

# The National Electrical Code—

## Past, Present, & Future

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center  
Sandia National Laboratories

The *National Electrical Code (NEC)*, updated and published every three years by the National Fire Protection Association (NFPA), is the most current and comprehensive electrical safety installation requirements document in the world. The 2002 *NEC* is the current edition, and work is nearly complete on the 2005 edition.

Hundreds of volunteers work on a three-year cycle to review and update the *NEC* to accommodate the latest technology and methods of wiring electrical systems. Representatives from the photovoltaic (PV) industry, academic institutions, the inspector community, testing laboratories, and the electric utility industry meet regularly to modify and update Article 690 of the *NEC*, which deals with PV systems. Although Article 690 covers only eleven pages in the *NEC*, most of the remaining 711 pages of the code also deal with wiring practices and requirements that affect PV installations.

The *NEC* has been legislated into law by nearly all states and by most major cities in the United States. It has been published for more than 100 years and represents the best ideas that have evolved in more than a century of electrical power systems theory, design, and installation practice. There is always room for improvement, and the document continues to evolve. Paperback copies of the *NEC* are available for less than US\$50 at most electrical equipment distributors. The *NEC* and the hardbound *NEC Handbook* are also available directly from NFPA (see Access). The *NEC Handbook* provides additional explanatory detail and numerous pictures and diagrams.

### A Safety Code

The *NEC* began as a fire safety code, but now includes personnel safety. It requires that all equipment be examined for safety. While the local electrical inspector or authority having jurisdiction (AHJ) will inspect the field-installed wiring, the AHJ relies on the listing or labeling mark of an acceptable nationally recognized testing laboratory like UL, ETL, or CSA to provide an indication that all equipment, conductors, and devices have been examined for safety. The listing mark ensures that the equipment has been tested to meet a number of appropriate safety standards relating to

electrical shock and fire hazards. Many inspectors will only inspect or approve systems that have been assembled with listed components. Insurance and mortgage companies may require electrical inspections, particularly on new construction or on additions to existing structures.

The inspector will be looking for the good workmanship required by the *NEC*. PV installations that resemble other electrical installations will be more readily accepted than those installations using equipment or unconventional installation practices that do not resemble normal electrical supply equipment.

All listed equipment comes with labels or instructions that define the requirements (developed in conjunction with the requirements of the *NEC*) for installation and use of that equipment. Violations of these instructions or requirements may result in unsafe systems and equipment damage. The inspector, in many cases, will verify that these instructions have been followed. Almost all of the material that is printed on labels attached to electrical equipment has been placed there to meet a safety requirement—either established by the *NEC* or by a listing laboratory. Much of the material found in equipment instruction and installation pamphlets and manuals is also mandated by safety requirements.

### Code Arrangement

The first four chapters of the *NEC* are general in nature and apply to nearly all electrical systems. Here are the chapter titles and some of the contents:

- Chapter 1. General: Includes definitions and general requirements for electrical installations.
- Chapter 2. Wiring and Protection: Includes the calculations of loads and circuit sizes, overcurrent protection, and grounding.
- Chapter 3. Wiring Methods and Materials: Includes all of the fixed (nonmoving) wiring methods, and ampacity tables showing the current-carrying ability for conductors.
- Chapter 4. Equipment for General Use: Includes numerous types of electrical equipment and portable cords and how they are to be connected and used.

The later chapters of the code cover all of the different types of electrical installations:

- Chapter 5. Special Occupancies: Includes hazardous locations, healthcare facilities, recreational vehicles, mobile homes, motion picture theaters, and numerous other commercial buildings.
- Chapter 6. Special Equipment: Includes items like electric vehicle chargers, audio systems, fuel cells, swimming pools, X-ray equipment, electric welders, and of course, PV systems.
- Chapter 7. Special Conditions: Includes emergency systems, standby systems, utility-interactive systems, fiber optic systems, and power-limited systems.
- Chapter 8. Communications Systems: Includes radio and TV transmitting and receiving systems, CATV systems, and broadband communications systems.
- Chapter 9. Useful tables on conductor properties and sizing, and using raceways and conduit.

### Requirements of the NEC Are Complex

Article 690 in Chapter 6 covers PV installations, but relies on the material in the first four chapters and much other information throughout the code for the basic electrical system requirements. Because many aspects of PV systems are sufficiently different from other electrical systems, Article 690 was developed in 1984 to cover them. Where the requirements of Article 690 differ from other requirements in the *NEC*, Article 690 takes precedence. However, the local electrical inspector has the final say.

The installation of PV systems is at least as complex as the installation of residential electrical systems, and in some cases more complex. To illustrate the complexity—one of the numerous training guides that covers the installation of residential electrical systems is 647 pages long! It takes the apprentice electrician nearly four years of study and practice to reach the journeyman level.

### Safety vs. Performance

*NEC* requirements for PV installations and the requirements found on labels and in instructions for listed equipment, when followed, will generally result in a safe installation. While using equipment listed to UL standards and installing that equipment to *NEC* requirements does not guarantee high levels of performance, higher performance and reliability frequently are achieved.

The code-required manner of sizing components, covered in past (and future) *Code Corner* columns, and the higher quality of listed equipment will generally result in PV systems that have higher levels of performance and reliability than systems that do not meet *NEC* requirements and are not listed. Of course, it is possible to install a code-compliant system using listed equipment in a poorly designed system or with misadjusted equipment, and performance and reliability may suffer.

Please remember that the *NEC* is not a design document, and to quote a senior code-making official: “The *NEC* will

not contain anything that will keep stupid people from making stupid mistakes.” On the other hand, the *NEC* does contain substantial amounts of guidance on how to make your PV system safer and perform better.

### The 2005 Code Cycle

Ward Bower at Sandia National Laboratories and a team of people from the PV industry met several times throughout 2002 and 2003 to write, substantiate, and coordinate proposals and comments for the 2005 *NEC*. Proposals and comments from the *NEC*'s PV industry forum were balanced and contrasted with proposals submitted by organizations like the International Brotherhood of Electrical Workers (IBEW) and others.

The initial proposals for the 2005 *NEC* were submitted on November 1, 2002, just eleven months after the 2002 *NEC* went into effect. The code-making panels met several times during 2002 and 2003. The report on these original proposals was published in July 2003. Comments on the original proposals were submitted at the end of October 2003, and the code-making panels met in late 2003 and early 2004 to formulate the final language. By the time this article is printed, the 2005 *NEC* will be finalized except for minor editorial changes. It will be published in late 2004, and will become effective in most locations on January 1, 2005. In the next *Code Corner*, I will present some of the code changes that have been approved for PV systems in 2005, and start covering some of the code basics.

### Access

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

Sponsor: Sandia National Laboratories, Ward Bower, Department 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206 • Fax: 505-844-6541 • [wibower@sandia.gov](mailto:wibower@sandia.gov) • [www.sandia.gov/pv](http://www.sandia.gov/pv)

The 2002 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (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](mailto:custserv@nfpa.org) • [www.nfpa.org](http://www.nfpa.org)

