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 Core Curriculum. It is also suggested that the trainee shall have completed the following modules from the Electrical curriculum: Electrical Level One, Modules 26101 through 26111; Electrical Level Two, Modules 26201, 26205, 26206, and 26208 through 26211; Electrical Level Three, Modules 26301 and 26302; and Electrical Level Four, Modules 26403 and 26413.

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
Multimedia projector and screen
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

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

**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 presents thorough resources for task training. The following resource material is suggested for further study.


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.

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<tr>
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<td>A. Introduction</td>
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<td>B. Applications</td>
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<td>1. Standalone Systems</td>
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<td>2. Grid-Connected Systems</td>
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<td>3. Grid-Interactive Systems</td>
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<td>4. Utility-Scale Solar Generating Systems</td>
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<td>Session III. Ohm’s Law and Power</td>
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<td>A. Ohm’s Law and Power</td>
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<tr>
<td>1. Applying Ohm’s Law to Series and Parallel Circuits</td>
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<td>2. Ohm’s Law and Power</td>
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<td>4. Peak Sun and Power</td>
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<td>Sessions IV and V. PV System Components</td>
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<td>A. PV System Components</td>
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<td>1. PV Panels</td>
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<td>2. Inverters</td>
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<td>3. Batteries</td>
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<td>4. Charge Controllers</td>
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<td>5. BOS Components</td>
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<td>Session VI. Safety Considerations in PV Systems</td>
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<td>A. Safety Considerations in PV Systems</td>
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<td>1. Fall Protection</td>
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<td>2. Battery Hazards</td>
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<td>3. Electrical Hazards</td>
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<td>4. Meter Safety</td>
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<td>Sessions VII and VIII. Site Assessment</td>
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<td>A. Site Assessment</td>
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<td>1. Customer Interview</td>
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<td>2. Power Consumption</td>
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<td>3. Roof Evaluation</td>
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<td>4. Array Orientation</td>
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<td>5. Equipment Location</td>
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</tbody>
</table>
**Sessions IX and X. 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 XI and XII. 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

**Sessions XIII and XIV. 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

**Sessions XV. Codes and Standards; Emerging Technologies**

A. Codes and Standards
B. Emerging Technologies

**Session XVI. Review and Testing**

A. Module Review
B. 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.
Module Overview

A thorough site assessment is essential to the installation of an efficient system that meets the customer’s needs. This module introduces the trainee to the site assessment process for a photovoltaic system.

Objectives

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

1. Determine customer needs:
   - Determine electrical load and energy use by review of utility bills, meter readings, measurements, and/or customer interviews.
   - Estimate and/or measure the peak load demand and average daily energy use for all connected loads.
2. Assess any site-specific safety hazards and/or installation considerations.
3. Identify and use the tools and equipment required for conducting site surveys for PV installations.
4. Identify, select, and sketch a suitable location for PV array installation, including proper orientation, sufficient area, adequate solar access, and structural integrity.
5. Select suitable locations for installing inverters, control(s), batteries, and other components.
   - Identify essential loads for battery systems.
   - Identify opportunities for the use of energy-efficient equipment/appliances, conservation, and energy management practices.
6. Acquire and interpret site solar radiation and temperature data to establish performance expectations and use in electrical system calculations.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum and Solar Photovoltaic Systems Installer, Module 57101-11. It is also suggested that the trainee shall have successfully completed the following modules from the Electrical curriculum: Electrical Level One, Modules 26101 through 26111; Electrical Level Two, Modules 26201, 26205, 26206, and 26208 through 26211; Electrical Level Three, Modules 26301 and 26302; and Electrical Level Four, Modules 26403 and 26413.

Performance Task

Under the supervision of the instructor, the trainee should be able to do the following:

1. Given the results of a customer interview and the sample house drawing provided, complete a site survey and checklist.

Materials and Equipment

- Markers/chalk
- Pencils and scratch paper
- Whiteboard/chalkboard
- Multimedia projector and screen
- Computers with Internet access
- Appropriate personal protective equipment
- Selection of assessment tools
- Sample electric bills
- Pictures of sagging or obviously bad roofs, marginal roofs, and good roofs
- Picture with roof and lot dimensions, roof angle, and number of panels
- Several addresses with good aerial views available on the Internet
- Compass
- Solar Pathfinder™, if possible

(continued)
Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review safety guidelines associated with working on or around photovoltaic systems, including fall protection. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

- Aerial photographs:
- National Geophysical Data Center website: www.ngdc.noaa.gov.
- Solar Source Institute website: www.solarsource.net.
- University of Oregon Solar Radiation Monitoring Laboratory website: solardat.uoregon.edu.

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 10 hours are suggested to cover Site Assessment. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
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<td>Session I. Introduction; Determining Customer Needs</td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>1. Assessment Tools and Equipment</td>
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<tr>
<td>B. Determining Customer Needs</td>
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<tr>
<td>1. Energy Loads</td>
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<td>2. Available Sunlight</td>
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<tr>
<td>3. Mounting Options</td>
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</tbody>
</table>

*Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.
Session II. Mounting Surface Information; Acquiring and Interpreting Site Solar Data

A. Mounting Surface Information
   1. Inspecting Proposed Installation Areas
   2. Inspecting Attic Spaces
   3. Roofing Materials
   4. Spacing
   5. Anchoring

B. Acquiring and Interpreting Site Solar Data
   1. Identifying Sun Paths and Intensity Levels
   2. Shading at the Customer’s Location

Session III. Locations for BOS Components; Documenting Site Assessment; New Technology

A. Locations for BOS Components
   1. Support and Security Structures
   2. Combiners
   3. Charge Controllers
   4. Batteries
   5. Inverters
   6. Disconnects
   7. Grounding

B. Documenting Site Assessment
C. New Technology
D. Laboratory

Given the results of a customer interview and the sample house drawing provided, have the trainees complete a site survey and checklist. This laboratory corresponds to Performance Task 1.

Session IV. Review and Testing

A. Review
B. 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.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.
Module Overview

This module describes system design considerations, including array configurations, component selection, and wire sizing. It also covers bonding, grounding, and the selection of overcurrent protection and disconnects.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum and Solar Photovoltaic Systems Installer, Modules 57101-11 and 57102-11. It is also suggested that the trainee shall have successfully completed the following modules from the Electrical curriculum: Electrical Level One, Modules 26101 through 26111; Electrical Level Two, Modules 26201, 26205, 26206, and 26208 through 26211; Electrical Level Three, Modules 26301 and 26302; and Electrical Level Four, Modules 26403 and 26413.

Objectives

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

1. Identify appropriate system designs and array configurations based on user loads, customer expectations, and site conditions.
2. Determine the size and capacities for major system components based on user load, desired energy production, autonomy requirements, and costs.
3. Determine the PV module layout, orientation, and mounting method for optimum system production and integrity.
4. Determine the ampacity requirement for all components and wiring of the PV system.
5. Select the appropriate conductor types and sizes for each portion of the electrical circuit.
6. Identify the appropriate size, rating, and location of required overcurrent protection and power disconnect devices.
7. Determine the appropriate size, rating, and location for bonding, grounding, and surge suppression.

Performance Task

Under the supervision of the instructor, the trainee should be able to do the following:

1. Given a completed site assessment, design a grid-connected PV system.

Materials and Equipment

<table>
<thead>
<tr>
<th>Markers/chalk</th>
<th>Several battery catalogs</th>
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<tbody>
<tr>
<td>Pencils and scratch paper</td>
<td>Several solar panel specification sheets</td>
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<tr>
<td>Whiteboard/chalkboard</td>
<td>PV system, working</td>
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<td>Multimedia projector and screen</td>
<td>Two or three copies of the NEC®</td>
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<td>Computers with Internet access</td>
<td>A couple of wire specifications for the trainees to determine wire sizes</td>
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<tr>
<td>Appropriate personal protective equipment</td>
<td>An electrical diagram of a PV system with the grounding and disconnects removed</td>
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<tr>
<td>Several multimeters</td>
<td>Factor values for determining array size</td>
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<td>A list of battery requirements including:</td>
<td>Completed site assessment</td>
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<td>Current load</td>
<td>Module Examinations*</td>
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<td>Inverter efficiency</td>
<td>Performance Profile Sheets*</td>
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<td>DC system voltage</td>
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<td>Days of autonomy</td>
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<td>Battery design discharge limit</td>
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* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.
Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review safety guidelines associated with working on or around solar PV systems. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


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 25 hours are suggested to cover System Design. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

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<tr>
<th>Topic</th>
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<td>A. Introduction</td>
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<td>B. Stand-Alone System Design</td>
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<td>1. The Electrical Load</td>
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<td>2. Battery Selection</td>
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<td>3. Solar PV Panel Selection</td>
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<td>4. Charge Controller Selection</td>
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<td>5. Inverters</td>
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<td>6. System Design and Equipment Review</td>
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</tbody>
</table>
C. System Wiring
   1. Wire, Cable, and Raceway
   2. Wiring Diagram
   3. Solar Array Wiring
   4. Battery and Controller Wiring
   5. Inverter Wiring
   6. Overcurrent Protection and Disconnects

Sessions VIII–IX. Grid-Tied Systems
   A. Grid-Tied Systems
      1. Grid-Tied System Component Selection
      2. PV System Grid Interface
   B. Laboratory
      Given a completed site assessment, have trainees design a grid-connected PV system. This laboratory corresponds to Performance Task 1.

Session X. Review and Testing
   A. Review
   B. 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.
   C. Performance Testing
      1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
      2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.
Module Overview

This module explains the process of installing a solar photovoltaic (PV) system, inspecting the entire system, and then activating the system.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum and Solar Photovoltaic Systems Installer, Modules 57101-11 through 57103-11. It is also suggested that the trainees shall have successfully completed the following modules from the Electrical curriculum: Electrical Level One, Modules 26101 through 26111; Electrical Level Two, Modules 26201, 26205, 26206, and 26208 through 26211; Electrical Level Three, Modules 26301 and 26302; and Electrical Level Four, Modules 26403 and 26413.

Objectives

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

1. Review the site assessment report, system design documents, and permits, and inspect the installation site.
2. Perform a job safety analysis (JSA) and deploy safety systems as needed.
3. Use system drawings and manufacturer’s instructions to plan the installation and to inventory the project materials and tools needed for the job.
4. Locate structural members and install mounting hardware and raceway.
5. Inspect photovoltaic (PV) system components prior to installation.
6. Install the mechanical parts of the PV modules (panels) and balance-of-system components.
7. Install, label, and terminate electrical wiring and devices in accordance with local and national codes.
8. Activate and test the system to verify overall system operation.

Performance Task

Under the supervision of the instructor, the trainee should be able to do the following:

1. Install and commission a system.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Solar Photovoltaic Systems Installer
PowerPoint® Presentation Slides
Multimedia projector and screen
Computers with Internet access
Appropriate personal protective equipment
Roof anchors
Harnesses and lanyards
Air-filtering respirator
ESD protection
Sufficient drills, torque wrenches, and tools for panel installation
Stud finder
Multimeter
Hydrometer
Set of panel output specifications
Bill of Materials for a PV system installation
Charge controller and user manual
Inverter and user manual
Combiner and user manual
Disconnect switches
Wiring diagram for solar PV system
Wire and raceway catalogs
Job safety analysis for each task in an installation
Site design plans
Section of a roof with shingles
Roofing sealant

(continued)
FLA batteries, dry Electrolyte Flange connections, both good and slightly damaged Sufficient standoffs, mounting beams, grounding lugs, sliders, and associated hardware

End clamps, 16 sets Mid clamps, 6 sets Solar panels, boxed Module Examinations* Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review safety guidelines associated with working on or near PV systems. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Solar Source Institute website: www.solarsource.net.
University of Oregon’s Solar Radiation Monitoring Laboratory website: http://solardat.uoregon.edu.

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 60 hours are suggested to cover System Installation and Inspection. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

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<td>A. Introduction</td>
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<td>B. Job Preparations</td>
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<td>2. Reviewing System Design Plans</td>
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<td>3. Inspecting Building Permits</td>
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<td>4. Inspecting Installation Sites</td>
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<td><strong>Sessions II and III. Safety</strong></td>
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<td>A. Safety</td>
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<td>1. Housekeeping</td>
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<td>2. Fall Protection</td>
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<td>3. Containment</td>
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<td>4. PPE and Heat or Sun Protection</td>
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<td>5. Material Handling</td>
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<td>6. Batteries</td>
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<td>7. Electrical Safety</td>
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<tr>
<td>A. Job Planning and Inventory of Materials and Tools</td>
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<td>1. Mounting Hardware</td>
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<td>2. Panels, Combiners, and Wiring to BOS Components</td>
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<td>3. BOS Components</td>
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<td>B. Installing Mounting Hardware and Raceways</td>
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<tr>
<td>1. Preparing Installation Site</td>
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<td>2. Installing Mounting Hardware</td>
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<td><strong>Sessions VIII and IX. Inspections of PV Components Prior to Installation</strong></td>
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<tr>
<td>A. Inspections of PV Components Prior to Installation</td>
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<td>1. Inspecting PV Panels</td>
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<td>2. Inspecting Combiner and DC Disconnect Switch</td>
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<td>3. Inspecting Charge Controller and Batteries</td>
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<td>4. Inspecting Inverters and AC Circuit Breakers</td>
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<td>5. Inspecting Raceway and Wiring</td>
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<tr>
<td><strong>Sessions X–XXIII. Installing PV Modules and BOS Components; Installing, Labeling, and Terminating Wiring per Code; Activating and Testing PV System to Verify Operations</strong></td>
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<tr>
<td>A. Installing PV Modules and BOS Components</td>
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<tr>
<td>1. Installing the Combiner</td>
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<td>2. Installing a DC Disconnect Switch</td>
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<td>3. Installing the Batteries</td>
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<td>4. Installing the Charge Controller</td>
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<td>5. Installing the Inverter</td>
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<td>6. Installing the PV Panels</td>
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<tr>
<td>B. Installing, Labeling, and Terminating Wiring per Code</td>
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<tr>
<td>1. Labeling</td>
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<tr>
<td>2. Checking Terminations</td>
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<tr>
<td>C. Activating and Testing PV System to Verify Operations</td>
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<tr>
<td>1. Final System Walkdown</td>
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<td>2. System Activation and Testing</td>
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<tr>
<td>D. Laboratory</td>
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<tr>
<td>Have trainees install and commission a system. This laboratory corresponds to Performance Task 1.</td>
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</tbody>
</table>
Session XXIV. Review and Testing

A. Review

B. 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.

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.
Module Overview

This module introduces the trainee to the components and operation of PV systems and describes how to maintain and troubleshoot them.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum and Solar Photovoltaic Systems Installer, Modules 57101-11 through 57104-11. It is also suggested that the trainees shall have successfully completed the following modules from the Electrical curriculum: Electrical Level One, Modules 26101 through 26111; Electrical Level Two, Modules 26201, 26205, 26206, and 26208 through 26211; Electrical Level Three, Modules 26301 and 26302; and Electrical Level Four, Modules 26403 and 26413.

Objectives

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

1. Identify the tools and equipment required for maintaining and troubleshooting PV systems.
2. Measure system performance and compare to expected performance.
3. Perform system maintenance as recommended by the PV equipment manufacturer.
4. Perform diagnostic procedures, interpret the results, and implement corrective measures on a malfunctioning system.
5. Verify system functionality, including startup, shutdown, normal operation, and emergency/bypass operation.
6. Compile and maintain records of system operation, performance, and maintenance.

Performance Tasks

Under the supervision of the instructor, the trainee should be able to do the following:

1. Demonstrate typical maintenance procedures on an installed PV system and document the results.
2. Troubleshoot a malfunctioning system and document the results.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Multimedia projector and screen
Computer
Appropriate personal protective equipment
PV system, working
Solar panel, clean and working
Solar panel, working but dirty with dust and debris
Manufacturer’s specifications and cleaning instructions
Appropriate soap and cleaning equipment
Solar panel, visibly worn or slightly damaged, and the manufacturer’s specifications
Cat III/IV multimeter
Pyranometer
Archimedes and refractive index hydrometers
Water cart, filler gun, and distilled water
Current-limiting battery charger
Noncontact IR thermometer
Batteries, including both sealed and flooded lead acid (FLA)
Sufficient electrolyte
PV system performance evaluation form
PV system maintenance record
Data from an actual PV system check

(continued)
Selection of mounting hardware, some good and some damaged or corroded. 
Sufficient batteries for cleaning. 
Sufficient inverters for cleaning and any necessary tools, such as soft brushes or cloths. 
Manufacturer’s troubleshooting chart.

Manufacturer’s maintenance and lubrication charts. 
Two or three actual maintenance records and logs. 
Module Examinations*. 
Performance Profile Sheets*.

*Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review safety guidelines associated with working on or around photovoltaic systems, including fall protection and lockout/tagout. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

- Solar Source Institute website: www.solarsource.net.

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 10 hours are suggested to cover Maintenance and Troubleshooting. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tr>
<td>Session I. Introduction; Preventive Maintenance</td>
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</tbody>
</table>
A. Introduction | 
B. Preventive Maintenance | 
1. Tools and Test Equipment | 
2. Cleaning and Inspecting PV Equipment | 
3. Evaluating Performance of PV Systems |
Session II. Manufacturer-Recommended Maintenance Activities

A. Manufacturer-Recommended Maintenance Activities
   1. Recommended Panel and Mounting Hardware Maintenance
   2. Recommended Combiner, DC Disconnect Switch, and Conduit Maintenance
   3. Recommended Charge Controller Maintenance
   4. Recommended Battery Maintenance
   5. Recommended Inverter Maintenance

B. Laboratory
   Have trainees demonstrate typical maintenance procedures on an installed PV system and document the results. This laboratory corresponds to Performance Task 1.

Session III. Troubleshooting

A. Troubleshooting
   1. Alarms and Indicators
   2. Baseline Data
   3. Breaking Down a PV System
   4. Inverters
   5. Charge Controllers
   6. Combiners and Panels
   7. Manufacturer’s Troubleshooting Data
   8. Record Keeping

B. Laboratory
   Have trainees troubleshoot a malfunctioning system and document the results. This laboratory corresponds to Performance Task 2.

Session IV. Review and Testing

A. Review

B. 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.

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.