POSTMODERN PV PIONEERS

Off Grid & All Sunshine

by Ian Woofenden

Everyone has heroes. Jennifer and Lance Barker are some of mine. They've managed to do what my family has done—live without utility electricity for decades—but without relying on nonrenewable fuels for cooking, space heating, or backup electricity. Here's how these two postmodern pioneers meet their energy needs—using electricity solely from the sun.

Postmodern pioneers Jennifer and Lance Barker put the sun to work on their homestead.

Left: A 5-kilowatt solar-electric array provides the homestead with electricity, as well as powers pumps that irrigate Lance and Jennifer's extensive vegetable gardens (above).

Fossil-fuel generators and propane have long been "enablers" for off-gridders. Generators provide the convenience of abundant energy without having to spend a fortune up-front on renewable generation capacity, and they minimize the need to change energy use habits. But an off-grid "renewable energy" lifestyle has its contradictions when it can't be pulled off without the fossil-fuel crutch—after all, how much independence is really gained by getting off the electricity grid only to jump on the propane, gasoline, or diesel bandwagon?

When I first met Lance and Jennifer, and heard how they had gradually developed their rural, off-grid homestead without relying on a backup generator, I was intrigued—and envious. I remembered the thousands of dollars I'd spent on generators, fuel, and repairs. I remembered the hundreds of hours I'd spent dealing with noisy, smelly, stubborn generators. And I still wonder what my renewable energy (RE) systems would look like today if I'd invested all that time and money spent on generators, fuel, and maintenance into more renewable generation capacity instead.

Lance and Jennifer's homestead and energy systems evolved over time in a thoughtful and organic way—a reflection of their life philosophy that has been very purposefully shaped around the sun, optimizing its usefulness, and maximizing their independence from fossil fuels. Their success spans not only their fossil-fuel-free energy supply, but also their ability to grow, process, and store the majority of their food, further reducing their reliance on the nonrenewable fuels required by conventional agriculture.

FOLLOWING THE SUN

Lance first encountered solar electricity and the idea of renewable energy in high school science class, and was immediately captivated by the independence it offered. So when he struck out on his own, he searched specifically for off-grid property where he could establish a self-sufficient homestead. Inspired by his father, who restored worn-out Kansas farms to native grass pasture, Lance found 40 acres of overcut, overgrazed pine forest in the southern Blue Mountains, near Canyon City in Grant County, Oregon, and put his roots down.

With only 1.7 people per square mile, Grant County is the size of Connecticut in land area, but has only 8,000 people—so it's intensely rural. Lance picked this area for its clean land, air, and water, and for its solar potential—more than 250 days of sunshine per year. About ten families live in the Barkers' neighborhood, and they're evenly split between those who have punched the grid in, and those who live off grid. He watched his off-grid neighbors throw money and time at generators, and wasn't interested in the hassle or expense

Well-placed meters inside their home provide Lance and Jennifer with immediate feedback on the status of their PV system.

The Barkers' pole-mounted PV system has grown from one 32-watt module in 1979 to a 5,000-watt array using 44 modules today.

Beyond PV

Lance and Jennifer dedicate their lives to using the sun and promoting its usefulness. Jennifer is founder and executive director of EORenew, a nonprofit organization that coordinates the annual SolWest Renewable Energy Fair in John Day and provides ongoing energy education in eastern Oregon. Lance designs and installs solar-electric systems for both on- and off-grid clients. A large and enjoyable part of his business is building small stand-alone PV power and control systems for fish screens. The solar-powered DC motors clean debris off the screens, which keep fish from entering stream-fed irrigation ditches.

As much as possible, Lance and Jennifer work from their home office and workshop, which allows them to keep their life centered on developing their self-sufficient homestead and reduces their reliance on fossil fuels for transportation. Lots of time at home enables them to use the sun's energy for more than just generating electricity for the household, pumping water, and growing their food. Jennifer is somewhat of a solar cooking guru, after years of solar cooking, teaching workshops, and publishing two cookbooks. Lance is just learning how to cook with the sun. "I find solar cooking is easier for inattentive cooks like me," he says, "because if the cooker is neglected, the sun goes by, and the dish cools down, instead of burning as it would on a conventional stove."

The sun also provides energy for another important part of the Barkers' life—restoring the second-growth pine forests on their property to an old-growth ponderosa pine plant community. The Oregon Tree Farm System named them "Oregon Tree Farmer of the Year" in 2000, and the governor of Oregon cited their restoration project as one of Oregon's best examples of sustainable forestry.

of importing propane for cooking and heating either. From the start, Lance was committed to developing a system that would produce all of the homestead's energy on site, and to living within the energy "budget" that the sun provided.

As the PV array expanded, so did the Barkers' power center. Although some of their primary loads are DC, three inverters (left and below) also convert the PV array's output for standard AC appliances.

SOLAR EVOLUTION

Lance moved onto the property in 1979. In the late 1970s, residential solar-electric equipment was in its infancy, very expensive—and beyond Lance's budget. Connecting to the grid was expensive and outside of his scope for a self-sufficient homestead. So Lance chose to live with no electricity at all, until he saved enough money to buy his first Arco 32-watt (W) solar-electric (photovoltaic; PV) module. With this small system, he ran a single DC fluorescent light, and "never had to buy kerosene again for the lanterns."

Jennifer joined Lance on the land in 1991, after already spending some time living off-grid with a one-module DC system at her ski lodge in the Cascades. Over the years, they have slowly grown their solar-electric system. Living within the limits of the solar energy they could harvest gave them increased economic flexibility. They added to their system when the money was available, and during lean times, didn't put any money into it at all. Folks who rely on propane and generators don't generally have this option—they are dependent on continually purchasing fuel.

Along with increasing the capacity of their PV array, the Barkers also purchased newer, higher performance inverters and controllers as they became available. "Our system was pretty much built that way, one step at a time," says Lance. "Since I'm not an inventor, everything we do is with off-

Left: Comfortable, efficient country living.

Below: Jennifer takes advantage of the sun's free energy to cook delicious meals in their solar ovens.

the-shelf equipment." Over 28 years, the system has slowly grown to 44 modules—and 5,000 watts (5 KW) of solar-electric independence.

For space and water heating, as well as cooking, Lance and Jennifer use wood they harvest from their sustainably managed woodlot. "Biomass accumulates here faster than it decomposes," says Lance. "This material is going to burn—and we get to choose how and when! So we have wood for ample thermal energy here, and that makes it easier for us to avoid using propane." Their modest-sized, passive solar home is built to take advantage of solar gain in winter and is well insulated. Plus, Jennifer says, "Any time I'm cooking on the woodstove, it's producing enough heat for our small house." A coil in a Pioneer Maid wood cookstove produces hot water for domestic use.

GENERATOR-FREE

Lance and Jennifer took a hard line on having a generator—they just didn't do it! Instead, they invested all the money that they didn't spend on generators, generator sheds, fuel, and maintenance into expanding the PV system. The guiding principle they used to develop their RE system is in many ways 180 degrees from the standard design approach used for off-grid sites. "It's what we call production determination of a system," says Lance, "rather than load determination. You produce electricity, and that's how much you have available to use. It's not really a difficult concept, but it's very different from the normal North American way of doing things."

Lance sums up their basic philosophy: "We have adequate solar-electric capacity to support our base loads, and we add to those base loads only as we can afford to add to our array." The Barkers' base load (and dates of installation) consists of these individual energy uses: lighting (1981), water pumping (1982), refrigeration (1984), computers (1991), and a chest freezer (1994). These total 1.2 KWH per day, including losses from battery inefficiency. Over the years, the Barkers have been able to reduce their base load by switching from an AC Vestfrost to a DC SunDanzer freezer that uses less energy and doesn't incur additional inverter conversion losses. Beyond the base loads, Lance says, "All other electrical loads—of which we have many—are discretionary, depending on energy availability. That philosophy has remained the same, even though our system has expanded in ways that were unimaginable in the beginning, because the hardware simply did not exist."

At critical junctures in their equipment upgrades, Lance and Jennifer had to examine the future of the system. They knew that most modern off-grid systems exclusively use AC appliances due to the wide selection of models available and to simplify home wiring during

Overview

System type: Off-grid, battery-based solar-electric

Location: Near Canyon City, Oregon

Solar resource: 5 average daily peak sun-hours

Production: 560 AC KWH per month average

Photovoltaics

Modules: Forty-four BP 80s, 85s, and 170s; 80, 85, and 170 W STC; 12 or 24 VDC nominal, depending on module

Array: Fifteen, 2- or 4-module series strings (depending on module voltage), 5,000 W STC total, 48 VDC nominal

Array installation: UniRac, General Specialties, and home-made pole mounts; seasonal tilt: 55 degrees in summer, 90 degrees in winter

Energy Storage

Batteries: Single string of 12 Concorde PVX-6480T, 2 VDC nominal, 640 AH at 20-hour rate, sealed AGM

Battery bank: 24 VDC nominal, 640 AH total

Balance of System

Charge controllers: Two networked Apollo T80s, 80 A, MPPT, 48 VDC nominal input, 24 VDC nominal output

Inverters: OutBack VFX3524, Trace SW4024, Magnum MagnaSine, 24 VDC nominal input, 120 VAC output

System performance metering: E-Meter battery monitor and 9 analog meters

construction. But Lance says, "When we examined this carefully, we came to the conclusion that running DC loads for lights, refrigeration, and fans cuts the daily electric use significantly by eliminating the inverter losses, which may be 10 to 15 percent, or even more than 50 percent on a very small load like a single light." Using DC loads instead of AC ones saves Lance and Jennifer more than 200 watt-hours per day. In a generator-free, off-grid PV system, every watt-hour counts. Minimizing the base load is essential to ensuring an adequate electricity supply through cloudy stretches of weather. Lance points out that "because straight AC systems are the 'modern' method of having an off-grid system, we call our system 'post-modern,' because we are aiming for the future, not the past."

In his business as an RE consultant, Lance uses standard load analysis and sizing methods when he designs systems for off-grid customers. But his personal conclusions and lifestyle are different. "By setting limits to what Jennifer and I are able to consume, and living within these limits, we get a closer feel for what we are doing with our lives. It helps give our life purpose and meaning, and it helps make us happy. Our system is often called 'pure' or 'purist.' I see it as pure, all right—purely practical."

DESIGN LESSONS

Running a system like Lance and Jennifer's takes tools. Lance says, "Our most important tools for making our system work are our brains! Sometimes visitors look at what we do and say, 'I wouldn't want to have to think about it.' Well, we *do* want to have the opportunity to think about it and apply ourselves accordingly. Living without a generator gives us a close personal relationship with our energy use—how much energy is coming in and how much we are using."

Another essential tool is a battery state-of-charge monitor (amp-hour meter), which provides cumulative and net battery charge data. It is installed where Lance can see it when sitting in his easy chair. Along with the amp-hour meter, they also have analog ammeters so they can see at a glance how the system is running throughout the day.

When Lance and Jennifer replaced their more than 20-year-old battery bank four years ago, they found that their battery sizing philosophy had changed because of their previous investment in increased PV capacity. As more modules are added to an array with maximum power point tracking (MPPT), more electricity is generated during low-light, overcast, or partly sunny weather. The result is that even with the sun's limited availability on mostly cloudy days, the system's batteries often still receive a full charge. By watching their battery monitor over the years, Lance and Jennifer determined that they really didn't need the 800 amp-hour (AH) battery bank capacity they originally had (about 10 KWH of usable storage at 50 percent depth of discharge), and replaced it with a 640 AH bank, for about 8 KWH of storage (at 50 percent DOD).

SURPLUS ENERGY

The combination of a small base load, large PV array, and a very sunny location has enabled Lance and Jennifer to live off grid for close to three decades without any fossil-fuel-based backup energy source. During the winter months, this approach has continually provided them with ample electricity, when most off-grid system users would have to resort to firing up the engine generator to keep the batteries from being too deeply discharged. During the non-winter months, the PV array produces significant amounts of energy beyond what the base loads require.

When asked about managing the additional energy available during many months of the year, Lance responds, "For a long time, I thought that we would be able to buy off-the-shelf hardware to electrolyze water with our extra energy. Then we'd have hydrogen for instantaneous water heating and for summer cooking. It hasn't happened yet, but I try to remain hopeful that the equipment will someday become available."

For now, they use a different approach. During the growing season, once the batteries are charged, solar energy is used to pump a large daily volume of water to their extensive vegetable gardens and tree seedlings. Lance's irrigation setup pumps 1 gallon of well water for crops with each watt-hour of energy the PV system generates. Considering that the average meal in the United States travels about 1,500 miles before it hits the dinner table, both Lance and Jennifer are quick to point out that growing as much of their own food as possible has a huge

impact on the amount of petroleum they use. Having ample solar energy for water pumping makes this possible.

Their 40-acre Morning Hill Forest Farm produces much of their food and all the wood needed to heat their home and outbuildings. Lance says, "Our garden produces as many vegetables as we can possibly eat year-round, a large amount of the seed for replanting, and an increasing amount of our fruit. Our food storage includes some canning—jam, tomatoes, pickles, and salsa—but most foods are stored in the freezer or root cellar. By summer's end, Jennifer has our 8-cubic-foot freezer packed into a nearly solid cube of frozen vegetables and fruit! The more water we are able to pump, the more food we are able to grow, and the less dependent we are on oil-intensive agriculture, shipping, and food storage."

SUNSHINE IS SUFFICIENT

Since most off-grid folks do not have enough RE generation capacity to get them through sunless or windless periods, living with an engine generator has more often than not become a fact of life. But it doesn't *have* to be that way. When asked about renewable energy droughts, Lance responds, "It's back to that question that folks always ask us, 'What happens when you run out of electricity?' Well, we don't run out of electricity—we never have! I reset the battery monitor when I installed the new set of Concorde AGM batteries four years ago, and the cumulative data shows they've never been drawn below 75 percent of full charge. So our hands-on, base-load-plus-discretionary-load management system works well.

"In more than 25 years now, we have never had an unplanned outage," says Lance. "I have shut down the system for work and maintenance, but it never—and I do mean *never*—has just gone out. By accepting that we have limitations, we build reliability into our systems." A reliable system, and a lifestyle focused on sustainability, self-reliance, and independence, is exactly what Lance and Jennifer have built.

ACCESS

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

Lance & Jennifer Barker, 15013 Geary Crk. Rd., Canyon City, OR 97820 • 541-542-2525 • jbarker@highdesertnet.com • www.highdesertnet.com/morninghill

SolWest Fair • 541-575-3633 • www.solwest.org • RE educational event

PV System & Homestead Gear:

Apollo Solar • 203-790-6400 • www.apollo-solar.net • Charge controllers

Bogart Engineering • 831-338-0616 • www.bogartengineering.com • TriMetric battery monitor

BP Solar • 800-521-7652 • www.bpsolar.com • PV modules

Concorde Battery Corp. • 800-757-0303 • www.concordebattery.com • Batteries

General Specialties • 208-265-5244 • PV racks

Magnum Energy • 425-353-8833 • www.magnumenergy.com • Inverter

MidNite Solar Inc. • 425-374-9060 • www.midnitesolar.com • E-Panel

OutBack Power Systems • 360-435-6030 • www.outbackpower.com • Inverter

RCH Fan Works • 509-685-0535 • www.fanworks.com • DC ceiling fans

SunDanzer • 915-821-0042 • www.sundanzer.com • DC freezer

UniRac Inc. • 505-242-6411 • www.unirac.com • PV racks