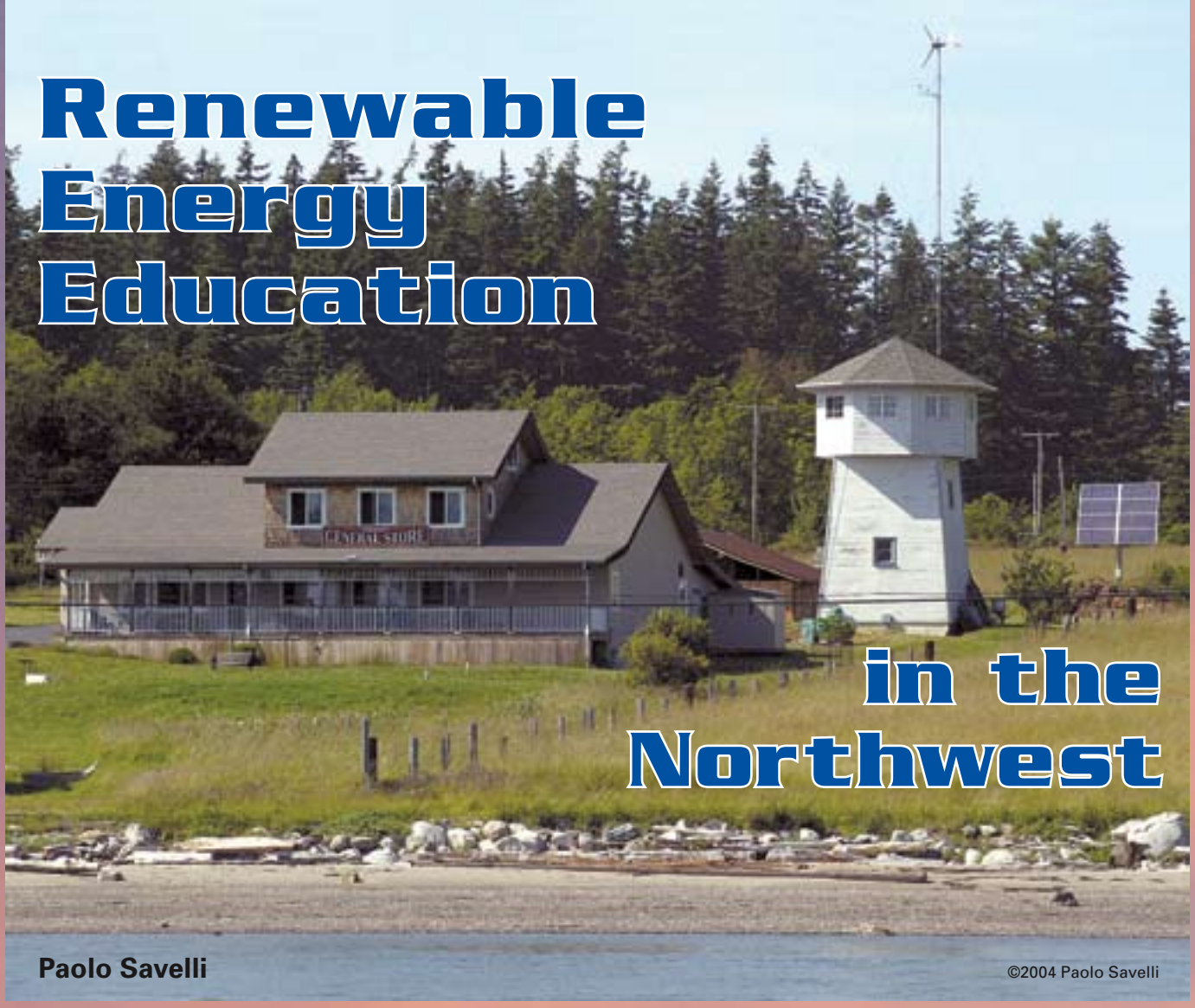
Renewable Energy Education in the Northwest



Paolo Savelli

Photo by www.joshroot.com

Anderson's General Store with its wind generator and PV array—as seen from the Guemes Island ferry.

It was a long two weeks, and I learned more than I ever thought possible about wind and solar-electric systems, and renewable energy in general. Solar Energy International (SEI) put together two workshops back to back in the middle of October on Guemes Island, home of Ian Woofenden, senior editor of *Home Power* and our host for the two weeks. The first workshop was "Solar-Electric Design and Installation" and the second was "Wind Power." Since I had a strong interest in wind energy and knew next to nothing about photovoltaics (PV), I went to Washington State to learn about these two exciting technologies.

I grew up mostly in Europe, where I was exposed to frequent shortages of electricity and subsequent shortages of water (no electricity means no electric pumps). Some of my memories of growing up were of our family maintaining our bathtubs and assorted containers full of water (whenever the water pressure was up) so that we would have drinking, cooking, and cleaning water available whenever there was no running water.

Because I frequently travel back to Europe, I am regularly exposed to their more energy aware and energy efficient culture. I bring this back to my home in Rochester, New York, and try to live as energy cheap a life as I can. But I felt that I could do more, so one of my goals in attending these workshops was to see if I could step it up, and both increase my energy conservation and find ways to actually generate some of my own energy.

Photo by www.joshroot.com

Charlotte Anderson Clifton proudly shows off their store's magazine rack, while her husband Dave minds the till.

Instruction

Both weeks were chock full of instruction. The workshops were really made up of four distinct parts:

Classroom sessions. In the classroom we learned theory, were introduced to concepts and technologies, and looked at slides of existing PV and wind systems.

Field trips. There were two flavors of field trips. The first involved visiting on and off-grid renewable energy homes. The second involved visiting manufacturers of renewable energy components.

Informal evening sessions. Guest speakers were invited to the Guemes Island Resort every evening, and after brief presentations, would engage in question and answer sessions with the students. For those staying in Guemes House, the main "lodge" at the resort, these discussions would usually start up again around coffee in the morning and usually around the dinner table as well.

Hands-on. The heart of the training was installation of solar-electric and wind-electric systems (complete with tower) for a grid-tied RE system. This made up the bulk of the hands-on training, but there was also quite a bit of exposure to various tools and components used in setting up renewable energy systems.

First Week—Solar-Electric Workshop

The Solar-Electric Design and Installation workshop took place during the first week. Our main instructor was E. H. Roy of Stewartstown, New Hampshire, who was a wealth of knowledge, both on the technology of solar electricity, and on the business end.

The general goal for the workshop was to be able to evaluate a potential site and decide how to add PV to it. To do this, we learned many things:

- How to determine the site's electrical loads and how those could (and should) be reduced
- How to match the PV array to those loads
- Where to locate the PV array based on shading and what season the energy from the PV array was most likely to be used
- How to wire systems, taking into account voltage drop based on wiring resistance
- How to compensate for basic inefficiencies in the various components

To make sense of all this, we also learned some basic electricity theory, and the immutable relationship between volts, amps, and ohms. We learned about maintenance and care of a PV system (especially batteries), and we learned about safety. Finally, as a way to stress what we had learned, we designed a PV system and installed and wired all the component parts of that system on a real site.

To point out design constraints and technologies, we visited a number of homes on the island that use PVs as a source (sometimes the only source) of electricity. One home, the Buchmans', built entirely with renewable energy and conservation in mind, was particularly inspiring. It was fueled by an array of twelve Shell SP150s, wired in parallel and series to generate 1,800 W at 48 V. The energy

Background: Sunrise over Mt. Baker as seen from the Guemes Island Resort.

Anderson's General Store System Tech Specs

System Overview

System type: Battery-based, grid-intertied, PV and wind hybrid
Location: Guemes Island, Washington
Solar resource: 4 average daily peak sun hours
Solar production: 90 DC KWH per month average
Wind resource: 7 mph (3 m/s) per month average
Wind production: 59 DC KWH per month average

Wind Turbine

Wind turbine: Homebuilt by SEI students, Hugh Piggott axial design
Rotor diameter: 8 feet (2.4 m)
Energy output: 75 DC KWH at 12 mph (5.35 m/s)
Power output: 500 W at 22 mph (10 m/s) peak
Wind turbine controller: Xantrex C40
Tower: 80 foot Southwest Windpower tilt-up kit (2.5 inch, schedule 40, galvanized steel pipe)

Photovoltaics

Modules: 8 Shell SP140s, 140 W STC, 24 VDC nominal
Array: 1,120 W STC, 48 VDC
Array disconnect: 60 A
Array combiner box: OutBack PSPV combiner with 15 A breakers
Array installation: UniRac U-PT/128L mounted on 20 feet (6 m) of galvanized 6 inch schedule 40 pipe, south facing, 45 degree tilt angle

Balance of System

Inverter: Xantrex SW5548, 48 VDC input, 120 VAC sine wave output
PV charge controller: Blue Sky Solar Boost 3048DL, MPPT, PWM
Wind charge controller for diversion load regulation: Xantrex C40, PWM
System performance metering: RightHand Engineering Winverter software; two Xantrex Link 10 AH meters; NRG Windwatcher and Clean Energy Products recording anemometers

Energy Storage

Batteries: 4 Interstate VRLA AGM, 12 VDC, 100 AH at the 20-hour rate
Battery pack: 48 VDC, 100 AH total
Battery/inverter disconnect: 250 A

is inverted using an AEI Multi-Mode grid-tie inverter that provides electricity to the house and feeds any excess to the grid. With Washington's net metering law, the Buchmans can bank surplus energy credit in the summer, and generate almost all of their energy with their solar-electric array. Their total electricity bill for the last year was US$60.

In addition, the inverter keeps a bank of batteries charged for limited backup in the event of a utility outage. This home was inspiring not only because of its source of energy (PV), but because of its very efficient use of energy. All of the appliances were chosen for their limited energy requirements, and all appliances that are phantom loads are on switches, so they can be totally disconnected when not in use, and thus reduce the load.

We also visited the Xantrex and OutBack Power manufacturing facilities. Inverters are the bread and butter products of both of these companies, although they also make other components for RE systems. Visiting these facilities exposed us to some of the engineering, marketing, and regulation constraints that these outfits have to deal with when building new products. Indeed, at both locations, we learned of upcoming new grid-tie inverters that we were told should be market-ready shortly.

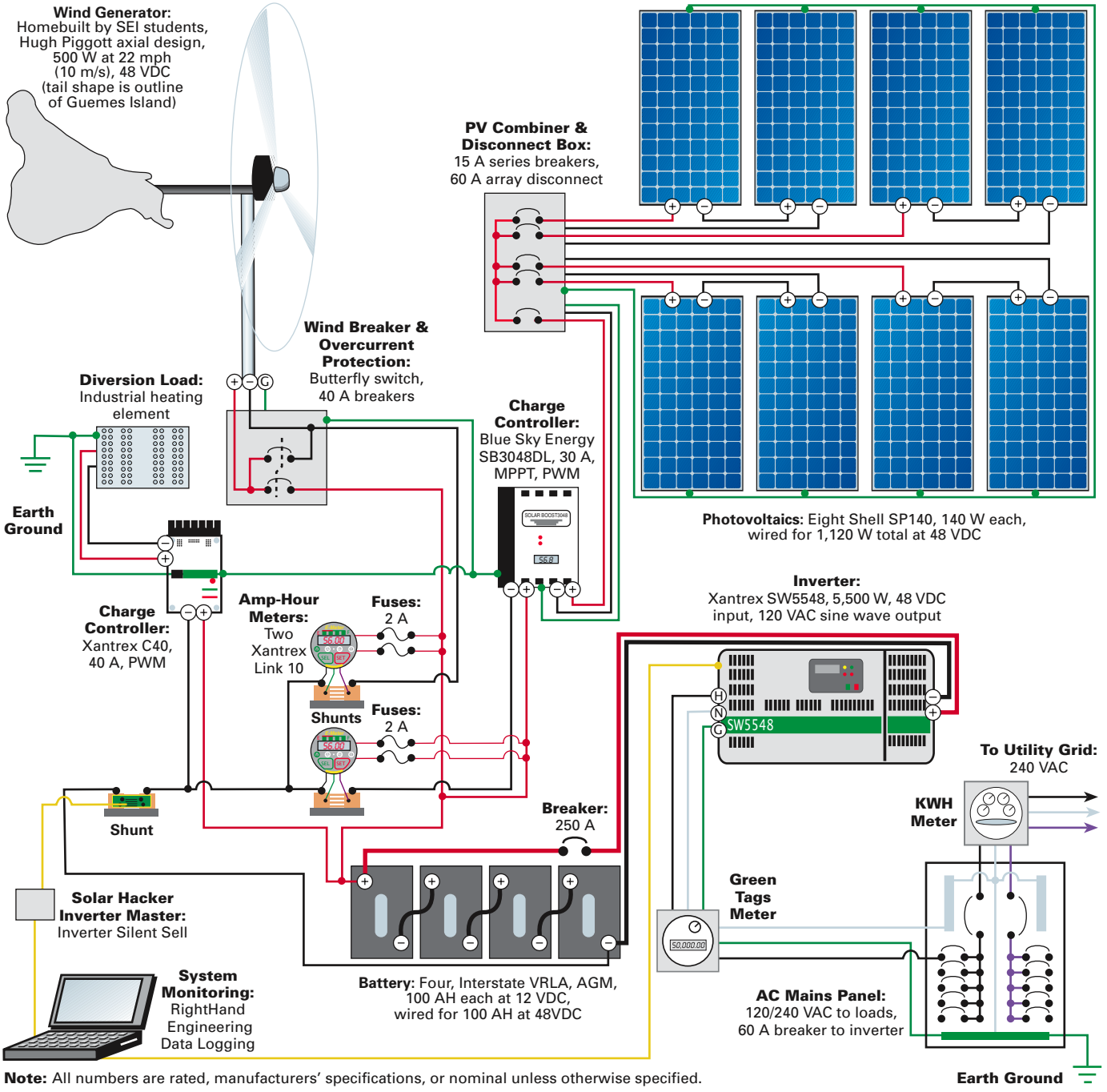
Photo by www.joshroot.com

The store's power room.

Second Week—Wind Power Workshop

My second week in Washington was a very intense workshop on wind turbines and wind turbine installation. Mick Sagrillo of Sagrillo Power and Light, with more than 700 installations behind him, was our instructor for the week. The purpose of this workshop was to learn about wind turbines—wind turbine design, siting, maintenance, and installation.

Relying heavily on past experience and lessons learned, Mick spent a good amount of time discussing the economics of wind siting based on wind speeds at various tower heights, and how to determine wind speed at those tower heights. A large component part of wind-electric systems is the tower, so we learned about different tower types, how to install them, how to maintain them, and what their pros and cons are.



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

We visited a grid-tied home that is powered by wind and PV. An African Wind Power 3.6 provides the wind power. This is a three-bladed, 3.6 meter (12 ft.) diameter wind turbine that is rated at 1,000 W at 48 V. Due to its large swept area, this machine generates even in moderate winds. Indeed, on at least two occasions, we noticed that it was generating electricity (albeit not very much) in as little as 8 mph (3.6 m/s).

The tower was a guyed lattice tower, with three guys every 35 feet (11 m). Part of our training was doing maintenance on this tower and turbine. The tower maintenance consisted of checking for any loose bolts or guy cables, and checking for rust both at the ground anchors and at the tower anchors. The turbine maintenance involved inspecting the turbine for wear, cleaning the blades (to maintain efficiency), and greasing all pivot points.

All these things seem easy enough, but they are quite daunting and challenging when you are hanging from a harness 140 plus feet (43 m+) in the air. Besides the obvious tip of not looking down, another good tip is to not look up, since the moving clouds lend the impression that the tower is falling.

Hands-On PV & Wind Installations

Both weeks were set up around the installation of a grid-tied, battery-backup wind and PV system. The project was at Anderson's General Store at the ferry dock

SEI students Larry Owens (left) and Tom Brenton fastening PV modules to the top-of-pole rack.

Fully installed turbine. The two anemometers supply wind data, which is accessible at the tower base and inside the power room.

on Guemes Island. The site is a south-facing slope with great solar and wind exposure. In addition to generating electricity, the site was chosen as a demonstration site. The store is right at the island's ferry terminal, and the project will attract curious passersby and introduce them to renewable energy.

The generating sources consist of an array of eight Shell Solar SP140 PVs, and a homebuilt, 8 foot (2.4 m) diameter wind turbine perched on an 80 foot (24 m) Southwest Windpower tilt-up tower. The PV panels are wired in series and parallel to generate 1,120 W at 48 VDC. The wind turbine, built in the April 2003 SEI Homebuilt Wind Generators workshop, generates about 500 watts in a 22 mph (10 m/s) wind.

Since about 25 students were in each workshop, we broke up into teams to install all the components. In the PV workshop, one team wired the PV modules, another mounted them, and a third team ran the conduit to the building. There was also a team that first laid out and then installed the inverter, controllers, and batteries.

Everyone was urged to rotate among teams to get exposure to the various parts, and although the instructors were always present, their main goal was to advise, steer, and mostly get out of the way. It was a good learning experience, and it became obvious that although the wiring diagram may have appeared straightforward on the white board, the actual wiring was no easy task. We ended up working late most nights getting the system up, and were rewarded by AC output late on the last day of the workshop.

A handful of us from the first week stayed on for the wind workshop. Joined by new students, our job was to install and wire the wind turbine into the same system. Given the forces that are levied against a tower-mounted generator, it is important to ensure a very strong tower installation. Much of our hands-on experience revolved around that.

After a first half-day of introduction and basic theory, the group marched outdoors in the Washington wind and rain. We spent the rest of the daylight hours and the first twilight hours measuring out and locating tower anchor points and mixing and pouring concrete to set the anchors. It was necessary to do this early in the week to ensure that the concrete would be cured by the end of the week, when the tower would be erected.

As with the solar crew, we broke up into teams focusing on specific tasks. Although the tower erection was daunting and quite intimidating, it proved to be less of a bottleneck than the wiring of all the components in the control room. No doubt the wiring should become easier with experience, but it is a testament to how hands-on these workshops were that as students we wired, and then rewired, and rewired away our mistakes instead of just having an instructor do it right the first time.

For this installation, Kelly Keilwitz of Whidbey Sun & Wind was the site supervisor. Kelly was always present to steer us in the right direction. In addition, he put countless miles on his biodiesel Ford to pick up whatever connector, wire, or conduit was missing for the task at hand.

Proud PV installation workshop group after connecting the Anderson's Store PV array to the power system and the grid.

Place & People

Guemes Island is a truly beautiful place, and I would recommend visiting it just for the bald eagles, sea otters, and herons. It is a bit remote—only accessible by ferry—but that just adds to its charm. Be forewarned, if you come out to one of these sessions, read the information packet and arrive prepared. The island is not the big city with all the conveniences you might have at home. You'll certainly want to pack enough clothes for the week, and definitely bring your rain gear.

The students and guest speakers stayed at the Guemes Island Resort, an older, low-key facility that sits right on the edge of the beach. You couldn't have asked for a more picturesque place, with views of Mount Baker and access to boats, kayaks, and crab pots.

The students were as big a part of the education process as the instructors and guest speakers. The slice of cultures that made up the student base was amazing—from a Pennsylvania-based river guide, to a retired airline pilot living on a 2,500 acre ranch in Utah, to an off-grid fishing guide living with his wife and two children on a remote island in Alaska. Everyone was eager to learn and eager to help, and it seemed that someone always had a legitimate and useful contribution right when you needed it.

More to Learn

It was a great two weeks. I would recommend it to anyone who is interested in learning more about these two renewable technologies in specific, and renewable energy in general. I was glad that I took the two workshops instead of just the wind workshop. I don't know that the PV workshop should be a prerequisite for the wind workshop, but certainly so much of what we covered about system components in the PV workshop made the wind workshop more understandable and enjoyable to me. If I had any complaints, I suspect this would be it—the wind workshop contained an enormous amount of advanced information, and I believe I would have been overwhelmed without the preceding PV workshop.

I came to these workshops with three very specific goals: to learn more about the technologies of renewables; to learn more about the economics of renewables; and to meet other members of the renewable community. I can honestly say that those goals were met and I am seriously considering returning to Guemes Island for the wind turbine building workshop.

Access

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E. H. Roy, 11 Roy Rd., Stewartstown, NH 03576 • 603-237-8194 • ehroy@usadatanet.net • PV instructor

Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 • 920-837-7523 • msagrillo@itol.com • Wind instructor

Kelly Keilwitz, Whidbey Sun & Wind, 986 Wanamaker Rd., Coupeville, WA 98239 • Phone/Fax: 360-678-7131 • sunwind@whidbeysunwind.com • www.whidbeysunwind.com • Installation coordination

Project Sponsors

Anderson's General Store, 7885 Guemes Island Rd., Anacortes, WA 98221 • 360-293-4548 • Fax: 360-299-9798 • www.guemesislandstore.com

Abundant Renewable Energy, Newberg, Oregon • www.abundantre.com • Dump load

All Battery Sales and Service, Everett, Washington • 800-562-3212 • Batteries

Alternative Energy Engineering, Redway, California • www.alt-energy.com • PVs

Blue Sky Energy, Vista, California • www.blueskyenergyinc.com • PV charge controller

Chili Pepper Signs, Anacortes, Washington • Signs

Clean Energy Products, Redondo, Washington • 253-946-1761 • Recording anemometer

Down Under Guemes, Guemes Island, Washington • Sand and gravel

Island Electric, Anacortes, Washington • Conduit and consultation

Mimnaugh Excavation, Anacortes, Washington • Excavation

NRG Systems, Hinesburg, Vermont • www.nrgsystems.com • Recording anemometer

OutBack Power Systems, Arlington, Washington • www.outbackpower.com • AC, DC, and combiner boxes

SEI Homebuilt Wind Generators workshop • www.scoraigwind.co.uk/sei2003 • Wind generator

Skagit River Steel & Recycling, Burlington, Washington • www.skagitriversteel.com • Tower pipe

Solarhacker Software, North Bend, Washington • www.solarhacker.com • Inverter Master

Southwest Windpower, Flagstaff, Arizona • www.windenergy.com • Tower kit

RightHand Engineering, Woodinville, Washington • www.righthandeng.com • Data logging equipment and software

UniRac, Albuquerque, New Mexico • www.unirac.com • PV rack

Xantrex Technology Inc., Arlington, Washington • www.xantrex.com • Inverter, wind charge controller, metering