

**This is a placeholder page.
The article starts on the following page.**

**By keeping this page in a PDF document,
you will be able to view this article as 2-page spreads
as they will appear in the printed version of *Home Power*.**

**Select: View>Page layout>Facing in Adobe Acrobat
to see facing page spreads.**



Gene Foster at his off-grid golf course.



Off Grid in Arkansas

John Miggins

©2006 John Miggins

A Hybrid Solar and Wind System

Gene Foster is a modern-day pioneer, a self-made man who has transformed his 40-acre property in Paris, Arkansas, into a self-sufficient homestead. Over the last nine years, Gene has converted a piece of raw land nestled in the beautiful Arkansas valley to a virtual oasis, complete with a 1,600-square-foot rock home, a 5-acre fish pond, and his own nine-hole golf course.

Gene has been in the machining business as owner of Foster Enterprises for 25 years, a trade that has helped him build and modify his independent energy system. When he took a serious look at his retirement options, he realized that his energy costs for 2004 were more than US\$3,500, and increasing every year.

The alarm bells started ringing, and he asked himself, "How can I get a better return on the investment in my new home, and plan for my energy future?" Gene set out to lower his energy bills, which at his rate of consumption would total US\$35,000 over ten years. He started researching his options on how to provide the four main elements of his home energy needs—heating, hot water, cooling, and electricity. Here is how he did it.

Conservation

As a first step, Gene set out to reduce his energy demand by insulating his home and shop thoroughly. The home was wrapped with 1-foot (0.3 m) walls of natural Arkansas stone and the attic insulation was boosted to R-40. The original house had wood siding with R-13 insulation. A stone facade was added to the home's exterior, with a 1- to 2-inch (2.5–5 cm) gap between the rock and the original siding. Gene then built a large, south-facing screened porch overlooking the lake to manage the afternoon sun's impact on his house, and provide a pleasant place to oversee his property.

He replaced his natural gas-fueled range, cooktop, and clothes dryer with propane appliances that are supplied by a 100-pound (45 kg) propane tank that is usually filled for about US\$50 and lasts about six months. He continues to use these appliances sparingly along with his microwave, which had its clock disconnected to reduce the phantom load. All the lighting in his home and workshop is either compact fluorescent or tubular fluorescent for higher efficiency. He has three ceiling fans and a 3-ton central air conditioner to cool his home. With the exception of the air conditioner, the electrical needs in the house are relatively modest.

In the 40- by 60-foot (12 x 18 m) workshop, he has a full machine shop with lathe, mill, sharpeners, grinders, air compressors, and other assorted tools. These are used to maintain his golf course, and to fabricate the many innovations he has developed. The shop's electrical load can be large, but most of the time only one device is running. A separate load center in the shop is fed from the main panel at the house. These two AC distribution panels are connected, and now his independent energy system feeds them both. An 18 KW diesel generator is used for large loads like the air conditioner.

Gene Foster's large workshop has served as a useful place for fabricating his wind tower and PV rack system.



This sunroom provides passive heating and daylighting.



Heating & Hot Water

Heating and hot water was the easy part. Gene purchased an outside wood-burning furnace from Hardy Manufacturing. The unit provides both heat and hot water to his home and workshop. It works very well, is made of stainless steel, and will burn for 24 hours or more on a single load of logs, which are plentiful around the property. This furnace is extremely efficient and uses an open-loop water heat exchanger that provides ample hot water to two water tanks and also feeds hot water to two water-to-air heaters for the shop.

Gene then designed and installed a drip oil-assist booster that feeds used oil to the heater on a timed basis to boost the heating capacity of the furnace. The unit injects 2 ounces (60 g) of oil at timed intervals that allow the fire and flame in the firebox to burn hotter and reduce the amount of wood needed by half.

The house is heated with a large wood-burning fireplace that draws in cool air at the bottom and blows warmed air out at the top. Gene ducted this heated air stream to each room to heat his whole home comfortably. These innovations are simple but very effective.

Cooling

Cooling the house presented the largest load. The 10-year-old, 3-ton air conditioning unit is not efficient (newer models use about half as much energy), and worked the inverters hard when the compressor kicked in. To rectify this, Gene had his air conditioning service technician install a soft-start kit (capacitor) to reduce the compressor's start-up surge.

The inverters can now handle the air conditioner with no problem, but to limit its high energy demand and use, Gene designed and installed a fresh water, open-loop cool water booster. By pumping cool water from the bottom



An outdoor wood-burning furnace provides most of the home's space-heating needs.



An open-loop heat exchanger provides hot water for the house.



This drip oil-assist booster increases heat and reduces the amount of wood needed.

of his 80-foot (24 m) well into an A-coil installed in the indoor blower unit, the home's interior air temperature is significantly reduced. The water is then returned to the top of the well and cycled again. The system is a simple and effective for short periods of time.

Electricity

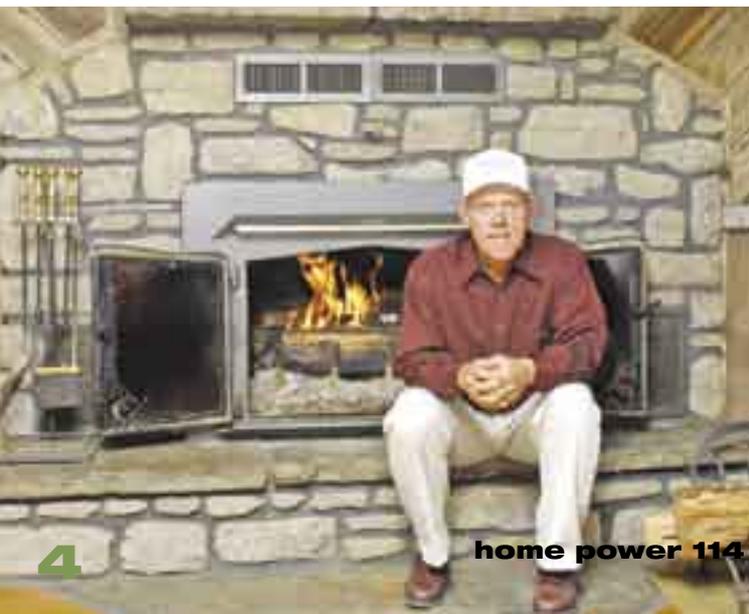
Gene enlisted my company, Harvest Solar & Wind Power, to design and install his independent electricity system. After our first meeting, we realized that he had already taken most of the initial steps toward conservation that we normally recommend. He knew his energy needs, and was perfectly willing to manage them and his energy generation to achieve the goal of energy independence.

Gene wanted multiple charging sources capable of producing in any weather condition at any time of day. We designed an off-grid hybrid system using solar electricity, a wind generator, and a backup engine generator. Gene is currently building a custom microhydroelectric turbine to add to the energy mix.

We chose components carefully to allow for maximum production and flexibility, and to provide for future growth of the system. A 48-volt system was chosen to keep system efficiency high and wiring costs low.

We specified an OutBack power panel with two OutBack VFX3648 inverters and all the options. The panel includes an OutBack MX60 charge controller, the Mate

A hybrid heating system keeps Gene's home at a comfortable temperature.



Author John Miggins shows off the power room.



system monitor, and OutBack disconnects all prewired. This UL-approved power panel supplied by Conergy Inc. simplified the installation and can accommodate up to four inverters if needed. Phil Undercuffler at Conergy and Matt Rust at OutBack were very helpful in the design of this panel, and Conergy had it built and shipped in two days!



These Surrette batteries provide energy storage.

We selected the Surrette S-530 batteries because of their excellent reputation, long life, 10-year warranty, and safe design. The battery bank is made up of three strings of eight batteries, wired in series and parallel to give a 48-volt system

with about 80 KWH of total capacity (40 KWH usable at 50% DOD). The battery system has worked flawlessly. The batteries are installed next to the power panel in the shop on a custom rack that Gene built, and placed next to the south wall to help keep them warm in the winter.



The African Wind Power turbine provides energy on days when there's more wind than sun.



Just another sunny day at the course for Gene Foster.

Photovoltaics

The solar-electric array is made up of 22 Sharp 165-watt modules, wired at 48 volts to provide 3,630 rated watts and about 12 AC KWH per day. At the time, these were the largest panels we could get, and we received excellent service and design assistance from Doug Broach with Carmanah.

The modules were installed on two custom, tracking mounts that Gene built on site. Setting the charge parameters for the OutBack inverters and MX60 was simple and straightforward, given the information from James Surrette at Surrette Batteries and Matt at OutBack. The batteries and inverters have risen to meet any electrical demand that Gene has thrown at them. The ability to recharge the batteries with a strong generator and Gene's willingness to manage his demand are keys to the success of the system.

Wind Generator

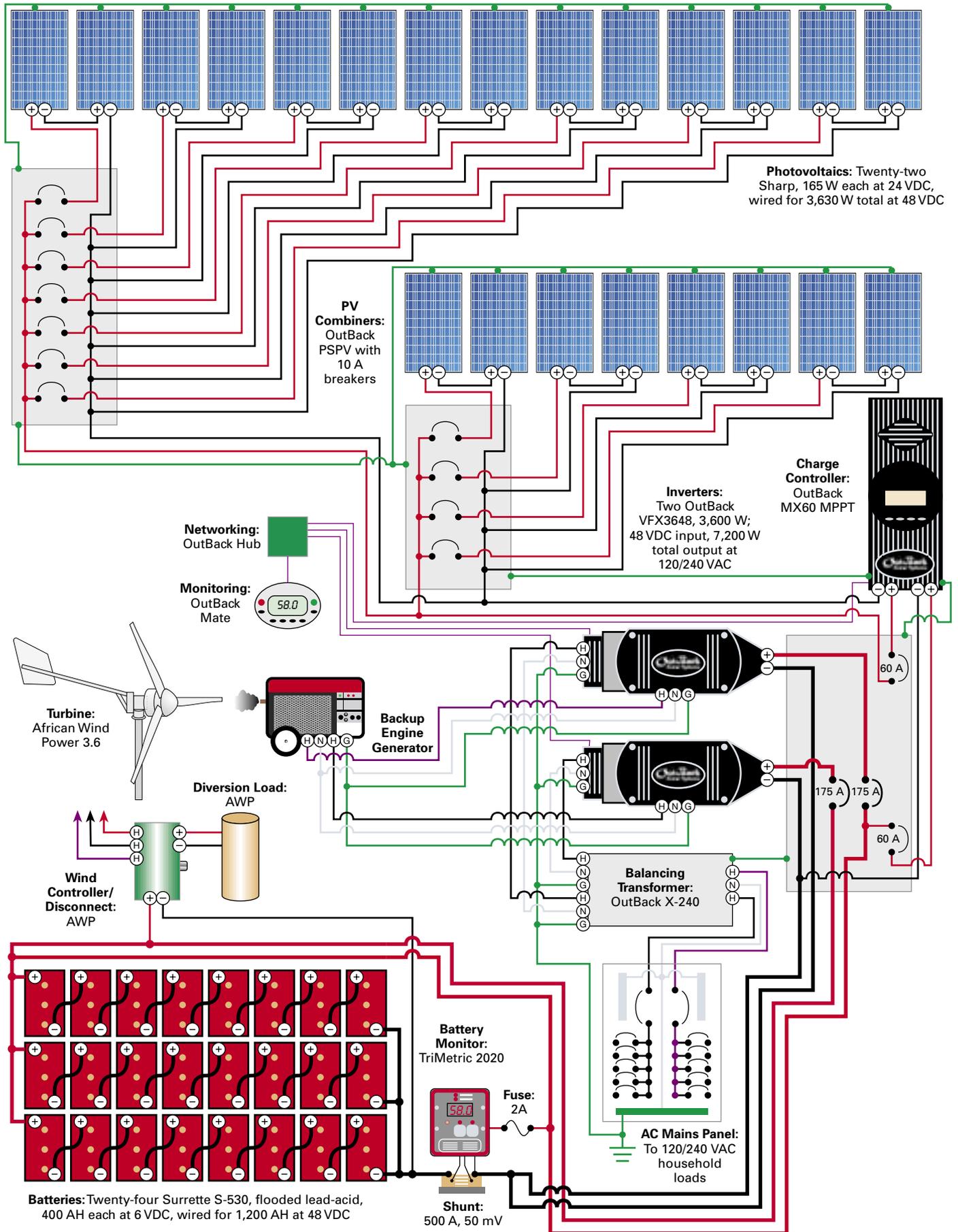
Gene selected the African Wind Power (AWP) 3.6, 48-volt wind generator with its own controller and air heater dump load. This generator sits on an 80-foot (24 m) tower that Gene designed and built. The tower's design allows him to single-handedly raise and lower the wind generator, another of his engineering feats.

Gene installed the tower and wind generator himself, with buried cables to the power room, where the three-phase wild AC output of the generator is converted to 48 volts DC. The AWP 3.6 is a robust machine that starts generating at about 9 mph (4 m/s), and is a quiet yet reliable addition to the system.

Microhydro

Gene's golf course is small, but the greens require a lot of water, so he created a 5-acre pond. Two 240-volt pumps supply water to each green for an hour each morning in the summer, with ample power and energy from the system.

There is a 10-foot (3 m) drop on one side of the pond where Gene built and is installing his own microhydroelectric turbine. When the seasons change and the greens need less water, the hydro system will be



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

Tech Specs

Overview

System type: Off-grid, battery-based PV and wind-electric

Location: Paris, Arkansas

Solar resource: 4.5 average daily peak sun-hours

PV production: 360 AC KWH per month

Wind resource: 10 mph (4.5 m/s) average wind speed

Wind production: 160 AC KWH per month

Photovoltaics

Modules: 22 Sharp, 165 W STC, 34.6 Vmp, 24 VDC nominal

Array: 11 two-module series strings, 3,630 W STC total, 69.2 Vmp, 48 VDC nominal

Array installation: Homebuilt trackers

Wind Turbine & Tower

Turbine: African Wind Power (AWP) 3.6, 48 VDC

Rotor diameter: 11.8 feet (3.6 m)

Rated energy output: 192 DC KWH per month at 12 mph (5.4 m/s)

Rated peak power output: 1,000 W at 22 mph (9.8 m/s)

Tower: 80-foot guyed, homebuilt

Energy Storage

Batteries: 24 Surrette S-530, 6 VDC nominal, 400 AH at 20-hour rate, flooded lead-acid

Battery bank: 48 VDC nominal, 1,200 AH total

Balance of System

PV charge controller: OutBack MX60, 60 A, MPPT, 48 VDC nominal input voltage, 48 VDC nominal output

Wind turbine charge controller: AWP controller with diversion load

Inverters: Two OutBack VFX3648, 48 VDC nominal input, 120/240 VAC output

System performance metering: TriMetric battery monitor

System Costs

Description	Cost (US\$)
22 Sharp 165 W panels	\$15,950
OutBack power panel	6,950
Deutz diesel engine generator	6,500
24 Surrette S-530 batteries	5,664
AWP wind generator	3,015
PV rack, homebuilt	2,500
Tower, homebuilt	1,500
Wiring, other	400
Installation	400
Wiring, batteries	360
TriMetric battery monitor	200
OutBack combiner box/wiring	199
Total	\$43,638

employed to charge the batteries. In the fall and spring, the creek-fed pond used to run over the spillway. Now Gene will divert this water into the hydro generator for additional charging capability about four months out of the year. When the pond is full enough, the generator will be able to run for 48 hours nonstop.

Diesel Generator

The fuel-fired generator is a new Deutz diesel 18 KW generator that runs on 1/2 gallon (2 l) of fuel per hour at half load, and puts out stable 240 volts AC. Gene will have to pay for diesel to run it, but he can buy off-road diesel by the tanker load. This backup generator provides a nice buffer should his system require more input. The engine generator's AC output feeds into the AC input of the OutBack power panel and is immediately available for direct use, to charge batteries, or both.

Pulling the Plug

After the system was installed and tested, Gene pulled the plug on his utility service. In many cases, this wouldn't make economic or environmental sense, but the local utility is not supportive of grid-tied systems. They would have paid a low rate for Gene's surplus electricity, while requiring him to spend at least US\$2,500 to meet their equipment standards. Gene enjoys both the independence and the responsibility of having a stand-alone renewable energy system.

The system is designed with the ability to harvest the energy abundant around us in multiple ways and allows Gene to live off the land, while still enjoying all the comforts of a modern home. Having an independent energy system is a dream of many that is now a reality and a source of pride for this Arkansas homeowner. Having plenty of golfing buddies to enjoy it with makes it that much more fun.

Access

John Miggins, Harvest Solar & Wind Power, 1571 E. 22 Pl.,
Tulsa, OK 74114 • 877-743-2299 or 918-743-2299 •
Fax: 877-743-2299 or 918-743-2299 • jmiggins@cox.net •
www.harvest-energy.com • System designer & integrator

Gene Foster, Foster Enterprises, 8591 W. State Hwy
22, Paris, AR 72855 • 479-635-2651 • Owner & system
designer

Abundant Renewable Energy (ARE) • 503-538-8298 •
www.abundantre.com • AWP 3.6 wind generator

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

Carmanah • 800-671-0169 or 801-501-9353 •
www.carmanah.com • PVs & design support

Conergy • 888-396-6611 or 505-473-3800 •
www.conergy.us • Design & engineering support

Deutz Corp. • 770-564-7100 • www.deutzamericas.com •
Diesel engine generator

Hardy Manufacturing Co. Inc. • 800-5-Hardy-5 or
601-656-5866 • www.hardyheater.com •
Outdoor wood-burning furnace

OutBack Power Systems • 360-435-6030 •
www.outbackpower.com • Power panel, inverter, etc.

Sharp Solar • 800-237-4277 • <http://solar.sharppusa.com> •
PVs

Surrette Battery Co. Ltd. • 800-681-9914 or
902-597-3767 • www.surrette.com • Batteries

