The 2008 NEC

Changes to the *National Electrical Code*

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

Proposals for the 2008 *National Electrical Code (NEC)* are due to the National Fire Protection Association (NFPA) in early November 2005. A team of more than 50 volunteers is developing, reviewing, and coordinating these proposals. Half of the current proposals are outlined below. The second half will be presented in the next issue of *Home Power*. If you want to see the entire list now and keep abreast of any changes, the current set of proposals may be downloaded from the SWTDI Web site (see Access).

690.2 Definitions (New)

Proposal: Add the following new definition to 690.2:
Connector, Locking. A connector that requires a tool or other device to open.
Substantiation: Defines a term used in 690.33(C).

690.5 Ground Fault Protection (Revised)

Proposal: Revise 690.5 as follows:
690.5 Ground Fault Protection. Grounded DC photovoltaic arrays shall be provided with a DC ground-fault protection device meeting the requirements of 690.5 (A) through (C). Ungrounded DC photovoltaic arrays shall comply with 690.35.
Substantiation: Recent events and analyses of PV systems and various types of ground faults and circulating ground-fault currents have revealed the necessity of requiring these fire hazard reduction devices on all PV arrays, not just PV arrays on the roofs of dwellings. Ground faults in PV source and output circuits can carry current continuously without tripping overcurrent devices. It is not possible to place an overcurrent device in a circuit conductor (either grounded or ungrounded) that can interrupt these ground-fault currents without affecting the ability of the circuits to carry normal and expected operating currents. Certain unique aspects of PV modules, subarrays, and arrays, and the ability to generate sustained ground-fault currents dictate that these ground-fault currents are sensed and interrupted at a level of no more than 5 amps. This minimizes the need for significant oversizing of equipment-grounding conductors. Ground faults involving arcing-fault currents will also be held to this value or less.

690.5(A) Ground-Fault Detection and Interruption (Revised)

Proposal: Revise 690.5(A) as follows:
690.5(A) Ground-Fault Detection and Interruption. The ground-fault protection device shall be capable of detecting a ground-fault current at levels of 5 amps or less, interrupting the flow of fault current, and providing an indication of the fault.

Automatically opening the grounded conductor of the faulted circuit shall be permitted to interrupt the ground-fault path. If a grounded conductor is opened to interrupt the ground-fault path, all conductors of the faulted source circuit shall be automatically and simultaneously opened. Manual operation of the main PV DC disconnect shall not activate the ground-fault protection device or result in grounded conductors becoming ungrounded.
Substantiation: See the substantiation for 690.5. The 5-amp level is consistent with IEEE standards on ground faults. The 5-amp level will not result in false trips on older PV arrays that may have distributed ground leakage currents of several amps in rainy weather. Ground-fault devices for small PV systems (up to about 10 KW) will continue to have ground-fault sensing levels in the 0.5 to 1 amp range.

The second paragraph is moved from 690.5(B) to 690.5(A), where it properly describes the various optional methods of interrupting the fault current as required by 690.5(A).

The addition of the last sentence in the second paragraph prevents interconnecting the main DC PV disconnect with the ground-fault protection device, which could leave the PV array ungrounded when the PV disconnect was opened manually during normal service operations or in other situations. This wording also parallels the wording used in 690.35(C)(3) for ungrounded systems.

690.5(B) Disconnection of Conductors (Revised)

Proposal: Revise 690.5(B) as follows:
(B) Isolating Faulted Circuits. The faulted circuits shall be isolated by one of the two following means:

- The ungrounded conductors of the faulted circuit shall be automatically disconnected.
- The inverter or charge controller fed by the faulted circuit shall automatically cease to export energy.

Substantiation: Revising the title from "Disconnection of Conductors" to "Isolating Faulted Circuits" more accurately reflects the intent and actions of the section. An inverter that ceases to export energy, or disconnected ungrounded conductors of the faulted source circuit, both give the same desired effect: The faulted PV circuit produces no power, and the lack of output power provides additional safety and an additional indication that there is a problem. UL is currently listing inverters that cease to export energy under ground-fault conditions as meeting this requirement as written in the 2005 *NEC*. A similar requirement would apply to charge controllers if the first option is not used.

The rewording allows the code requirements to agree with the existing listed hardware.

690.10(A) Inverter Output (Revised)

Proposal: Revise 690.10(A) as follows:

(A) Inverter Output. The AC inverter output shall be permitted to supply AC power to the building or structure service disconnecting means at current levels less than the calculated load of that building or structure. The inverter output rating or the rating of an alternate energy source shall not be less than the largest, single, connected load. General lighting loads shall not be considered to be a single load.

Substantiation: Stand-alone PV systems (PV array, inverters, batteries) are designed and operated based on the available solar energy. Energy conservation by the users allows the supplied buildings or structures to be operated on significantly less power and energy than would normally be used in similar buildings. While the building wiring should meet all code requirements from the main service disconnect through the branch circuits for safety reasons as required by 690.10, the power and energy supplied by the PV system needs to meet only the actual use requirements of the building.

Although not a safety issue, good system design dictates that the electrical system is able to start and run the largest connected load. Many systems have an alternate energy source (backup or standby generator) that is used routinely to start and run larger connected loads. Either the inverter or the alternate energy source should be rated to start that single, largest connected load. Because lighting loads (3 watts per square foot) are under the direct control of the users, are intermittent in nature, and may be reduced to zero as desired, they are not considered a single load.

690.10(D) Energy Storage Requirements (New)

Proposal: Add the new section 690.10(D) as follows:

690.10(D) Energy Storage Requirements. This code does not require any minimum size for the energy storage system in a stand-alone photovoltaic power system.

Substantiation: Stand-alone PV systems (PV array, inverters, batteries) are designed and operated, based on the available solar energy. Many stand-alone PV systems are directly connected to the loads without any energy storage (for example, water pumping systems). Users of systems with energy storage manually adjust energy usage to match available solar energy and the size of the energy storage system. Energy use may be reduced to zero or near zero during extended periods of cloudy weather, or a backup energy supply may be used. Specifying some minimum size for the energy storage system is not practical given the numerous variables, nor is such a specification an electrical safety issue.

690.10(E) Backup Power System (New)

Proposal: Add the new section as follows:

690.10(E) Backup Power System. This code does not require any backup power system in a stand-alone photovoltaic power system.

Substantiation: See the substantiation for 690.10(D). Many stand-alone PV systems do not employ backup power systems. Specifying the requirement for a backup power system is not practical given the numerous variables, nor is such a requirement an electrical safety issue.

690.13 Switch or Circuit Breaker (Revised)

Proposal: Revise the second sentence of 690.13 as shown with the exception. The first sentence and the FPN [fine print note] remain unchanged.

690.13 All Conductors. A switch, circuit breaker, or other device shall not be installed in a grounded conductor, either AC or DC, where operation of that switch, circuit breaker, or other device may leave the marked grounded conductor in an ungrounded and energized state.

Exception: A switch or circuit breaker that is a part of a ground-fault detection system required by 690.5 and where that switch or circuit breaker is only automatically opened and indicated as a normal function of the device in responding to ground faults.

Substantiation: Other sections of the code (240.22) allow a multipole overcurrent device to open a grounded conductor. This allowance is acceptable in a load circuit where the disconnected and now ungrounded conductor becomes unenergized when it is disconnected from the source of energy. However, in many power source circuits, such as DC PV source circuits and AC generator or inverter output circuits, the grounded circuit conductor is usually bonded to ground at a central location on the load side of any disconnecting means. If the disconnecting means or overcurrent device opens the grounded circuit conductor, then that conductor (marked as a grounded conductor) may be energized and ungrounded. This is an unsafe condition. This proposal addresses the issue for PV circuits (AC and DC), where these types of source/supply circuits may be more common than elsewhere, and prevents the ungrounded conductor from being opened under normal operation.

The exception is slightly reworded to allow the grounded conductor to be opened when, and only when, opened as an

automatic function of a code-required ground-fault device. This clarified requirement will ensure that 690.5 ground-fault protection devices are not included as part of the main user-accessible PV disconnect switch that could open a grounded conductor or unground the PV array under normal, manual shutdown operations.

690.14 Additional Provisions (Revised)

Proposal: Revise the 690.14 as shown:

690.14 Additional Provisions. The primary direct current (DC) photovoltaic disconnecting means shall comply with 690.14(A) through 690.14(D).

Substantiation: Clarifies the intent of this section to apply to the primary (main) DC PV disconnect and not to any secondary DC disconnects or AC disconnects that may be installed in the same circuit, such as combiner fuse disconnects or equipment servicing disconnects.

690.31(B) Single-Conductor Cable (Revised)

Proposal: Revise 690.31(B) as shown:

(B) Single-Conductor Cable. Single-conductor cable types SE, UF, USE-2, and single-conductor cable listed and labeled as photovoltaic (PV) cable shall be permitted in exposed outdoor locations for photovoltaic module interconnections in the photovoltaic array. Where exposed to sunlight, Type UF cable shall be identified as sunlight resistant.

Substantiation: Type USE cable was removed from the list of acceptable cables because it does not have the necessary 90°C, wet-rated insulation required in PV module wiring. [USE-2 is acceptable.] A listed and labeled photovoltaic (PV) cable was added and is available for these installations. This cable has a 90°C, wet-rated insulation that is more durable than SE and USE cable insulation, and it has passed the long-duration, 700 hours, accelerated sunlight exposure tests. This PV cable will also meet the requirements for PV cables on the ungrounded PV systems allowed by 690.35.

The revised sentence restricts the use of these exposed cables to module interconnections, and that should prevent them from being used away from the PV array (as some installers are doing). The reference to article 340 is removed because connecting and routing conductors between modules has little relationship to the wiring requirements in 340 II. Long, series-connected strings of PV modules and the listed grounding points preclude routing all conductors of a circuit together inside the PV array as required in 340 II. Away from the PV array, all conductors will be grouped together in a normal *NEC* Chapter 3 wiring system.

690.31(C) Flexible Cords and Cables (Revised)

Proposal: Add the following second paragraph to 690.31(C):

Flexible, fine-stranded cables (finer than Class C stranding) shall only be used with connectors and terminals (individually or on devices) that are specifically listed and marked or otherwise identified for use with such cables.

Substantiation: UL Standard 486 A&B requires that connectors and terminals that are intended for use with flexible, fine-stranded cables be so marked for use with such cables. Very few connectors and terminals have been listed for such use and are so marked. The vast majority of connectors and terminals are unsuitable for use with fine-stranded, flexible cables. However, the limited distribution and wording of the standard has resulted in these unmarked connectors being used improperly with flexible, fine-stranded cables. Failures in several widely different industries have been reported.

690.31(F) Fine-Stranded Cables (New)

Proposal: Add the new section 690.31(F) as follows:

690.31(F) Fine-Stranded Cables. Flexible, fine-stranded cables shall only be used with terminals and connectors that are listed and marked for such use.

Substantiation: See the substantiation for 690.31(C) above.

Code Help

As a *Home Power* reader, your assistance is requested for helping the PV industry formulate the 2008 *NEC*. Grab a copy of the *2005 NEC Handbook* (which explains the code in detail) to see where we are, and then send me your comments and suggestions. You may also submit proposals directly to the NFPA; see the procedure and form in the back of the code. However, substantiations must be strong and technically verifiable.

The 2005 version of my *Photovoltaic Power Systems and the National Electrical Code: Suggested Practices* manual is now available. You may download a color copy from the SWTDI Web site, or you may order a black and white printed copy from Connie Brooks at cjbrook@sandia.gov.

Correction: In the *Code Corner* in *HP102*, the reference to "thread-forming" screws used for module grounding should be changed to "thread-cutting" screws.

Access

John C. Wiles, Southwest Technology Development Institute (SWTDI), New Mexico State University, Box 30,001/ MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 • Fax: 505-646-3841 • jwiles@nmsu.edu • www.nmsu.edu/~tdi

2008 *NEC* Proposals PDF • www.nmsu.edu/~tdi/pdf-resources/2008NECproposals2.pdf

Sponsor: Sandia National Laboratories, Ward Bower, Dept. 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206 • Fax: 505-844-6541 • wibower@sandia.gov • www.sandia.gov/pv

The 2005 *NEC* & the *NEC Handbook* are available from the NFPA, 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org