

Getting the most out of a solar electric system

By Paul Jeffrey Fowler

When our son Terry was born in March of 1992, my wife Lea and I made the formidable decision to sell the remaining half of our solar electric business to our partner. We wanted to spend as much time as possible with Terry during his preschool years. In addition to our homestead work, we hoped to make ends meet through independent, home-based employment, such as writing books and articles about independent living.

As the head of our solar electric business for 10 years, I had spent a major portion of each day designing solar electric systems. These ranged from sample systems for the next catalog or book to the solar electric systems for our many customers. When I was not designing systems, I was trouble-shooting them on the phone. I enjoyed the work and found time to upgrade our home system as an example for customers, but I never had enough energy left over to play with my own solar electric toys.

Within months of my departure from Fowler Solar Electric, Inc., my interest in solar electricity started to percolate once again. Lea and I had decided not to work professionally for the first year, to compensate for the vacation days we had always neglected to take. We wanted to finish the house and the home-related projects we had been waiting for years to do. I began to daydream about improving our solar electric system. I would follow my wife around, accosting her with my latest brainstormers. It was great fun thinking about our own solar electric system instead of a customer's system.

After a year of finishing the house and working on our homestead, I start-



The Fowlers' home has solar modules on the house and on the garage.

ed writing my new book, [The Evolution of an Independent Home](#). As I chronicled the development of our home and the coming of age of solar electricity for four hours each day on the computer, I relived the design and installation of each generation of our own solar electric system. In the afternoons, while I cared for Terry, I would design my next and ultimate solar electric system.

I had one problem: Lea and I were already the proud owners of a very large solar electric system. We owned a large system because we had tried to be an example for our customers, and we had had the good fortune to own a business that sold the components to us at distributor cost. Our solar array consisted of 24 33-watt Mobil Solar modules on the house and eight 48-watt Hoxan modules on the garage. These modules produced 1200 peak watts, the equivalent of an array of 20 modern 60-watt modules.

We stored our power in a 1600-amp-hour 24V (24-volt) battery bank consisting of 32 200-amp-hour, 6V Trojan golf-cart batteries (the equivalent of 16 L-16 6V batteries). Our large battery bank was designed to even out the sporadic winter sunlight in New England, and to decrease the need for a generator to supplement our low winter solar electric production. Our Trace 2624SB 2600-watt inverter was large enough to power any and all of our 120VAC (120-volt alternating current) loads.

A wind machine?

A few weeks after I completed the first draft of my book, Lea, Terry, and I helped our neighbors, Bob and Karin Cook, raise their new Bergey 850-watt wind machine and tower. Bob had read Paul Gipe's new book ([Wind Power for Home and Business](#)) on wind power. He decided not to expand his 440 peak-watt solar electric system, but instead to add a wind

machine to it. He hoped to produce a lot of power from winter winds to balance the low winter output of his solar electric system. Bob, a great student and researcher, came to the conclusion that the Bergey was the best in its size class. My old business offered to purchase the wind machine for him at a discount, to facilitate the experiment.

Naturally, I got personally involved in the project. Our solar electric system was large, but we could still benefit from an additional supply of electricity in the winter. I wanted a new alternative energy project so badly that I too considered installing a wind machine that fall. I hesitated even though we live at a good wind site. We have grown to live in awe of the lightning at our home site. Summer thunder storms are violent. I spent my early years with solar electricity learning to protect our solar electric system from lightning damage. I was worried that the addition of a tower would give me another source of lightning-induced high-voltage surges to endanger the inverter and controls that I had worked so hard to protect. And Lea and I knew we really could not rationalize the \$3000 it would cost for a wind machine and tower.

Our neighbor's new wind machine was just visible above the tree line from our upstairs bedroom, a third of a mile away. Though I knew that installing a wind machine at our house was unlikely, I could still watch our neighbors' wind machine every day. I realized I had a unique opportunity to monitor the wind machine's energy production in comparison with our own solar electric system. I learned to roughly estimate the output of the wind machine by watching the speed of the propeller. Every day, I observed the production of the wind machine and then checked the state of charge of the battery bank in my system. Whenever the battery bank was fully charged, I knew that the wind machine, if it had been part of our system, would have been producing power that we could not have stored.

On other days I could see that the wind machine could have restored our battery bank to full charge, but that the next several days were sunny. Our solar modules would soon have recharged our batteries without the additional power from the wind machine. There were also cloudy spells when my solar modules did no charging, but the wind machine had no wind to turn it.

A generator?

After monitoring my neighbor's wind machine that fall and winter, I knew it would not be a good partner to my large alternative energy system. I began to suspect that I really did not need additional electrical production for the whole winter. What I needed was an on-demand source of electricity for a few selected days during the occasional winter when there were one or two three-week cloudy spells. In the past, we had managed these cloudy spells by lowering our electrical usage until the sun returned. We had avoided the obvious solution of owning a backup generator.

We had always owned an inverter with an integral battery charger and transfer switch. If ever we accidentally ran our batteries too low, we could always get a generator and power the house with it while the inverter's internal battery charger replenished the battery bank. I had considered improving our winter supply of electricity by charging the batteries with a backup generator. However, I could



4000-watt Trace sinewave inverter

not rationalize purchasing a \$1,500 generator that would sit idle in the garage for most of the year. It would require plenty of maintenance just to keep it ready to use. My final solution was to rent a generator for one day during an occasional bad winter and run it for 24 hours to get our money's worth.

The more I worked on plans to expand our solar electric system, the more I realized that I could get the greatest amount of usable output by balancing our energy use to the system's production. Instead of purchasing a wind machine, a generator, or more solar electric modules, I could conserve electricity in the winter when sunlight is less plentiful, or find a suitable way to provide on-demand additional power, or both.

A new inverter

Once I have worked long enough on a project to have my theory in place, I find many of the practical considerations just happen. An old friend of mine in the alternative energy world offered me a 4000-watt Trace 4024 sinewave inverter at a great price. It was an early test model that had been scratched and dented but was fully updated to the latest specifications.

I bought the inverter because it was the right price to upgrade to a true sinewave inverter from my standard quasi-sinewave inverter. The increase in output from 2600 watts to 4000 watts did not seem very important, because the old inverter was adequate for my home. Even the true sinewave output did not seem that important. However, the new inverter had one feature that I coveted, a completely redesigned internal battery charger. My old inverter could produce a 60-amp maximum charge at 24V, but unfortunately it worked by taking the tops of a generator's sinewave. That type of charger really needed to be powered by at least a 5000-watt generator to supply its full 60 amps of charging. Furthermore, the charger

was fussy about which makes of generators powered it.

The new charger in the Trace 4024 was much more efficient in its conversion of 120VAC power to 24VDC. It could produce a maximum of 120 amps, and do it from most generators 2500 watts or larger. This charger would charge my battery bank in half the time, so the generator would only run half as long and consume only half as much fuel. With the new charger, we could theoretically run our large battery bank down to half-full during a long cloudy spell and recharge it on eight hours of generator run time. The new charger made it more attractive to utilize a backup generator to supplement our system, because the generator would be running fewer hours.

Tractor power

One day, I had the brainstorm to track down a PTO (power takeoff) generator to be powered by our tractor. PTO generators have no engine: they are rotated by a drive shaft that connects to a power takeoff on the rear of a tractor. The tractor is parked in neutral, and the tractor motor turns the drive shaft and the generator. This sounded good to me, because our tractor is new and in good repair, and there would be no extra motor to maintain.

I was disappointed to find that 8000-watt PTO generators were not available, and the larger models cost \$2000-3000. However, several more phone calls produced a 25-year-old 15,000 watt model that had been gathering dust for years at my tractor dealer. I tested the windings, gave them \$475, and loaded the 400 lb. unit in my Bronco II. Somewhat serendipitously, I had completed my design for an on-demand source of power for our independent energy system.

I upgraded the three-point hitch frame for the generator to make it mount easily on the tractor. I could even mount it in the garage, back the

tractor up to it, and exhaust the diesel fumes out the wall of the garage, if ever I planned to use the generator regularly. Ideally, I might never need to use the generator.

Reducing demand

The second part of my plan to enhance our power for winter was really another anti-expansion plan. I wanted to improve the load side of our system such that we would use less power for the same appliances and level of comfort, and thus have more power for additional loads and a lesser likelihood of utilizing the backup generator in cloudy times.

I had been slightly concerned about the efficiency of our new 4000-watt inverter. The efficiency curves looked good, but the unit required 15 watts to power its own electronics whenever it was powering a load, while our old inverter had only used eight watts. This would be a negligible factor for large loads, but would be very inefficient when we were powering 25 to 50 watts of lighting. I estimated the inverter would be on for ten hours per day and use 70 more watt-hours per day than our old inverter.

I noticed that our large vacuum cleaner ran quieter on the new inverter. It also ran cooler. The same pattern was true for our clothes washer, large power tools, and most likely for our deep-well pump. With the help of my friends at Trace, I came to the rough conclusion that our motor loads were running 10-20% more efficiently on our new sinewave inverter. At 1000 watt-hours per day of motor loads, we were saving more watt-hours than I was worried about losing to the 15 watt base drain of the electronics of the inverter.

I purchased an AST notebook computer to use as my main computer, and relegated my desktop computer to my wife's computer needs, which take less time than mine. The desktop computer consumes 100 watts, but the new notebook only consumes 15 watts.

That first winter, I averaged three hours of computer use per day while I completed my book project. I saved 255 watt-hours per day of electrical energy.

In the spring, we purchased a Staber washer machine because of its high efficiency. The Staber is a full-size washing machine that uses 250 watt-hours per load, versus the 450 watt-hours per load consumed by our old standard clothes washer. This innovative washer also cleans so much better that we save another 25 watt-hours because we can wash clothes on a shorter wash cycle. The Staber needs only one ounce of powdered detergent per wash load, one quarter what we used in our old washer. This feature saves no power, but it does save a lot of money. Finally, it washes with half the amount of the water, a savings of 40 watt-hours of water pumping per load. In total, the Staber saves 265 watt-hours per load, which at two loads per day represents a savings of 530 watt-hours per day.

We had been somewhat sloppy in our use of lighting. We had several pretty brass and glass ceiling fixtures in the living room, kitchen, and bathroom (installed before compact fluorescent bulbs came to market), which used 40-watt 120VAC incandescent bulbs. They were fairly efficient, because all of the light that they produced was transmitted to the room through the clear glass. To increase our efficiency, we installed extra fixtures and lamps in these rooms that hold 15-watt compact fluorescent bulbs. When the weather is cloudy, we can use these new lights to save another 250 watt-hours per day.

Adding up the savings

Our conservation methods saved us an average of 1035 watt-hours per day. These savings were projected for the winter when our solar electric array produces only half of what it does in the summer. For our area, one 50-watt solar electric module pro-

duces a daily average of 100 watt-hours per day of electrical energy that is actually usable in our home. Therefore, our conservation resulted in a “negative-need” for ten 50-watt solar electric modules, or 500 peak-watts of our array. You could consider that 500 watts had been freed up to be used to make the long no-sun parts of winter easier, or to power additional loads. Or, to look at it another way, if we were purchasing our solar electric system today, we would need ten fewer 50-watt modules.

It cost \$500 to upgrade to the newer sine-wave 4000-watt Trace inverter. We also spent \$475 for a backup generator. For a total of \$975, we now have an on-demand power supply to supplement our alternative energy system in the worst years of electrical production.

We spent \$500 more for a notebook computer than for a comparable desktop computer. We spent \$900 on a Staber washing machine, which is \$450 more than a standard model. We spent \$200 on compact fluorescent bulbs, lamps, and fixtures. This comes to a total of \$1150 we invested to conserve 1035 watt-hours per day in the winter. To produce these 1035 watt-hours of electricity energy in the winter, we would have needed ten \$300 50-watt modules, a \$3000 investment.

In the beginning, I flirted with spending \$3000 to install a wind machine and tower to supplement our solar electric system in the winter. I invested much less money to conserve energy and meet the same goal. If you have a very small solar electric system, you will most likely find that it will be necessary to invest in more energy-producing components, such as a wind machine or solar electric modules, and additional storage capacity. But if you have a medium or large system, you might spend some time to see if you could invest in more efficient appliances to meet all or part of your expansion needs.

(Paul Jeffrey Fowler is the author of the Solar Electric Independent Home Book,

available from *Backwoods Home Magazine*, and most recently the author of The Evolution of an Independent Home: The

Story of a Solar Electric Pioneer, 1995, ISBN 0-9645111-7-7, distributed by Chelsea Green.) Δ

Sometimes a good old bucket of coals is the best solution

By Nancy Owen

Twenty years ago, like many beginning homesteaders who don't plan ahead carefully enough, we created a problem for ourselves. Our well, with its pump and tank, needed protection, so when we had cement blocks left over from a construction project, we built a 4' x 4' well house. The thought of freezing pipes didn't worry us: those heating cables with thermostats would supply the needed BTUs.

But what about those winter ice storms that knocked out the electricity? Or the mouse that chewed a cord in two? Or those unusual cold fronts that whipped through our woods with 20 mph winds and temperatures near zero? We hadn't planned for those nights and for pipes freezing in only a few hours because cement blocks with an insulating R-value of about one simply won't hold heat.

Our first solution was to collect styrofoam “peanuts,” remove the well house's portable roof, and painstakingly fill the cores of the cement

blocks. Halfway through that chore, we decided sand or sawdust might have worked better, as the peanuts were difficult to poke through the off-set cores. But we persisted, and probably got the R-value up near two. But then on windy, bitterly cold nights, the pressure switch line would still freeze.

One day, after surviving a night of 2°, it froze at 8:15 a.m., and that morning we stumbled onto an answer. We set a small bucket of live coals from our woodstove in a corner of the well house. Fifteen minutes later the temperature had hit 85°, and the pump came on.

Experimenting with the coals, we discovered the best method is to use a minnow bucket, which has a perforated container inside a regular bucket. We put ashes on the bottom, coals in the middle, and more ashes on top. Then the coals don't just die as they do in a regular bucket, but, breathing through the holes, burn slowly and keep the temperature above 32°.

Our bucket of coals also enables us to be just a little bit less dependent on the electric company. Δ