home power

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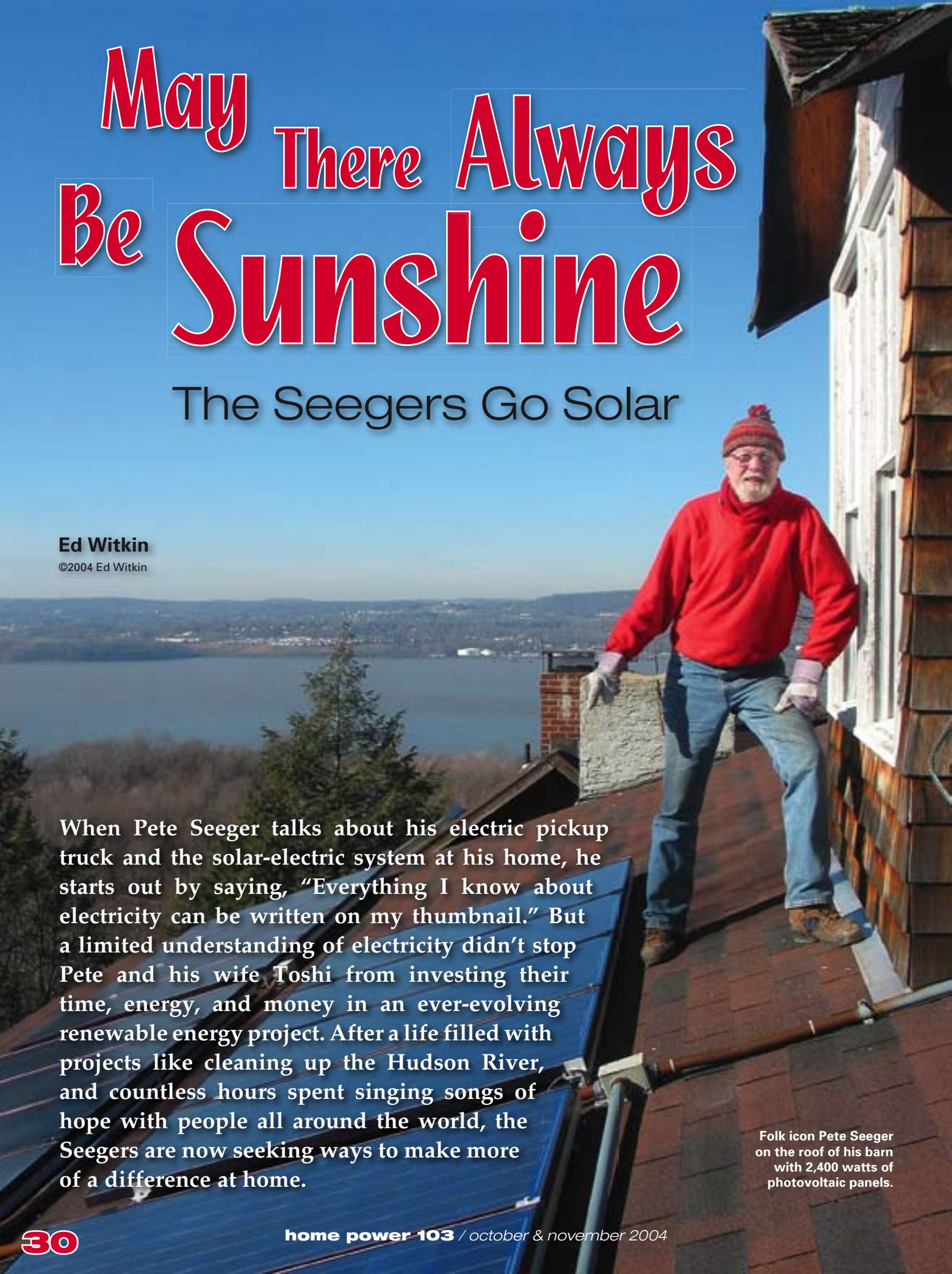
May There Always Be Sunshine

The Seegers Go Solar

Ed Witkin



When Pete Seeger talks about his electric pickup truck and the solar-electric system at his home, he starts out by saying, "Everything I know about electricity can be written on my thumbnail." But a limited understanding of electricity didn't stop Pete and his wife Toshi from investing their time, energy, and money in an ever-evolving renewable energy project. After a life filled with projects like cleaning up the Hudson River, and countless hours spent singing songs of hope with people all around the world, the Seegers are now seeking ways to make more of a difference at home.

Folk icon Pete Seeger on the roof of his barn with 2,400 watts of photovoltaic panels.

Pete was born in 1919, and has been involved with the social and environmental movement for decades. In his twenties, he traveled and sang with Woody Guthrie, "from California to the New York Island." In 1941, Pete, Lee Hayes, and other activists formed the Almanac Singers to sing for unions. After a stint in the army during World War II, Pete continued to sing songs of support for working people. In 1948, Pete, Lee, Fred Hellerman, and Ronnie Gilbert formed the Weavers, a quartet that recorded songs including "If I Had a Hammer," "Kisses Sweeter than Wine," and "Good Night Irene."

Pete and Toshi married in 1943, and in 1949 they found a few acres for sale on a wooded mountainside overlooking the Hudson River. It was here that they built their home and raised their family. Pete, with others, helped found the Clearwater Organization, which built and maintains a replica of a Hudson River sloop. Each summer at the annual Clearwater Festival, in Croton, New York, people from up and down the river gather to celebrate.

I met Pete at Clearwater in 1991, when he stopped by to check out my 1969 solar-electric VW microbus. The bus was being used to provide electricity for one of the many music stages at the festival. Pete said he was interested in finding a four-wheel-drive, electric pickup truck that could be charged with solar electricity. He wanted to be able to navigate his steep, dirt driveway, haul firewood for his home, and drive to town and back.

People gather around to hear what Pete has to say about energy and the future during the Clearwater Festival.

Truxie

After the festival, I got in touch with my friend Bob Batson of Electric Vehicles of America. Within a few weeks, Bob had located a converted 1988 Ford Ranger, four-wheel-drive, electric pickup. A week or two later, "Truxie," as Pete calls her, was towed from near Boston to the Seegers' hillside home.

A 120 VDC receptacle under the hood of Truxie is used to plug in the battery charger.

From the outside, Truxie looks like any other small pickup truck. But a look at the dashboard reveals that the fuel and oil pressure gauges have been removed and replaced with voltmeters, ammeters, and a Curtis Instruments state-of-charge meter. Truxie's propulsion system has only a few components. They include an Advanced DC Motors, 9-inch motor; twenty, 220-amp-hour, U.S. Battery, flooded lead-acid batteries; a Curtis 1231C power controller; contactors (heavy-duty relays); fuses; and wiring. There are significantly fewer mechanical parts in an electric vehicle than in a typical gasoline vehicle.

On the main roads, Pete takes his time driving. He's discovered that

Pete enjoys an ice cream cone and talks to a crowd about electric vehicles during the Clearwater Festival.

being light on the accelerator increases the range of the vehicle. Once while riding with him, we passed a 10 mph (16 kph) sign in his town. Pete said, "I've never understood why they put that sign there, but since there's a police car behind us, I'll drive nice and slow. Truxie will like that." So we crept along the road, first Pete in Truxie, then a police car, and then a long line of cars, eager to get on down the road. I think Pete got a kick out of holding the police to the speed limit in his electric truck!

EV Operation

To run Truxie, Pete turns the ignition key, which engages the primary contactor located in the motor compartment. This completes an electrical circuit between the battery pack and the controller. Truxie is "on," but cannot start moving until Pete puts it in gear. (There are four forward gears, plus low range and four-wheel drive.) Then he steps on the accelerator pedal, which engages the secondary contactor in the motor compartment. At this point, electricity can flow from the battery pack through the controller to the drive motor. Pushing down on the accelerator pedal tells the controller to give more juice from the battery bank to the electric motor, which increases the speed.

The state-of-charge meter is the "fuel gauge" for the truck. It has ten LED lights stacked neatly on top of one another. When all ten LEDs are lit, the battery bank is full. The battery bank's state of charge will start to drop at varying rates, depending on the terrain, the speed, the temperature, and the driving style of the person behind the wheel.

The terrain is quite hilly where Pete and Toshi live, which isn't ideal for an electric vehicle. The truck needs quite a bit of energy to pull all that weight up the hills. Truxie tends to have an average range of 10 to 20 miles (16–32 km), depending on the hills and the load Pete is hauling.

At home, Truxie is plugged into a Lester battery charger, which is the size of a breadbox. This device converts 240-volt AC electricity into the 120-volt DC electricity needed by the battery bank. When initially plugged in, the batteries will be charged at about a 25 amp rate. As the voltage increases in the battery bank during charging and starts reaching a full state of charge, the current (amperage) will begin to taper off. A complete charge takes five to seven hours. Once the battery bank is completely full, the charger automatically shuts off.

Electric Firewood

Pete and Truxie can often be found out on a steep dirt road around his land, cutting and hauling firewood. Pete wondered why he couldn't use some of the energy stored in the truck's battery bank to run his electric chainsaw. Truxie's 120-volt DC battery bank has a storage capacity of about 26 kilowatt-hours.

Exeltech makes an inverter that uses 120 volts DC input and generates 1,100 watts at 120 volts AC. The chain saw uses 8 amps at 120 volts AC. Though the chain saw surges to twice that at startup, the Exeltech inverter is able to handle this surge, and runs it very well. To hook the inverter up to Truxie, we wired a #8 (8 mm^2), 2-conductor, 5-foot (1.5 m) extension cord to the inverter, and on the other end we

Pete's electric chain saw runs off of an inverter installed in the pickup.

installed the same type of safety plug that is used to plug the Lester battery charger into the truck.

When Pete is ready to saw, he lifts the hood of the truck and plugs the inverter into the 120-volt DC charging receptacle of the truck. The inverter could be permanently hardwired to the truck battery pack, but this plug-in approach works fine, and Pete has stuck with it. In addition to running his chain saw, Pete has used the Exeltech inverter to run amplifiers for a PA system. The Exeltech is a high-quality, sine wave inverter, which is actually better for this type of sensitive electrical load, so it works well for both applications.

The primary maintenance performed on Truxie is checking the sixty cells in the batteries (twenty batteries with three cells each). Pete makes sure that the plates are covered with distilled water and the specific gravity of the electrolyte is OK. Sixteen of the twenty traction batteries are under the tilt-up bed of the pickup truck, and the other four are lined up in the front of the motor compartment under the hood. There is also a standard, 12-volt DC accessory battery in the motor compartment for lights, radio, etc.

Solar-Electricity for Truxie

While Truxie has zero emissions out of the nonexistent tailpipe, the electricity to charge the vehicle was initially coming from the utility grid. The majority of the electricity in Pete's area comes from various polluting sources. Pete and Toshi have spent fifty years downwind of the Indian Point nuclear power station, located several miles down the Hudson River from their home. Ten miles (16 km) north of them is the Central Hudson Power Company's oil-fired generating station. The idea that Truxie was getting its electricity from Indian Point led Pete and Toshi to invest in the next phase of their project—a solar-electric system for their home.

Pete suggested that the roof of the barn might be a good spot for solar-electric panels. "Up we go," he said, as he nimbly scampered up a hand-built ladder, leading through a trap door and into the cupola on the barn roof. His 6-foot (1.8 m) square cupola has windows on all four sides, giving a grand view of the Hudson Valley.

The roof of the barn faces slightly southwest, and has access to unobstructed sun for most of the day. There was a bit of shading from a large red oak tree to the southeast, but Pete thought that he could sacrifice that tree for firewood and lumber. We chose this roof for the location of the solar-electric panels.

PV System

We measured the available roof area on the barn, and found that we could mount twenty, 120-watt photovoltaic (PV) modules in five, four-module subarrays. With the PV modules in place, there would be room remaining for a solar hot water system if the Seegers decide to install one later.

While the primary objective of installing the PV panels was to provide solar electricity for Truxie, Pete and Toshi also wanted to have some backup electricity available during the inevitable utility outages that occur up on the hill. Toshi recalls times when Pete was out on the road performing, and the electricity would go out so the water

Clearwater Festival

In the late 1960s, Pete and Toshi started to raise a little money to build and maintain a full-size replica of a 75-foot (23 m) cargo sloop once common on the rivers. This sloop, Clearwater, is used as a floating classroom. Hundreds of thousands of children of all ages, from all over, have sailed the Clearwater up and down the golden Hudson River.

At one of the Hudson River Revival festivals in the 1980s, Pete was seen climbing a tree early in the morning to hang a large "No Nukes, Shut Indian Point Power Plant" banner. The Indian Point power plant looms a few miles downstream from the Seegers' hillside home overlooking the Hudson River. It is only one of many sources of Hudson River pollution.

Since then, solar electricity and other forms of renewable energy have become an integral part of the festival. In 1985, Richard Gotlieb and Carol Levin, of Sunnyside Solar, brought a solar-electric system to the festival to provide electricity for one of the stages. In the 1990s, Pete suggested that we create a renewable energy (RE) area at the festival, and have workshops, displays, and discussions about RE. Today all five stages at the festival are powered by some form of renewable energy.

This area has become a popular attraction at the festival. Young and old enjoy playing with the solar toys and looking at the various examples of how to incorporate sustainable technologies and techniques into their own lives. Crowds gather around to hear Pete talk about his electric truck, and learn about biodiesel, wind power, straw bale construction, and solar cooking.

The Clearwater Festival is held each June at Croton Point Park in Croton-on-Hudson, New York.

The author with a sculpture of Pete Seeger he constructed. The PV panel activates the rocking chair and a recording of Pete playing banjo.

Tech Specs

System Overview

System type: Battery-based, grid-intertied PV

Location: Beacon, New York

Solar resource: 4.5 average daily peak sun hours

Production: 227 AC KWH per month average

Utility electricity offset by PV system: 22 percent

Photovoltaics

Modules: Twenty AstroPower, AP 1206 F, 120 W STC, 12 VDC

Array: 2,400 W STC, 48 VDC

Array combiner box: Xantrex TCB-10 with 15 A fuses

Array installation: Roof mount with AstroPower track system

Balance of System

Inverter: Xantrex SW4048, 48 VDC input, 120 VAC output

DC power center: Xantrex PC250 with 60 A array disconnect breakers, and 60 A PWM charge controller

System performance metering: TriMetric 2020 AH meter

Energy Storage

Batteries: Eight Concorde, PVX-1040, VRLA, 12 VDC, 100 AH at 20-hour rate

Battery pack: 48 VDC, 200 AH total

Battery/inverter disconnect: 250 A mounted in the Xantrex PC250 enclosure

Utility outages haven't had a significant effect on the Seegers' heating system, since they primarily heat the house with two woodstoves. So the basic plan was to use the solar electricity for Truxie, and have electricity available during utility outages to pump water, run the freezer, and keep a few lights running.

Installation

We mounted the PV panels on the roof using a track system designed by AstroPower. The one big advantage of this mounting system is that the tracks are first attached to the roof, and the panels can be installed one at a time. This type of mounting system, which was fairly new at the time, has become common in the industry. The four, 12 V modules in each subarray are wired in series to produce 48 volts DC.

Each subarray has a junction box that connects to a central junction box via metal conduit. From this point, we ran 1-inch conduit down to a Xantrex TCB-10 combiner box. We used #10 (5 mm^2)THHN wiring from each four-module subarray. A ground wire from each subarray also comes into this combiner box.

Two #6 (13 mm^2) THHN and one ground wire exit the combiner box and are carried in conduit to Pete's shop, two stories down, where the balance of system (BOS) components are located. These include a Xantrex PC250 power center, which contains the main PV/battery and charge controller circuit breakers, and a 60-amp, PWM charge controller. Balance of system components are the batteries, the inverter, and a transformer, which provides 240 volts AC for the well pump.

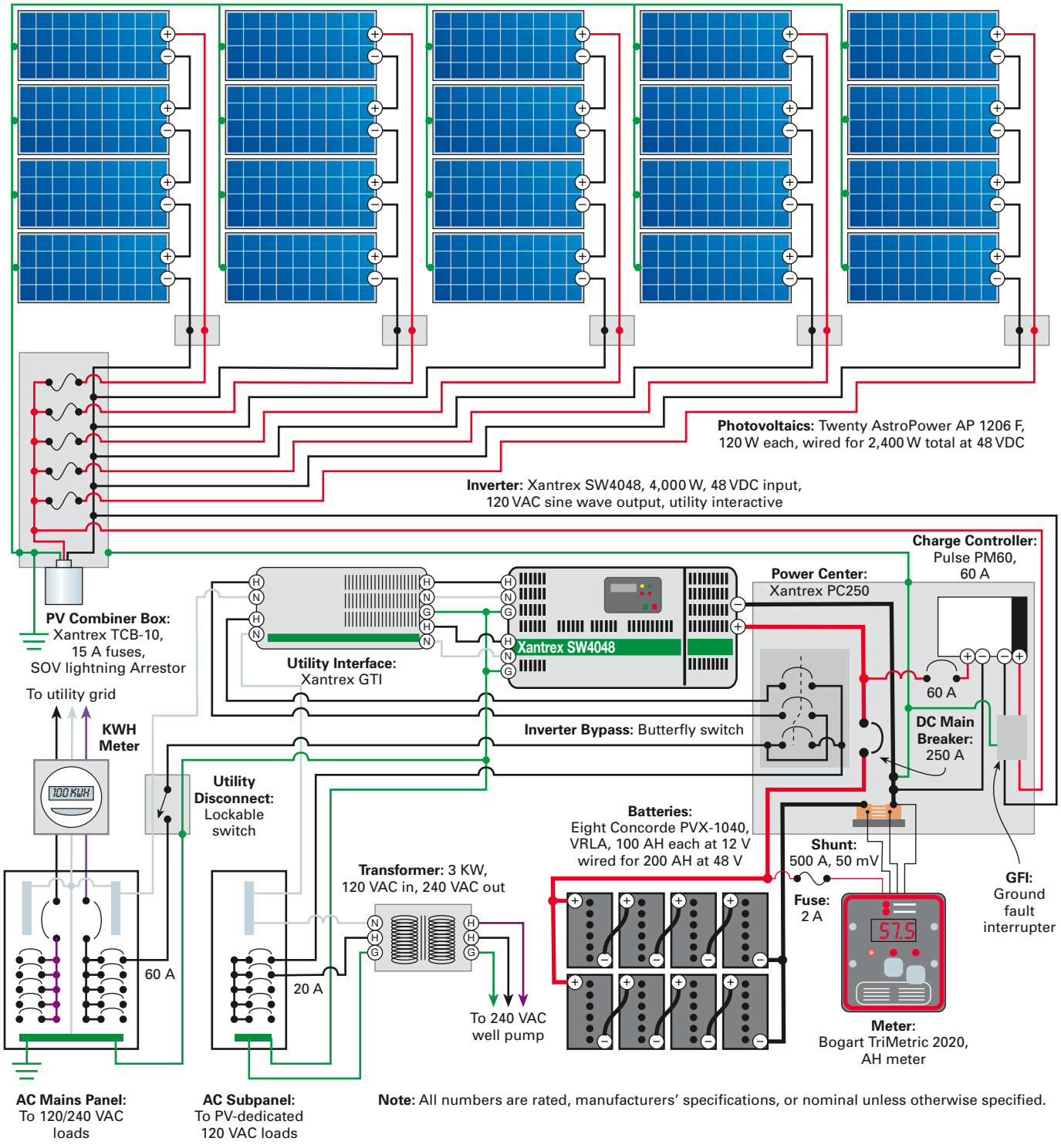
We chose an area adjacent to an electrical service panel to install this equipment. This allowed us to make an easy connection to the AC input of the inverter. In a grid-tied system, the inverter uses electricity from the utility grid, if needed, for battery charging, and also can sell electricity back through the same circuit breaker in the service panel.

The PV system components are located in Pete's workshop.

pumps wouldn't work. She would have to go down to the brook in the woods below their house and haul water up in buckets for the family.

In addition to wanting to keep the water flowing, the Seegers have a large deep freezer out in the barn. It is always full of food (much of which Toshi has grown in her bountiful garden) that feeds the constant flow of people living and visiting with the Seegers. Keeping this freezer running during utility outages was another important role for the solar-electric system. We installed 2 inches (5 cm) of rigid insulation around the deep freeze to keep as much of the cold in and heat out as possible.

The Seegers' Photovoltaic System



We pulled the wiring for the critical loads (the freezer, the well pump, and a couple of outlets in Pete and Toshi's bedroom and bathroom) out of the main service panel, and moved them to a subpanel connected to the output of the inverter. During utility outages, this critical load panel gets its electricity from solar energy stored in the batteries.

Net Metering

If the batteries are fully charged, the electricity will find its way to an electrical load that can use it. If, for instance, Truxie is hooked up to the Lester battery charger, the solar electricity can help charge the truck. If the freezer is running, or the well pump is pumping, the electricity from

Seeger System Costs

Item	Cost (US$)
20 AstroPower 120-watt PV modules	$15,700
Labor	5,390
Xantrex SW4048 inverter	3,250
Xantrex PC250 power center	1,495
8 Concorde batteries, 12 V, 100 AH	1,264
5 AstroPower 4-AP-1206 mounts	750
Two Seas battery box	408
Transformer, 120 to 240 VAC	360
TriMetric battery monitor	328
Subpanel & breakers	285
5 Junction boxes	264
Conduit & wire	230
Combiner box, 10 lug	229
Xantrex GFI option	149
Cable to stage, 30 ft.	133
Hardware for mount	125
Utility disconnect switch	120
Xantrex inverter conduit box	85
2 Inverter cables	72
6 Battery interconnect cables	72
System manual (Solar Works)	25
Battery temperature probe	24
10 Fuses, 15 A	10
2 Cable Lugs	3
System Total	$30,771
NYSERDA rebate, $3/watt	-$7,200
NY tax credit, $1.50/watt	-3,600
Grand Total	$19,971

the PVs can help power those loads. If none of the loads in the critical load panel are being used, and Truxie is not being charged, the inverter (which is programmed to be in the "sell" mode) will send the electricity back through the AC1 input circuit breaker and into the main service panel of the house. Any electrical loads that are turned on can use the solar electricity.

If more energy is being produced by the solar-electric system than is being consumed by the house, the electricity will head out through the electric utility meter, which will spin backwards. The solar-electric system will offset the Seegers' Central Hudson utility bill by the amount of electricity produced by the PV panels. This arrangement, called "net metering," is becoming widely accepted throughout the country. The Seegers, in effect, sell electricity to Central Hudson whenever they have a surplus.

At the time of this installation, the NY Shines solar initiative was just getting underway, and the Seegers were one of the first families to take advantage of the state tax credits and rebates. The state was giving a US$3 per watt rebate off the cost of a solar-electric system, and an additional US$1.50 per watt tax credit.

Production

How much can the system produce? Since there are twenty panels rated at 120 watts each, the most the array can produce is 2,400 watts. Very rarely will a photovoltaic panel produce its rated output. This will only occur in ideal conditions with intense sunlight and cold temperatures. An example would be a crystal-clear winter day, when snow is on the ground and the PV panels don't have any snow on them. Considering losses from wire resistance, equipment efficiency losses, and weather patterns, grid-tied systems like this can produce approximately 60 to 70 percent of the PV array's rated output.

To get a rough idea of how much energy this system would produce for the Seegers, I computed the output using 4.5 for the average daily sun hours, based on National Renewable Energy Lab (NREL) weather data for New York City. So, 2,400 watts for 4.5 sun hours at 70 percent system efficiency is about 7.6 KWH per day.

If we go back to the original plan for the system—to provide solar electricity for Truxie—we can see how long it will take to make enough energy for the truck from the solar-electric panels. As mentioned earlier, the electrical storage capacity in Truxie is 26.4 kilowatt-hours. Batteries should never be completely discharged. An 80 percent discharge would be 21.12 kilowatt-hours. If you divide that by the 7.56 kilowatt-hours per day produced by the solar-electric system, it will take an average of 2.8 days to make enough electricity to charge the truck if the batteries are empty.

Pete doesn't discharge the batteries to 80 percent depth-of-discharge in the truck every time he drives. If he's only used one-third of the capacity of the batteries, it will take a little less than a day for the solar-electric panels to generate that much electricity.

During the course of the day, the solar-electric system may only offset a small percentage of the Seegers' overall energy usage. On average, they use about 35 KWH per day in their home. So the PV system accounts for about 22 percent of their electrical consumption.

At the Seegers' house, there are times of heavy electrical usage, such as when Pete and Toshi's daughter, Tinya, is running the electric kilns (which can approach 100 KWH per firing) to fire her exquisite pottery. There are also seasonal electrical demands. One comes in the winter when Pete pumps a lot of water to make an ice skating rink. Many years ago, Pete had an inspiration to flood the parking area in front of their house to make the rink. In the fall, he creates a curb of earth around the low parts of the perimeter. Once the ground has frozen, Pete turns on the hose and pumps water for a few cold nights to fill the "pond."

While Pete claims the rink is for his children and grandchildren, he loves to skate as much as anyone. One day while my daughters and I were skating with Pete and his grandchildren, Toshi came outside to tell Pete he needed

to meet someone in town for an interview. "Oh good," said Pete, "I'll drive Truxie to town right now. I've always wanted to try driving with my skates on." Toshi convinced Pete that he should change into his boots, but we all had a good laugh.

How to Change the World

Pete and Toshi continue to go about their life on the hill overlooking the Hudson. Pete makes regular trips to town in Truxie, attending meetings at the Sloop Club, where folks come to share food, sing songs, and think of new ways to continue to clean up the Hudson River.

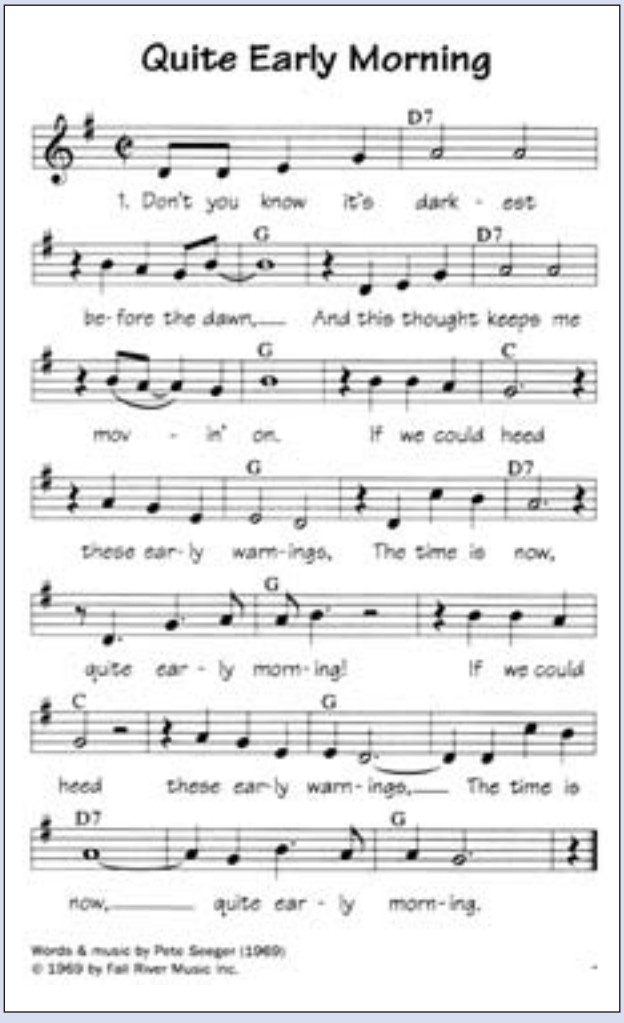
Pete summarizes where he is today:

My wife Toshi and I are in our eighties but in moderately good health, on good terms with our neighbors, and working with others in our town of 13,000. We're involved in half a dozen projects, such as a floating swimming pool, now that the Hudson River is clean enough to swim in again. For 65 years, I made a living as a musician. Now my voice is gone, eyes and ears are going, but I would like to live another ten years just to see what surprises will come next.

If there is a human race still here in a hundred years, I think it will be hundreds of millions of little things that will have saved us. Imagine a big seesaw: one end is on the ground with a basket

Pete's Song

While we were doing the solar-electric installation, Toshi was often digging into the freezer, the pantry, and the garden to create delicious meals for everyone. Sitting around the Seegers' table, we'd discuss politics, talk about how to make the Hudson River Revival better, and hear stories of days gone by. After a meal, we'd sometimes take out some instruments and sing a few songs. When asked about a song to include with this article, Pete suggested this one he'd written in 1966 called "Quite Early Morning."



Don't you know it's darkest before the dawn
And this thought keeps me movin' on
If we could heed these early warnings
The time is now quite early morning
If we could heed these early warnings
The time is now quite early morning

Some say that humankind won't long endure
But what makes them so doggone sure?
I know that you who hear my singing
Could make those freedom bells go ringing
I know that you who hear my singing
Could make those freedom bells go ringing

And so we keep on while we live
Until we have no, no more to give
And when these fingers can strum no longer
Hand the old banjo to young ones stronger
And when these fingers can strum no longer
Hand the old banjo to young ones stronger

So though it's darkest before the dawn
These thoughts keep us moving on
Through all this world of joy and sorrow
We still can have singing tomorrows
Through all this world of joy and sorrow
We still can have singing tomorrows

Don't you know it's darkest before the dawn
And this thought keeps me movin' on
If we could heed these early warnings
The time is now quite early morning
If we could heed these early warnings
The time is now quite early morning

half-full of rocks on it. The other end is up in the air with a basket one-quarter-full of sand on it. Some of us have teaspoons and are trying to put more sand in the basket.

Most people are scoffing at us: "Don't you see the sand is leaking out as fast as you put it in?" We say, "That's true, but we're getting more people with teaspoons all the time." One of these days, you'll see that basket so full that the whole seesaw will go zoo-oop in the opposite direction, and people will say, "Gee, how did it happen so suddenly?" Us and all our little teaspoons.

Access

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Sunnyside Solar Inc., 1014 Green River Rd., Guilford, VT 05301 • Phone/Fax: 802-254-4670 • info@sunnysidesolar.com • www.sunnysidesolar.com • Project support and installation

Electric Vehicles of America, PO Box 2037, Wolfeboro, NH 03894 • 603-569-2100 • Fax: 603-569-2900 • EVAmerica@aol.com • www.ev-america.com • Truxie support and equipment

Clearwater Festival: The Great Hudson River Revival, Hudson River Sloop Clearwater Inc., 112 Little Market St., Poughkeepsie, NY 12601 • 800-67-SLOOP or 845-454-7673 • Fax: 845-454-7953 • office@clearwater.org • www.clearwater.org