PV and the 1999 National Electrical Code

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The 1999 NEC has been published. It is available in large bookstores, local electrical supply houses, and directly from NFPA and other organizations. It will be automatically adopted by many states on January 1, 1999, but other jurisdictions may require legislative actions for adoption. The following information summarizes the most significant changes that were made in this code cycle.

Figure 690-1, long a source of confusion to many who thought it was a design diagram for a PV system, has been completely revised to show most of the components in different types of PV systems and how they typically interrelate.

In Section 690-2, many definitions were updated and five new ones were added to clarify the terms used in Article 690. For example, the term "Power Conditioner" was replaced with the more commonly used term "Inverter" and confusing references to solar hot water control systems were removed. The new AC PV module was defined (by the NFPA editors) as an Alternating Current Module, and definitions relating to stand-alone, hybrid, and utility-interactive systems were revised.

Section 690-4 was revised to clarify the interconnections of modules. Except for the Underwriters Laboratory (UL) label requirement for module-protection fuses, "daisy chaining" modules from junction box to junction box should not cause any problems.

Section 690-5, requiring ground-fault protection for the PV array on dwellings, was extensively revised for clarity and to simplify the requirement, while still maintaining system safety. Listed equipment (in utility-interactive inverters, power centers, and as separate components) is now available to meet this requirement. The hard-to-define term "disable" was removed from this section and from Section 690-18.

Section 690-6 is new, and was added to fully define the uses and connection requirements of the AC PV module. Among other things, a ground-fault protection device is required on the dedicated circuit connecting the AC PV module or modules to the load center. Since a receptacle outlet GFCI violates the dedicated circuit requirement, a panel device must be used. Some of the equipment protection ground-fault circuit breakers are not suitable for back feeding.

The UL requirements (found in the instruction manual of listed modules) for multiplying module open-circuit voltage and short-circuit current by 125% before using the NEC have now been included in the NEC. Section 690-7 includes new Table 690-7 that assigns the voltage multiplier as a function of the lowest expected ambient temperature. The factor will increase to 1.25 only when the expected temperature reaches -21° C (-5° F). The correction factor on open-circuit voltage will only be 1.06 if the modules are to be installed where the coldest expected temperature is a balmy 10-25° C (50-77° F). UL Standard 1703 will be modified to remove the requirement from the module instruction manuals. While that is being done, there may be modules in the pipeline that still have this requirement in the instruction manual. Those using the 1999 NEC are cautioned not to duplicate the requirement.

In a similar manner, Section 690-8 was revised to include the 125% multiplier on PV source circuit and PV output circuit currents, previously required in the PV module instruction manual. This section now includes both the 125% multiplying factor required to deal with daily variations in PV module output and the same 125% multiplier required to derate all conductors and overcurrent devices throughout the code. The combined factor of both 125% multipliers for PV source and output circuits is 156%. All other circuits are subject to only a single 125% multiplier (or the 80% derating factor found throughout the NEC).

Section 690-9 has exceptions that do not require overcurrent devices on limited types of circuits. These exceptions generally apply to small, single-module, direct-connected water pumping systems.

Section 690-10 is a new section that should benefit the installer and owner of stand-alone PV systems when

the overly cautious inspector has questions. The code now allows the PV system inverter AC current output to be less than the rating of the building load center or service entrance equipment. A 500 watt inverter may now be legally connected to a 120/240 volt, 200 amp load center. The conductor that is used for this connection only has to be rated to carry the 500 watt output of the inverter, not the 48,000 watts that the service entrance can carry. Also, it is now legal to connect a 120 volt inverter to a 120/240 volt load center when certain conditions are met. There must be no 240 volt circuits and no multi-wire branch circuits in the building.

Section 690-13 was revised to clearly state (at least as clearly as is possible in a code) that a switch or circuit breaker should not be placed in a grounded conductor.

AC PV modules may be grouped together on a single circuit with a single disconnect for all modules according to additions in Section 690-15.

Section 690-17 allows the use of a connector for a disconnect device as long as it is listed for the use and meets certain other code requirements. This applies primarily to AC PV modules.

The new Section 690-52 lists the markings required on AC PV modules.

Utility-interactive systems (including AC PV modules) received considerable attention in the 1999 NEC because of the expected proliferation of these systems. Marking the points of connection of these systems is required by Section 690-54. Most of Part G (Connection to Other Sources) was revised to allow easier connection of utility-interactive systems while still maintaining high levels of safety.

Section 690-72 was revised to require no charge controls for batteries on systems where the maximum charging currents are very low (less than 3% of battery capacity).

A new Part I was added to Article 690 to specifically address systems operating over 600 volts. Some of the larger utility-interactive systems may operate above 600 volts.

1999 NEC Handbook

The 1999 NEC Handbook (available from NFPA) includes significantly more detail, substantiation, and explanation of Article 690 and the changes that were made for 1999. It is also an excellent reference to have for other articles of the NEC, many of which apply to PV systems. It is now in an 8 1/2 by 11 inch format which makes for easier reading, but harder handling.

Changes to the NEC

The 1999 National Electrical Code® (NEC®) has just hit the streets, but complete and well-substantiated proposals for changes to the 2002 NEC are due to the National Fire Protection Association (NFPA) no later than 5 PM EST on Friday, November 5, 1999.

This gives those individuals wishing to change the new 1999 Code less than a year to write and submit the proposed changes and required substantiations. The correct form for submittal to the NFPA can be found in the back of the 1999 NEC. Electronic submissions may also be made. Contact NFPA for details. I can also forward substantiated proposals to the established PV Working Group regarding Article 690 for review.

Questions or Comments?

If you have questions about the NEC or the implementation of PV systems following the requirements of the NEC, feel free to call, fax, email, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work is supported by the United States Department of Energy under Contract DE-AC04-94AL8500. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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