TOP SECRET

GUERRILLA SOLAR: the unauthorized placement of renewable energy on a utility grid.

PROFILE: 0008

DATE: December, 1999

Location: Somewhere in the USA

Installer Name: Classified

Owner Name: Yeah, right!

Intertied Utility: Classified

System Size: 130 watts of PV

Percent of Annual Load: 3%

Time in Service: 3 months

We've always been into energy conservation. We run compact fluorescent lighting, and turn lights off when we leave the room. We've eliminated most of our home's phantom loads. We dry our clothes on a clothesline, and we're slowly replacing our older appliances with newer, more efficient ones.

Three months ago, we took the next step and got involved in what we like to think of as active conservation. By using PV to produce clean electricity, we offset part of the polluting, coal-fired electricity our reckless, profit-blinded utility sells us.

We purchased and installed a Trace MicroSine inverter and a used 130 watt Sanyo PV. The entire system cost less than a thousand bucks. We installed the MicroSine inside the building rather than on the back of the module, to keep the inverter at a lower operating temperature. The length of the DC wiring between the PV and the inverter is only 48 inches, so voltage drop isn't a problem.

To check out the performance of the system, we did a little plug-and-play with a Brand Electronics watt-hour meter (originally purchased to evaluate our household appliances). On a sunny day, the system produces about 500 watt-hours of clean electricity--enough to offset our daily lighting load.

Why guerrilla? Three reasons. Technically we live in a net metering state. But local RE system owners who have attempted to get utility approval to intertie their systems have been held up by red tape for years. This, by the way, didn't stop any of them from pressing the sell button on their inverters. Technically we also live in a democracy. By going guerrilla, we're casting our vote for a sane energy future. And there's no way the utility can lock this ballot box.

The last reason we went guerrilla has to do with our site. The best solar location is on the roof of an outbuilding several hundred feet from the utility meter. To intertie our MicroSine system, all we had to do is plug the inverter into an AC receptacle inside the building. To meet the standards the utility dreamed up, a separate, lockable disconnect would need to be installed between our MicroSine inverter and the meter. To do this, we'd have to purchase the disconnect and 300 feet of wire and conduit, and dig a 300 foot trench. By the time it was done, this would add at least 50 percent to the cost of the system. All this for a 100 watt inverter that's UL listed to be safe, just like the toaster in our kitchen? Gimme a break.

If the utilities were smart, they'd be pushing RE instead of making it tough for us to install it. They could install dedicated meters on customers' RE systems. As an incentive, the utility would pay customers more than the retail rate for privately produced green electricity. Then they could sell this power at a premium retail rate through their optional green power billing programs. That way, everybody would win. Most of the green pricing programs are selling KWHs like hotcakes. This represents huge earning potential for the utilities, and less pollution for the rest of us.

In the meantime, while we all wait around for the utilities to get their act together, we'll be putting green electricity on the grid anyway. For us, this system is just the beginning. You never know what goes on out behind the barn…

GUERRILLA SOLAR— ONE STEP AT A TIME

Solar Guerrilla 0008

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If you're interested in going solar, but your local utility isn't so keen on the idea, do the right thing—go guerrilla! A little solar civil disobedience is good for the planet and good for your head. Connecting a small photovoltaic (PV) system to the grid can be easy and safe. So here's a step-by-step approach to building a small, safe, and effective guerrilla solar-electric system.

All guerrilla solar-electric systems rely on inverters that are capable of synchronizing their AC output with utility power in order to feed renewable energy (RE) onto the grid. Every inverter capable of doing this is designed to disconnect from the grid in a matter of milliseconds when the grid fails. These inverters can't feed electricity onto the grid during a power outage. Regardless of utility approval, all utility interactive (UI) systems are inherently safe as far as utility workers are concerned.

So far, thirty-four U.S. states have enacted net metering legislation. This requires utilities to offset retail KWH rates to customers feeding renewably generated electricity onto the grid. Sixteen states have yet to implement similar legislation.

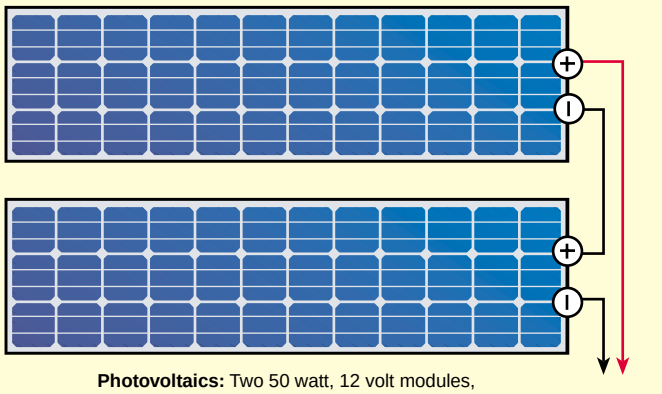
But even in states with net metering legislation, utilities often bypass laws governing the interconnection of utility intertied RE systems, in an effort to stunt the growth of distributed power generation. As a result, many clean energy advocates are operating clandestine RE systems with the simple, utilitarian goal of greening up the grid.

We've been operating a small, unauthorized, UI PV system for almost two years. Check out *HP75,* page 74. We estimate that we've put about 250 KWH of pollution free, solar electricity onto the grid since we installed the system. And every sunny day, it quietly keeps making more!

After reading the article in *HP85* about the whacky portable guerrilla solar-electric system, I thought that folks ought to check out my guerrilla rig. Our installation uses an OK4U inverter and a 130 watt Sanyo PV. I hope to inspire some people to get active and install their own UI PV system—utility approved or otherwise.

Our barn has a shed roof that faces true south and gets full sun all day long—a perfect place for PVs. Ideally, you want to install your PVs in a location that receives full sun throughout the day. Any shade on the PVs will radically reduce their output. In the northern hemisphere, orient your PVs toward true south. Then they'll produce the most energy on a daily basis.

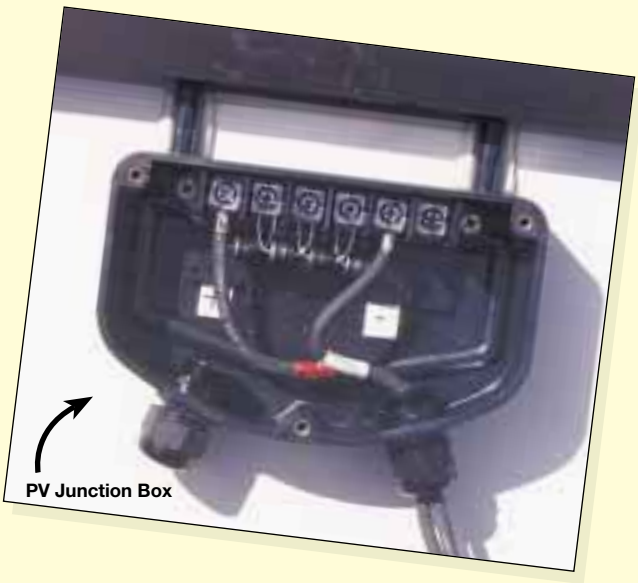
Our OK4U inverter has a 24 VDC input and a 100 watt, 120 VAC output. Trace Engineering was importing these inverters and selling them under their MicroSine brand name. Trace is no longer importing them. But the OK4U inverter is still available through the manufacturer, NKF Electronics in the Netherlands. Many U.S. RE equipment resellers still have OK4 series inverters in stock under the Trace MicroSine brand name.



Photovoltaics: Two 50 watt, 12 volt modules, wired in series for 100 watts at 24 VDC

Our Sanyo PV has a 24 VDC nominal output. But most PVs have a 12 VDC nominal output. If you wire two 12 VDC, 50 watt PVs in series (positive from one PV to negative on the other), you get 100 watts output at 24 VDC, which meets the OK4U's DC input requirements.

You'll need a rack to mount your PVs. We made mounting feet using 1-1/2 by 1-1/2 inch (3.8 x 3.8 cm) galvanized steel angle. We mounted the feet to the roof framing, using 3 by 3/8 inch (7.6 x 0.95 cm) lag screws. The module frame is connected (bonded) to the main system ground at the inverter using #12 (3.3 mm^2) solid copper wire.



Two types of wire are commonly used between the PVs and the inverter. You can use copper USE wire, which is rated for UV exposure (direct sunlight). You can also use copper THHN-2 wire, run in flexible, liquidtight, nonmetallic conduit. THHN wire needs to be installed in

conduit because the insulation will eventually break down if exposed to direct sunlight. We used USE wire in our system.

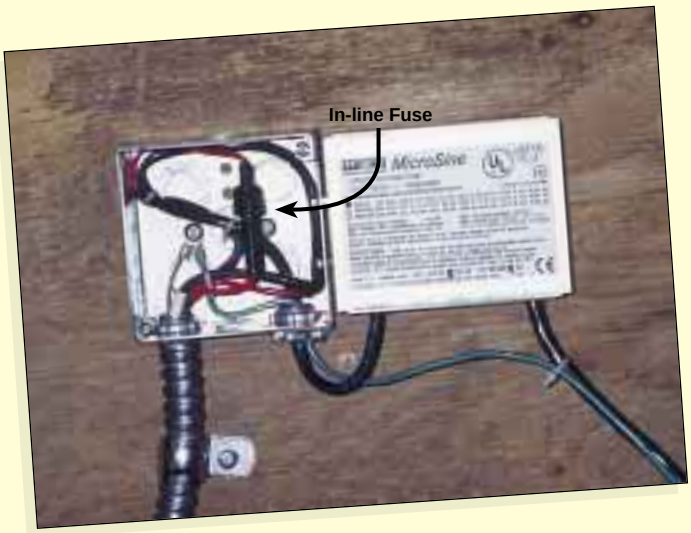
The inverter has two wires for DC input. Connect the positive PV output wire to the red (positive) DC input wire on the inverter. Connect the negative PV output wire to the black (negative) DC input wire on the inverter. Make sure to double-check the polarity of the PV output wires before you connect them to the inverter!

Low voltage systems move more current (amps) than if the same system was configured at a higher voltage. As the current moving through a wire increases, the voltage drop increases too. This means some energy is lost. So I'm a big fan of soldering low voltage connections to keep the resistance and voltage drop as low as possible. Properly applied solder ensures a solid electrical connection. I cover the soldered connections with heat shrink tubing to insulate them from one another.

In our case, the Isc of the Sanyo PV is 3.27 amps at 24 VDC nominal. So 3.27 amps x 1.56 = 5.1 amps. We rounded up and installed a 10 amp fuse. Remember that the fuse size always needs to be smaller than or equal to the ampacity rating of the wire you're using and the series fuse rating of the module.

The OK4U inverter is designed to be mounted directly on the back of a PV module. But we decided to play it safe and install the inverter inside to keep it at a lower operating temperature. It gets very hot on our barn roof. Besides, PVs often operate at temperatures above 50°C (122°F) because they absorb the sun's heat, while only using its light.

The distance between our inverter and the PV module is only 48 inches (122 cm). I used #10 (5.3 mm^2) copper wire, so the voltage drop is really minimal at 0.1 percent. If you decide not to install your OK4U inverter on the PV module, make sure to size the PV to inverter wire run for the specific distance between your PV and inverter. You can get a wire sizing spreadsheet from the "Promised" section of the Downloads page of *Home Power's* Web site at: www.homepower.com.

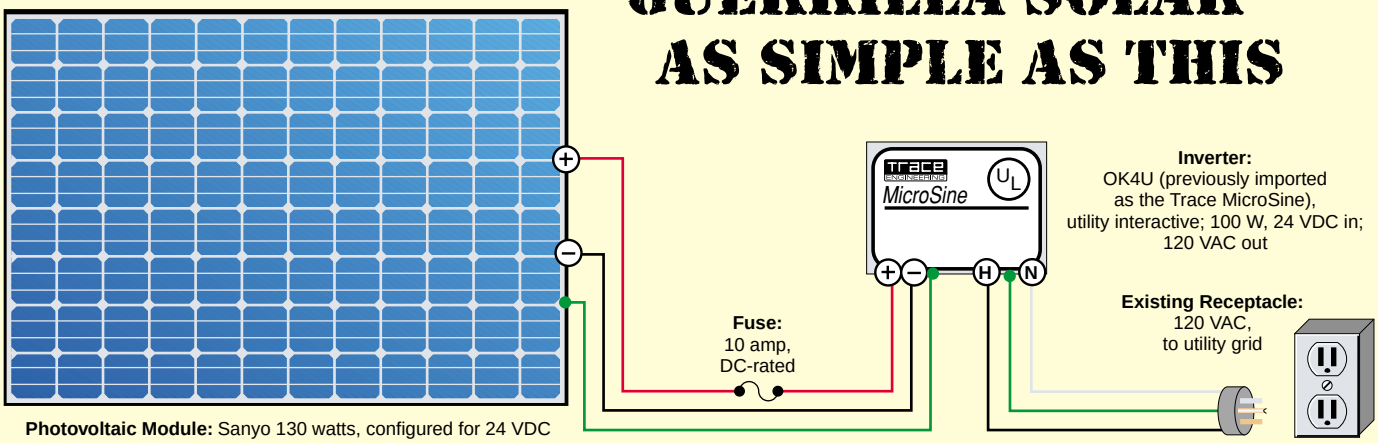


Make sure to include a DC-rated fuse in the positive wire between the PVs and the inverter. This will protect the DC wiring from a short circuit, and allow you to electrically disconnect the PV from the inverter.

To figure out the correct fuse size, multiply the PV short circuit current (Isc) by 1.56. This is the constant used for sizing PV overcurrent fuses or breakers. The Isc rating is usually listed on the back of the PV module. If you are using two 12 volt panels wired in series for 24 VDC, you still only multiply one module's Isc by 1.56. A series connection increases voltage, but not current.

I mounted the inverter to the side of a 4 by 4 by 2 inch (10.2 x 10.2 x 5 cm) metal handibox using hardware

GUERRILLA SOLAR— AS SIMPLE AS THIS



that was included with the inverter. This hardware can also be used to attach the inverter directly to the module frame if you're installing it on the back side of the PV. The inverter has cooling fins that will accept 1/4 inch (6 mm) bolt heads. Position the inverter on the inside edge of the module frame near the J box.

Locate and drill two holes so the inverter is not up against the substrate (back of the PV module). This will allow both the PV and the inverter to operate at lower temperatures. Use a nut and a star washer to hold each bolt tight to the inverter. A second nut and star washer is used to secure the bolts to the module frame. Then the fins of the OK4U will be set off a bit from the frame.

The inverter's AC output has four wires. Two of the wires (the blue and orange ones) are for an optional communications adapter that allows you to monitor system performance via a PC. We didn't purchase this adapter, so these two wires are not being used in our system.

The hot inverter AC output wire is black. The neutral inverter AC output wire is white. These wires can simply be wired to a standard 15 amp, male cord cap (plug). The hot wire goes to the gold terminal screw in the cord cap and the neutral goes to the silver one. Take a look at the detail photo of the cord cap wiring.

To eliminate the possibility of electrical shock, I ran a separate #12 (3.3 mm^2) ground wire from the cord cap's green ground terminal screw, and connected it to the inverter mounting hardware. This means that the inverter and handibox are bonded to the AC ground system.

The OK4U inverter won't generate AC electricity unless it senses acceptable grid voltage, current, and frequency conditions. But it's a good idea to get in the habit of electrically disconnecting all generation sources when you work on your system. In my case, I just have to remove the 10 amp fuse on the DC side and unplug the inverter.

The inverter output can safely be plugged directly into any standard AC receptacle (plug-in) in your home, as long as the circuit is protected by an existing breaker. This breaker will provide overcurrent protection for the AC side of the PV/inverter system. Double-check all your wiring and plug it in! The AC output of our inverter is plugged into a receptacle located right below the inverter. The inverter makes a slight buzzing sound when operating.

OK4U inverters have internal data acquisition capabilities. The inverter tracks real-time DC module voltage, AC output voltage, current, watts, and total watt-hours. It also measures inverter temperature. An

optional serial port computer interface module is available with special software to access the data (see *HP67,* page 34).

Spin the Meter Backwards—Safely
Getting approval from a stubborn utility has absolutely no bearing on the safety of a grid intertied RE system. Inverters that are capable of interfacing with the grid are designed and certified specifically for this application. And it's just common sense that you should follow safe wiring, overcurrent protection, and installation practices to protect your investment.

So install your system right, kick back, and watch the meter spin the *right* direction. If you disconnect all your household loads except the circuit that the inverter's plugged into, you'll be able to see your utility meter spinning backwards, ever so slowly. No doubt you'll want to make it spin faster. Luckily, all you have to do is add a couple more PVs and another OK4U inverter! One step at a time...

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