The First Small Wind System in Lassen County

Leslie Morán

Raising the 84 foot tower with the Proven WT2500 for the first time—keep clear of the fall zone.

"I've always liked the idea of a property paying for itself," says Paul Thomas, who with his wife and family, own 77 acres in Litchfield, California. Ever since Paul graduated from high school in the mid-seventies, he has wanted renewable energy in his life. He credits his mother with instilling a vision in him for being self-sufficient.

After construction on their home was completed, Paul began his research. A *Home Power* article—"Apples and Oranges," by Mick Sagrillo—explained the basics about small wind turbines. On the Internet, he found information on the rebate program offered by the California Energy Commission (CEC) for customers of Lassen Municipal Utility District (LMUD), and he picked up a copy of the Lassen County ordinances. Paul also found my husband Chris Worcester's company, Solar Wind Works, online. He called and spoke with Chris.

Chris first visited the Thomas homestead in May 2002. At an elevation of 4,050 feet (1,234 m), the only trees visible grow along a few scarce waterways, or had been planted at farms, ranches, or homesites. In the summer, it is hot and dry, while during the winter it can snow and get as cold as -20°F (-29°C), with the mercury often hovering just above zero.

As options for the site were discussed, the presence of a significant prevailing wind spurred us to quantify the wind resource. Several months later, maps, documents, and information had been compiled from a variety of agencies. After reviewing the often-conflicting material, it was determined that the property sat in a Class 2 wind designation, a usable resource for a small wind turbine.

California Energy Crisis Hits Home

Originally, Paul had planned to pay for up to fifty percent of the wind turbine installation through the CEC rebate program. Unfortunately, the original program ended in December 2002, just as Paul was getting ready to apply for the funds.

Installer Chris Worcester, and owner Paul Thomas attach blades to the Proven's downwind hub.

Almost ready for raising—the Proven WT2500 weighs more than 450 pounds.

This could have brought their renewable energy project to a standstill. But Paul's wife wanted to keep her husband's dream alive and encouraged him to, "Go for it!" She liked the idea of having uninterruptible power when winter storms take out the overhead utility lines and leave the rest of their valley in the dark.

Together they reviewed their finances and found a way to keep the project moving forward. This hurdle caused the system to be downsized from a Proven WT6000 to the WT2500 wind turbine.

Answering to the County

In April 2003, the application package was submitted to the county. This was the first small wind turbine permit submitted in Lassen County. The planning department handed Paul a long list of items they wanted justified, and Chris began gathering answers. The county wanted proof that the wind turbine would not interfere with television and radio transmissions, and they wanted UL or equivalent safety listings on all of the electronic components used in the system.

To meet these requirements, a letter was received from Proven Engineering Products Ltd. of Scotland stating the British standards that their wind turbines and controllers are

Chris attaches a spring pack which tensions the blade during high-wind governing.

built to. Next the ETL (Electrical Testing Laboratory) listings for the two OutBack FX2548 inverters and the OutBack AC and DC boxes were obtained. A copy of an article written by Mick Sagrillo addressed the county's concern, ensuring that operation of the wind generator and blades could not and would not interfere with radio or television transmissions. With this information, Paul resubmitted his package in May.

Preparation

Lassen County issued the permit for the renewable energy system later in May, without any further questions or changes. Meanwhile, Paul had kept busy. After hanging the plywood backing for the power center, he built a vented insulated battery box consisting of a wood frame with plywood sides coated with fiberglass resin.

The battery box holds sixteen, Surrette S-530, 6 V, lead-acid batteries wired in two parallel strings of eight batteries. This battery system stores 800 AH at 48 VDC, enough to run the household's loads for 24 hours, at 50 percent depth of discharge. The box is covered with a hinged, sloping, clear Lexan lid. The automatic vent fan is powered and controlled by a 12 VDC auxiliary output on one of the inverters.

Paul planned to install an anemometer on the wind turbine tower. After reviewing all the options, an NRG Systems Wind Explorer anemometer and data logging system was ordered in July.

Paul's property sits on an old lake bed, is level, sandy, and treeless, save for a vegetable garden and some young aspen trees. Trenching and digging the foundation footings in such sandy soil proved to be a challenging job. The vertical walls had to be kept wet constantly; otherwise the sandy soil would collapse into the excavated areas and need to be dug out again.

It took Paul two days of backhoe work to complete 180 feet (55 m) of trench and the foundation holes for the tower and four guy anchors. With the trenches open, the conduit runs—two, 2 inch and two, 1 inch of schedule 40 PVC—were laid in. They provide for this turbine installation and for a future PV array.

Tower & Power Center Design

The higher off the ground, the faster and less turbulent the wind. Since Lassen County required a variance for a wind turbine higher than 100 feet (30 m), an 84 foot (26 m) tilt-up tower kit was planned. A tilt-up tower is less expensive than

Tech Specs

System Overview

System type: Grid-tied, battery-based wind

Location: Litchfield, California

Wind resource: 9 to 10 mph (4 to 4.5 m/s) annual average

Production: 420 AC KWH per month average

Utility electricity offset: 25 to 50 percent

Wind Turbine

Turbine: Proven WT2500/048

Rotor diameter: 3.5 meters (11.5 feet)

Average rated AC KWH per month: 417 KWH at 12 mph (5.4 m/s)

Peak rated KW output and wind speed: 2.5 KW at 26.8 mph (12 m/s)

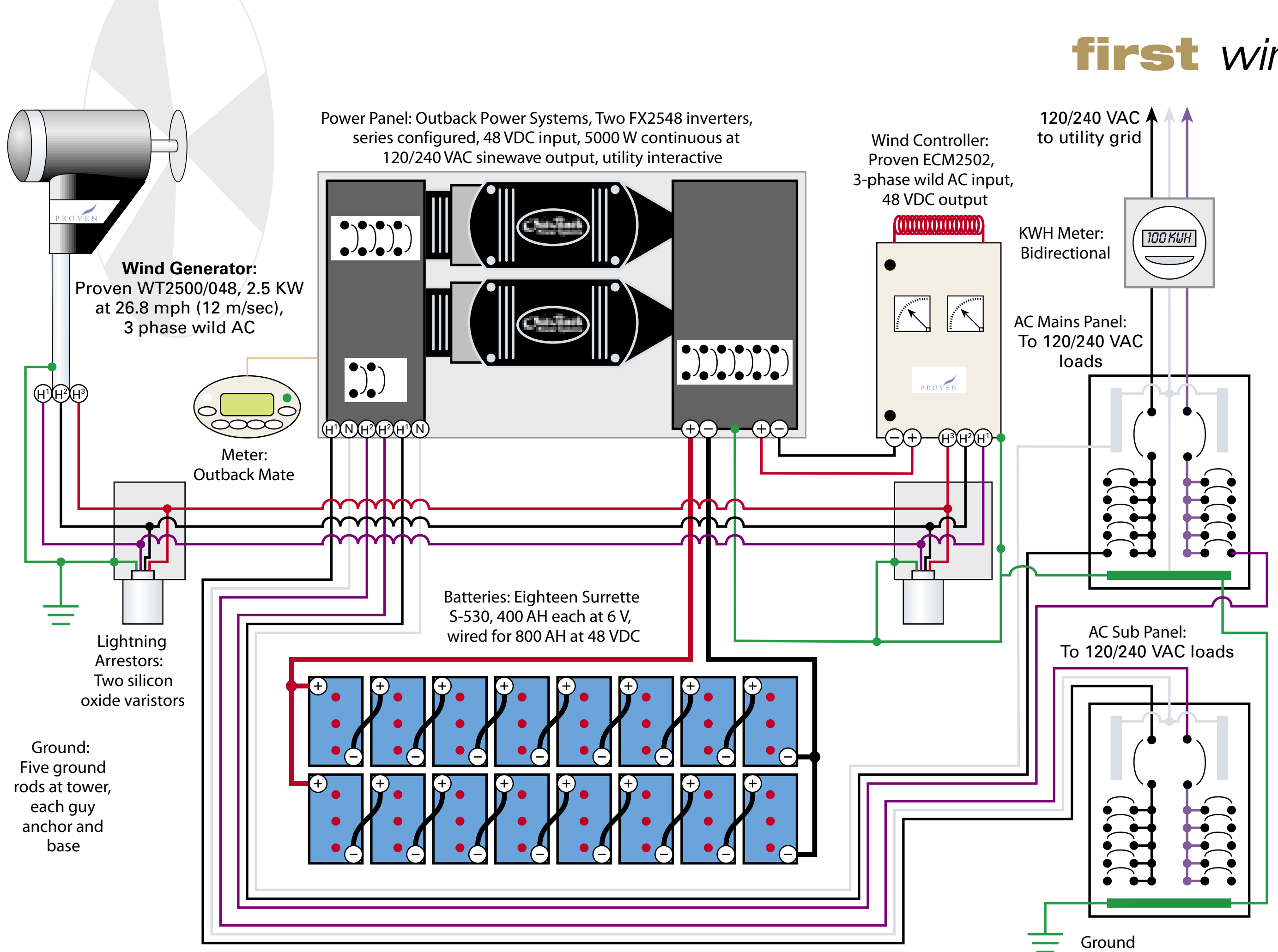
Tower: 84 foot (26 m) Lake Michigan Wind and Sun, 5 inch pipe, tilt-up

Balance of System

Inverter: Two OutBack FX2548s, 120/240 VAC output

System performance metering: AC watt meter between the inverters and the home's subpanel

Energy storage: 16 Surrette S-530, 6 V, lead-acid batteries wired in two parallel strings of eight batteries for 800 AH at 48 VDC



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

a freestanding tower, and makes maintenance easier, but it needs room for the guy wires. The pipe for the tower is a 5 inch diameter, schedule 40, hot dip galvanized steel pipe.

After reviewing the 120/240 VAC loads in the home's electrical subpanel, Chris determined that at least two inverters supplying a combined 5,000 W at 240 VAC, drawing from a 48 V battery bank, would be needed for the power center. The grid-connected inverters supply household loads and charge the battery from the grid. However, when the wind is blowing, the electricity made by the wind turbine charges the batteries, helping to power household energy loads. Since they planned is to sell back to the utility, a net metering agreement was set up with LMUD.

Paul's system contains two, series wired, OutBack Power Systems FX2548 inverters for 120/240 VAC. An OutBack X240 AC autotransformer steps AC output up or down to match the load requirements on the individual AC buses at the home's AC load center. The power center also contains the required AC and DC circuit breakers. The system has plenty of room for expansion, including the future photovoltaic (PV) array charge controller circuit breakers.

The power system also boasts a Hub 4, which is used to connect the inverters to the OutBack Mate. The Mate has a digital display, and coordinates the operation of the inverters. In the future, when the PV array is installed, the Mate will also communicate with the OutBack MX60 charge controller.

The Outback power center with two FX2548 inverters, and the Proven ECM2502 controller (at right).

Sixteen Surrette S-530s store wind energy for later.

Assembling the Power Center

A cable tray (or gutter) that measured 6 inches by 6 inches by 8 feet long (15 x 15 cm x 2.4 m) was mounted to the wall. Six conduit nipples extend upward from the gutter, and align with knockouts (punched holes) coming out of the bottom of primary components in the power center. This design simplified the cable runs between the various components in the system, and really makes for a clean installation.

The prewired OutBack Power System board weighed in at more than 300 pounds (136 kg). Paul attached a strap to the preassembled power center and let his automotive engine hoist do the heavy lifting. With the engine hoist, the panel was gingerly moved into place and the conduits easily slid into alignment with the knockouts.

Pouring the Foundations & Tower Assembly

The tower foundation and anchors needed 16 yards of concrete. It took most of the day to complete the pour and finish the concrete. Meanwhile, crew members worked on drilling pipe and laying out the tower kit.

The entire next day was spent assembling the tower, laying out the guy wires, and measuring and attaching them to the turnbuckles and tower. When assembling a tilt-up tower, it's important to pay close attention to the geometry. Keep the distance between the two side guy anchors and the top of the tower equal. This ensures that the guy wires will be the same length, which will allow the tower to be raised and lowered easily.

With each section of pipe weighing 305 pounds (138 kg), the crew aligned and blocked up the tower pieces using cinder blocks and scrap lumber. This gradually increased the height of each section, so that the top piece of pipe would be high enough off of the ground to keep the wind turbine out of the dirt when it was mounted.

Tower Grounding 101

A vital yet often underrated aspect of installing a complete wind-electric system is the grounding electrode system. Six, 8 foot (2.4 m) by 5/8 inch (16 mm) ground rods (grounding electrodes) were used. Ground rods were pounded in next to each guy anchor, at the tower base, and at the electrical pull box near the base of the tower.

The guy anchor grounding rods were bonded back to the central tower footing ground rod using #4 (21 mm^2) bare solid copper laid in 30 inch (76 cm) deep trenches. In each of these runs, a 2 foot (0.6 m) long "Z" was bent into the wire. In theory, this will help dissipate lightning into the earth, since lightning likes to follow a straight path.

A ground rod was also installed outside the power center building to provide a close path to ground at the power center. Another bare #4 copper went from this ground rod back to the tower grounding system, with two Zs bent along its length. The power panel was then bonded back 90 feet (27 m) through the framing with #2 (33 mm^2) THHN to the building's main electric panel's common grounding electrode.

Tower grounding is critical to prevent electrolysis between metal and earth, which can result in tower failure, and for dissipating the static electric charge buildup that can attract lightning. Proper grounding also provides an equipment ground in the event of a short in the electrical system, providing safety to the workers and the owner.

Tower Grounding 102

After assembling the tower, with all of the guy wires and turnbuckles in place, a stranded #4/0 (107 mm^2) bare copper grounding conductor was bonded to the pivot plate at the tower base and to its respective ground rod. Then #4 (21 mm^2) bare copper grounding conductors were bonded to the ground rod at each guy anchor. Stair stepping up from the ground rod to each guy wire, they were bonded to each guy wire individually with split bolts.

Internal Tower Cables

The main electrical cable, which would carry the electricity down through the inside of the tower, and the braking cable had to be installed as the tower was

Gin pole down, tower up—with careful measuring, the gin pole turnbuckle will come out plumb, making tensioning easier.

assembled. The electric cable, a #2 (33 mm^2) tray cable (a jacketed conductor) was used. The $^3/_{16}$ inch (5 mm) aircraft cable for the manual brake was taped to the end of the tray cable and together both cables were drawn up the inside the pipe tower. The tray cable was then suspended at the very top with a Kellums grip, hung on a $^3/_8$ inch (10 mm) stainless steel bolt. As the tension on the Kellums grip increases from the weight of the cable, it tightens its hold.

The cable comes out the tower base and runs through a Liquidtight flexible metal conduit to a raintight electrical splice box near the tower base. At this splice box, it is connected to three #4/0 (107 mm^2) THWN cables using NSI insulated in-line splice reducers. The #4/0 was sized to keep the voltage drop to an absolute minimum. Two, Delta, 3-phase, 600 VAC lightning arrestors were also wired in, one here and one at the Proven controller's 3-phase circuit breaker.

All Proven wind turbines come equipped with a manual braking system so the turbine can be stopped for routine maintenance. This feature fit one of the county's requirements. A mechanical hand brake was installed at the base of the gin pole. A quick flip of a lever at the bottom of the tower activates the caliper braking system in the turbine and stops the Proven's blades from spinning.

A Gin Pole for the Gin Pole

The gin pole (the lever arm that lifts a tilt-up tower) was built above and parallel to the lower section of the tower. The front guy wires and turnbuckles were attached to the gin pole. A smaller, lighter weight gin pole can be heaved into position with muscle power. This gin pole was 32 feet (10 m) long and weighed 460 pounds (209 kg). To lift the gin pole into its proper upright position, a temporary 10 foot (3 m) wooden gin pole was constructed.

The lifting cable was tossed up and over the wooden gin pole and attached to the end of the permanent gin pole that needed raising. Paul's John Deere backhoe provided the muscle, and the gin pole went up without a hitch. Once in place vertically, it was bolted to the tower's pivot plate and the temporary wooden gin pole was removed.

Raising the Tower—The Trial Run

During a test tower raising, the pulley system and lifting cables are being used for the very first time. This trial run also lets the crew clarify communication commands and directions, and is vital to ensure that there are no unforeseen problems with the tower and lifting assembly. Without this trial tower raising, if something goes wrong on the first lift, the wind turbine could be destroyed. It's very important to carefully adjust the tower rigging before mounting the turbine. When being raised for the first time, the guy wires need to be a little loose so the tower will raise without being bent.

This 84 foot (26 m) tower has four levels of guy wires anchored in four directions with sixteen turnbuckles. Using the backhoe to pull on the lifting cable, the gin pole lowered as the pivot plate rotated, and the tower went up effortlessly. This practice run provided the perfect opportunity to plumb the tower to vertical and adjust all the guy wires to their proper tension before adding the additional weight of the wind turbine. The tower lowered as easily as it went up.

Grinning ear to ear, Paul releases the brake and the Proven spins out its first amps.

Success—the Proven WT2500 up and running on the 84 foot tilt-up tower.

Why a Proven?

Proven turbines are manufactured in Scotland and known for their industrial strength durability. (They are named after the company owner, Gordon Proven, whose name is pronounced with a long "o" as in "pro".) Provens are considered "heavy metal" small wind turbines. Their heavy weight and low rpm leads to a long service life. The turbine's inherently simple design has few moving parts, and the downwind design means that no tail is needed. The over-sized, greasable bearings make maintenance easy.

Three down-wind blades are hinged at the base, allowing them to flex in relationship to the wind speed. The large diameter, direct drive, 3-phase AC permanent magnet alternator enables full production at a low rpm. The lower the rpm, the longer the turbine will last and the quieter it will be.

With a Proven, the output does not drop off in high winds as it does with many wind generators. As the wind speed increases, the hinged blades cone back, away from the force of the wind, reducing the swept area. The variably pitching blades then spill more wind. This also helps keep the rotor speed constant in high winds. The Proven is warranted to withstand 145 mph (65 m/s) winds, the highest warranted wind speed in the industry. The variable pitching blades also prevent the turbine from overspeeding, even when the load is disconnected.

Paul's Proven ECM 2502 48 V wind turbine controller has three AC diversion load relays. This controller has four different battery charging modes, including full charge, sequential dump load operation, trickle charge, and complete disconnect. LED (light emitting diode) indicator lights, voltmeter, ammeter, a 3-phase rectifier, and circuit breaker round out the controller's electronics.

Mounting the Turbine

The Proven comes with a mounting shaft, the link between the tower and the turbine. After connecting the 3-phase output wiring in the mounting shaft to the wiring in the tower, the mounting shaft was securely bolted into place. The wind turbine head weighs in at more than 440 pounds (200 kg), so the turbine was gently strapped under the tractor bucket. It slipped right onto the mounting shaft.

The bearings inside the turbine were greased, the slip rings and brushes were mounted, and the 3-phase wiring in the mounting shaft was connected to the slip rings. The turbine blades and spring sets were attached, the brake cable was secured, and the cover was fastened on. In an hour, the turbine was ready to go! All that remained was lifting the tower, and letting her fly!

Paul and Carrie Thomas, with their girls, Katelyn, Breanna, and Heather.

Thomas System Costs

Item	Cost (US$)
Proven WT2500 wind genny, controller, & tower mount	$9,540
Labor, design, & consultation	6,400
OutBack power system, incl. inverters, transformer, & AC & DC breakers	6,050
Lake Michigan Wind & Sun tower kit & pipe	5,890
16 Surrette S-530 batteries with cables, trays	3,950
Shipping	2,785
Tower engineering	2,500
Tax	2,146
Misc. electrical	1,950
Concrete & rebar	1,400
NRG Wind Explorer wind monitoring system	1,010
Total	$43,621

Saving with Renewable Energy

Several months have passed since Paul Thomas' Proven began flying. Even though last winter was below normal for wind, the family is offsetting their electric bill by as much as 50 percent.

When asked how he feels about actualizing a long-range goal, Paul replied, "It's exciting." Even though he saw the cost per kilowatt-hour of utility electricity double during the summer of 2002, he continues, "I'm not doing it for the economic payback. I'm doing this because I want renewable energy to be a part of my life."

Access

Leslie Moran, PO Box 2140, Truckee, California 96160

Chris Worcester, Solar Wind Works, PO Box 2511, Truckee, CA 96160 • 877-682-4503 or 530-582-4503 • Fax: 530-582-4603 • chris@solarwindworks.com • www.solarwindworks.com

Proven Engineering Products, Ltd., Wardhead Park, By Stewarton, Ayrshire, KA3 5LH Scotland • +44 (0) 1560 485 570 • Fax: ++44 (0) 1560 485 580 • info@provenenergy.com • www.provenenergy.com • Wind turbine

OutBack Power Systems, Inc., 19009 62nd Ave. NE, Arlington, WA 98223 • 360-435-6030 • Fax: 360-435-6019 • sales@outbackpower.com • www.outbackpower.com • Inverter and power center

Lake Michigan Wind and Sun, Ltd., 1015 County Rd. U, Sturgeon Bay, WI 54235 • 920-743-0456 • Fax: 920-743-0466 • info@windandsun.com • www.windandsun.com • Tower

NRG Systems, Inc., PO Box 509, Hinesburg, VT 05461 • 802-482-2255 • Fax: 802-482-2272 • info@nrgsystems.com • www.nrgsystems.com • Wind monitoring system

Rolls Battery Engineering Ltd., PO Box 671, Salem, MA 01970 • 800-681-9914 or 902-597-3765 • Fax: 800-681-9915 or 902-597-8447 • sales@rollsbattery.com • www.rollsbattery.com • Surrette batteries

"Apples & Oranges" wind generator comparison article by Mick Sagrillo, *HP90*

"What the Heck?, Gin Pole," by Ian Woofenden, *HP99*

"Fishy Business in the Falklands," early Proven wind system article by Clive Wilkinson, *HP55*.