of the system for two weeks, so that our local utility could inspect the system prior to bringing it online. This delay was the only one that did me no good; after more than a year of anticipation, two weeks of perfectly good summer sunshine wasted on inoperative PVs was almost too much to handle! But on June 27, the system came online, and the modules and inverter went to work making electricity from sunshine.

System Monitoring & Performance

My techhead tendencies drove me to create a seamless way to monitor the PV array and inverter output, and automatically display the data on the Web. Being a Unix System Administrator and a heavy Linux user, I was not overjoyed to hear that the Aurora inverter came with software that only ran on Windows operating systems. But with some help from the inverter manufacturer, I was able to sort through the inverter's communications protocol and write the necessary code that enabled monitoring via my Linux-based computer network. I've been collecting performance data since the system came online, which is available for viewing on my Web site (see Access). If you're a Linux/Unix user, you can download my Aurora communications program as well.



Datalogging snapshots of the PV system's production.

A little bit of programming magic lets Curt keep tabs on his PV array and inverter output via the Web.

The Big Payback

So far, my PV system has produced more than 4 megawatt-hours of electricity, and knocked close to $900 off my electric bills. Originally, I'd predicted a ten- to twelve-year financial payback for my PV investment. After living with the system for awhile, it looks like I may end up on the high side of my original estimate. But even if it does take twelve years for the system to offset its original cost, my modules are warranted to generate electricity for another thirteen years, and will likely continue to do so for fifteen or more years beyond that. After the twelve-year mark, it's all *free* electricity. And that'll be right around the time I'll be thinking about retirement. Perfect.

Access

Curt Blank • Curt.Blank@curtronics.com • www.curtronics.com/solar

Andrew Bangert or Chris Collins, H&H Solar Energy Services Inc. • 2801 Syene Rd., Madison, WI 53713 • 608-273-3434 • info@hhsolarenergy.com • www.hhsolarenergy.com • Installer

Focus on Energy • 800-762-7077 • www.focusonenergy.com • Wisconsin RE & efficiency incentives

PV System Components:

Kyocera • www.kyocerasolar.com • PV modules

Power-One • 805-987-8741 • www.power-one.com • Aurora (formerly Magnetek) inverter

UniRac • 505-242-6411 • www.unirac.com • PV mounts