SOLAR ENERGY EDUCATION & TRAINING

BEST PRACTICES

Solar Content Integration

IREC

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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The following individuals are responsible for the creation of the Solar Energy Education and Training Best Practices Documents; some as lead writers and others as contributors and/or reviewers. As part of the Interstate Renewable Energy Council, Inc. (IREC) Team, these subject matter experts worked tirelessly; devoting time and talent to ensure the Solar Instructor Training Network (SITN) has the best possible instructional resources available for the delivery of solar education and training.

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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

In developing and expanding the solar workforce, the question arises as to whether it is better to educate and train "solar specialists," or it is better to provide supplemental solar knowledge and add-on skills to more traditional occupations. Focus group meetings held by both IREC and the Florida Solar Energy Center have shown that, by a two-to-one margin, industry representatives feel that the added-skills approach is the best strategy at the present time—or at least until there is greater certainty about the demand for solar energy.

For example, providing a journeyman electrician with the added skills to install PV systems may be more prudent than training a "PV installer" from the ground up. If the solar market declines, the PV installer may be out of work, whereas the electrician is still an electrician and can apply his broader talents to non-solar electrical work. Even in a stable solar market, workloads may not be significant enough to keep PV installers fully employed.

This document examines options for educating and training individuals by integrating or infusing solar content into existing education and training programs. Options will be considered for a variety of solar occupations due to the current heavy dependency of solar markets and related solar jobs on federal, state, and utility policies. The recommended approach provides the needed instruction, while minimizing the effects of market volatility and job uncertainty.

Solar Content Integration
What Is It?

Solar content integration is simply the process of determining ways to infuse needed solar content into education and training programs for certain occupations that are closely related to solar occupations. Supplemental solar topics can be integrated into existing courses, or entirely new courses can be integrated into existing programs.

Examples of this are discussed in the Solar Energy Education and Training Best Practices document on Exemplary Solar Programs. For the five-year electrical construction trades apprenticeship program, from 40 to more than 100 instructional hours of PV design and installation have been integrated as advanced course material at most IBEW training centers. Core requirements for training electricians have remained the same, but now apprentices can add PV installation to their marketable skills.

Hudson Valley Community College took required and elective courses from their two-year Electrical Construction and Maintenance Program—including two new PV courses covering theory, design, installation, and maintenance—to create a five-course Photovoltaic Installation Certificate Program (with 420 instructional hours). The two new PV courses can also be taken as part of their existing Associate in Occupational Studies (A.O.S.) two-year degree program.

Diablo Valley College created four new solar courses, combined them with four existing courses that are part of their two-year Associate in Science (A.S.) Degree program in Energy Systems, and created two new certificate programs: Energy Systems—Photovoltaics (nine courses) and Energy Systems—Solar Thermal (eight courses).

Lane Community College created a Renewable Energy Technician (RET) Option as part of its two-year Associate in Applied Science (A.A.S.) Degree program for energy management technicians. The first year of coursework is identical for both the Energy Management Technician (EMT) program and the Renewable Energy Technician option. Renewable energy, PV, and solar thermal courses have been integrated into the second year to provide an attractive option for the A.A.S. degree program.

Figure 1 shows both the total number of instructional hours and hours of solar-specific content that was integrated into existing programs. Students who successfully complete these programs should be able to make an immediate positive contribution to their solar employer and have attained additional knowledge and skills that are transferrable to non-solar occupations.

FIGURE 1:
Hours of Solar-Specific Content Integrated into Six Existing Programs

Program Name	Type of Program	Instructional Hours*	Hours of Integrated Solar Content*
Electrical Construction Trades Five-Year Apprenticeship Program	Apprenticeship (5 years)	900	40 – 100+
Hudson Valley Community College PV Installation	Certificate (5 courses)	420	90
Diablo Valley College Energy Systems – Photovoltaic	Certificate (9 courses)	522	96
Diablo Valley College Energy Systems – Solar Thermal	Certificate (8 courses)	576	138
Lane Community College Energy Management Technician	A.A.S. Degree (2 years)	970	Not Applicable
Lane Community College Renewable Energy Technician	A.A.S. Degree (2 years)	1,010	230

* Approximate Numbers

Opportunities for integrating solar content are shown in Figure 2 below.

In Figure 2, the left column applies to a five-year construction trade apprenticeship program, such as that used by the IBEW to train electricians. Approximately 70 percent of the curriculum involves required core training, while the remaining 30 percent (or approximately 270 hours) is applied to advanced-training options. It is within these advanced-training options that solar PV content can be integrated. As indicated above, the amount of instruction dedicated to PV varies from a minimum of about 40 hours to more than 100 hours. As PV technology, markets, and types of applications expand, the number of instructional hours devoted to PV may increase as well.

The middle column in Figure 2 shows opportunities for integrating solar courses into existing multi-course certificate programs. For example, the National Science Foundation (NSF) continues to sponsor numerous Centers of Excellence through its Advanced Technological Education (ATE) program. Educational institutions, primarily community colleges and their industrial partners that are part of these centers, focus on relevant topics such as advanced manufacturing technology, energy and environmental technologies, electronics, micro- and nanotechnologies, engineering technology, construction technology, and industrial technology. As a result, there are many multi-course certificate programs that develop knowledge and skills that are closely related to the needs of the solar industry. Appropriately integrating one or more solar courses into existing certificate programs both enhances them and makes students more marketable in pursuing job opportunities.

FIGURE 2:
Opportunities for Integrating Solar Content

The right column in Figure 2 shows the wealth of opportunities for positively affecting both two- and four-year degree programs by simply adding one or more solar courses or projects to the curriculum. This can be done with vocational, technology, engineering, business, and other professional degree programs. The Lane Community College option, which leads to an A.A.S. degree for Renewable Energy Technicians (RETs), is a notable example. In addition, incorporating one or more solar courses and/or capstone solar design projects into Bachelor of Science (B.S.) degree programs may interest graduating engineers in a career in solar energy.

Solar Occupations and the SunShot Solar Career Map

Dr. Sarah White recently led an effort to develop a web-based Solar Career Map that describes the many job opportunities available in the solar industry. Readers are encouraged to visit the highly interactive map at the following web address: www1.eere.energy.gov/solar/career-map (see Figure 3 below).

Note that the map is divided into four industry sectors and three job levels. The four industry sectors are: 1) component production; 2) system design; 3) marketing, sales and permitting; and 4) installation and operations. The three job levels are entry, mid-level, and advanced. For each occupation on the career map, the web site provides information about the job—including desired skills, competencies, education, and career pathways.

The interactive career lattice lets users explore opportunities for entering into a specific solar occupation as well as identifying possible routes for lateral career changes and career advancement. Rather than being restricted to just one sector, routes for career advancement often cross into one or more sectors. With the proper experience, education, and training, for example, a solar site assessor (in the marketing, sales, and permitting sector) may advance to a residential PV installer (in the installation and operations sector) or to a residential PV system designer (in the system design sector).

Figure 4 lists all 36 occupations on the Solar Career Map by sector and job level.

Each one of the 36 occupations is discussed in the following sections with respect to desired and preferred level of education and training (from the interactive solar career map) and options for solar content integration.

FIGURE 3:
Interactive Online Solar Career Map

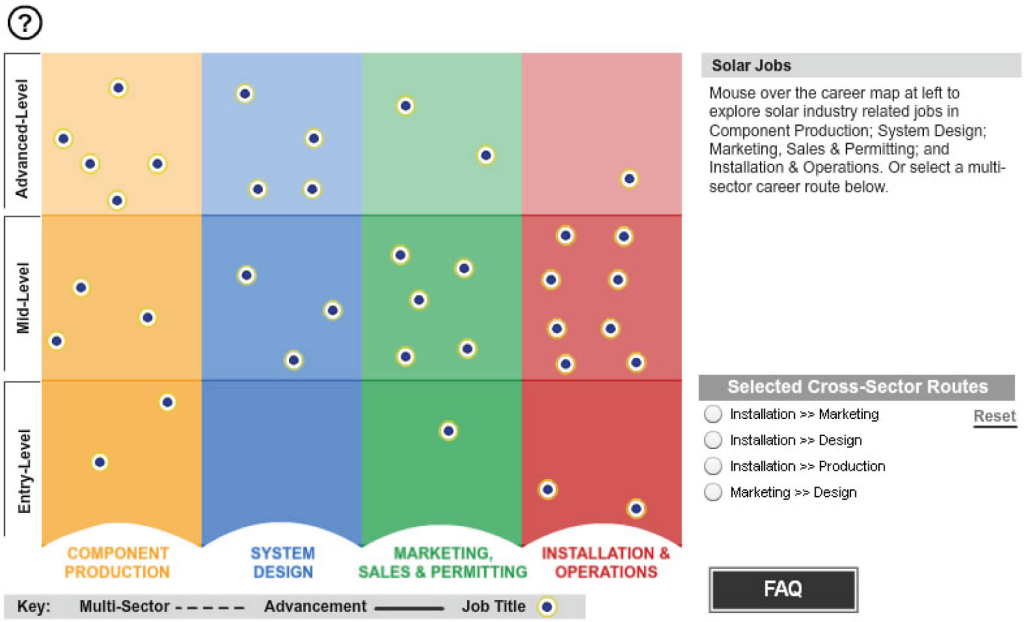

FIGURE 4:
Occupations on the Solar Career Map by Sector and Job Level

	Component Production	System Design	Marketing, Sales and Permitting	Installation and Operations
Advanced Level	Materials Scientist Environmental Engineer Electrical Engineer Mechanical Engineer Industrial Engineer	Solar Energy Systems Designer Power Systems Engineer Structural Engineer Solar Utility Procurement Specialist	Lawyer with Solar Expertise Solar Project Developer/Sales Representative (Wholesale)	Solar Installation Contractor
Mid Level	Process Control Technician Quality Assurance Specialist Instrumentation and Electronics Technician	Utility Interconnection Engineer Residential PV System Designer Engineering Technician	Electrical Inspector with Solar Expertise Code Official with Solar Expertise Building Inspector with Solar Expertise Solar Marketing Specialist Solar Sales Representative (Retail)	Plumber with Solar Expertise Electrician with Solar Expertise Solar PV Technician (Commercial/Utility) Solar Thermal Technician (Commercial/Utility) Solar PV Installer (Residential/Small Commercial) Solar Thermal Installer (Residential/Small Commercial) Roofer with Solar Expertise HVAC Technician with Solar Expertise
Entry Level	Advanced Manufacturing Technician Computer Numerical Control (CNC) Operator		Solar Site Assessor	Mechanical Assembler Solar Installation Helper

Solar Career Map
Component Production Sector

Of the 36 occupations on the career map, ten are associated with the component production sector. Many are associated with designing and manufacturing solar components such as PV modules, power conditioning systems, charge controllers, batteries, tracking and array mounting equipment, electric motors, solar thermal collectors, storage tanks, pumps, and other balance-of-system hardware. Occupations for this sector are classified under entry, mid, and advanced levels.

Component Production
ENTRY LEVEL OCCUPATIONS

	Component Production
Entry Level	Computer Numerical Control (CNC) Operator
	Advanced Manufacturing Technician

Computer Numerical Control (CNC) Operator

Education and Training Level: CNC Operators can learn on the job and/or in post-secondary technical programs, many of which offer short-term diplomas or certificates. Some workers advance through registered apprenticeships; others earn an A.S. or A.A.S. degree to move to higher-level machining, set-up, or programming jobs. *Preferred: Post-secondary credential*

Solar Content Integration: Well-accepted standards for CNC Operators are in place, as are embedded CNC certificate programs in Engineering Technology A.S. and A.A.S. degree programs. A single course in photovoltaic module and/or solar thermal collector fabrication could easily be integrated into one of these certificate programs, which usually consist of approximately 12 semester credit hours of coursework.

Advanced Manufacturing Technician

Education and Training Level: Routes for Advanced Manufacturing Technicians include post-secondary technical diplomas or certificates of varying length and focus that cover everything from lean manufacturing to electronics maintenance. An A.A.S. degree can jump start a Manufacturing or Engineering Technician career. *Preferred: A.A.S. degree; certification*

Solar Content Integration: Well-accepted standards for Advanced Manufacturing Specialists are in place, as are embedded automation certificate programs in Engineering Technology A.S. and A.A.S. degree programs. A single course in photovoltaic and/or solar thermal technology and applications could easily be integrated into one of these certificate programs, which usually consist of approximately 12 semester credit hours of coursework.

Component Production
MID LEVEL OCCUPATIONS

	Component Production
Mid Level	Instrumentation and Electronics Technician
	Quality Assurance Specialist
	Process Control Technician

Instrumentation and Electronics Technician

Education and Training Level: It is possible to become a technician in this field with some focused post-secondary training and a fair amount of experience, but prospects are best for those with an A.A.S. degree. A B.S. degree opens the path to become a technologist or engineer. *Preferred: A.A.S. degree*

Solar Content Integration: Well-defined and accepted standards and curriculum for Electronics Technicians have been developed by the Electronics Technicians Association International (ETAI) and are widely used by education and training institutions throughout the country. ETAI has also developed numerous solar courses for PV installers. Integrating one or more of these courses into degree programs that are already available could be easily accomplished. More specifically, courses in the operation, maintenance, troubleshooting, and repair of photovoltaic systems as part of a two-year A.A.S. degree program can be added. An embedded certificate program that includes the above—as well as courses in test equipment, instrumentation, measurements, computer networking, and diagnostics—would be an attractive option.

Quality Assurance Specialist

Education and Training Level: This position requires a two-year college degree in Quality Assurance and experi-

ence with data, statistics, and technical work. A B.S. degree or higher may be required to pursue management or engineering pathways. Quality Assurance Specialists may start as Inspectors and advance to Engineering Technicians. *Preferred: B.S. degree*

Solar Content Integration: Well-accepted standards for Manufacturing Quality Assurance Specialists are in place, as are embedded six sigma lean-manufacturing certificate programs in A.S. and A.A.S. degree programs for Engineering Technology. A single course in photovoltaic cell, module and/or solar thermal collector fabrication could easily be integrated into one of these certificate programs, which usually consist of approximately 12 semester credit hours of coursework.

Process Control Technician

Education and Training Level: Process Control Technicians typically need at least a two-year A.S. or A.A.S. degree. While Industrial Engineering Technicians may participate in registered apprenticeships, a B.S. in Engineering Technology may be required to advance in management or engineering pathways. *Preferred: B.S. degree*

Solar Content Integration: Well-accepted standards for Process Control Technicians are in place, as are embedded automation and lean-manufacturing certificate programs in Engineering Technology A.S. and A.A.S. degree programs. A single course in photovoltaic cell and module and/or solar thermal-collector fabrication could easily be integrated into one of these certificate programs, which usually consist of approximately 12 semester credit hours of coursework.

Component Production

ADVANCED LEVEL OCCUPATIONS

	Component Production
Advanced Level	Industrial Engineer
	Mechanical Engineer
	Electrical Engineer
	Environmental Engineer
	Materials Scientist

Industrial Engineer

Education and Training Level: A four-year degree in math, science or engineering is the basic requirement for all potential Industrial Engineers. To advance, an Industrial Engineer should pursue a Master of Science (M.S.) degree and become licensed as a Professional Engineer. *Preferred: Postgraduate degree*

Solar Content Integration: An attractive option for students interested in working in the solar-manufacturing industry would be a three-semester, credit-hour (or equivalent) course in photovoltaic systems engineering, possibly as an upper-division elective, combined with a capstone engineering-design project related to PV or solar thermal component manufacturing processes.

Mechanical Engineer

Education and Training Level: A B.S. degree in Mechanical Engineering is required. To advance their careers, Mechanical Engineers can take formal courses, study professional or trade journals, and/or pursue post-graduate degrees in engineering. *Preferred: Postgraduate degree*

Solar Content Integration: An attractive option for students interested in working in the solar-manufacturing industry would be a 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic systems engineering, possibly as an upper-division elective, combined with a capstone engineering-design project related to PV or solar thermal component manufacturing processes.

Electrical Engineer

Education and Training Level: A B.S. in Electrical Engineering is required. To advance in the solar field, Electrical Engineers also need several years of work-related experience and relevant on-the-job training. Entry-level engineers work as junior team members under the supervision of senior engineers. Some jobs require a Professional Engineer (P.E.) license. *Preferred: Postgraduate degree, P.E. license*

Solar Content Integration: An attractive option for students interested in working in the solar-manufacturing industry would be a 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photo-voltaic systems engineering, possibly as an upper-division elective, combined with a capstone engineering-design project related to PV component manufacturing processes.

Environmental Engineer

Education and Training Level: An Environmental Engineer must have a B.S. degree in Environmental Engineering and be conversant in analytical and scientific software, compliance software, and graphic imaging and CAD technology. An M.S. or Ph.D. degree would assist further advancement. *Preferred: Postgraduate degree*

Solar Content Integration: An attractive option for students interested in working as Environmental Engineers in the solar manufacturing industry would be a 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic manufacturing processes and/or photovoltaic systems engineering, possibly as an upper division elective, combined with a capstone engineering-design project related to photovoltaic and semiconductor manufacturing processes.

Materials Scientist

Education and Training Level: This position requires either an M.S. or Ph.D. in Materials Science or Applied Physics, with working knowledge of physics of materials, crystal growth, ceramic fabrication, thin-film deposition, and characterization. It also requires a thorough understanding of materials at elevated temperatures, adhesion, and process optimization. *Preferred: Doctorate degree*

Solar Content Integration: Masters or doctorate-level courses in solar cells and semiconductor manufacturing processes, combined with a related thesis or dissertation topic, would be very useful to Material Scientists interested in working in the solar manufacturing industry.

Solar Career Map
System Design Sector

System design involves the combination of selecting, sizing, and properly integrating the components that have been produced into a solar power system that meets all applicable codes, standards, and accepted industry practices. Seven occupations are shown on the solar career map for the system design sector. For large PV and concentrating solar power (CSP) systems, design is primarily an engineering function. For residential and small commercial PV and solar thermal systems, a two-year technical degree is a typical minimum requirement for most solar companies. Note that no entry-level occupations are listed for this sector.

System Design
MID LEVEL OCCUPATIONS

	System Design
Mid Level	Engineering Technician
	Residential PV System Designer
	Utility Interconnection Engineer

Engineering Technician

Education and Training Level: High school-level trigonometry, geometry, and algebra are essential for this position. The A.S. or A.A.S. degree in Engineering Technology is strongly preferred. Education paths vary depending on the type of engineering involved. Technicians usually need a four-year degree to advance to Technologists or Applied Engineers. *Preferred: A.S. or A.A.S. degree; certification*

Solar Content Integration: Standards and curriculum frameworks for two-year A.S. and A.A.S. Engineering Technician programs are well established. Two or more solar-specific

courses in PV and/or solar thermal system fundamentals, installation, operation, and maintenance, possibly as part of embedded certificate programs, would provide an attractive option and would add to the marketable skills of students interested in working as Technicians in the solar design field.

Residential PV System Designer

Education and Training Level: A.A.S. degree programs that combine green building and residential PV system design provide excellent entry into the solar industry. Other technical design professionals can move into this area with supplemental training. A B.S. in Engineering Technology is recommended to advance. *Preferred: B.S. Degree; certification*

Solar Content Integration: Standards and curriculum frameworks for Construction Technology and Residential Design are well established. Two or more courses in the fundamentals and design of residential and small commercial solar systems, possibly embedded in certificate programs, would be excellent preparation for future PV and solar thermal system designers.

Utility Interconnection Engineer

Education and Training Level: Utility Interconnection Engineers have at least an A.S. or A.A.S. degree and significant experience. They may be promoted from the skilled trades, particularly electricians familiar with grid infrastructure, and advance into management. A B.S. in engineering is becoming the expected entry-level degree. *Preferred: B.S. degree*

Solar Content Integration: A B.S. in Engineering Technology (BSET), with a major in electrical, electromechanical, or electronics, would provide excellent preparation for Utility Interconnection Engineers and offer an excellent vehicle for incorporating at least one course in photovoltaic systems engineering into the curriculum.

System Design

ADVANCED LEVEL OCCUPATIONS

	System Design
Advanced Level	Solar Utility Procurement Specialist
	Structural Engineer
	Power Systems Engineer
	Solar Energy Systems Designer

Solar Utility Procurement Specialist

Education and Training Level: A bachelor's degree with a strong background in math and writing is required for this position. Prior experience with energy markets, renewable energy, energy distribution, and/or grid infrastructure is preferred. To be competitive at the entry level or to advance, an M.B.A. is recommended. *Preferred: Postgraduate degree*

Solar Content Integration: For this important position, especially when dealing with large commercial or utility-scale solar systems, a single course in photovoltaic systems engineering would be extremely valuable. This could be done as an upper-division elective in an undergraduate program, or as part of a highly focused continuing education course.

Structural Engineer

Education and Training Level: A B.S. in engineering (typically civil, mechanical or aerospace) with experience in commercial construction and structural evaluation of buildings is preferred for this position. Entry-level engineers are hired as junior team members and work under the close supervision of senior engineers. Professional Engineer (P.E.) license may be required. *Preferred: P.E. license*

Solar Content Integration: An attractive option for students interested in working in this sector of the solar industry would be a 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic systems engi-

neering, possibly as an upper-division elective, combined with a capstone engineering-design project related to PV or solar thermal system design and applications.

Power Systems Engineer

Education and Training Level: A B.S. in Electrical Engineering, or a graduate degree in Power Engineering, a professional engineering license, and, sometimes, certification in specific power systems are required for this position. An M.S. degree is often necessary for advancement. New engineers generally enter as junior team members under supervision. *Preferred: Postgraduate degree; P.E. license*

Solar Content Integration: An attractive option for students interested in working for a solar system integrator would be at least one 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic systems engineering, possibly as an upper-division undergraduate or graduate elective.

Solar Energy Systems Designer

Education and Training Level: Those interested in this position must possess at least a B.S. degree in science or engineering. To lead large projects, a significant amount of experience in the solar industry and an M.S. Degree may be preferred. *Preferred: Postgraduate degree; P.E. license*

Solar Content Integration: An attractive option for students interested in becoming Solar System Designers would be at least one 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic systems engineering, possibly as an upper-division undergraduate or graduate elective, combined with a capstone engineering-design project related to PV or solar thermal system design and applications.

Solar Career Map
Marketing, Sales, and Permitting Sector

Eight occupations are shown on the career map for the marketing, sales, and permitting sector. Although there will never likely be an occupation entitled Solar Building Official, building code officials and inspectors are included in this sector because of the very important role they play in assuring the quality and safety of installed solar systems. Also, because of the number and type of contracts, permits, approvals and other legal requirements—especially for larger systems—lawyers with solar expertise are shown on the career map in this sector.

Marketing, Sales and Permitting
ENTRY LEVEL OCCUPATIONS

	Marketing, Sales and Permitting
Entry Level	Solar Site Assessor

Solar Site Assessor

Education and Training Level: Solar Site Assessors should pursue industry-specific training and certification to improve skills in site assessment and report writing for residential solar electric, non-residential solar electric, residential solar hot water, and non-residential solar hot water technologies. *Preferred: Apprentice level or post-secondary credential; certification*

Solar Content Integration: The tasks and subtasks associated with solar site assessment are well defined in several of the North American Board of Certified Energy Practitioners (NABCEP) job task analyses. Numerous short courses and workshops that provide comprehensive instruction in this area are widely available. In addition, site assessment can be easily integrated into a post-secondary adult vocational (PSAV) certificate program in solar energy.

Marketing, Sales and Permitting
MID LEVEL OCCUPATIONS

	Marketing, Sales and Permitting
Mid Level	Solar Sales Representative (Retail)
	Solar Marketing Specialist
	Building Inspector with Solar Expertise
	Code Official with Solar Expertise
	Electrical Inspector with Solar Expertise

Solar Sales Representative (Retail)

Education and Training Level: Some companies accept an associate's degree for this position, but many require a bachelor's degree in a technical or scientific discipline. New employees receive product-specific, on-the-job training. Certification is one way to advance PV technical sales expertise. *Preferred: Bachelor's degree; certification*

Solar Content Integration: Many of the tasks and subtasks associated with solar sales are well defined in the NABCEP job task analysis for certification of PV technical salespersons, although the analysis does not emphasize actual sales techniques or salesmanship. New short courses and workshops of two to three days duration are being offered and will soon become more widely available. Solar sales can easily be integrated into a College Credit Certificate (CCC) in business and entrepreneurship, and would typically be complemented with company training on their specific solar products.

Solar Marketing Specialist

Education and Training Level: Those interested in this position should have at least two years of marketing experience, specific industry training, and a related associate's degree. Five years of experience, certification, and a four-year degree in business or marketing supports advancement into more senior analyst positions. An M.B.A. opens the door to management. *Preferred: Bachelor's degree; certification*

Solar Content Integration: A single short course or workshop in photovoltaic and/or solar thermal systems, combined with company training and on-the-job experience with the company-specific solar products that are being marketed, should provide sufficient training for the solar marketing specialist.

Building Inspector with Solar Expertise

Education and Training Level: Inspectors usually have experience in the construction trades, and employers may look for an A.S. or A.A.S. degree in engineering technology. Many states require licensure or certification. Specific solar training is critical for quality inspections, even if only a small part of the job involves solar installations. *Preferred: A.S. or A.A.S. degree; license*

Solar Content Integration: Solar training for code officials can be offered through state associations of building officials, the International Association of Electrical Inspectors, and other industry organizations. IREC is in the process of developing a series of online course modules in solar energy for building officials that can be used to satisfy their professional development requirements.

Code Official with Solar Expertise

Education and Training Level: Code officials typically have at least some post-secondary training. A two- or four-year degree is preferred. Code officials often need a license, depending on the state and their field of expertise. *Preferred: Associate's degree, license*

Solar Content Integration: Solar content can be offered through state associations of building officials, the International Association of Electrical Inspectors, and other industry organizations. IREC is developing a series of online course modules in solar energy for building officials that can be used to satisfy their professional development requirements.

Electrical Inspector with Solar Expertise

Education and Training Level: Electrical Inspectors usually have journey-level electrical construction training. Licensing and certification requirements vary by state. Specific solar training is critical for quality inspections, even if only a small portion of the typical inspector's job involves solar installations. *Preferred: Master Tradesperson certification; license*

Solar Content Integration: Solar training for electrical inspectors can be offered through state associations of building officials, the International Association of Electrical Inspectors, and other industry organizations. IREC is developing a series of online course modules in solar energy for building officials that can be used to satisfy their professional development requirements.

Marketing, Sales and Permitting
ADVANCED LEVEL OCCUPATIONS

	Marketing, Sales and Permitting
Advanced Level	Solar Project Developer/Sales Representative (Wholesale)
	Lawyer with Solar Expertise

Solar Project Developer/Sales Representative (Wholesale)

Education and Training Level: Ideally, the Solar Project Developer or Wholesale Sales Representative has a B.S. degree in engineering, science, or finance, and an M.B.A. *Preferred: Postgraduate degree, certification*

Solar Content Integration: A 3 credit-hour course (for a semester or an equivalent number of instructional hours) in photovoltaic or solar systems engineering, possibly as an upper-division elective, combined with at least three to five years of experience in designing and managing the installation of both small and large-scale PV or solar thermal systems would be desirable for those seeking this high-level responsibility.

Lawyer with Solar Expertise

Education and Training Level: Lawyers are required to earn a four-year college degree followed by three years of law school to earn the J.D. degree and pass the written bar exam. *Preferred: Postgraduate degree*

Solar Content Integration: Solar expertise may be gained on the job or through a certificate in environmental or energy law that includes solar-specific instruction.

Solar Career Map
INSTALLATION AND OPERATIONS SECTOR

Quality installation of solar systems has been a major focus of education and training efforts for many years. Installing solar systems is a job for the construction trades. PV system installation relies very heavily on the skills and competencies of electricians. Roofing, carpentry, and other trade skills are often required as well. Solar thermal installation relies very heavily on plumbing skills and competencies—with roofing, electrical, carpentry, and other trade skills often required. System operation, monitoring, maintenance, troubleshooting and repair activities are typically served by trained technicians. Eleven occupations are shown on the career map for the installation and operations sector.

Installation and Operations
ENTRY LEVEL OCCUPATIONS

	Installation and Operations
Entry Level	Solar Installation Helper
	Mechanical Assembler

Solar Installation Helper

Education and Training Level: This is an entry-level position. Most of those seeking the position have a high school diploma or equivalent and learn through on-the-job training. Ideally, they have at least one year of field and classroom experience in solar. To advance, apprentice-

ship or an A.S. or A.A.S. degree is recommended. *Preferred: Apprenticeship in the construction trades*

Solar Content Integration: Solar content can easily be integrated into post-secondary adult vocational (PSAV) training at community colleges or vocational-technical institutes, and complemented with on-the-job mentoring.

Mechanical Assembler

Education and Training Level: Solar Equipment Assemblers typically learn on the job. *Preferred: High school diploma or equivalent*

Solar Content Integration: Solar content can easily be integrated into post-secondary adult vocational (PSAV) training at community colleges or vocational-technical institutes, and complemented with on-the-job mentoring.

Installation and Operations

MID LEVEL OCCUPATIONS

	Installation and Operations
Mid Level	HVAC Technician with Solar Expertise
	Roofer with Solar Expertise
	Solar Thermal Installer (Residential/Small Commercial)
	Solar PV Installer (Residential/Small Commercial)
	Solar Thermal Technician (Commercial/Utility)
	Solar PV Technician (Commercial/Utility)
	Electrician with Solar Expertise
	Plumber with Solar Expertise

HVAC Technician with Solar Expertise

Education and Training Level: This position requires a two-year HVAC degree and four years of experience, or participation in a registered apprenticeship program that combines paid, on-the-job training with classroom education. Solar-related instruction is often available in both programs. Some states require HVAC technicians to be licensed. *Preferred: Associate or Journey-Level degree; license*

Solar Content Integration: Well-defined and accepted standards and curriculum frameworks for HVAC technicians have been developed and are widely used in apprenticeship programs by education and training institutions throughout the country. A single course in the installation, operation, maintenance, troubleshooting, and repair of solar systems—possibly embedded in an apprentice program or in a certificate program as part of a two-year A.A.S. degree program—would provide the skills needed to work with solar systems.

Roofer with Solar Expertise

Education and Training Level: Roofers are typically trained on the job. They may undergo a three-year apprenticeship, but it is not required. Many solar companies hire roofers and train them to work with solar panels, or train solar electricians to install them properly on roofs. *Preferred: Journeyman Roofer*

Solar Content Integration: The National Roofing Contractors Association has developed a job-task analysis specifically for roof-integrated solar energy that is used to certify roofing professionals involved with solar installations. The solar content that is integrated in the training deals only with those aspects of installations that are within the scope of work for roofing contractors. Alternatives for integrating solar content include on-the-job training with a solar contractor or short courses and workshops that specifically address solar system installation.

Solar Thermal Installer (Residential/Small Commercial)

Education and Training Level: Entry-level Solar Thermal Installers are trained by more experienced installers. Most states require a plumbing license. In addition to licensure, advanced installers can seek certification. *Preferred: Associate Degree or Journeyman Plumber certification; license*

Solar Content Integration: Solar Thermal Installers can receive installation training via plumbing apprenticeship programs that teach solar installation, or via certificate programs embedded in A.S. or A.A.S. programs in plumbing.

Solar PV Installer (Residential/Small Commercial)

Education and Training Level: Entry-level Solar PV Installers typically have a high school degree, or equivalent, and construction experience. To advance, PV Installers should complete a two-year degree or apprenticeship in the construction trades, as well as solar training at an industry-recognized institution. License is required in some states. *Preferred: Associate degree or Journeyman Electrician certification; license*

Solar Content Integration: Solar PV Installers can receive PV installation training via electrical construction apprenticeship programs that teach PV system installation, or via certificate programs embedded in A.S. or A.A.S. programs in PV energy systems or in A.O.S. programs in electrical construction and maintenance.

Solar Thermal Technician (Commercial/Utility)

Education and Training Level: Entrants into this occupation usually transfer into solar from related construction jobs. Many have come up through apprenticeship programs. Certification, master plumber licensing, or a B.S. in engineering can assist in career advancement. *Preferred: Master Plumber or B.S. degree; certification*

Solar Content Integration: In addition to a plumbing trade apprenticeship program and added journeyman training with integrated solar content, training in solar thermal system monitoring, instrumentation, measurements, and troubleshooting would be of significant value for this occupation.

Solar PV Technician (Commercial/Utility)

Education and Training Level: This position requires a Journeyman Electrician license or Journey Power Plant Electrician license. To advance, certification or a master electrician license is encouraged. *Preferred: Master Electrician degree; certification*

Solar Content Integration: In addition to electrical construction apprenticeship programs with integrated solar content, well-defined and accepted standards and curriculum for electronics technicians have been developed by the Electronics Technicians Association International (ETAI) and are widely used by education and training institutions throughout the country. ETAI has also developed a variety of solar courses related to installation, operation, instrumentation, measurements, computer networking, and diagnostics for PV systems. Integrating one or more of these courses into already available degree programs could be easily accomplished.

Electrician with Solar Expertise

Education and Training Level: Electricians can be trained through registered apprenticeships that combine worksite and classroom instruction. Advancing to Journeyman Electrician requires three to five years of experience and successfully passing an examination. Solar expertise requires further experience and training. Master electricians typically need seven years of experience or a B.S. degree and must pass an examination. *Preferred: Journeyman Electrician degree; license*

Solar Content Integration: Organizations such as the National Joint Apprenticeship and Training Committee, jointly sponsored by the IBEW and the National Electrical Contractors Association (NECA), have made efforts to integrate PV training into their electrical apprenticeship programs over much of the last decade. Consequently, many of the more than 300 IBEW training centers include PV system training in their apprenticeship program, as well as similar training for journeyman electricians and electrical contractors. The Independent Electrical Contractors (IEC) Association has made similar efforts among their constituents, as have Underwriters Laboratory University, the Electronics Technicians Association International, and the National Center for Construction Education and Research. In addition, many community colleges and vocational-technical institutes offer solar training as part of their electrical construction programs.

Plumber with Solar Expertise

Education and Training Level: Plumbers may receive training through supervised apprenticeships combining work-site and classroom instruction and can be licensed after two to five years of experience and successfully passing an examination. They can also earn a two-year degree in plumbing/HVAC. To enter the solar industry, plumbers need specialized training. *Preferred: Journeyman Plumber degree; license*

Solar Content Integration: Many plumbing apprenticeship programs are integrating solar thermal content into their instruction and on-the-job training. In addition, community colleges and vocational-technical institutes can easily integrate solar training into their plumbing curriculum.

Installation and Operations

ADVANCED LEVEL OCCUPATIONS

	Installation and Operations
Advanced Level	Solar Installation Contractor

Solar Installation Contractor

Education and Training Level: This position requires an approved state or local license. A master tradesman license may also be required. Solar certification and specific training in construction project management is ideal. *Preferred: Bachelor's or Master Tradesman Degree; certification*

Solar Content Integration: Licensing requirements for contractors who install solar systems vary from state to state, and sometimes from jurisdiction to jurisdiction within a state. To become a contractor, candidates are required to pass examinations that cover both business contracting and technical content. Required solar knowledge and skills can be obtained in many different ways—including continuing education courses in solar design and installation, apprenticeship training for the construction trades, certificate programs, or individual courses offered as part of degree programs.

Special Roles for Community Colleges

Considering the broad spectrum of training needs in solar energy, community colleges can play special roles. Community college offerings include the following:

- Vocational and apprenticeship programs for the construction trades
- Post-secondary adult vocational (PSAV) certificates
- Multi-course certificate programs in solar, renewable energy, and related technologies
- Associate in Applied Science Degree programs
- Associate in Science Degree programs
- Associate in Occupational Studies Degree programs
- Applied Technology Diplomas as part of A.S. or A.A.S. degree programs
- Associate in Arts Degree programs
- 2+2 articulation agreements between community colleges and four-year institutions
- 2+2+2 articulation agreements among high schools, community colleges, and four-year institutions

All of the above offerings lend themselves to meeting specific needs of the solar community. Solar education and training is being integrated into well-established programs such as construction technology, industrial technology, and engineering technology. In the future, as solar technology and markets expand, solar content will increasingly be integrated into advanced manufacturing technology, energy and environmental technologies, and electronics, micro, and nanotechnologies.

Special Role for the Solar Instructor Training Network

IREC is the National Administrator for the Solar Instructor Training Network (SITN). The SITN consists of nine competitively-selected Regional Training Providers (RTPs) dedicated to making high-quality solar training locally available in areas where it is most needed.

The RTPs train faculty throughout their regions to develop and implement solar courses and programs. Because the majority of instructors trained are faculty from community colleges, the SITN and RTPs are in an excellent position to provide guidance and assistance to them in integrating solar content into their certificate and degree programs. Through the SITN, RTPs, and trained faculty, many of the needs of the 36 occupations on the Solar Career Map can be met.