Adventures with a Solar Powered Lawn Tractor

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The author's children playing "farmer" on the Elec-Trak lawn tractor (safely turned off, of course).

It all started back in the summer of 2000 when the power line to my work shed shorted out. Replacing the line would have cost well over US$1,000, along with the inconvenience of tearing up my driveway and yard. It was at this point that I thought: "Now would be a great time to try solar electricity!"

So I installed my first solar-electric panel, got a few batteries, ran some wires, threw the disconnect switch, and lit up the shed. At that point, I knew I was hooked.

Making a Difference

One of the things I quickly noticed about solar electricity was its ability to make a difference. Here I was with a single solar-electric panel, two batteries, and an inverter, and I had enough energy to light my shed and use some small power tools as well. Every time I flipped the light switch, I felt a sense of pride in the fact that this was energy I had generated cleanly, and it was truly mine to use.

I began to think about other uses for all that energy coming down from the sky. What I really wanted was to use the solar-electric panels to make the biggest dent possible in my pollution output, while spending a reasonable amount of money, and providing a solution that would clearly display to anyone the benefits of solar energy. While I was pondering this, I went outside and sat down on the biggest, loudest, most pollution-generating device I owned—my Craftsman 16 horsepower lawn tractor.

The Craftsman

Small, gasoline powered yard tools are notorious for the amount of noise and extreme amounts of pollution that they generate. This is partially due to the small sizes of the engines, but mostly to a complete lack of anything resembling pollution control. Garden tool motors typically have single-stage carburetors, so they run very rich. They also have limited (if any) mufflers; and no air injection, fuel injection, or any of the clean air features found on even the most basic automobile engines. The gas tanks are typically vented to open air, and the crankcase fumes aren't reburned.

According to an article from the CNN Web site, lawn mowers in the Los Angeles basin put out more pollution than all the aircraft in that area. In fact, per hour of use, a lawn mower puts out more pollution than 73 automobiles.

Thus, my choice was clear. The gasoline powered lawn tractor was the biggest polluter I owned. But I use it a lot. It mows the lawn, it lugs around loads, and it's a very useful tool to have. What could I possibly replace it with?

The Elec-Trak

In browsing past issues of *Home Power* magazine, I read about the General Electric Elec-Trak line of lawn tractors in *HP70*. These units were built in the early 1970s, and instead of using a gasoline engine, they were powered by electric motors run from six golf cart batteries.

The solar-electric charging system hooks up to the Elec-Trak's 36 volt accessory port.

My first thought was, "Wow, I've got to get one of those." I could plug it into the wall and get rid of the tractor. Then the second thought hit me: "Why not take this idea to the limit and run an Elec-Trak on solar electricity?"

The idea of mowing a lawn with solar electricity is not quite a new one. At least one manufacturer makes a tiny solar powered lawn mower. But the Elec-Trak isn't a little plastic contraption. It's a 900 pound (408 kg) steel tractor with a 42 inch (107 cm) cutting deck—a difference in scale to be sure. My next steps were to find an Elec-Trak, and then figure out a way to run it on solar electricity.

Buying an Elec-Trak was actually not too difficult. General Electric made a lot of them, and they were built extremely well, so many still survive. I checked on eBay for a few weeks, and found an E20 model (the biggest they made) for the low price of US$520. The batteries were shot, and it had some surface rust, but the basic mechanics were solid. I rented a small pickup truck, drove from my home in Maryland up to New Jersey, and hauled it back.

It took a bit of work to get it running, but thanks to lots of help from the Elec-Trak Web site (www.elec-trak.org) and a very helpful e-mail list, I was able to find local people who could help me bring it back to operation. So now that I had the tractor, it was time to build a solar powered charger.

The Solar Charging System

The first step in designing any solar-electric system is to answer these three questions:

1. How much do your loads draw?
2. How much time do your loads run?
3. How good is your solar resource?

The first question was answered with a bit of basic research: I estimated that the Elec-Trak would draw approximately 60 amps at 36 volts while cutting my lawn.

The second question was the key to designing this system. My 1 acre lawn takes about an hour to mow. So the electrical load would be 60 amps at 36 volts for one hour, or about 2,160 watt-hours. I mow my lawn about once a week. In the hot summer months, I might only need to mow the lawn every other week. The rest of the time, the tractor sits idle. So the solar-electric array for my electric tractor needed to provide 2,160 watt-hours once every week or two weeks.

The third question has to do with the environment the system is installed in. I live in Maryland, on the south side of a nice hill, and have a heavily wooded backyard around my shed. During the summer, when I use the tractor most, I can typically get only about four useful hours of sun per day because of the number of the trees in my backyard. Due to clouds, I can count on about five days of sun a week, or about twenty hours of peak sun per week.

When I take into account the decrease of PV output as temperature increases, the losses inherent in charging batteries, and the losses in the wiring, I figure that about 80 percent of the PV array's rated output is available for charging the tractor's batteries.

Fill 'er up! The tractor getting topped off with solar electricity.

Given these assumptions, I made the following calculations: A solar-electric array that is rated at 180 watts can probably charge the batteries at about 80 percent or 144 watts. Multiplying this by an average of four peak sun hours a day, I have about 575 watt-hours (WH) of daily energy production.

So in five sunny days, I can expect 2,880 WH of energy production. If I get a full week's worth of sun (all seven days) I'll get more than 4,000 WH. A 180 W rated solar-electric array would provide more than enough energy to mow my lawn every other week, and might provide just enough to mow my lawn every week (depending on the amount of sun).

A great deal of assistance in the design process was provided by Kirk Mulligan from Atlantic Solar Products. In addition to providing the equipment, he was quite helpful in determining the right products to use and answering my questions.

Building the Solar Charger

Building the solar-electric system was not as complicated as I anticipated. I mounted the panels to my shed's roof with zinc plated steel girders. The girders are mounted to the panels with standard 5/16 inch (8 mm) bolts, and screwed into the shed's roof. The roof of my shed consists of 1 by 12 lumber planking, nailed to 2 by 4s, and covered with 20 year shingles, so I am rather confident that the rack will not come apart in a windstorm.

I first used one BP Solarex MSX120 panel configured for 24 volts, series connected to an MSX60 panel configured for 12 volts. (These PVs are field configurable for 6, 12, or 24 volts.) This provides a combined output voltage of 36 volts at 180 W rated, which matches the power requirements of the tractor. The outputs of the panels are connected via #10 (5 mm^2) wires to a junction box, which is connected via conduit to a weatherproof Cutler-Hammer 30 amp disconnect.

The disconnect serves two functions. First, it allows me to turn off the panels when I want to work on the downstream wiring. I make it a personal policy to ensure that all connections from a solar-electric panel can be disconnected with the simple throw of a switch.

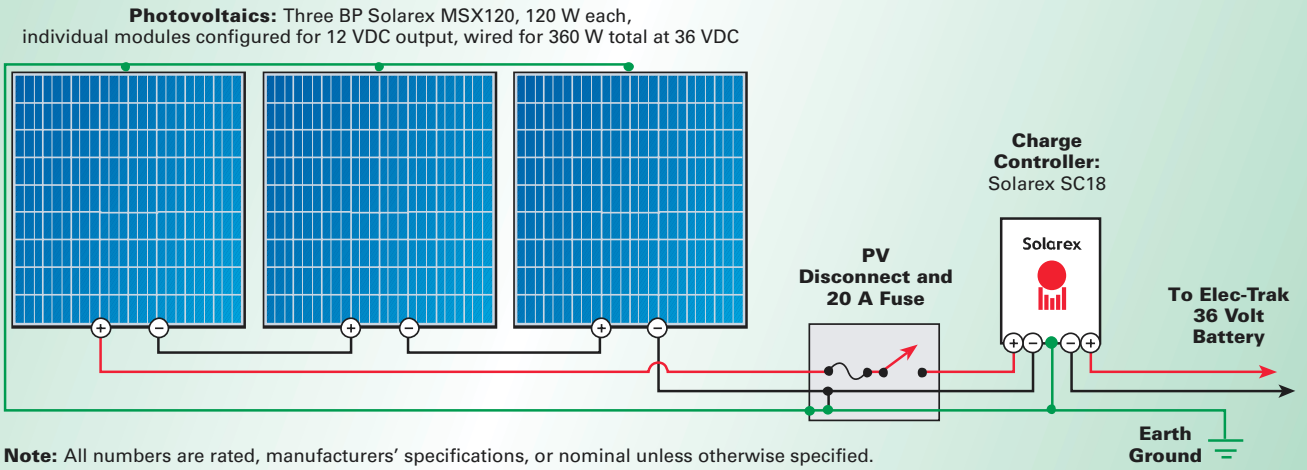
Boost the Power

The 180 W rated solution I installed was working well. But I wanted to decrease the time it took to fully charge the tractor battery, so I could mow my lawn weekly, and have power to spare to drive my tractor around. So I went out to Atlantic Solar and picked up two more 120 watt panels. Installing them on the roof was a simple matter of building a mount and wiring them in.

For the 360 watt solution, I configured the three BP Solarex MSX120 panels to output 12 volts nominal. Then I wired the three modules in series. This gave me a 360 watt output at 36 volts. The original MSX60 is now being used to charge spare batteries.

The three MSX120s are providing the tractor with more than 7.5 amps of charge at 36 volts nominal. With this much solar electricity, I can run the batteries down and bring them up in three days. It turns out that this is more than I need, so I'm starting to reconfigure my system again so I can sell some of the surplus to the utility.

360 Watt, 36 Volt Charging System



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

Second, it serves as the carrier for my 20 amp RK5 fuse. I use DC-rated fuses, which have an interrupt rating of 10,000 amps. I cannot stress enough the importance of properly fusing your solar-electric panels. If your panels or wiring were ever to short, the current from the Elec-Trak's batteries could destroy your panels and possibly set fire to your dwelling. Always remember to use DC-rated fuses; common fuses are typically not rated for DC circuits.

From the disconnect, the wires run in 3/4 inch conduit to my Solarex SC18 charge controller. Finding a charge controller was a bit of a challenge, since most are designed to work on 12, 24, or 48 volt systems. The Elec-Trak uses a 36 volt power supply, so you need to ensure that your charge controller can support 36 volts. I found the Solarex SC18 controller on eBay from for about US$100. Oddly enough they are normally only sold in Australia, though I've recently heard that B.Z. Products in Missouri makes a 36 volt controller.

The SC18 is a rather simple controller. It will charge the batteries to one of two set points based on the battery voltage. If the batteries are slightly discharged (above 37 volts but below 41), it will float charge them up to 42.3 volts. If the batteries are deeply discharged (below 36.9 volts), it will automatically charge the batteries to 45 volts.

The output of the SC18 is fed to a 25 foot (7.6 m) extension cord that plugs into the Elec-Trak's accessory port. This accessory port was originally designed to power things like chain saws, hedge trimmers, and other DC powered tools. It's connected to the battery, and is protected from overload by the tractor's internal disconnect and a circuit breaker. This makes it a perfect point to attach the solar-electric array.

I used a Hubbell (HBL7102C) twist-lock plug to connect to this port; this can be ordered at most electrical supply houses. When hooking up the twist-lock plug, make sure that you get the polarity right. Positive on the Elec-Trak *must* go to positive on the charge controller. Verify this with your voltmeter *before* connecting the charge controller to the Elec-Trak.

Grounding is important, even on a small system like this. The system is grounded with #6 (13 mm^2), bare, solid wire connecting the panels, the mounts, the disconnect boxes, and the negative side of all wiring to an 8 foot (2.4 m), 5/8 inch (16 mm) grounding rod hammered straight into the

Estimated Costs for Two Charging Scenarios

Item	Cost (US$) 180 W	360 W
2 Solarex MSX120, 120 W modules	-	$1,000
Solarex MSX120, 120 W module	$500	500
Solarex MSX60, 60 W module	280	-
Solarex SC18 charge controller	100	100
Conduit, fittings, & misc. parts	100	100
Cutler-Hammer 30 A disconnect	40	40
Totals	$1,020	$1,740

ground. Always use proper grounding to protect your equipment against lightning strikes and the possibility of electrical shorts.

Putting It All Together

Installing the panels and wiring the boxes took most of a weekend. The hardest part was ensuring that I had enough of the small things that go into a project like this. Items like nuts, bolts, and waterproof connectors always seem to be in short supply, and can keep you going back to the hardware store. I am fortunate to have a very nice hardware store a mile from my house. They carry just about everything, and have an extremely knowledgeable staff.

At each stage of the wiring, I checked my connections for proper polarity with my trusty voltmeter. It's actually pretty easy to make a mistake and wire a panel backwards, so it's very important to check that the output voltages and currents match what you anticipate.

When all the wires were run, and all the connections had been tested, I installed the fuses, hooked up the tractor, and threw the big disconnect switch. Thunk!

I was rewarded with a green charging light on the SC18, indicating that the tractor was being charged. A quick check at the Elec-Trak with my digital multimeter showed a voltage of 40 volts and a current of 3 amps, indicating a good solid charge.

Harness the Sun

After three days of charging, the controller's light went off. Checking the batteries showed a voltage of 41.5 volts, which indicated a full charge. I unplugged the charge cable and drove off.

I had fun that afternoon. There's no feeling quite like reaping the rewards of solar energy. I gave my two children rides around the yard, and later as I used my trailer to haul wood around, I realized that I had truly harnessed the power of the sun!

Amaze Your Friends

I love driving the Elec-Trak around. It's easily more powerful than the Craftsman tractor, due to the exceptional low-end torque of the electric motor. And the 900 pounds (408 kg) of weight provides plenty of traction. The larger tires are easier on the grass, and the mower works quite well.

Friends and neighbors are amazed when they stop to take a look at the Elec-Trak. It's different, and it's quiet. And when I tell them it's 100 percent powered by the sun, I can almost see their minds begin to expand. For most people, solar energy is abstract—it's what runs a little calculator, or maybe a child's solar powered toy.

Watching a 900 pound tractor powered by the sun allows them to see things in a new and different light. Green power from the sun isn't abstract; it can power big tools and do very visible tasks. Solar energy can make a difference.

But the thing that amazes me most is the quiet. A low whirr is all I can hear when it's running. No noise on a Sunday afternoon, no refueling, no gas cans, no pollution. I can listen to the birds while mowing the lawn, and can do it all with the knowledge that I am no longer a part of the problem—I'm a part of the solution.

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The Last Place You Looked.com, PO Box 925, Lynnfield, MA 01940 • Fax: 978-532-3151 • sales@thelastplaceyoulooked.com • www.thelastplaceyoulooked.com • SC18 controller

"The Elec-Trak Rides Again; Reviving G.E.'s Electric Lawn Tractors," Mike Bryce, *HP70*. Available in print or on the Solar4 CD.

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