Introduction to Solar Photovoltaics Annotated Instructor's Guide

Module 57101-10

Module Overview

This module is designed for trainees who wish to pursue a career in solar energy. It covers the basic concepts of PV systems and their components. It also explains how PV systems are sized, designed, and installed. Successful completion of this module will help prepare trainees for the North American Board of Certified Energy Practitioners (NABCEP) PV Entry Level Exam.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: *Core Curriculum*; *Electrical Level One*, Modules 26101-08 through 26111-08; *Electrical Level Two*, Modules 26201-08, 26205-08, 26206-08, and 26208-08 through 26211-08; *Electrical Level Three*, Modules 26301-08 and 26302-08; and *Electrical Level Four*, Modules 26403-08 and 26413-08.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Identify photovoltaic (PV) applications and advantages.
2. Identify system components and their functions.
3. Identify safety hazards associated with PV installations.
4. Trace a basic electrical circuit and perform calculations using Ohm's law.
5. List PV system sizing considerations.
6. Identify PV electrical and mechanical system design considerations.
7. Describe the tasks required to complete a site analysis.
8. Identify the effects of the environment on panel output.
9. Describe how to install a simple grid-connected PV system.
10. Explain how to assess system operation and efficiency.
11. Recognize the tasks required when performing PV maintenance and troubleshooting.
12. Identify appropriate codes and standards concerning installation, operation, and maintenance of PV systems and equipment.

Performance Tasks

This is a knowledge-based module; there are no performance tasks.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Solar Photovoltaic Systems Installer PowerPoint® Presentation Slides (ISBN 978-013-230593-8)
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Access to various installed PV systems
Digital AC/DC meter
Clamp-on ammeter
Pyranometer
Infrared thermal device
Torque wrench
Sun path calculator
Site survey checklist
Angle finder
Camera
Compass
Calculator
Tape measure
Ladder
Various types of solar panels and mounting system components
Inverter
Batteries

(*continued*)

Charge controller
AC and DC disconnects
Panel with breaker for inverter connection
Conduit and wire
Copy of the latest edition of the *National Electrical Code®* (*NEC®*)
Module Examinations*

* Available through the Instructor Resource Center by using the access code bound with this book.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Ensure that all trainees are briefed on appropriate field safety procedures, including fall protection, electrical hazards, sun exposure, and battery hazards. If the training center does not have various simple PV systems set up on site, this module will require that the trainees visit one or more job sites in order to view installed PV systems. Ensure that trainees are briefed on site safety policies prior to any site visits.

Additional Resources

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems, Latest Edition. Los Alamitos, CA: Institute of Electrical and Electronics Engineers (IEEE).

National Electrical Code® (NFPA 70), Latest Edition. National Fire Protection Association (NFPA): Quincy, MA.

Occupational Safety and Health Standard 1910.302, Electric Utilization Systems, Latest Edition. Washington, DC: OSHA Department of Labor, U.S. Government Printing Office.

Photovoltaic Systems, Second Edition. James P. Dunlop. Orland Park, IL: American Technical Publishers.

Standard for Electrical Safety in the Workplace® (NFPA 70E), Latest Edition. National Fire Protection Association (NFPA): Quincy, MA.

UL Standard 1703, UL Standard for Safety, Flat-Plate Photovoltaic Modules and Panels, Latest Edition. Camas, WA: Underwriters Laboratories.

UL Standard 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources, Latest Edition. Camas, WA: Underwriters Laboratories.

Uniform Solar Energy Code, Latest Edition. Ontario, CA: International Association of Plumbing and Mechanical Officials (IAPMO).

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 40 hours are suggested to cover *Introduction to Solar Photovoltaics*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Applications	
A. Introduction	_____
B. Applications	_____
1. Standalone Systems	_____
2. Grid-Connected Systems	_____
3. Grid-Interactive Systems	_____
4. Utility-Scale Solar Generating Systems	_____

Session II. Ohm's Law and Power

A. Ohm's Law and Power _____

1. Applying Ohm's Law to Series and Parallel Circuits _____
2. Ohm's Law and Power _____
3. Series and Parallel Circuits in Solar PV Systems _____
4. Peak Sun and Power _____

Session III. PV System Components

A. PV System Components _____

1. PV Panels _____
2. Inverters _____
3. Batteries _____
4. Charge Controllers _____
5. BOS Components _____

Session IV. Safety Considerations in PV Systems

A. Safety Considerations in PV Systems _____

1. Fall Protection _____
2. Battery Hazards _____
3. Electrical Hazards _____
4. Meter Safety _____

Sessions V and VI. Site Assessment

A. Site Assessment _____

1. Customer Interview _____
2. Power Consumption _____
3. Roof Evaluation _____
4. Array Orientation _____
5. Equipment Location _____

Sessions VII and VIII. System Design

A. System Design _____

1. Panel Nameplate Data _____
2. Solar Array Sizing _____
3. Inverter Selection _____
4. Battery Bank Sizing _____
5. Selecting a Charge Controller _____
6. Adjusting PV Conductors _____

Sessions IX and X. Installation

A. Installation _____

1. Forces Exerted on the Panels/Support System _____
2. Roof-Mounted Installations _____
3. Ground-Mounted Installation _____
4. Electrical System Installation _____
5. Assessing System Output Power _____

Session XI. Maintenance; Troubleshooting

A. Maintenance _____
B. Troubleshooting _____
   1. Loose or Corroded System Connections _____
   2. Inverter Losses _____
   3. Heat Fade _____
   4. Burnt Terminals _____
   5. Bypass Diode Failure _____

Session XII. Codes and Standards; Emerging Technologies; Review and Testing

A. Codes and Standards _____
B. Emerging Technologies _____
C. Module Review _____
D. Module Examination _____
   1. Trainees must score 70 percent or higher to receive recognition from NCCER.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.