Selecting the right PV voltage

By Windy Dankoff

The independent home power system is based on storage batteries and direct current (DC electric power. Batteries are low voltage modules that may be assembled in 6, 12, 24-volt or higher configurations. Voltage is the electrical "pressure" at which the system operates, and part of the battery's job is to maintain this pressure at a fairly constant level. Thus, a "12-volt" battery maintains a working voltage within the range of about 11 to 14.5 volts—a **standard**. A 12-volt appliance will run properly within this range of electrical pressure.

While the voltage remains fairly constant, the **current** (measured in **amps**) varies according to the power required by the appliance. As more lights are turned on in your house, more current is drawn from your batteries. A large bulb draws more current than a small one. Some appliances draw different amounts of current at different times; a circular saw draws more current cutting 2" wood than ½" wood, because the motor works harder.

Twelve volts is the most common standard for alternative energy homes only because it is already a conventional standard—for vehicles! As we progress to higher voltages, less current (amps) is required to deliver the same amount of power (watts/horsepower). Wire, switches, and other inline components are sized according to the **current** they carry; the voltage has little bearing on their sizing. Therefore, a 24-volt home electric system is less costly to wire—it requires half the wire size, and less labor to install. Control systems and inverters contain components that the current must pass through, so they too can be smaller and less expensive in a higher voltage system.

To confirm this for yourself, compare prices of 12 and 24-volt charge controllers and inverters. The 24 volt models handle far more watts per dollar! Efficiencies also tend to increase with higher voltage/lower current. To see an extreme example of relative wire sizes, look under the hood of your car and see the big wire that goes from the battery to the starter. A typical circular saw requires as much power as your starter, but look at the **little** wire it uses! The saw uses 120 volts, and requires 1/10 the wire size to carry the current.

The common voltage standards for independent-powered homes are **12 volts** and **24 volts**. Your choice of standard is based on these factors:

1. Overall system size: Small, cabin-size systems standardize on 12 volts, which offers the widest choice of small DC appliances and small inverters. Medium to large homes generally cost less to set up on 24 volts, for the reasons below.

2. Inverter size: Inverter requirements beyond 2,000 watts or so indicate 24 volts, for lower cost per watt and higher efficiency.

3. DC well pump or other large motors: Motors above ¼ HP often necessitate the use of 24 volts, whether they are DC motors or AC run by inverter. Large motors are more efficient at higher voltages. High current is required to start most motors, so both wire and inverter need to be oversized. So the potential savings are especially great in going to higher voltage for motor circuits.

4. Wiring distances: Long wire runs from PV (photovoltaics, or solar cells) or (especially) wind or hydro generators, to a DC well pump, or to other buildings, can be very costly at low voltage/high current. The longer the distance, the larger the wire must be to reduce losses. So cutting the current in half by using twice the voltage can cut your wire cost by nearly 75%.

5. Plans for future growth: If any of the above indicate a requirement for 24 volts in the **future**, set up for it from the start so you won't be left with obsolete equipment (such as electronics) on a 24-volt system. High quality 24-volt lights are nearly as common as 12. Many large DC motors and pumps are not available at all in 12 volts, because the lower voltage motors are less efficient and require costly, over-sized wire, breakers and switches.

We do not go to 48 volts very often, because we cannot get DC lights, refrigerators, and well pumps at that voltage. Most PV dealers and users agree that DC power still has its place for running the specialized, super-efficient DC appliances made specifically for independent power. Direct use of DC in well-engineered appliances reduces both energy consumption and inverter requirements.

We are maintaining 12 and 24 volts as our DC home standard because it is safer and less costly to use than higher DC voltages. (1) Less battery cells are required (they are 2 volts each) with less connections between them. (2) High DC voltage from batteries (120 volts) poses a serious shock hazard (twice that of 120 volt AC). (3) High DC voltage poses more fire hazard (it causes much bigger sparks) than AC power at the same voltage. Low voltage virtually eliminates these hazards. 120 volt DC is used in industrial power systems, but generally not in homes. Our use of high-efficiency appliances and our elimination of electric heating devices keeps power consumption low, so wire sizes in our DC homes need **not** be 5 or 10 times oversized for low voltage!

A system dedicated to one specialized purpose need **not** conform to the common 12 or 24-volt standard. When a solar system is designed only to power a well pump (with a motor range of ½ to 1 HP) we may go to 60 or 120 volts DC if that optimizes economy and efficiency.

Remember, the final product of your energy system is not volts—it's light, water, communication, mechanical energy, etc. The voltage selected should be that which produces these ends at the lowest overall cost, with a high degree of safety and reliability. Δ