The Code and Balance of Systems Equipment

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As PV systems become more widely distributed, the requirements established by various local codes and the National Electric Code may be imposed upon many of them. Balance of Systems (BOS) manufacturers need to become more aware of the requirements of the National Electric Code (NEC) and the implications of Underwriters Laboratory (UL) Standards concerning power handling equipment. In many cases, charge controllers, inverters, and other PV components may be required to meet the NEC or other codes. Early implementation of these requirements will result in products that are safer, have lower production costs through standardization, have greater performance, and possibly a greater market share. It is also necessary— at least until equipment is standardized— for installers, dealers, and end users to be aware of the internal configuration of these products so that proper system connections can be made.

Equipment and the Equipment Grounding Connection

One of the first things that many electrical inspectors examine is the grounding system. Each metal case (on switch gear, module frames, charge controllers, inverters, etc.) of an alternate energy system of any voltage (including 12 Volt systems) must have some provisions for connecting a grounding wire between the case and a ground rod. This is the equivalent of the green, equipment-grounding wire found on many ac appliances. Since PV equipment is not standardized to the point where plug-in connectors are used, a separate wire must be used. There are specific requirements for how the attachment is to be made (e.g. bare metal, no painted or anodized surfaces, certain sizes of screws and number of threads through the metal). These requirements are spelled out in the appropriate UL Standards and they tell the equipment manufacturer how to provide the grounding point.

Isolation Between Case and Conductors

In addition to this equipment grounding requirement, the metal chassis of any PV equipment must be isolated from the current-carrying conductors. This means that the case may not be internally tied to either the positive or negative current carrying conductor. If such a connection were made internally (as is done in some inverters) and one or more pieces of equipment were grounded, then current could flow through the possibly uninsulated equipment grounding conductors which is not safe and is not allowed by the NEC. UL standards also require this isolation so that one and only one definite connection can be made between the current-carrying conductors and the grounding system. This single connection in grounded systems is usually made at the PV disconnect switch, the battery disconnect switch, or possibly the negative battery terminal. The NEC requirement is that systems over 50 Volts open-circuit voltage must have one current-carrying conductor grounded. Performance requirements (less radio frequency noise, better lamp starting, etc) may also dictate that 12 and 24 Volt systems also be grounded.

Positive Processing Only Please

In a system where one of the conductors is intentionally grounded (usually the negative conductor), this conductor must have either white insulation or be marked with a white marker. In a grounded system, all points on the grounded conductor should be at essentially the same voltage (very near zero) with respect to ground— that is at ground potential. This generally means that no switches or relay contacts or transistors should be placed in the negative conductor inside any piece of equipment. Unfortunately many charge controllers and some inverters on the market use negative conductor processing. They modify or process currents flowing in the negative or grounded conductor. If an alternate energy system unintentionally had more than one connection to ground, then this device would not function properly since some portion of the internal circuitry would be bypassed by the external grounding connections. Even the use of shunts in the grounded or negative conductor may pose problems. BOS manufacturers should restrict all internal processing to the positive, ungrounded conductor. Installers and

users should place meter shunts in the positive legs using equipment designed for that purpose.

Exposed Terminals
All current-carrying terminals and connections in alternate energy systems must be enclosed or otherwise protected from inadvertent contact with people, tools, or other conductors that might cause shock, short circuits or equipment malfunctions. Exposed terminals on charge controllers, load panels, fuse blocks, inverters, batteries, and switches will generally not be allowed by electrical inspectors. This behooves the BOS manufacturer to package PV and other alternate energy systems equipment in enclosures and boxes much like those used by other power equipment manufacturers. These enclosures come in numerous styles and have a NEMA (National Electrical Manufacturers Association) designation as well as UL listing.

Panelboards and Other Control Boxes
The National Electric Code provides information on the construction and mounting of panelboards, switchboards, and other non-standardized control boxes. This information governs the internal layout, working clearances, accessibility, and many other details. It is found in NEC Articles 110, 240, 373, 384, and others. The UL standards also give specific information on construction details for these devices.

Safety, Standardization, and Performance
Adhering to accepted and existing standards such as those in the National Electric Code and those in the UL Standards will result in safer alternate energy systems. Even though component complexity may be increased, the only way that standardization can be achieved in the PV industry is to implement the existing standards and good engineering practices that have withstood the test of time.

Added benefits will accrue for both the user and the industry as these standards are adopted. Performance and durability will increase, costs will come down and PV and other renewable energy systems will become even more widely used.

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