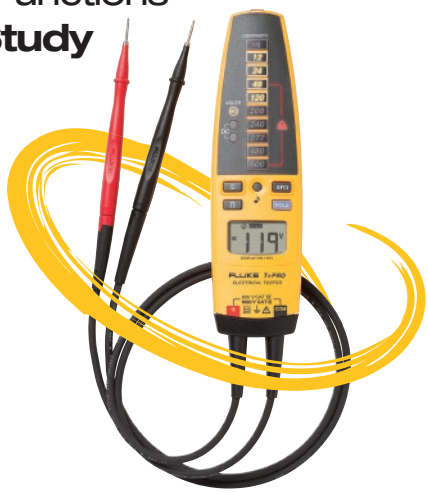
FLUKE®

Harnessing the power of the sun

Application Note

Testing Functions
Case Study



Tools: Fluke T+PRO Electrical Tester, Fluke 124 ScopeMeter® Test Tool, LH1060 Power Clamp Meter (the Fluke 345)

Operator: Robert Fonda, solar panel systems designer/installer

Measurements: Power usage audits, power output checks, continuity, voltage drop

Robert Fonda is a lucky man. He has left the bustle of Los Angeles and is living his dream in Joshua Tree, one of California's most remote and beautiful deserts. Robert and his wife live off the grid, ten miles from the nearest power line, yet they have all the comforts of modern life including Internet connectivity, satellite TV, laptop computers, cell phones and a microwave. The key to all this is the off-grid solar electric systems that Robert installs and maintains.

The rise of solar power

Solar-powered homes have been a staple of the Whole Earth Catalog for some years, but recently they have also become a mainstream reality. There are now over 180,000 solar-powered off-grid homes in the U.S. not connected to any electrical utility. (There are even more homes with grid connections plus solar power; 36 states require power utilities to purchase any excess power by running the meter backward whenever the home generates more power than it is using.)

There are a lot of reasons to install solar electric systems. They're quiet, the energy costs are falling—though not yet as low as utility power—and they emit no greenhouse gases. In addition, in places like Joshua Tree, there's another reason: this is beautiful, remote, open country, and the price of living in all that open space is that the utilities may be quite far away. Accordingly, people adapt. There's a water-delivery truck that will bring you one or two thousand gallons at a time, and you can use propane to run your stove and refrigerator. It's harder to do without power though, and the cost of getting on the grid can reach $50,000 if you're far away. That makes solar look pretty good, when you can get a system for as little as $10,000.

So if you live in Joshua Tree, or somewhere like it, a solar electric system may be the way to go. That doesn't mean it's all smooth sailing, though; if there's an Achilles heel to residential solar power at this time (besides the cost), it's the installation. Every system is custom, and the quality of the installation can make or break the system. That's where people like Robert Fonda come in.

Anatomy of a solar installation

Robert begins with extensive planning. The critical questions are how much power will be needed and when. If you want the ability to run several appliances at the same time, you'll need a larger system. If your stove and refrigerator are electric, add them to the load. Robert will take the amount of sunlight into account; there's lots of it,

because this is Joshua Tree, but there are still cloudy days, storms and shade trees. Finally, he'll look at where you need the power and then design your system.

Conceptually, the system is simple. On the outdoor side there are photovoltaic (PV) solar cells to convert sunlight to electricity and on the indoor side there's an inverter to generate ac. Most solar systems are more complex, though, because people don't use power only when the sun is shining; they also use it at night or on cloudy days, and that requires batteries. The next step, then, is to calculate the amount of battery capacity needed. Get too little and you won't have adequate reserve power when you need it. Get too much and your PV cells won't be able to fully charge the batteries during the available daylight hours. Besides that, batteries are expensive and you don't want to buy more than you need; see the sidebar for some typical costs.

After Robert calculates the size of the battery bank, he turns his attention to a bigger challenge: how to maximize its useful life. Batteries, it turns out, are surprisingly fragile. Overcharge them and they burn out. Undercharge them and they'll wear out faster than need be (plus you won't have the power you need at night or in cloudy weather). The prime directive of solar-power systems is to protect the batteries from overcharging and undercharging, and that requires a charge controller. Charge controllers are complex, and they need to be programmed differently for different battery types. Robert's controller, for example, has four charging phases. First is the bulk-charge phase; it typically comes on in the morning when the batteries are low and the sun comes up, and brings them to 28.7 volts. Then the charger goes to the absorb phase to keep the batteries at 28.4 volts or more during daytime use; it passes some of the PV power directly to the inverter for use in the home, and some to the battery bank. After that is a low-current 'float' phase and then the sleep phase.

Only two more pieces are needed. One is a generator, for power during long cloudy periods or high-demand usage and supplemental battery charging. The other is optional, but most modern solar systems have a power meter. You can use it to monitor your system and keep an eye on the voltage level in the batteries: they're usually at their lowest in the morning, before the sun recharges them.

Once Robert has designed the system, installing it is pretty straightforward. He knows what to expect of the components and he knows they will work together. Typically, the only testing he needs is to verify simple continuity and that the voltages are correct at each component. Then he turns on the system, the sun shines, and you get electricity.

Troubleshooting, upgrades and redesigns

A well-designed system will give years of quiet and trouble-free service. Sometimes there are problems though, and then it's time to call Robert. He'll bring his troubleshooting kit, which includes a cable tracer for working on older buildings (some of which started out as one-room homestead cabins, and have grown room by room), a Fluke 124 ScopeMeter® test tool, an LH1060 Power Clamp Meter (the Fluke 345), and a Fluke T+Pro Electrical Tester.

If the system is working but just not delivering enough power—you can tell from the wall meter when voltage in the battery bank is too low—Robert's first goal is to zero in on one of two basic causes. One possible cause is that your power consumption has gone up; the other is that the system's performance has gone down.

Testing a solar installation in Joshua Tree.

He starts by asking what has changed: New appliances? Different work schedule? Kids home for summer vacation? He follows that with a power-usage audit, using the ScopeMeter. Robert puts a current clamp on the ac output from the inverter and captures a 24-hour trend plot. The next day he comes back and looks at the peak usage times, using FlukeView® software and comparing the data to your previous trend plots. If your power demands have gone up and look likely to stay up, the result can be an upgrade in system capacity.

Robert Fonda's home system

Capacity: 1 kW. Total cost, installed: $13,000.

Sunlight

↓

PV panel

Eight 130-watt panels, $600 each (and each about 3 ft x 4 ft). Expected life: 30+ years.

↓

Charge controller

$400

↓

Battery bank

Eight 6 V/200 amp-hour batteries @ $200 each. Expected life: 3 to 5 years.

Generator

$700

↓

Inverter

$1800

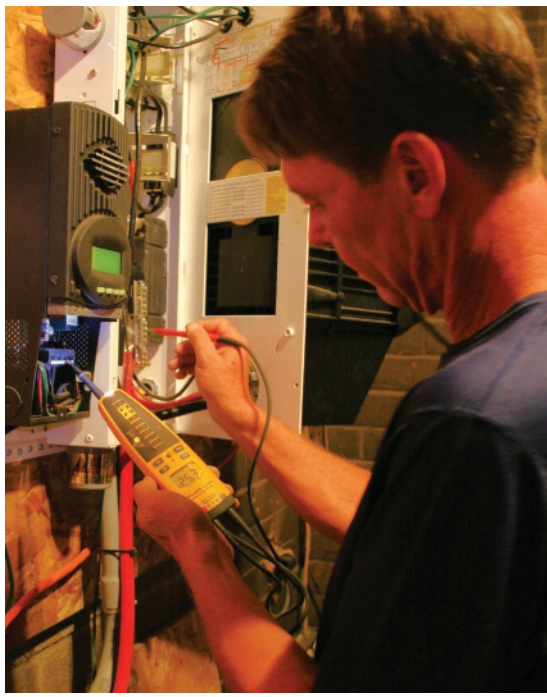
↓

Home power

If the cause is not a rise in your power usage, Robert looks for a decrease in system performance. He uses the power clamp meter to verify that each PV panel's power output is consistent with the manufacture's specifications, and he looks at the dc output from the battery bank. The 1060 may reveal a controller fault or show that the batteries are at the end of their useful life. If those are not the cause, it's time for some troubleshooting.

For troubleshooting, the tool he uses most is the T+Pro. It shows him faulty connections, such as the loose wire nuts he once found that were keeping power from the PV panels from reaching the charge controller. It shows him the voltage drop across cables; he's found a number of homebrew systems with cables that are too small, which translates into a significant voltage drop and a lot of lost power. On more than one occasion the continuity beeper has saved him hours of troubleshooting, such as the time he started looking to see why the bathroom GFCI circuit had tripped; he found that the same circuit had been used to power the refrigerator and a new icemaker. The spaces Robert works in are often cramped, and the Fluke T+Pro also saves him from having to carry multiple pieces of test equipment. In addition, he may have to turn a system off to work on it and then he's troubleshooting in the dark. The LED flashlight in the T+Pro is a small thing, but for Robert it's an important one. "Thanks to that little LED," he says, " I don't have to do any more work with a flashlight in my teeth or wearing a rock-climbing headlamp."

Now that solar power promises to enter the mainstream we'll probably see many more residential solar systems, both on-grid and off-grid. The price of power is likely to keep going up, and the price of solar will keep coming down. And whether you live in a remote place like Joshua Tree or in the big city, it's someone like Robert who will make that promise a reality.



Robert Fonda, testing solar controls.

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