

**SOLAR ENERGY**  
**EDUCATION & TRAINING**

**BEST**  
**PRACTICES**

Exemplary Solar Education  
and Training Programs



Interstate Renewable Energy Council, Inc.

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

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

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# 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

# Acknowledgements

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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

As solar markets expand and technology advances, there is a continual need to upgrade education and training of the solar workforce. Although most solar instruction to date has been based on task analyses developed by the North American Board of Certified Energy Practitioners, it has too often been limited to one or two short and intensive courses lasting three to six days. Such courses limit student time for problem solving, decision making, and demonstrating the hands-on skills necessary in the workplace. In addition, students in these courses often lack the prerequisites and academic foundation necessary for effective learning. Almost all of these short courses and workshops can or should be categorized as continuing education (CED) courses. They should not be categorized as education and/or training programs.

It should be noted, however, that the short courses can be extremely valuable in increasing the knowledge and skills of individuals who have already been trained extensively and have the background and experience to absorb the information presented fully and easily apply it in the workplace. For example, a 40-hour course in PV systems installation can be of great value to a journeyman electrician who has repeatedly demonstrated the knowledge application and psychomotor skills required to work safely with electrical circuits and equipment. Such a course can give the electrician valuable add-on knowledge and skills specific to PV system installation.

CED short courses and workshops offered by organizations such as the Florida Solar Energy Center, Solar

Energy International, North Carolina Solar Center, and Midwest Renewable Energy Association are excellent and have been the mainstay of solar training over the last three decades. They should continue to play an important role well into the future.

Although not created for this purpose, CED courses can be very useful for education and training institutions interested in developing for-credit certificate or degree programs. They can be used to: 1) gauge interest among prospective students in the subject matter; 2) provide faculty with valuable experience in teaching the subject matter; and 3) kick start the process of developing more extensive certificate or degree programs.

Developing new, for-credit courses and programs can be a daunting task that usually requires a series of approvals by curriculum committees, department chairs, deans, provosts, and, possibly, state agencies. A course may also have to comply with the requirements of a common course numbering system—a process that can take more than a year. A new continuing education course or independent studies course can be developed and implemented in short order and be offered several times during the period it takes to pursue new, for-credit courses and programs.

The progression that we have seen and encouraged in renewable energy education and training begins with non-credit CED courses. These eventually evolve into more substantial multi-course certificate programs and may culminate in two- or four-year degree programs (as shown in Figure 1 below).

**FIGURE 1:**  
Course Progression in Renewable Energy Education



This paper presents information on six exemplary solar education and training programs. These programs are complete, integrated, and well-organized and provide a solid foundation for those entering the solar workforce. They do not require significant background, experience, and prerequisites of entering students.

The programs include a construction trade apprenticeship program, three multi-course certificate programs, and two Associate in Applied Science (A.A.S.) degree program options. The number of instructional hours ranges from a minimum of 420 to more than 1,000. Each of the programs possesses distinguishing attributes that makes it exemplary and deserving of review and possible emulation by institutions that are considering new solar program development. The programs are described further in the following table.

Program Name	Type of Program	Number of Instructional Hours
Electrical Construction Trades 5-Year Apprenticeship	Apprenticeship	900
Hudson Valley Comm. College PV Installation	Certificate	420
Diablo Valley College Energy Systems – Photovoltaic	Certificate	522
Diablo Valley College Energy Systems – Solar Thermal	Certificate	576
Lane Comm. College Energy Management Technician	A.A.S. Degree	970
Lane Comm. College Renewable Energy Technician	A.A.S. Degree	1,010

## Five-Year Apprenticeship Programs for the Electrical Construction Trades, Including PV Design and Installation

### Description

Apprenticeship programs for electrical construction tradesmen are offered by the International Brotherhood of Electrical Workers (IBEW) training centers, community colleges, vocational training centers, and other institutions. This best-practice example focuses on training programs that use standards developed by the National Joint Apprenticeship and Training Committee (NJATC). The NJATC is jointly sponsored by the IBEW and the National Electrical Contractors Association (NECA), the management association for electrical contractors representing thousands of employers. The IBEW has more than 300 training centers throughout the U.S. Typical apprenticeship for an inside wireman takes five years and consists of 900 hours of classroom and laboratory training, as well as 8,000 hours of on-the-job training.

### Core Curriculum

*(offered over the entire five-year period)*

The core curriculum consists of the following subject matter: DC and AC electrical theory, boot camp, industry awareness, blueprint reading, occupational safety and health, electrical safe work practices, National Electrical Code, codes and practices, wiring and protection, wiring methods, conduit, test instruments, transformers, grounding and bonding, fire alarms, motors and motor controls, rigging, code calculations, and applications.

### Advanced Courses

*(offered over a two-year period)*

Photovoltaic system design and installation are offered at most IBEW training centers as one or more advanced courses. They are taught during the last year or two of the apprenticeship program. The number of instructional

hours varies from one training center to another and may range from 40 to more than 100 hours.

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TOTAL INSTRUCTIONAL HOURS (ELECTRICAL + PV)	900 HOURS
TOTAL INSTRUCTIONAL HOURS SPECIFICALLY IN PV	40 to 100+ HOURS
TOTAL HOURS OF ON-THE-JOB TRAINING (ELECTRICAL + PV)	8,000 HOURS

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### Distinguishing Attributes

Special features of this program include:

- Outstanding training materials such as the Photovoltaic Systems text (by James Dunlop), which was specifically developed for the electrical industry, and the Photovoltaic Systems Resource Guide, which contains an instructor’s guide, instructional outlines, Power-Point presentations for each chapter with explanatory notes, sample exams, electronic images, media clips, answer keys, and test development software
- 8,000 hours of on-the-job training with monthly evaluations in the field plus 900 hours of instruction in the classroom and outstanding hands-on training facilities
- Comprehensive instruction in and practice with the complete National Electrical Code
- A student workbook with 19 sections and numerous problem-solving exercises
- Well-organized and coordinated professional development of training center instructors offered annually through the National Training Institute (NTI)—which includes instruction in technology and processes and the improvement of teaching skills, as well as degrees in education
- Transferability of skills to a very broad range of electrical construction occupations

## Hudson Valley Community College

Troy, New York

Installation Certificate Program

Photovoltaic

### Description

Hudson Valley Community College (HVCC) offers a Photovoltaic Installation Certificate Program that trains students for entry into the expanding PV industry. In partnership with the New York State Energy Research and Development Authority (NYSERDA), HVCC developed a five-course certificate program to meet an expected high demand for rooftop PV systems and corresponding need for qualified PV installers.

The 19 semester credit-hour certificate program consists of both required and elective courses offered as part of the two-year Associate in Occupational Studies (A.O.S.) degree program in Electrical Construction and Maintenance.

*(Note: The duration of the academic semester at Hudson Valley Community College is 15 weeks, and each semester credit-hour (SCH) of purely classroom instruction translates into 15 instructional hours. Laboratory and hands-on sessions require additional contact hours. One semester credit hour of laboratory instruction requires two to three contact hours of instruction. Because of the large amount of hands-on laboratory work, the number of instructional hours shown below is considerably greater than SCH multiplied by 15.)*

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<b>Required Courses for the Photovoltaic Installation Certificate</b>			<b>SCH</b>
IDLT	120	Electricity	3
ECMN	121	Residential Construction Wiring	5
ECMN	122	Commercial Construction Wiring	5
ECMN	210	Photovoltaic Systems Theory and Design	3
ECMN	211	Photovoltaic Systems Installation and Maintenance	3
Total Semester Credit-Hours (SCH) Required			<u>19</u>

**TOTAL INSTRUCTIONAL HOURS FOR THE PV CERTIFICATE 420 HOURS**

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## Distinguishing Attributes

Special features of this program include:

- A solid foundation in DC and AC electrical theory
- Significant hands-on training and practice in residential and commercial wiring
- On-site practice and experience with actual PV system installations
- Approximately 420 hours of highly focused instruction, with an excellent balance of theory and applications
- Highly transferrable skills to a variety of electrical construction occupations

## Diablo Valley College Pleasant Hill, California Certificate of Achievement in Energy Systems Photovoltaic Certificate of Achievement in Energy Systems Solar Thermal

### Description

Diablo Valley College offers an Associate in Science (A.S.) Degree in energy systems. As part of this program, the College also offers two certificates of achievement in energy systems: one in photovoltaics and the other in solar thermal. Both programs prepare students for jobs in installing, designing, servicing, and maintaining residential, commercial, and industrial-size solar systems. To receive the A.S. Degree in Energy Systems, students must also complete general education courses, which are not shown below.

*(Note: The duration of an academic term for Diablo Valley College is 18 weeks. Because this program involves considerable hands-on laboratory work, the number of instructional hours shown below is considerably greater than the number of units multiplied by 18.)*

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<b>Required Courses for Both Specialty Areas</b>			<b>Units</b>
CONST	110	Occupational Safety	2
CONST	114	Blueprint Reading	3
CONST	135	Construction Processes (Residential)	4
ELECT	120	Direct Current Circuits	4
ELECT	266	Electrical Codes: Articles 90-398	3
			<hr/>
			16

### Photovoltaic Specialty Courses

ELECT	121	Alternating Current Circuits	4
ELECT	267	Electrical Codes: Articles 400-830	3
ENSYS	130	Photovoltaic Systems Design and Installation	2
ENSYS	230	Advanced Photovoltaic Systems	2
			<hr/>
			11

Total Units Required for PV Energy Systems Certificate 27 Units

**TOTAL INSTRUCTIONAL HOURS FOR THE PV CERTIFICATE 522 HOURS**

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### Solar Thermal Specialty Courses

CONST	191	Plumbing Code Interpretation	3
ENSYS	140	Solar Thermal Systems	4
ENSYS	260	Solar Photovoltaic and Thermal Installation Techniques	2
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			9

Total Units Required for Solar Thermal Energy Systems Certificate 25 Units

**TOTAL INSTRUCTIONAL HOURS FOR THE ST CERTIFICATE 576 HOURS**

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## Distinguishing Attributes

Special features of this program include:

- 36 hours of training in occupational safety and health
- A strong foundation in all relevant aspects of construction processes
- A solid foundation in DC and AC electrical theory
- Comprehensive instruction in all relevant sections of the National Electrical Code
- 522 hours of highly focused instruction relevant to photovoltaic training and 576 hours of instruction relevant to solar thermal training
- Skills that are highly transferable to a variety of electrical construction and/or plumbing occupations

## Lane Community College Eugene, Oregon

Energy Management Technician (EMT)

Two-Year A.A.S. Degree

Renewable Energy Technician (RET)

Two-Year A.A.S. Degree

### Description

Lane Community College offers a two-year Energy Management Technician A.A.S. degree that gives students several career options: energy management technician, renewable energy technician, and resource conservation management. Only the first two options are considered below. The first-year courses are the same for both energy management technicians (EMTs) and renewable energy technicians (RETs).

*(Note: Lane Community College is on the quarter system. The duration of an academic quarter is typically ten weeks.)*

### First-Year Courses for Both EMTs and RETs

General and foundational education, blueprint reading, introduction to energy management, sustainability in the built environment, energy analysis, alternative energy technologies, introduction to water resources, air conditioning systems analysis, lighting fundamentals and applications, and energy investment analysis.

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Total Quarter Credit-Hours (QCH) for EMT and RET First Year	53 QCH
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### Second-Year Courses for Energy Management Technicians

Commercial air conditioning systems analysis, lighting applications, energy investment analysis, commercial energy use analysis, energy control strategies, building energy simulations, energy accounting, electives, and cooperative education experience in energy management.

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Total Quarter Credit-Hours for the EMT Second Year	44 QCH
Total Quarter Credit-Hours for EMT Two-Year A.A.S. Degree	97 QCH

**TOTAL INSTRUCTIONAL HOURS FOR EMT A.A.S. DEGREE 970 HOURS**

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### Second-Year Courses for Renewable Energy Technicians

Electrical theory 1 and 2; energy investment analysis; renewable energy systems; photovoltaic system design and installation 1, 2, and 3; solar thermal design and installation 1 and 2; electives; and cooperative education experience in energy management.

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Total Quarter Credit-Hours for the RET Second Year	48 QCH
Total Quarter Credit-Hours for RET Two-Year A.A.S. Degree	101 QCH

**TOTAL INSTRUCTIONAL HOURS FOR RET A.A.S. DEGREE 1,010 HOURS**

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### Distinguishing Attributes

Special features of this program include:

- A comprehensive program for energy management technicians that includes approximately 970 hours of instruction with strong emphasis on fundamentals, applications, and analysis
- A comprehensive program for renewable energy technicians that includes approximately 1,010 hours of instruction with a strong foundation in electrical theory and renewable energy
- 120 hours of specific instruction in PV system design and installation in the RET program
- 80 hours of specific instruction in solar thermal system design and installation in the RET program
- Dual use of courses during the first year of both the EMT and RET programs
- Applied cooperative education experience in energy management

### Summary

The six programs discussed in this document are examples of successful education and training programs that are complete, integrated, and well-organized. The programs provide a solid foundation for those entering the solar workforce. Educators interested in developing solar curriculum are encouraged to learn and borrow from these outstanding program achievements.