

SOLAR ENERGY EDUCATION & TRAINING

BEST **PRACTICES**

Textbooks, References and Other
Instructional Resources



Interstate Renewable Energy Council, Inc.

U.S. DEPARTMENT OF
ENERGY | Solar Instructor
Training Network
National Administrator

 **SunShot**
U.S. Department of Energy

www.sitnusa.org

Letter from the Program Manager for IREC

National Administrator of the Solar Instructor Training Network

As a boy, I was fascinated with tools while working with my father, and later, as an electrician in the construction industry. The phrase, the right tool for the right job, became readily apparent to me. I appreciated the value of using the right tool to complete a task efficiently, producing a high-quality result. As a former community college professor of 32 years, I look at the Best Practices documents with the same appreciation of the right tool for the right job.

IREC assembled some of the best experts in the country on solar training, education, and workforce development to create this compendium of Best Practices. I am forever indebted to them for their efforts. The documents were thoughtfully designed to give solar instructors the right tools for the job of training a highly-skilled, globally-competitive solar energy workforce for the 21st Century. This suite of Best Practices documents builds on IREC's earlier versions of Best Practices from 2008 and 2010.

As a college professor building my solar program, I had scarce resources and tools to choose from to support my efforts. Separately and collectively, these Best Practices documents enable instructors to easily enhance current solar curriculum, while providing a detailed roadmap for instructors who are considering adding solar to related trades curriculum. These documents have the potential to significantly enhance the quality of solar education and training. How I wish I had something like these Best Practices when I was developing my solar program.

And now, thanks to the SITN, you do. As National Administrator of the SITN, IREC believes these documents will hasten the development of exemplary solar training programs. I am enormously proud to be associated with such an erudite team of solar educational professionals.

IREC will be working closely with the Regional Training Providers (RTPs) of the SITN to further enhance these Best Practices documents. By tapping the strengths of each RTP, the SITN will garner even more resources and best practices to share with solar instructors, creating an even brighter future for solar education and training here in the U.S.

From all of us at the SITN and IREC Team, we are pleased to offer these tools for you in your work.

Joe Sarubbi

PROJECT MANAGER

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About IREC

The Interstate Renewable Energy Council, Inc. supports market-oriented services targeted at education, coordination, procurement, the adoption and implementation of uniform guidelines and standards, workforce development, and consumer protection. IREC's mission is to accelerate the sustainable utilization of renewable energy and energy efficient sources and technologies. IREC is a nonprofit organization formed in 1982.

About the SITN

Launched in 2009, the U.S. Department of Energy established the Solar Instructor Training Network, composed of nine Regional Training Providers (RTPs) to help fulfill a critical need for high-quality, local, and accessible training in solar system design, installation, sales, and inspection through train-the-trainer programs. The nine RTPs are well-established solar training institutions that offer expert trainers and first-class training facilities across the U.S. The institutions and organizations are listed by region:

Region 1: Kennebec Valley Community College and Hudson Valley Community College

Region 2: Pennsylvania State University

Region 3: The Solar Center at North Carolina State University.

Region 4: Florida Solar Energy Center at University of Central Florida

Region 5: Midwest Renewable Energy Association

Region 6: Houston Community College-Northeast and Ontility

Region 7: Salt Lake Community College, Solar Energy International and Utah Solar Energy Association

Region 8: California Community Colleges Board of Governors, California Energy Commission, California Centers for Sustainable Energy, the Labor Management Cooperation Committee

About DOE SunShot Initiative

The U.S. Department of Energy SunShot Initiative is a collaborative national initiative to make solar energy cost competitive with other forms of energy by the end of the decade. Reducing the installed cost of solar energy systems by about 75% will drive widespread, large-scale adoption of this renewable energy technology and restore U.S. leadership in the global clean energy race.

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Introduction

The purpose of this document is to assist instructors in designing, developing, and implementing courses in photovoltaic (PV) systems and solar heating and cooling (SHC) systems. It lists recommended training suites for both PV and SHC instructors—as well as textbooks, key references, and teaching materials that may be useful. Key references relate to occupational safety and health, electrical codes, structural building codes, and plumbing codes in addition to design and installation, minimum standards for equipment certification, and effective training methods.

In addition to technical references for both PV and SHC systems, there are links to magazines, online documents, and Web sites that may be useful to you.

A Recommended Training Suite for PV Installation Instructors

Any institution interested in training PV system designers or installers should have a suite of training materials that instructors can use to design, develop, and implement their courses. These materials provide the substantive content for training. Instructors should be intimately familiar with the documents that are directly related to their areas of responsibility. Such a training suite might include the following documents:

- **Photovoltaic Systems, 3rd Edition, by James P. Dunlop, 2012**—ISBN 978-0-8269-1308-1, National Joint Apprenticeship and Training Committee and American Technical Publishers, available at www.jimdunlopsolar.com

This text, which is based on the Photovoltaic Installer task analysis developed by the North American Board of Certified Energy Practitioners (NABCEP), has been accepted by almost all of the electrical industry and many other education and training institutions as the primary reference for PV system design and installation training.

- **Photovoltaics: Design and Installation Manual, 2007**—ISBN 978-0-86571-520-2, Solar Energy International (SEI), available at www.solarenergy.org
Please check the website for a new edition expected in the coming months.

Available in both English and Spanish, this reference has been regularly updated to keep pace with changes in technology, codes and best practices. It has been used extensively by SEI to train PV practitioners in the U.S. and throughout the world. SEI also licenses the use of slides and other teaching material to accompany the text.

- **The Photovoltaic Systems Training Resource Guide**—available at www.jimdunlopsolar.com

This sixteen-set compendium of Microsoft PowerPoint® slides covers all aspects of solar PV systems technology and deployment. The explanatory notes that accompany the slides are very useful. The resource guide was

developed to help faculty and instructors create and teach courses in PV systems. It is a companion resource to the textbook Photovoltaic Systems by James P. Dunlop (listed above). Together, the textbook and resource guide can be used for both introductory and advanced courses and for audiences ranging from entry-level, young-adult learners to incumbent professionals in related trades and disciplines.

- **Code of Federal Regulations, Chapter 29 Part 1926: Safety and Health Regulations for Construction**—Occupational Safety and Health Administration, available at www.osha.gov

Safety is the single most important issue associated with PV system installation and maintenance. PV installers should become very familiar with Chapter 29, Part 1926 of the OSHA regulations for construction. It is recommended that instructors introduce a fairly comprehensive overview of this reference and associated safety issues early in PV installer training courses. Reference to specific safety issues should be reinforced throughout the courses.

- **2011 National Electrical Code®, NFPA 70 or 2011 National Electrical Code Handbook**—National Fire Protection Association, available at www.nfpa.org

This reference is the key document that governs installation practices for most electrical systems, including PV. All PV installers should be familiar with the latest version of the National Electrical Code, with special emphasis on Article 690 Solar Photovoltaic Systems.

- **NABCEP Photovoltaic (PV) Installer Resource Guide, prepared by William Brooks and James Dunlop**—North American Board of Certified Energy Practitioners (NABCEP), available at <http://www.nabcep.org/resources>

This guide is essential for course participants preparing for the PV entry-level exam or the PV installer certification exam. Instructors should use the examples and sample problems in this reference as practice exercises in problem solving, decision-making, and applying knowledge gained in training courses. This reference is updated by NABCEP periodically, check the website provided for the latest version.

Other Useful References for PV Designers and Installers

- **Photovoltaic Systems Engineering, 3rd Edition, 2010, by Roger Messenger and Jerry Ventre**—ISBN 978-1-4398-0292-2, CRC Press LLC, available at www.crcpress.com

This text covers fundamental and advanced system design principles for PV systems. It includes numerous sizing, design, and code calculations and examples and is suitable for both advanced undergraduate and graduate level design courses.

- **Mike Holt’s Illustrated Guide to Understanding NEC Requirements for Solar Photovoltaic Systems**—ISBN 978-1-932685-54-1, Mike Holt Enterprises, Inc., available at www.mikeholt.com

This reference covers all applicable requirements for PV system installations, including illustrated examples, and is based on the 2011 National Electrical Code.

- **Soares Book on Grounding and Bonding, NEC-2011**—ISBN 1-890659-57-6. International Association of Electrical Inspectors, available at www.iaei.org

This reference provides a fundamental and in-depth discussion on grounding and bonding all electrical systems. Complementary instructional resources and study guides are available.

- **Minimum Design Loads for Buildings and Other Structures, ASCE/SEI Standard 7-10**—American Society of Civil Engineers, Reston, Virginia, available at www.asce.org/codes-standards/list (Note: Both the book and CD are available at [http://www.asce.org/Books-and-Journals/Books---Personify/Standards-\(PSD\)/Minimum-Design-Loads-for-Buildings-and-Other-Structures-\(7-10\)-\(Book---CD-Set\)/](http://www.asce.org/Books-and-Journals/Books---Personify/Standards-(PSD)/Minimum-Design-Loads-for-Buildings-and-Other-Structures-(7-10)-(Book---CD-Set)/))

PV designers have a much greater need for this reference than PV system installers. However, installers should be introduced to this document, informed that it is the basis for the structural requirements in most building codes, and presented information on how most installation contractors satisfy those requirements.

- **2009 International Building Code® and 2009 International Residential Code®**—International Code Council (ICC), available at www.iccsafe.org

These model building codes are adopted in all U.S. states and territories by nearly every jurisdiction, and govern all aspects of commercial and residential building construction. In particular, the ICC codes have adopted the National Electrical Code® and the ASCE 7 standard.



- **Battery Service Manual, 12th Edition**—Battery Council International, available at www.batterycouncil.org

This reference provides details of maintenance requirements, practices, and procedures for lead-acid batteries.

- **Roofing Construction and Estimating, by Daniel Atcheson, 2006**—ISBN 978-1-57218-007-9, Craftsman Book Company, available at www.craftsman-book.com

This work provides details of typical roof construction methods and materials, including weather-sealing techniques, and applies to roof-mounted PV installations.

- **Electrical Safety in the Workplace, NFPA 70E, 2012**—National Fire Protection Association, available at www.nfpa.org

This standard defines safe working practices for electrical system installations and is referenced in the National Electrical Code and OSHA standards. It provides guidance on defining the extent and magnitude of electrical hazards and permissible methods for avoiding or mitigating the hazards, including specifications for personal protective equipment.

- **National Design Specification (NDS) for Wood Construction, ANSI/AWC NDS-2012**—American Wood Council, available at www.awc.org/standards/nds.html

This reference provides methods for determining withdrawal loads for screw and other attachments to wood structural members. It is especially useful for structural calculations for roof-mounted PV arrays and other solar collectors.

- **IEEE Standards Association**—<http://standards.ieee.org/>

The IEEE publishes consensus standards on a variety of electrical technologies, including PV systems under IEEE Working Group SCC 21.

- **International Electrotechnical Commission (IEC)**—<http://www.iec.ch/>

This organization coordinates and produces consensus international standards, including standards for PV systems and components under the TC82 working group.

A Recommended Training Suite for Solar Heating and Cooling Instructors



Institutions interested in training solar heating and cooling designers and installers should also have a suite of training materials that can be used by instructors in designing, developing, and implementing courses. A training suite recommended for this area includes the following documents:

- **Planning and Installing Solar Thermal Systems: A Guide for Installers, Architects and Engineers, by Deutsche Gesellschaft für Sonnenenergie, 2nd Edition, 2010**—ISBN 978-1-84407-760-1, James & James (Science Publishers) Ltd., available at <http://www.routledge.com/catalogs/energy/>

- **Solar Water and Pool Heating Manual: Design and Installation & Repair and Maintenance, January 2006**—Florida Solar Energy Center, available at www.fsec.ucf.edu
- **Code of Federal Regulations, Chapter 29 Part 1926: Safety and Health Regulations for Construction**—Occupational Safety and Health Administration, available at www.osha.gov

Safety is the single most important issue associated with the installation and operation of solar heating and cooling systems. System installers need to become very familiar with Chapter 29, Part 1926 of the OSHA regulations for construction. It is recommended that instructors introduce a fairly comprehensive overview of this reference and associated safety issues early in their solar heating and cooling training courses and reinforce specific safety issues throughout the courses.

- **Minimum Design Loads for Buildings and Other Structures, ASCE/SEI Standard 7-10**—American Society of Civil Engineers, Reston, Virginia, available at www.asce.org/codes-standards/list (Note: Both the book and CD are available at [http://www.asce.org/Books-and-Journals/Books—Personify/Standards-\(PSD\)/Minimum-Design-Loads-for-Buildings-and-Other-Structures-\(7-10\)-\(Book—CD-Set\)/](http://www.asce.org/Books-and-Journals/Books—Personify/Standards-(PSD)/Minimum-Design-Loads-for-Buildings-and-Other-Structures-(7-10)-(Book—CD-Set)/))

Solar heating and cooling system designers have a much greater need for this reference than installers. However, system installers should at least be introduced to it, informed that it is the basis for the structural requirements in most building codes, and presented information on how most installation contractors satisfy those requirements.

- **The Copper Tube Handbook**—Copper Development Association, www.copper.org
- **SRCC Document OG 300, Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems, 2010**—Solar Rating and Certification Corporation, www.solar-rating.org
- **Uniform Plumbing Code, 2009**—International Association of Plumbing & Mechanical Officials, available at <http://www.iapmo.org>
- **Active Solar Preheat Systems: Unified Facilities Criteria (UFC 3-440-01.pdf), 2007**—U.S. Department of Defense, available at www.wbdg.org

Other Useful References for Solar Heating and Cooling Designers and Installers

- **Roofing Construction and Estimating, by Daniel Atcheson, 2006**—ISBN 978-1-57218-007-9, Craftsman Book Company, available at www.craftsman-book.com

This work provides details of typical roof construction methods and materials, including weather-sealing techniques, and applies to roof-mounted SHC installations.

- **National Design Specification (NDS) for Wood Construction, ANSI/AWC NDS-2012**—American Wood Council, available at www.awc.org/standards/nds.html

This reference provides methods for determining withdrawal loads for screw and other attachments to wood structural members. It is especially useful for structural calculations for roof-mounted PV arrays and other solar collectors.

- **Solar Domestic Water Heating, by Chris Laughton, May 2010**—ISBN 978-1-84407-736-6, Routledge, available at <http://www.routledge.com/books/details/9781844077366/>
- **Solar Hot Water Systems Lessons Learned 1977 to Today, 2004**—Tom Lane Energy Conservation Services
- **Solar Hot Water Fundamentals: Siting, Design, and Installation, March 2011, by Peter Skinner, Todd Paternoster, Alan Paul, Betsy Ferris Wyman, and Will Skinner**—ISBN-10 0983355207 and ISBN-13 978-0983355205, E2G Solar.
- **Solar Thermal Systems: Successful Planning and Construction, by Felix A. Peuser, Karl-Heinz Remmers, Martin Schnauss, August 2011**—ISBN 978-1-84971-331-3, Routledge, available at <http://www.routledge.com/books/details/9781849713313/>
- **Solar Water Heating: A Comprehensive Guide to Solar Water and Space Heating Systems, by Bob Ramlow with Benjamim Nusz, 2010**—ISBN 978-0-86571-668-1, New Society Publishers, www.newsociety.com
- **NABCEP Solar Heating Study Guide, prepared by Chuck Marken and Vaughan Woodruff, May 2012**—North American Board of Certified Energy Practitioners (NABCEP), available at <http://www.nabcep.org/resources>

General Reference on Teaching-Learning Principles for Educators and Trainers

- **Telling Ain't Training, Harold D. Stolovitch and Erica J. Keeps**—ASTD Press, 2011

This book is an invaluable tool for anyone interested in understanding the learning process, developing training programs that enhance learning, or becoming a better instructor. The text is based on the latest research on human learning and training methods for performance improvement. It is very readable and can be practically applied to all solar training courses.

Links to Useful Magazines

- IAEI News, International Association of Electrical Inspectors<http://www.iaei.org/>
- PHOTON International<http://www.photon-international.com/>
- Home Power<https://homepower.com/>
- SolarPro.....<http://solarprofessional.com/home/>
- Solar Today Magazine<http://www.ases.org/solar-today-magazine/>

Web Sites that Include Links to Useful Information, Publications, and Software

- Solar Instructor Training Network (SITN).....<http://www.sitnusa.org/>
- U.S. DOE SunShot Initiative<http://www1.eere.energy.gov/solar/sunshot/index.html>
- The Solar Career Map.....<http://www1.eere.energy.gov/solar/careermap/>
- National Renewable Energy Laboratory<http://www.nrel.gov/>
- Interstate Renewable Energy Council, Inc.<http://www.irecusa.org/>
- North American Board of Certified Energy Practitioners<http://www.nabcep.org/>
- Florida Solar Energy Center.....<http://www.fsec.ucf.edu/en/>
- Solar Energy Industries Association<http://www.seia.org/>
- Solar Electric Power Association<http://www.solarelectricpower.org>
- The Solar Foundation.....<http://thesolarfoundation.org/>
- The American Solar Energy Society<http://ases.org/>
- PV Watts.....<http://www.nrel.gov/rredc/pvwatts/>
- Southwest Technology Development Institute, PV Codes and Standards Website<http://www.nmsu.edu/~tdi/>
- Database of State Incentives for Renewable Energy (DSIRE).....<http://www.dsireusa.org/>
- OnGrid Solar<http://www.ongrid.net/>
- RETScreen International<http://www.etscreen.net/>
- James and James Science Publishers Ltd.....<http://www.cplbookshop.com/glossary/G267.htm>
- Solar Energy International Publications<http://www.solarenergy.org/publications>
(*new interactive textbook series to be published in 2012/2013*)