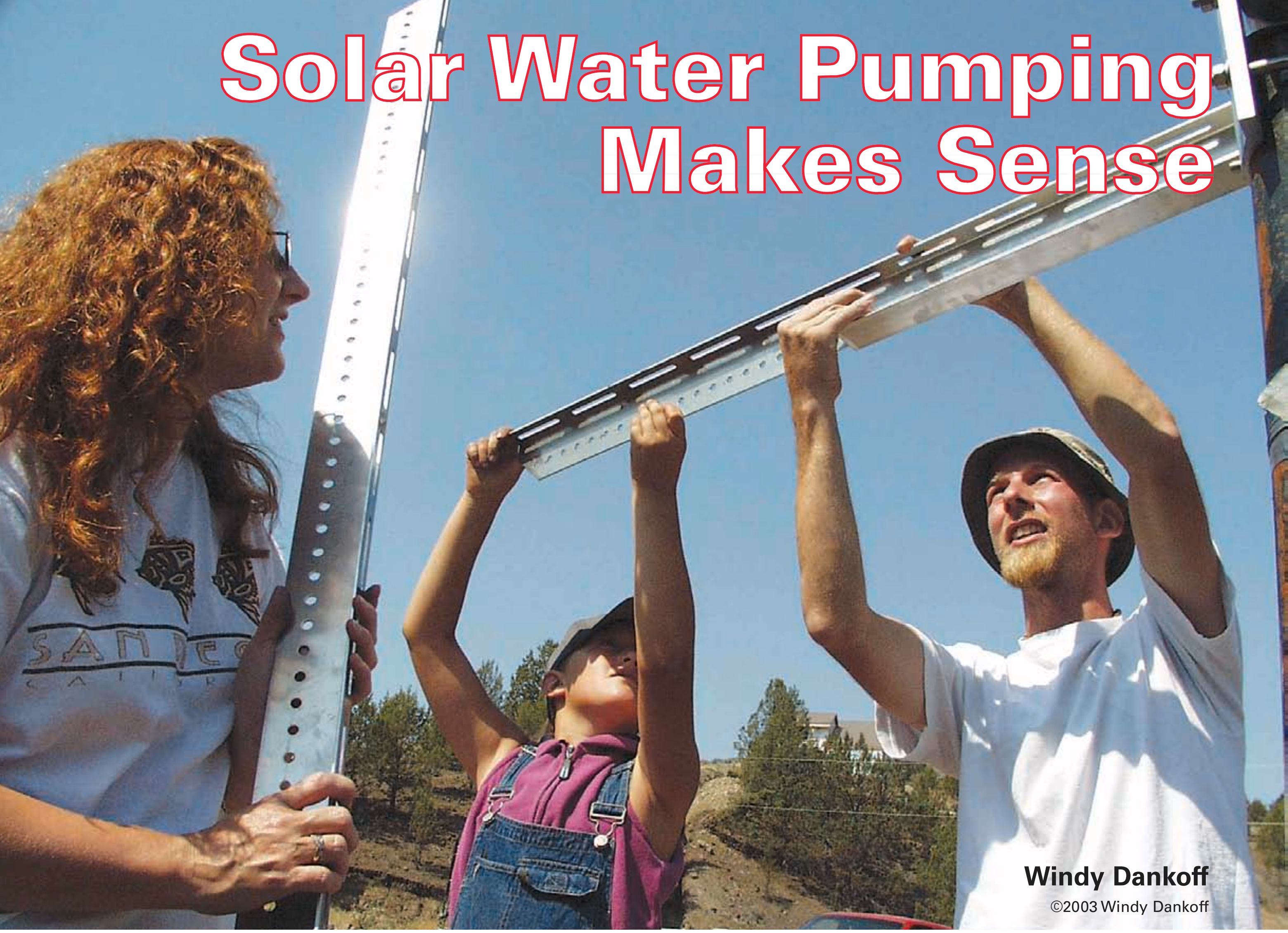
Solar Water Pumping Makes Sense



Windy Dankoff

©2003 Windy Dankoff

Workshop participants assemble the rack for the pumping system's solar array.

Butch and Linda Sagaser have a spectacular homesite in sunny eastern Oregon, overlooking the John Day River. After 15 years in a mobile home, they are finally building their dream house. They have grid electricity, so solar electricity was a distant dream, until it began to make sense for their water supply. With their finances already stretched by their homebuilding project, solar electricity had to be economically viable.

For Butch and Linda, energy efficiency has been a priority for a long time. Before moving to their property, they lived off-grid both on land and on a boat, so they learned how to minimize their energy consumption. Since then, they have followed the basic guidelines of avoiding electric heating and cooling, and buying efficient appliances.

Water pumping was the Sagasers' biggest electrical load, until this project was completed. Although they have a shallow well, their pump accounted for more than one-third of their electrical energy consumption. It was a 230 VAC jet pump, a nonsubmersible pump that is not very energy efficient. When they ran water up to their new homesite, 80 vertical feet (24 m) uphill from their old house, they found that the water came out at a dribbling rate. Installing a more powerful pump did not fit their energy goals. It was time to look for an efficient solution.

Butch and Linda also have frequent grid failures. They are hooked to a long rural utility line, exposed to frequent lightning and ice storms. Utility failures can last for hours and sometimes days. With wood and propane for heating and cooking, and some handy oil lamps, the grid outages would only be an inconvenience if they weren't deprived of their water supply. A solar powered water pump sounded like the ideal solution.

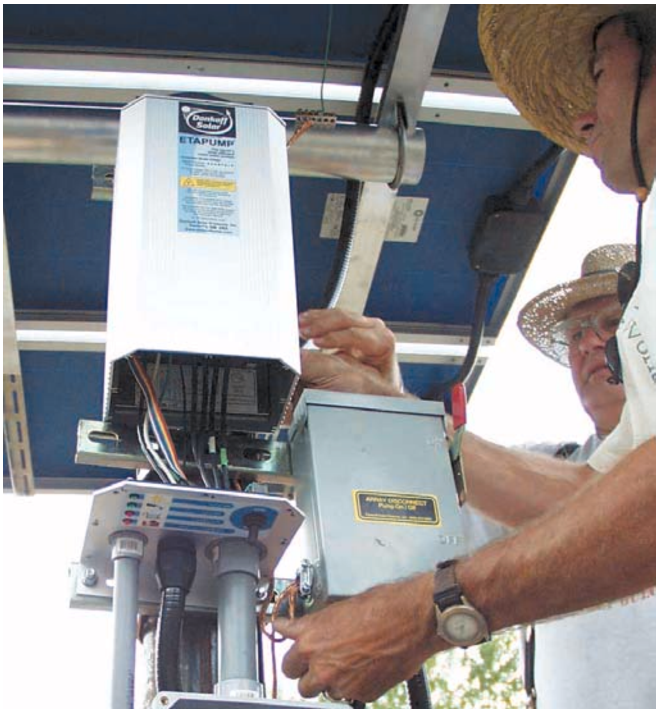
Considering a Solar Powered Pump

The Sagasers had seen solar pumps demonstrated at the SolWest Renewable Energy Fair, and knew that ranchers and off-grid homeowners had been using them since the 1980s. Recently, the pumps have become very reliable, and the costs have dropped. A low-volume solar pump can draw the water slowly, using a small solar-electric array, and pump all day long into a storage tank. The Sagasers have a well that only produces a few gallons per minute, so the slow pumping concept sounded most appropriate. They asked their friend Jennifer Barker for advice.

Jennifer heads the Eastern Oregon Renewable Energy Association, and lives with her husband Lance on a solar powered homestead (See *HP83*, page 50). Jennifer offered to help survey the Sagasers' homesite, to see how much pumping lift would be required.

Jennifer and Linda set out to measure the elevation gain from the water well up to the proposed storage tank site. Their tool of choice was a laser level (a common construction tool) on a 5 foot (1.5 m) stand. Starting from the well, which is located 30 feet (9 m) below the old house, they pointed the light horizontally in the direction that they would walk up the hill. The spot where the light struck the ground became the next measuring point. They only had to count the number of stages of measurement, and multiply by 5 feet.

The elevation gain proved to be 30 feet (9 m) from the top of the well to the old house, plus 80 feet (25 m) up to the



The pump controller wired.

How the Sagasers' Solar Pump Works

The photovoltaic array is built from typical crystalline modules. Four, 75 watt modules are wired in series for 300 rated watts at 48 volts nominal. The DC output from the PV array runs through a safety disconnect switch to a pump controller that is made especially for their pump. The controller gives the motor the form of electricity that it needs to start and run under widely varying conditions. The controller also allows the use of a remote float switch to turn the pump off when the tank is full, and a low-water probe to prevent the pump from running dry if the water source drops too low.

Cut-away view of the helical rotor mechanism, showing cavities that form between the rotor and the rubber stator.

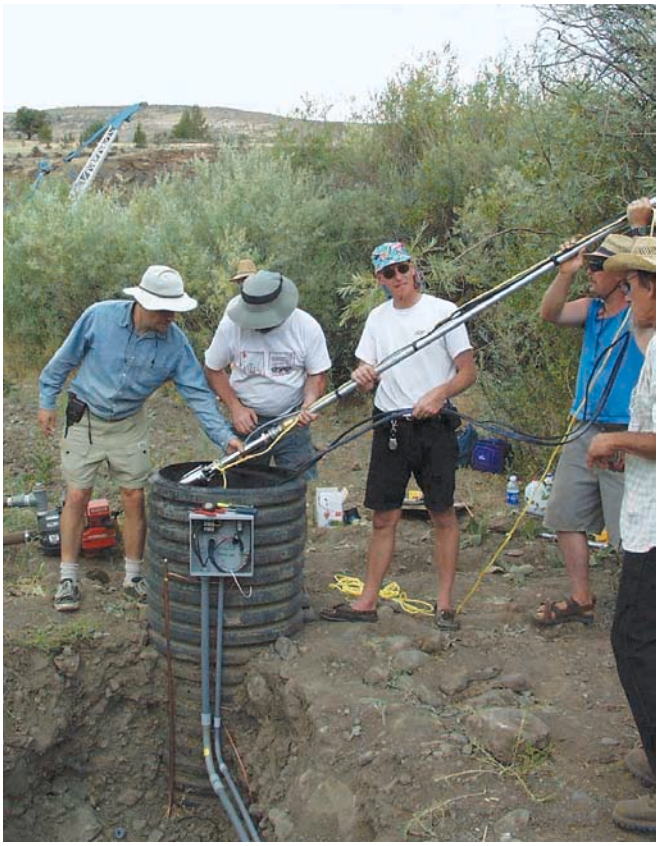
The pump uses a "helical rotor" that seals water into cavities and forces it up as it turns. When it slows down in low-sun conditions, it can still produce the full lift. This forcing action is called "positive displacement." It is much more energy efficient than a conventional submersible pump that uses impellers and centrifugal force.

The controller gets the pump started and running in low-light conditions by reducing the voltage from the solar-electric array, and boosting the current. This is like putting a vehicle into low gear. It then "inverts" the DC output of the array to 3-phase AC. This means that overlapping AC waves deliver energy continuously, unlike ordinary single-phase AC that we have in our homes. The controller varies the frequency of the AC output to vary the motor speed. At startup, it brings the speed up slowly, so no power surge is required. It limits the frequency to prevent overspeed, and cuts the power when sunlight is insufficient.

Battery Systems

Solar pumps are also available for battery systems. They can run on demand to supply pressure any time. This is how most domestic wells work, and it's economical where an elevated tank isn't feasible. If the Sagasers had a battery-based system within about 250 feet (75 m) of the well, and a faster-flowing well, I would have recommended tying their pump to the battery system and using an 80 gallon (300 l) pressure tank instead of the elevated storage tanks.

new house, plus 90 feet (27 m) up to the tank site. Adding the well depth of 20 feet (6 m), the total vertical lift (pumping height) is 220 vertical feet (67 m). The 90 foot drop from the tank to the house produces 40 psi (2.7 bar), which is excellent pressure for a house that has well-designed (low-friction) plumbing.



Windy Dankoff (far left) advises the crew on lowering the pump—the well is only 20 feet (6 m) deep.

Solar Pump Selection & Planning

Jennifer called me to see what kind of solar pump I would suggest. I looked at the sizing chart for our submersible solar ETAPUMP to find a system that would perform the necessary vertical lift at a modest cost. I selected a system with a peak flow rate of 2.5 gallons (9.5 l) per minute, because their well can't produce much more than that.

The chart indicated that the daily output of water from this system would range from about 400 gallons (1,500 l) per day in winter, to about 1,000 gallons (4,000 l) per day in summer. That's about twice the water that the Sagasers were consuming. They said they would be happy to make a pond and expand their garden, lawn, and orchard, if the system wouldn't cost too much and would last for years without trouble.

I explained that the ETAPUMP system was new on the market, but has only one moving part, no batteries, and a four-year warranty. They were getting more interested. What about installation? I was planning a return trip to the SolWest Renewable Energy Fair in July 2002. Jennifer proposed that I do the installation as part of a hands-on educational workshop just before the fair. It sounded like a great idea.

I only needed to find a local dealer to supply the pumping system, and to do some of the groundwork in advance. Jim Slater of Eastern Oregon Solar Electric was the likely suspect. He had not yet seen the new ETAPUMP, so he was wary of being in the spotlight. I sent him the instruction manual, and it gave him the confidence to accept the job.

The pump sits below the surface. A pitless adapter fitting allows the pipe to pass through the well casing below the frost line, and it seals dirt out.

Installing the Pump

Jim worked with Butch Sagaser to do the groundwork in advance. They set the support pipe for the solar-electric array, and buried electrical conduit to the well. Butch ran water pipe all the way up to a 1,200 gallon (4,500 l) storage tank, and buried the pipe below the frost line. We planned to have the students install the solar array, controller, and pump in one day.

The workshop was scheduled for two days in late July. Ten eager participants showed up, including some homeowners, a teenager and his mother, and an Americorps volunteer. Two experienced volunteers came from Solar Wind Works in Truckee, California. They helped answer questions and tried not to work too hard.

Technical Specifications

System type: Batteryless PV water pumping system

Pump: ETAPUMP Model HR-04 helical rotor pump with 65 V, 3-phase brushless permanent magnet AC motor; maximum capacity, 0.55 KW

Controller: ETAPUMP PV-Direct Controller, Model EP-600. Controller contains maximum power point tracking and linear current booster circuitry, variable frequency 3-phase inverter, remote float switch, and low-water shutoff functions.

LEDs on the controller indicate: System On, Pump On, Full Tank/Off, and Low Water/Off

PV manufacturer and model: BP Solar 75TU

PV module STC wattage rating: 75 W

Nominal array voltage: 48 V

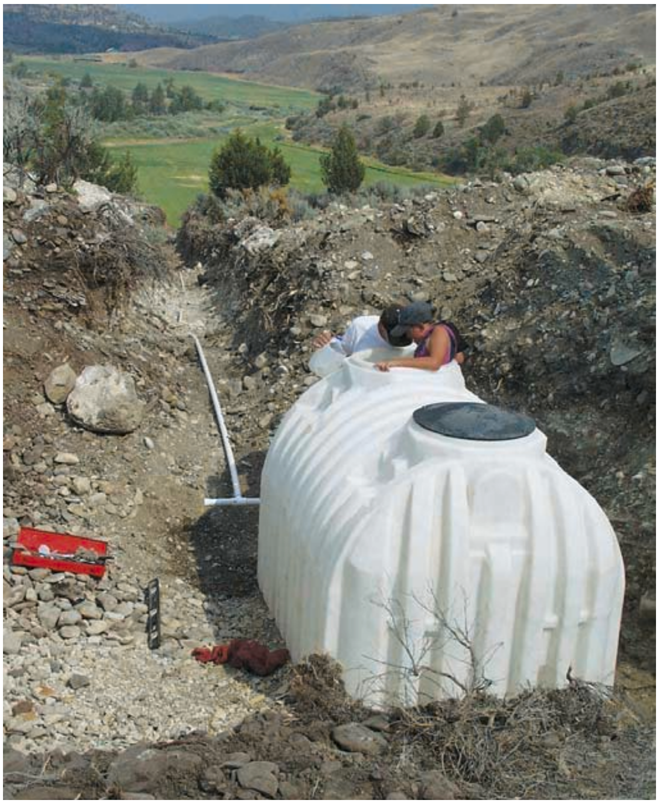
Array disconnect model and fuse/breaker size: Square D 30 A fused disconnect with 10 amp fuses

We spent the first day in the classroom where I explained the basics of water pumping, solar electricity, solar pumps, and system design. The second day began with a drive out to the Sagasers' homesite. I was happy to see that Jim and Butch had prepared everything "by the book."

The participants got to work bolting up panels, wiring, splicing cable, plumbing, and simply watching and learning. We dropped the pump in by hand because the well is only 20 feet (6 m) deep. The sun was hot, but nobody complained—it would be our fuel source! At about 3:30 PM, we turned the switch on. We heard a gurgling sound in the pipe as water started its way up to the storage tank. The sun was getting low, and clouds were blowing by, but luck was with us. It took a half hour to fill 600 lineal feet (180 m) of 1 1/4 inch pipe. We took a little break, and then hiked up the hill to watch the water start spilling into the tank 220 vertical feet (67 m) up the hill.

Next, we scrambled down the hill and got out our multimeters to measure voltage and current at the pump

Butch and his daughter Rachel watch the first water enter their 1,200 gallon (4,500 l) storage tank. A second tank has since been added, and both are buried.



Letter from the Sagasers

Butch and I are thrilled with our water system. We have two tanks above the house now, piped together, for a total storage of 2,400 gallons. I frequently check their water levels, and am happy to see that they are almost full even when I think I've used a lot of water that day. Butch says the overflow is running daily. We use it to water fruit trees and grass.

We have already seen a decrease in our electricity bill. It would be safe to say that we are saving 3 KWH a day with our new system. At US$0.08 per KWH, we are saving US$7.20 a month, but we are pumping to twice the height, now that we are in our new house, and using more water. This summer, when we used the overflow in the yard, we saved still more because we no longer needed the small electric pump that we used to have for irrigation.

We thank Windy, Jim, and Jennifer for their help, and hope our project will spark other people's interest.

Thanks,

Linda & Butch

Pump System Costs

Item	Cost (US$)
ETAPUMP Integrated System #ETA-04-300, includes: Pump, HR-04 with motor; Controller, EP-600; 4 BP Solar 75TU PV modules, 75 W; UniRac fixed PV rack; Disconnect; Low-water probe	$4,100
2 Polyethylene water tanks, 1,200 gal.	1,400
Wire, conduit, etc.	180
Total	$5,680

connections. I explained to the students that the voltage to the pump varies with the sunshine, and determines the speed of the motor. The torque load on the motor (how hard it is to turn) determines the current draw, and that is determined by the height of the water lift. We watched the voltage vary with the sunshine. The current stayed constant, as expected, because the height of the water lift doesn't change.

The pump is supplied with a low-water probe. If the water level drops lower than the probe, the controller turns the pump off. This prevents the pump from being damaged if the well runs dry. To demonstrate this function, we pulled the probe out of the water, and sure enough, the pump stopped. We also watched the effect of changing sun conditions. As clouds came by, the pump slowed down and stopped occasionally. As we were ready to leave, with the sun nearly setting, we were surprised that the pump was still going—very slowly—but still producing a trickle.

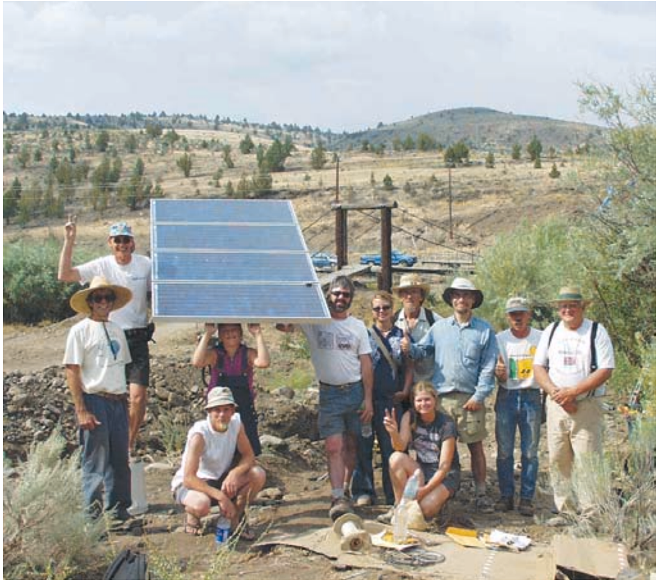
Celebration by Candlelight!

That evening, Butch and Linda's neighborhood had a five-hour power-grid failure! We couldn't have planned it better. The solar pump had already pumped enough water into their tank for them to wash the dishes and to shower off the day's dust, and to invite a neighbor for a shower. Cheers!

Butch and Linda recently added one more 1,200 gallon (4,500 l) tank so they can be totally independent. The Sagasers' solar pump has supplied their water for more than a year. The only time they ran low was in December when they had practically no sunshine for more than a month. Their 2,400 gallon (9,000 l) storage was nearly depleted. Their old AC pump was still installed however, so they used it to supply the house for two days. After the fourth half-day of sun, the solar water tanks began to overflow once again.

Butch says "It works like a champ. This is simplicity at its best." He estimates that in about ten years, the system will have paid for itself and he'll be pumping free water. Their utility rate is quite low, at US$.08 per KWH, but the system cost was lowered by an Oregon tax credit.

Solar pumps are making a difference in the world, especially in areas that are remote from utility lines where it is expensive to buy and transport fuel, and to maintain engines. The Sagasers found solar pumping to be cost effective even though they have utility electricity. The most water is needed when the sun shines brightest, so solar electricity is the logical renewable energy source for water supply.



The installation crew says, "We did it!"

Access

Windy Dankoff, Dankoff Solar Products, Inc., 1730 Camino Carlos Rey, Unit 103, Santa Fe, NM 87507 • 888-396-6611 or 505-473-3800 • Fax: 505-473-3830 • info@dankoffsolar.com • www.dankoffsolar.com

Butch and Linda Sagaser, 49002 Hwy. 26, Mt. Vernon, OR 97865 • 541-932-4753 • skibums@highdesertnet.com

Jim Slater, Eastern Oregon Solar Electric, 28599 SCC Dunhan Rd., Prineville, OR, 97754

Eastern Oregon Renewable Energies Non-Profit (EORenew) and SolWest Renewable Energy Fair, Jennifer Barker, PO Box 485, Canyon City, OR 97820 • Phone/Fax: 541-575-3633 • info@solwest.org • www.solwest.org • The author thanks Jennifer Barker of EORenew for her contributions to this article.