

What Hath the 2011 NEC Wrought for PV?

By **John Wiles** - March 16, 2011

The 2011 *National Electrical Code (NEC)* has been published by the National Fire Protection Association (NFPA) and is now available from numerous sources. It was adopted by some jurisdictions automatically on 1 January 2011, and will be adopted throughout the country over the next three years or even longer in some areas that are slow to change.

Anyone working with PV systems and equipment in either manufacturing, design, installation, or inspection arenas should get a copy of the 2011 NEC and the 2011 *NEC Handbook*. The *NEC* indicates the code changes (which will not be repeated verbatim here) by highlighting and the Handbook provides additional explanations.

I hope that the following information is reviewed with the 2011 *NEC* in hand or at least it whets the appetite for getting the Code ASAP. Inspectors will usually start reading the new Code as soon as it becomes available for clarifications of the existing code, even though their jurisdiction may not adopt the newest Code for several years. In many cases where safety enhancements are involved, AHJs will permit or even enforce the requirements of the new Code before it is officially adopted by the jurisdiction.

Overview

Code-making panel (CMP) 4 processed Articles 690, Solar Photovoltaic (PV) Systems, and 705, Interconnected Electrical Power Production Sources, for the 2011 NEC. Those articles had previously been handled in CMP-13 for many years. CMP-4 did not have the long-term exposure to PV systems and the unique PV characteristics of current-limited dc generators and utility-interactive ac sources. Many of the carefully thought out and substantiated proposals were rejected for obscure reasons.

In general, we have many areas of Article 690 that were clarified, some that were not, and some added requirements, plus a move of several sections from Article 690 to Article 705. Minor clarifications and grammatical corrections will not be addressed in the following.

690.2 Definitions. Definitions of *subarray* and *monopole subarray* were added so that they can be used in requirements dealing with the return of bipolar arrays. They have not been in evidence since the mid-1990s and at that time the safety issues resulted in code changes.

690.4(A) Installation. Clarification

690.4(B) Installation. 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) Installation. Qualified persons shall install all PV equipment and systems. See the definition of *qualified person* in Article 100. Specific skills and training including safety training are mentioned in the definition.

690.4(F) Installation. Circuit routing requirements were added to reduce the likelihood that fire fighters will come into contact with energized circuits. PV circuits inside and outside the building are affected.

690.4(G) Installation. More stringent requirements for bipolar arrays were added to avoid exceeding the voltage rating on equipment. Inspectors will have to look closely at these new systems since the UL Standard 1741 does not

specifically address these types of inverters.

690.4(H) Installation. Directory requirements were established for multiple inverters on a single building.

690.7(A) Maximum Photovoltaic System Voltage. An Informational Note (previously a Fine Print Note) gives a source of temperature data that could be used to calculate cold weather open-circuit voltage.

690.7(E) Bipolar Source and Output Circuits. A clarification of ground-fault actions on a bipolar array was added.

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 January-February 2011 IAEI News, "Perspectives on PV" for details. DC PV conductor ampacity calculations do not always involve $1.56 I_{sc}$.

690.9(A) Circuits and Equipment. Exception: Clarification.

690.9(B) Power Transformers. Clarification

690.9(E) Series Overcurrent Protection. Clarification

690.10(E) Backfed Circuit Breakers. Clamping requirements for backfed circuit breakers in stand-alone system were modified to include requirements for multi-mode inverters in battery backed up utility-interactive PV systems.

690.11 Arc-Fault Circuit Protection (Direct Current). A new requirement was added for a dc PV arc-fault circuit interrupter. It must detect series arcs in the dc PV circuits, interrupt them, disable equipment, and annunciate. Equipment is in the market addressing this equipment, at least for off grid systems, and other equipment is coming.

690.13 All Conductors. Clarifications.

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

690.14 PV Disconnecting Means. Unfortunately, no changes were approved.

690.16(A) Disconnecting Means. Clarification

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 large inverters which have dc fuses bolted to an input bus bar with no way to de-energize those fuses without opening every single one of the possibly hundreds of fuse holders in the distant combiner boxes.

690.31(B) 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. Corrects longstanding typo and indicates that only dc circuits must be in a metal raceway, not ac inverter output circuits. Allows type MC metal-clad cable to be used for DC circuits inside the structure. Four new paragraphs of requirements have been added on routing, protection, and marking of PV circuits inside the building. Addresses conductor protection, maintenance and fire fighter concerns.

Conductors under the roof shall be 10" below the roof decking. Small metallic raceways and cable assemblies shall be protected from physical abuse in accessible areas. All access points and exposed conduits will be marked as containing PV power sources.

690.43 Equipment Grounding. Clarifications in (A) through (F).

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) 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 2005NEC were merged with the requirements of 690.47(C) in the 2008NEC. See September-October 2009IAEINews "Perspectives on PV" for details.

690.47(D) was deleted.

690.62 Ampacity of Neutral Conductor. Deleted and moved with califications 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; 690.64(A) becomes 705.12(A), and 690.64(B) becomes 705.12(D).

Both sections have needed substantial revisions since 1984.

690.72(C) Buck/Boost Direct-Current Converters. A new section has been added to establish how ampacity and voltage requirements are to be calculated for these devices. Although in Part VIII, Storage Batteries, these requirements may also be used for module circuit dc-to-dc converters.

705.6 System Installation. Qualified persons must do installations of parallel power sources. *Qualified persons* is defined in Article 100.

705.12(A) Supply Side. The sum of the ratings of power production sources shall not exceed the rating of the service.

705.12(D)(2) Exception. Describes a method of sizing ac output circuits for battery-sourced, multi-mode inverters operating in utility-interactive systems. The 120% equation, where allowed, may use 125% of the rated inverter utility-interactive current instead of the rating of the backfed circuit breaker.

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

The Future

We are already working on proposals for the 2014NEC, which are due to NFPA by November 4, 2011. Sections that are being examined for revisions include 250.32, Figure 690.1(A), 690.2, 690.4(D), 690.6, 690.x (microinverters), 690.y

(dc-to-dc converters), 690.7(E), 690.14, 705.12 and others. If you see a section of the Code in 690 that is not abundantly clear, send me e-mail with your proposed changes and substantiations.

Please visit the Solar America Board of Codes and Standards web site www.SOLARABCs.org for updates on proposals being developed by the PV Industry Forum.

For Additional Information

If this article has raised questions, do not hesitate to contact the author by phone or e-mail. E-mail: jwiles@nmsu.edu
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See the web site below for a schedule of presentations on PV and the Code.

A color copy of the latest version (1.91) of the 150-page, Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices, written by the author, may be downloaded from this web site:

<http://www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html>

The Southwest Technology Development Institute web site maintains a PV Systems Inspector/Installer Checklist and all copies of the previous "Perspectives on PV" articles for easy downloading. Copies of "Code Corner" written by the author and published in Home Power Magazine over the last 15 years are also available on this web site:

<http://www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html>

This work was supported by the United States Department of Energy under Contract DE-FC 36-05-G015149



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John Wiles retired in April 2013 as a Senior Research Engineer at the Southwest Technology Development Institute at New Mexico State University. However, he works part time as 25% employee and continues to assist the PV industry, electrical contractors, electrical inspectors, and purchasing agencies in understanding the PV requirements of the National Electrical Code (NEC). He is an active member on six UL Standards Technical Panels. John served as Secretary for the PV Industry Forum involved with Article 690 of the NEC. Over 30 submissions were accepted for the 2011 NEC and 55 proposals were submitted for the 2014 Code. He drafted the text for Article 690 in the 2005 NEC Handbook and 2008 NEC Handbook. Fieldwork involves balance of systems design for PV systems, inspections and acceptance testing of PV systems, test and evaluation of PV components, and the design and installation of data acquisition systems. He bought his first codebook in 1960 and installed his first PV system in 1984. He lived in an off-grid, PV/wind-powered home (permitted and inspected, of course) with his wife Patti, two dogs, and a cat for more than 16 years. His retirement home currently has a 8.5 kW utility-interactive PV system with full-house battery backup and now has three dogs and two cats. He writes the "Perspectives on PV" series of articles for the International Association of Electrical Inspectors in their IAEI News magazine and has published an IAEI book on PV and the NEC for inspectors and plan reviewers. He has a Master of Science Degree in Electrical Engineering.