systems processing up to about 2,000 watt-hours are fine at 12 volts. Systems processing 2,000 to 7,000 watt-hours will function better at 24 volts, and systems running more than 7,000 watt-hours should probably be running at 48 volts. These are guidelines, not hard and fast rules! The modular design of PV panels allows systems to grow and change as system needs change. Modules of different manufacture and age can be intermixed with no problems, so long as all modules have rated voltage output within about 1.0 volt of each other. Buy what you can afford now, then add to it in a few years when you can afford to expand.

Efficiency

On average, the sun delivers 1000 watts (1 kilowatt) per square meter at noon on a clear day at sea level. This is defined as a "full sun" and is the benchmark by which modules are rated and compared. That is certainly a nice round figure, but it is not what most of us actually see. Dust, water vapor, air pollution, seasonal variations, altitude, and temperature all affect how much power your modules actually receive. For instance, the 1991 eruption of Mt. Pinatubo in the Philippines reduced available sunlight worldwide by 10% to 20% for a couple of years. It is reasonable to assume that most sites will actually average about 85% of full sun, unless they are over 7,000 feet in elevation, in which case they'll probably receive more than 100% of full sun.

PV modules do not convert 100% of the energy that strikes them into electricity (we wish!). Current commercial technology averages about 10% to 12% conversion efficiency for single- and multicrystalline modules, and 5% to 7% for amorphous modules. Conversion rates slightly over 20% have been achieved in the laboratory by using experimental cells made with esoteric and rare elements. But these elements are far too expensive to ever see commercial production. Conversion efficiency for commercial single and multicrystalline modules is not expected to improve, this is a mature technology. There's better hope for increased efficiency with amorphous technology, and much research is currently underway.

How Long Do PV Modules Last?

PV modules last a long, long time. How long we honestly don't yet know, as the oldest terrestrial modules are barely 30 years old, and still going strong. In decades-long tests the fully-developed technology of single- and poly-crystal modules has shown to degrade at fairly steady rates of 0.25% to 0.5% per year. First-generation amorphous modules degraded faster, but there are so many new wrinkles and improvements in amorphous production that we can't draw any blanket generalizations for this module type. The best amorphous products now seem to closely match the degradation of single-crystal products, but there is little long-term data. All full-size modules carry 10- to 25-year warranties, reflecting their manufacturers' faith in the durability of these products. PV technology is closely related to transistor technology. Based on our experience with transistors, which just fade away after 20 years of constant use, most manufacturers have been confidently predicting 20-year or longer lifespans. However, keep in mind that PV modules are only seeing six to eight hours of active use per day, so we may find that lifespans of 60 to 80 years are normal. Cells that were put into the truly nasty environment of space in the late 1960s are still functioning well. The bottom line? We're going to measure the life expectancy of PV modules in many decades—how many, we don't know yet.

A Mercifully Brief Glossary of PV System Terminology

AC—Alternating Current. This refers to the standard utility-supplied power, which alternates its direction of flow 60 times per second, and for normal household use has a voltage of approximately 120 or 240 (in the USA). AC is easy to transmit over long distances, but it is impossible to store. Most household appliances require this kind of electricity.

DC—Direct Current. This is electricity that flows in one direction only. PV modules, small wind turbines, and small hydroelectric turbines produce this type, and batteries of all kinds store it. Appliances that operate on DC very rarely will operate directly on AC and vice versa. Conversion devices are necessary.

***Inverter**—An electronic device that converts the low voltage DC power we can store in batteries, to conventional 120-volt AC power as needed by lights and appliances. This makes it possible to utilize the lower cost (and often higher quality) mass-produced appliances made for the conventional grid-supplied market. Inverters are available in a wide range of wattage capabilities. We commonly deal with inverters from 50- thru 10,000-watts capacity.*

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