Quarterly
VOLUME 2 • 1999

Highlights of Sandia's Photovoltaics Program

Sandia National Laboratories

Sandia is a partner in the National Center for Photovoltaics and is funded by the U.S. Department of Energy, Office of Photovoltaic and Wind Technology.

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This issue of the Photovoltaic Highlights describes the 1999 modifications to Article 690—Solar Photovoltaic Systems—of the National Electrical Code®, which spells out the unique requirements in the United States for the safe installation of photovoltaic systems. Publication of the 1999 NEC®, with a strong and well-developed Article 690 addressing photovoltaic power systems, represents a safety code that enables photovoltaic systems to be installed following clear requirements; it makes the systems easier to inspect, and, above all, makes them safer for the user and for maintenance. Compliance with the NEC requirements may also improve long-term system performance and reliability. Convergence of the publication of this code and other standards and guidelines in 1999 will strengthen the photovoltaic industry's ability to design, install, and apply the technology in a wide range of applications. We provide here an overview of the most significant changes appearing in Article 690, together with related and coordinated efforts of other standards-making groups.

THE 1999 NATIONAL ELECTRICAL CODE® AND NEW STANDARDS CLARIFY REQUIREMENTS FOR INSTALLING PHOTOVOLTAIC SYSTEMS IN THE UNITED STATES

A multitude of guidelines, codes, and standards are available in the U.S. for installing photovoltaic systems. They generally apply to utility-grid-connected, stand-alone, and photovoltaic-hybrid systems. However, an almost universal requirement is that photovoltaic system installations meet the requirements of the National Electrical Code (NEC), which focuses primarily on installation requirements and is legally required in at least 40 states and by most major cities. Some states or municipalities adopt local codes that supplement the NEC to better fit the local environment, while some jurisdictions use only local codes.

The NEC covers installation requirements for fire protection and safety. Other organizations issue publications on related issues such as waveform quality, electromagnetic interference, power factor, voltage ranges, photovoltaic system anti-islanding, and system performance. These publications are generated by the Institute of Electrical and Electronic Engineers (IEEE), the American National Standards Institute (ANSI), the American Society for Testing and Materials (ASTM), and the International Electrotechnical Commission (IEC). In addition, Underwriters Laboratories, Inc. (UL) writes standards for recognizing and listing components, and the International Energy Agency (IEA) sponsors a Photovoltaic Power System (PVPS) implementing agreement through which participating countries collaborate internationally to research and report on photovoltaic system issues such as interconnection, applications, and building-integration. Although the IEA reports are not standards, they are often used as references while new standards and guidelines are being written.

THE NATIONAL ELECTRICAL CODE

The NEC was established in 1897 and has been continually revised and expanded since then. Nearly all devices with external electrical terminals that must be wired or connected to other powered or power-supplying devices come under the auspices of its requirements. Article 690—Solar Photovoltaic Systems—was added to the NEC in 1984 and has been revised and expanded since that time in the course of the NEC's three-year renewal cycle.

The NEC is published as ANSI/NFPA 70 by the American National Standards Institute/National Fire Protection Association and was originally written as a fire-protection document, but now also addresses the issue of human safety, with requirements for ground-fault interrupters and devices that minimize electrical shock hazards. The NEC covers small to large electrical systems. There are no categorizations in the NEC for size of photovoltaic installations.

The NEC requires that, if available, all components used in electrical power systems, including those for photovoltaic systems, be listed by a qualified laboratory. (The term "listed" refers to equipment tested and approved by a qualified electrical testing laboratory that is recognized as having certain specialized facilities and requires suitability for installation in accordance with the NEC.)

The 1999 NEC was published in September 1998 and became effective on January 1, 1999. Most localities that adopt the NEC must legislate the NEC before it is legally required. Fifty-seven proposals for changes to Article 690 were submitted during the latest review cycle by an ad hoc task group and by the general public. The task group, consisting of nine members, was appointed by the National Fire Protection Association and was supported by the U.S. Department of Energy's National Photovoltaics Program, the Solar Energy Industries Association (SEIA), and more importantly, by all sectors of the photovoltaic module and balance-of-system industries. Underwriters Laboratories, Inc. also participated and contributed historical information and coordination with its component and hardware listing standards. Other participants included utility engineers, university experts, systems installers, and users of photovoltaic systems. More than 60 experts participated in formulating the proposed changes for the 1999 NEC.

The advances considered for code changes included ac photovoltaic modules, modular inverters with multiple modes of operation (utility-interactive, stand-alone, and hybrid), photovoltaic module technologies, and building-integrated photovoltaics such as roofing shingles, photovoltaic-laminated roofing, window walls, and facades. Many changes were written to provide clarifications of the current language or to change ambiguous requirements in the existing NEC. All proposed changes made by the task group were based on safety. Other important considerations taken into account while formulating the proposals were photovoltaic system installation impacts, good engineering practices, practicality, interconnection with the utility grid, availability of hardware, cost, and system performance. All of the proposed changes from the task group were accepted, including some with minor changes, during the NEC review process.

Topics covered by significant changes to Article 690 in 1999

Changes to Article 690 for the 1999 NEC are evident throughout the article:

- A new Part I was added to provide guidance for systems over 600 volts.
- Section 690-6 (Alternating Current Modules) was added to address requirements for the new ac photovoltaic module products and their connection to utility lines.
- New sections were added, including 690-10 (Stand-alone Systems), 690-52 (Marking, Alternating-Current Photovoltaic Modules), 690-54 (Interactive System Point-of-Interconnection), 690-60 (Identified Interactive Equipment), and 690-72 (Charge Control). The topics covered below include only the most significant changes for the 1999 NEC.
- *Definitions:* A number of changes and additions were proposed in the definition section (690-2) of the NEC to assure consistent terminology in the remaining sections of Article 690. They defined new devices, cross-referenced the sections of Article 690 to the remainder of the code, and improved consistency in language throughout Article 690. Table 1 lists the new and changed definitions for the 1999 Article 690, along with explanatory details for each.

Definition	Type of Change	Impact, Consequence or Description
AC Module (AC PV Module)	New definition.	Defines AC modules as a complete listed package for Section 690-6 (AC Modules . Allows for code compliant AC module applications.
Array	Minor change to clarify and correct.	Removed the old reference to thermal controllers.
Charge Controller	New definition.	Defined the role of charge controller in photovoltaic systems.
Electric Production and Distribution System	New definition.	Defined a utility grid as one that is not controlled by the photovoltaic system. This was needed to better differentiate hybrid systems.
Hybrid System:	New definition.	Defined hybrid systems and energy sources in hybrid systems. Defined battery as an energy storage device and not a source of energy for Article 690
Interactive System	Change to definition.	Defined an interactive system as tied to the utility grid.
Inverter	Change to definition.	Better defined charging functions associated with some inverters. Retained the reference to "power conditioner" but made code language consistent with common usage.
Inverter Input Circuit	Minor change clarify application definitions.	Defined inverter input circuit for both stand-alone and interactive inverters.
Inverter Output Circuit	Minor change to clarify with new Figure 1.	Clarified definition to be consistent with new Figure 1.
Module	Minor change to clarify new definition.	Clarified definition of conventional photovoltaic modules and differentiated the AC modules.
Photovoltaic Output Circuit	Minor language change.	Changed to make the code language consistent.
Photovoltaic Source Circuit	Minor language change.	Changed to make the code language consistent.
Stand-alone System	Change to clarify.	Clarified and removed the cross-reference to other utility interactive systems.
System Voltage	New definition.	Added to provide consistency throughout Article 690.

Table 1. List of definition changes and additions for Article 690 of the 1999 NEC.

Photovoltaic-unique components figure revised: Revisions to Figure 690-1 were needed since numerous installations were plagued with uncertainty when designers tried to use the existing figure for system design or when electrical inspectors insisted the installed system should look like the figure. The revised figures (now 690-1a and 690-1b) are clearly labeled 'for component identification only' and are purposely designed to identify photovoltaic-unique components, connections, and system options while not resembling an electrical schematic. New Figures 690-1a and 690-1b are shown here as Figures 1 and 2 and include connection and configuration nomenclature and options for grid-tied, stand-alone, and hybrid photovoltaic system applications.

Removal of cross references: Deletion of an old requirement in Article 690-3 requiring interconnected photovoltaic systems to be installed in accordance with the provisions of Article 705 (Interconnected Electric Power Production Sources) removed confusion by placing all photovoltaic-system installation requirements into Article 690. Justification for this action arises from the fact that photovoltaic systems and equipment have characteristics (limited fault current and non rotating equipment for instance) that are different from those of other interactive equipment such as emergency and standby generators addressed in Article 705. This deletion allows Article 690 to stand on its own for all photovoltaic installations.

Ground-fault protection: A revised Section 690-5 (changed from Ground-fault Detection and Interruption to Ground-fault Protection) for photovoltaic arrays on dwellings, was revised extensively to provide clarity and allow alternative methods for satisfying the requirement while still maintaining system safety. Listed equipment that may be included in utility-interactive inverters, power centers, or as individual components are now available to meet this requirement. The revisions provide rules for fault detection, interruption and further requirements for an indication of ground fault.

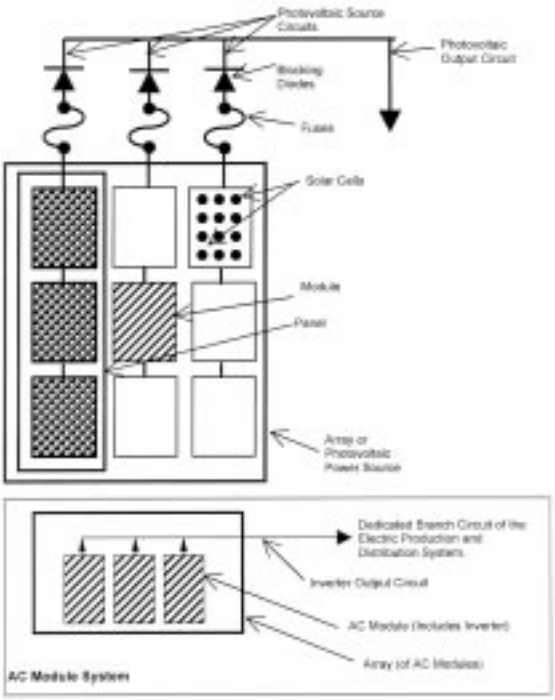

Figure 1. Figure 690-1a, Identification of solar photovoltaic system components, as it appears in the 1999 NEC.

Note 1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
Note 2. Disconnecting means required by 690-Part C are not shown.
Note 3. System grounding and equipment grounding are not shown. See 690-Part E.
Note 4. Custom designs occur in each configuration, and some components are optional.

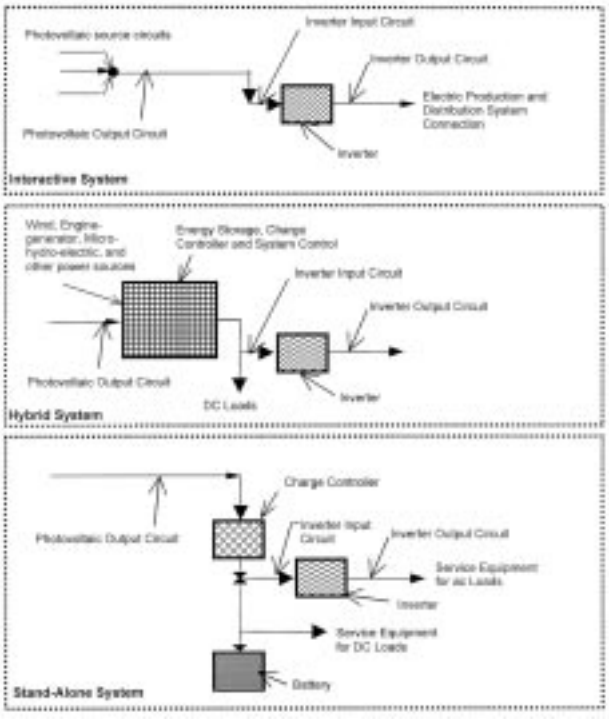

Figure 2. Figure 690-lb, Identification of Solar Photovoltaic System Components in Common System Configurations, as it appears in the NEC.

Alternating-current photovoltaic modules: A significant change to include new photovoltaic devices was the addition of Section 690-6 (Alternating Current Modules). It provides the requirements for hardware, circuits, and labeling for installation of the new and evolving ac photovoltaic module technologies. Although just emerging as a new product, these devices will soon find their way to retail stores, architects' manuals, and builders' product lines. More than 200 ac photovoltaic modules were installed in the U.S. in the past 18 months.

The new section provides the necessary functional requirements for the safe installation and connection of listed ac photovoltaic modules to the utility lines and details the requirements for labeling ac photovoltaic modules. Section (a) acknowledges that ac -photovoltaic modules have no user-accessible dc circuits and that requirements of photovoltaic source circuits in Article 690 are not applicable. Section (c) allows the combined output of multiple ac modules to feed a single dedicated branch circuit as long as each ac module is provided with an accessible disconnect.

Figure 3 shows the world's first UL-listed, complete ac photovoltaic module during installation on a manufactured Roof Jack™ system. The inverter for the ac photovoltaic module is attached at the top-center on the back of the module, and the only electrical connections are through attached and integrated cables and connectors. A licensed electrician normally installs a dedicated branch circuit to which the ac connections are made. Multiple ac modules, up to the capacity of the branch circuit, can then be connected to that circuit at a later time.

System voltage requires temperature compensation: The new section 690-7 (Circuit Requirements, Maximum Voltage) begins with new language for determining maximum system voltage (which is temperature dependent) and other circuit requirements. The new Table 690-7, "Voltage Correction Factors for Crystalline and Multi-crystalline Photovoltaic Modules," and the rules for applying the temperature correction for crystalline and multi-crystalline photovoltaic applications more accurately use local temperature corrections to open-circuit voltage in those

Figure 3. An installation of a Sunsine 300™ ac photovoltaic module showing the fully integrated inverter mounted to the back surface of the photovoltaic module. The integrated connect cables run along the sides of the module.

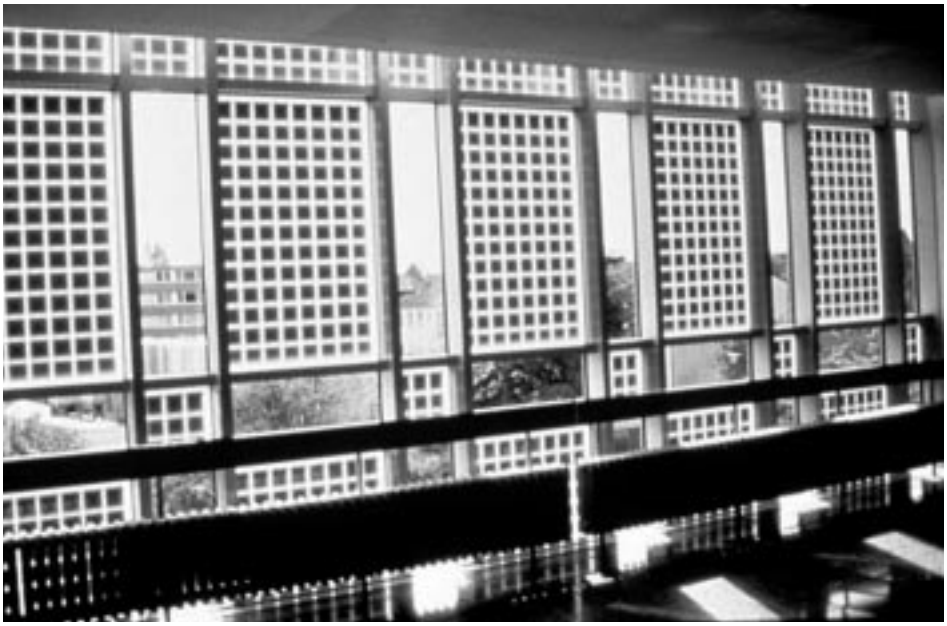

Figure 4. Code compliant photovoltaic system improves safety and long-term performance.

systems. This table addresses the photovoltaic module technology (crystalline) that has the greatest temperature coefficient for open-circuit voltage. The temperature break points for the temperature ranges in the table were carefully selected to match commercially available photovoltaic modules. Section 690-7(a) also gives instructions referring readers to manufacturer's specifications when other than crystalline photovoltaic technologies are installed. Table 2 reproduces the new table in this section of the NEC.

Solar irradiance and conductor deratings: Solar irradiance of 1250 W/m^2 is common for brief periods of time in many parts of the U.S, and that irradiance exceeds the reference 1000W/m^2 for several hours each day in many localities. There has been much confusion in applying the solar

Ambient Temp. °C	For ambient temperatures below 25°C (77°F), multiply the rated open-circuit voltage by the appropriate factor shown below	Ambient Temp. °F
25 to 10	1.06	77 to 50
9 to 0	1.10	49 to 32
-1 to -10	1.13	31 to 14
-11 to -20	1.17	13 to -4
-21 to -40	1.25	-5 to -40

Table 2. Table appearing in Article 690-7 of the 1999 NEC— Correction Factors for Crystalline and Multi-crystalline Silicon Modules.

enhancement and the conductor derating factors because they appeared in different documents. The change in Article 690-8 (Circuit Sizing and Current) for 1999 puts all requirements in the NEC and steps through the calculation. The new NEC language for system voltage and circuit current calculations for wire sizes does require careful coordination with UL Standard 1703. The 1999 NEC requirements will duplicate UL until the requirements of the UL Standard 1703 are modified to remove its solar irradiation and voltage/temperature requirements from the module instruction manuals. In the meantime, there may be modules in the manufacturer-to-user supply line that still have the UL requirement in the instruction manual. Designers and installers using the 1999 NEC are now cautioned not to duplicate the solar irradiation and voltage/temperature requirements. UL has begun a 1999 code compatibility review of its UL Standard 1703 called "Standard for Flat-Plate Photovoltaic Modules and Panels."

Interconnection requirements: Two related new sections in the 1999 NEC address connecting inverters to service entrance panels and were written to clarify the requirements for supplying power in Article 690-10 (Stand-Alone Systems) to service entrance hardware at lower than service-panel-rated currents and for sizing conductors. Changes using "maximum system voltage" terminology were also included to provide code language consistency.

Changes were included to provide the necessary language in Section 690-64(b) (Point-of-Connection) to allow the ac connection of photovoltaic systems at the load side of the service disconnecting means or at any distribution equipment on the premises. This serves as a practical means of connecting photovoltaic systems, since photovoltaic arrays

Photovoltaics and NEC Training for Inspectors

Sandia National Laboratories has sponsored photovoltaic system training for electrical inspectors over the last four years. The Southwest Technology Development Institute (SWTDI) has trained electrical inspectors in New Mexico, Hawaii, Arizona, Colorado, Minnesota, Washington, Maine, North Carolina, and elsewhere. Some of these states have received multiple training sessions. It is estimated that fewer than 5% of the nation's electrical inspectors have been exposed to photovoltaics and the NEC or received formal training on the unique characteristics of photovoltaic power systems.

SWTDI has corresponded with numerous inspectors and state officials in many other states. Its staff gives presentations at annual meetings of the Northwest and Southwest sections of the International Association of Electrical Inspectors and writes articles on photovoltaics and the NEC that are published in the IAEI News magazine. A presentation to the Northwest section of the IAEI is scheduled for September, 1999.

Other training classes for general audiences are given at scheduled events such as the American Solar Energy Society Annual Conference as joint SWTDI/Sandia National Laboratories training courses.

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or
Ward Bower, 505-844-5206, wibower@sandia.gov.)

Please see related article on back page about Solar Training on Sandia's website.

Figure 5. Building integration of photovoltaic systems relies on code compliance for Installation.

may be located on the roof of buildings and the service disconnecting means is usually at a lower level in an equipment room. These changes will better facilitate installation of building-integrated photovoltaic systems (see Figures 4 and 5). The designers and installers are cautioned to observe maximum current ratings on service panels and feeders.

Inverters and multi-wire branch circuits: A change to permit a single-phase, 120-volt inverter to supply power to a split-phase, 120/240-volt service entrance panel (provided there are no multi-wire branch circuits) was made in Article 690-10 (Stand-Alone Systems) to clarify photovoltaic system connections to service entrance panels. It is estimated that there are already more than 50,000 such inverter installations, but no allowance for them was made in the previous editions of the NEC.

New Part I added for systems greater than 600 V: For photovoltaic systems operating at greater than 600Vdc (possibly some of the larger utility-interactive systems), a new Part I (Systems Over 600 Volts) was added. The new section directs that they meet the requirements of the new Article 490 (Equipment, Over 600 Volts, Nominal) added to collect all parts of the code for over 600 volts into one article. The new Part I includes sections that define the maximum battery voltage as the highest voltage experienced under charging conditions. Maximum system voltage is used for the photovoltaic source- and output-circuits.

IEEE STANDARDS, RECOMMENDED PRACTICES, AND GUIDELINES

Because the NEC primarily provides installation requirements, it is worth noting that other standards should be used to assess system or component performance, other safety requirements, and device characteristics. The IEEE Standards Coordinating Committee 21 (SCC21) on photovoltaics has published eight standards and guidelines related to photovoltaic system components. IEEE Standard 1262, "Recommended Practice for Qualification of Photovoltaic Modules," was published in 1997. Other important SCC21 documents include guidelines for terrestrial photovoltaic system criteria, recommended practices for installation of batteries for photovoltaic systems, and recommended practices for sizing of batteries for photovoltaic systems.

Photovoltaic system safety guideline:
A new guide, the IEEE Standard 1374, "Guide for Terrestrial Photovoltaic Power Systems Safety," was published in October 1998. It was written to provide an easy-to-read safety document targeted specifically for photovoltaic systems and closely correlated with the NEC and other ANSI/IEEE

recommended practices and standards. It addresses photovoltaic-specific topics and components related to the design and installation of photovoltaic power systems that affect safety, and suggests good engineering safety practices for photovoltaic electrical balance-of-system design, equipment selection, and hardware installation. Many photovoltaic-unique electrical power requirements are emphasized in the guide. Particular attention is given to the critical temperature requirements for photovoltaic systems at the module and array level. The voltage ratings for cable and insulation types, wiring ampacity, and sizing calculations needed for safe and reliable design are also explained. Other important topics, such as overcurrent protection, required disconnects, grounding, ground-fault protection, surges, transient protection, and instrumentation are also described. Informational examples and recommendations for the selection of the hardware are given in the appendices. The guide is carefully cross-referenced to the applicable articles and sections in the 1996 NEC and will be revised to correspond to the 1999 NEC.

Utility interconnect and interface guidelines

A critical standard for defining utility interface and interconnects, now designated Project Authorization Request (PAR929, "Recommended Practice for Utility Interface of Photovoltaic (PV) Systems") is currently being written to replace an outdated IEEE Standard 929. The targeted publication date is 1999. This document is being revised by utility and photovoltaic industry experts to integrate both the utility and photovoltaic system issues into a document that can be used by utilities, designers, and installers for utility acceptance of installations of utility-interactive photovoltaic systems. Important issues that are the focus of the PAR929 include defining requirements for inverter shutdown under abnormal utility conditions, anti-islanding protection, reconnect times after a utility disturbance, the need for manual disconnects, power quality requirements, and direct current isolation.

(Contact John Stevens at Sandia National Laboratories; 505-844-7717; jwsteve@sandia.gov)

Underwriters Laboratories Listing Standards

Listing standards for photovoltaic components and systems go hand in hand with the requirements of the 1999 NEC. Underwriters Laboratories, Inc. has just published the first edition of the "UL Standard for Safety: Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems, UL1741," after an Industry Advisory Group (IAG) reviewed the final draft of Subject 1741. The IAG consisted of participants associated with photovoltaic module manufacturing, inverter manufacturing, charge controller manufacturing, ac module development, systems integration, and the U.S. Department of Energy Photovoltaics Program. UL incorporated requirements spelled out in the revised IEEE929 into the UL 1741 standard. The UL1741 standard now includes new language for testing and listing of ac photovoltaic modules, charge controllers, and inverters that meet the revised IEEE Standard 929 requirements.

IEA PHOTOVOLTAIC POWER SYSTEMS COLLABORATION

The IEA Photovoltaic Power Systems (PVPS) Implementing Agreement was established in 1993 as an effort by 20 countries to focus on the planning, design, construction, operation, performance, and promotion of photovoltaic power systems. The mission of the program is to enhance international collaboration efforts through which photovoltaics becomes a more significant energy option in the near future. Task V of the IEA PVPS has an overall objective of developing and verifying technical requirements that will serve as technical guidelines for grid interconnections for building-integrated and other dispersed-power systems. These guidelines focus on safety and reliable interties to the grid at the lowest cost. The work focuses on three categories: photovoltaic system and utility system review, definition of guidelines, and collaborative testing to address technical issues such as islanding or control algorithms with solutions to identified problem areas. Task V has already published several reports on existing interconnect guidelines for photovoltaics on utility distribution systems. A report on interconnection equipment is also available for distribution to industry. Nine technical topics are under investigation in Task V for addressing utility-interconnect guidelines. A summary of the findings for each has been published as part of the final report for Task V and distributed through Sandia National Laboratories and the IEA.

Another important milestone for Task V work was an international workshop held in Zurich, Switzerland on September 15 and 16, 1997. The workshop was designed to involve utilities, inverter manufacturers, photovoltaic system suppliers, and engineers in international discussions on interconnect guidelines. Topics included islanding, reclosing, external-disconnect requirements, overvoltage protection, grounding, and dc injection.

For more information about the information in this issue, contact Ward Bower at Sandia National Laboratories, 505-844-5206, wibower@sandia.gov. The author acknowledges the work of dedicated engineers for their collaborative efforts to bring codes and standards for photovoltaic systems applications to a state-of-the-art level in this technology. A few of the leaders are: Richard DeBlasio of the National Renewable Energy Laboratory who chairs of the IEEE Standards Coordinating Committee 21 [SCC21] on Photovoltaics; Paul Duks, assistant to UL's chief engineer, who provided invaluable correlation with UL standards; Tim Zgonena of UL's Engineering Services Department, who spearheaded review and publishing of the UL Standard 1741; and subcommittee chairs working on code-related PA Rs under the SCC21, including John Stevens of Sandia National Laboratories for PAR929, and John Wiles of the Southwest Technology Development Institute for the IEEE Standard 1374.

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NOTICES

PROPOSALS FOR THE 2002 NEC ARE DUE ON NOVEMBER 5, 1999!

Upcoming Industry Forum to Discuss 2002 Proposals.

The Utility PhotoVoltaic Group UPEx'99 Conference will be held in Tucson, Arizona October 4–6, 1999. An Interconnect Workshop will also be held on Wednesday–Thursday, October 6–7 as part of this conference and it will include NEC topics and issues. An industry forum is scheduled for the afternoon of October 7 to hear proposals and to discuss proposed changes in the 2002 NEC, some of which will cross the Article 690 boundary. Issues already identified for proposed changes include:

1. New definitions.
2. Labeling (especially for batteries associated with photovoltaic systems.)
3. Battery requirements and operating limits for some batteries.
4. Grounding of batteries versus grounding of photovoltaic systems and proposed solutions.
5. Is 690-5 (Ground Fault Protection) an over kill? (What needs to be changed?)
6. Module connection and interrupting the grounded conductor.
7. GFCI and AC photovoltaic modules. (Results of testing GFCI devices that are not rated to be backfed.)
8. Point of interconnection clarifications.
9. Sizing of overcurrent devices and conductors for inverters that have limited output.
10. Requirements for fuses in photovoltaic source circuits.
11. Sizing requirements for photovoltaic source and output circuit equipment-grounding conductors.
12. Elimination of the clamping requirement or restrictions on back fed circuit breakers.

The meeting will include presentations of solutions and suggested proposals. Time will be allotted for discussion. Proposals will be circulated and discussed through a list of participants via e-mail, and all will be given a time allocation (in some instances a presentation will be required). Unresolved issues will be communicated via e-mail. Final proposals may be completed at a similar meeting at the NCPV Performance and Reliability Workshop in Vail, Colorado, October 18–21.

(Contact Ward Bower at 505-844-6541, wibower@sandia.gov, if you want to be included in the email-working group.)

New Web Page Being Developed

The SWTDI is developing a new Web page that will contain a number of links to SWTDI activities, Sandia National Laboratories' Photovoltaics page, NREL, and the DOE photovoltaic programs. One important section will include photovoltaic-related training and code-compliant issues, starting with code-related articles such as *Home Power Magazine* "Code Corner" columns. PV/NEC Frequently Asked Questions will be added. Other renewable energy topics, such as geothermal exploration, wind, battery storage, photovoltaic system performance (data section), and a section on how to test photovoltaic systems, will also be added. The site will be announced here and at Sandia's http://www.sandia.gov/pv. It is expected to be up and running this fall.

(Contact John Wiles, SWTDI, 505-646-6105, jwiles@nmsu.edu or Mike Thomas, 505-844-1548, mgthoma@sandia.gov)

BRIEFS

Performance and Reliability Workshop

The annual Photovoltaic Systems Performance and Reliability Workshop is planned for October 18–21 in Vail, Colorado. Topical sessions are planned for the mornings, followed by standards development meetings to address the issues raised in the morning sessions. Sessions include module performance rating, module qualification testing, power processing, and systems evaluation.

The $200 registration fee includes a daily continental breakfast, lunch, and dinner. Principal organizers are Peter McNutt and Tom Basso of the National Renewable Energy Laboratory. For registration and information, contact Kim Taylor, 303-275-4358.

The National Center for Photovoltaics facilitates technology roadmapping workshop

The photovoltaic industry convened a technology roadmapping workshop in Chicago, June 23–25, 1999. It was attended by nearly 50 members of the photovoltaic industry. One strength of the meeting was that all segments of the industry were represented. Discussion groups focused on four areas: Markets and Applications; Components, Systems, and Integration; Manufacturing, Equipment, and Processes; and Fundamental and Applied Research. The workshop resulted in productive discussions and ideas, which will be documented in a report now being prepared by Energetics, Inc., a consulting firm with a great deal of experience in facilitating roadmapping exercises. After the report is prepared, industry representatives will have the opportunity to review it. The final release is scheduled for September, and it can be viewed on the web at http://www.nrel.gov/ncpv/roadmap.html Preliminary results from the roadmapping workshop will be used by NCPV staff in assisting DOE with its Five-Year Plan for the national Photovoltaics Program and in helping set annual operating plans for the national laboratories and universities involved.

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Solar training programs added to Sandia's Website

On behalf of DOE's Million Solar Roofs Initiative and to make available courses for solar systems of all types, Sandia added to its website training programs offered throughout the country.

To access them, go to www.sandia.gov/pv then click on "What's Hot" and "Solar Training and Education Courses," or access the list directly from the homepage (see the upper left-hand corner for the "Solar Training Courses" teaser).

If your institution, company, or organization offers coursework to the solar community, please consider having your courses listed on Sandia's website. At a minimum, you will be asked to provide the course name and a brief course description (three or four sentences). If you have these courses listed on your own website, Sandia will then create a link for interested persons that will allow them to access your enrollment and other information directly.

If you not have an electronic posting of the courses you offer, we will ask for a one-page description of the course, the intended audience and level of expertise necessary, the price, and contact information that an interested individual can use to reach you directly. For information on having your courses included, please reply to the PV Systems Assistance Center (505) 844-3698 (phone), (505) 844-6541 (fax); pvsac@sandia.gov.

Sandia is a partner in the National Center for Photovoltaics. Work performed for the Million Solar Roofs Initiative is jointly funded by the Department of Energy's Million Solar Roofs Program, Peter Dreyfuss, Director, and the Department of Energy's Office of Photovoltaic and Wind Technology, James Rannels, Director.

Sandia creates and distributes a variety of publications on photovoltaic systems and their applications. For a list of these documents, please contact the Photovoltaic Systems Assistance Center:

through e-mail: *pvsac@sandia.gov*
by phone: *505-844-3698*
by FAX: *505-844-6541*

by mail: *Photovoltaic Systems Assistance Center*
MS 0753
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185-0753

SAND99-2207 Printed September 1999
This work was supported by the United States Department of Energy under Contract DE-AC04-94AL85000. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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Printed September 1999