

PV Changes in the 2011 NEC

by John Wiles

The 2011 *National Electrical Code (NEC)*, published by the National Fire Protection Association (NFPA), is now available, and adopted by some jurisdictions automatically on January 1, 2011. It will be adopted throughout the country over the next three years (possibly longer in some areas).

PV systems and equipment manufacturers, designers, installers and inspectors should get a copy of the 2011 *NEC* and the 2011 *NEC Handbook* (in print or digital). Both the *NEC* and the *Handbook* indicate the code changes with highlighting.

As soon as it becomes available, inspectors typically start reviewing the new *Code* for clarifications of the previous editions, even though their jurisdiction may not adopt the newest *Code* for several years. In many cases where safety enhancements are involved, an authority having jurisdiction (AHJ) will permit or even enforce the requirements of the new *Code* before it is officially adopted.

Overview

For the 2011 *NEC*, the Code-Making Panel 4 (CMP-4) processed Article 690, Solar Photovoltaic PV Systems, and 705, Interconnected Electric Power Production Sources. Previously, CMP-13 had processed those articles. Unfortunately, many carefully thought-out and substantiated proposals were rejected.

Many areas of Article 690 were clarified, some were not, and some added requirements. The 2011 *NEC* moved several sections from Article 690 to Article 705.

General

690.2 Definitions. With the return of *bipolar* arrays, definitions to distinguish *subarray* and *monopole subarray* were added. Bipolar arrays have not been in evidence since the mid 1990s and at that time safety issues with them resulted in *Code* changes.

690.4(B) Identification and Grouping. Extensive marking requirements were added for all circuits in a PV system. Safe maintenance was the justification. When you open a junction box or combiner, circuit identification should be easy.

690.4(E) Wiring and Connections. *Qualified persons* (defined in Article 100) shall install all PV equipment and systems. Specific skills and training including safety training are mentioned in the definition.

690.4(F) Circuit Routing. Circuit routing requirements, such as routing conductors and conduit along beams and rafters, instead of hanging between structural members, were added to reduce the likelihood that firefighters will come into contact with energized circuits. PV circuits inside and outside the building are affected.

690.4(G) Bipolar Photovoltaic Systems. More stringent requirements, such as the physical separation of circuits for bipolar arrays, were added to avoid exceeding the voltage rating on equipment. Inspectors will have to look closely at the voltage ratings of the arrays, inverters and conductors of new systems to make sure monopole subarrays and their circuits are separated when voltage ratings are exceeded, since UL Standard 1741 does not specifically address these types of inverters.

690.4(H) Multiple Inverters. Directory requirements were established for multiple inverters on a single building, so that disconnecting means can be located for each inverter.

Circuit Requirements

690.7(A) Maximum Photovoltaic System Voltage. An "informational note" (previously called a "fine print note") gives a source of temperature data that could be used to calculate cold weather open-circuit voltage.

690.8(B) Ampacity and Overcurrent Device Ratings. An extensive revision was made to clarify and align PV overcurrent device rating and conductor size calculations with basic requirements found elsewhere in the *Code*. See "Code Corner" in *HP141* for details. DC PV conductor ampacity calculations do not always use the 1.56 I_{sc} factor.

690.10(E) Back-fed Circuit Breakers. Clamping requirements for back-fed circuit breakers in stand-alone systems now include requirements for multimode inverters in grid-tied PV systems with battery backup.

690.11 Arc-Fault Circuit Protection (Direct Current). A new requirement was added for a DC PV arc-fault circuit interrupter. It is required for PV systems having a maximum system voltage of 80 volts or greater with PV circuits on or penetrating a building. The arc-fault protection method must detect series arcs in DC PV circuits, interrupt them, disable equipment, and annunciate. Equipment for off-grid systems is available that addresses this need; other equipment is in development.

Disconnecting Means

690.13 Exception No. 2. A disconnecting means will be permitted in the grounded conductor for maintenance actions and made accessible only to qualified people.

690.16(B) Fuse Servicing. Disconnecting means from all sources of energy shall be located at the fuse location or a directory shall be provided to show disconnect location(s). This requirement is aimed at systems with large inverters, which have DC fuses bolted to an input bus bar, with no way

Code Clarifications

Clarifications to the *NEC* may include grammatical corrections or further explanation. The 2011 *NEC* includes clarifications in the following sections:

- 690.4(A) Photovoltaic Systems.
- 690.7(E) Bipolar Source and Output Circuits.
- 690.9(A) Circuits and Equipment. Exception.
- 690.9(B) Power Transformers.
- 690.9(E) Series Overcurrent Protection.
- 690.13 All Conductors.
- 690.16(A) Disconnecting Means.
- 690.43 Equipment Grounding. Clarifications in (A) through (F).
- 690.74(A) Flexible Cables.

to de-energize those fuses without opening every one of the possibly hundreds to thousands of fuse holders in the distant combiner boxes.

Wiring Methods

690.31(B) Single-Conductor Cable. Informational Note. PV wire has a nonstandard outer diameter and conduit fill tables cannot be used.

690.31(E) Direct-Current Photovoltaic Source and Output Circuits Inside a Building. Corrects a long-standing typographical error and indicates that only DC circuits, not AC inverter output circuits, must be in a metal raceway. Allows metal-clad (type MC) cable to be used for DC circuits inside a structure. Four new paragraphs of requirements have been added regarding routing, protection and marking PV circuits inside the building. Addresses conductor protection, maintenance and firefighter concerns.

Conductors under the roof shall be located a minimum of 10 inches below the roof decking. In accessible areas, small metallic raceways and cable assemblies shall be protected from physical abuse. All access points and exposed conduits will be marked as containing PV power sources.

Grounding

690.43(C). Mounting structures for PV modules shall be identified as equipment-grounding conductors or shall have all parts bonded together and to the equipment-grounding system.

690.43(D). PV module mounting devices used for grounding modules shall also be identified as grounding devices.

690.47 Grounding Electrode System. Substantially revised and clarified. The requirements 690.47(C) in the 2005 *NEC*

were merged with the requirements of 690.47(C) in the 2008 *NEC*. See *Code Corner* in *HP133* for details.

690.47(D) Additional Electrodes for Array Grounding, which required additional electrodes for array grounding at all ground- and pole-mounted and some roof-mounted PV arrays, was deleted.

Connection to Other Sources

690.62 Ampacity of Neutral Conductor. This section was moved, with clarifications, to 705.95.

690.63 Unbalanced Interconnections. Referred to 705.100, without changes.

690.64 Point of Connection. Referred to 705.12 with only two changes that affect supply-side connections and multimode inverter utility connections. 690.64(A) becomes 705.12(A) and 690.64(B) becomes 705.12(D).

Storage Batteries

690.72(C) Buck/Boost Direct-Current Converters. Because these devices are designed to alter voltage and current of a PV module or array, a new section has been added to establish how ampacity and voltage requirements are to be calculated for these devices. Although in Section VIII, Storage Batteries, these requirements may also be used for module circuit DC-to-DC converters.

Interconnected Electric Power Production Sources

705.6 System Installation. Qualified persons must do installations of parallel power production sources. Article 100 defines “qualified persons,” similar to 690.4(E) Wiring and Connections.

705.12(A) Supply Side. The sum of the ratings of power production sources shall not exceed the rating of the service—you cannot connect bigger PV systems than the utility service conductors can handle.

705.12(D)(2) Exception. This section describes a method of sizing AC output circuits for battery-sourced, multimode inverters operating in utility-interactive systems. The 120% bus bar (or conductor) equation, where allowed, may use 125% of the rated grid-tied inverter current instead of the rating of the back-fed circuit breaker.

Utility-Interactive Inverters

705.60, .65, .70, .80, .82, .95, and .100 contain requirements that duplicate information in various sections of 690.

The Future

Proposals for the 2014 *NEC* are due to the NFPA by November 4, 2011. Sections that are being examined for revisions include: 250.32—Buildings or Structures Supplied by Feeders or Branch Circuits; Figure 690.1(A)—Identification of Solar Photovoltaic

System Components; 690.2—Definitions; 690.4(D)—Equipment; 690.6—AC PV Modules; 690.x—Microinverters; 690.y—DC-to-DC converters; 690.7(E)—Bipolar Source and Output Circuits; 690.14—Additional Provisions; 705.12—Point of Connection; and others. If you see a section of the *Code* in 690 that is not abundantly clear, contact me with your proposed changes and substantiations.

For updates on proposals being developed by the PV Industry Forum, visit the Solar America Board of Codes and Standards website at www.solarabcs.org.

Note: This will be the last *Code Corner* written by John Wiles. He will continue to discuss code issues in his “Perspectives on PV” column in the IAEI News (www.iaei.com). These articles will also be available on his website (see Access).

Access

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Southwest Technology Development Institute • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html • PV systems inspector/installer checklist, previous “Perspectives on PV,” and *Code Corner* articles

