

# ALTERNATIVE ENERGY PV INSTALLER SCHOOL VERSION Job Training Guide



Good science, good engineering, good technology and good business practices delivered by ethical, well-trained and motivated people will lead the way.

## **Renewable Energy Career Path Milestones**

### **Photovoltaic Installer (PVI)**

#### **Level One Apprentice**

- Attend an ETAI-approved school
- Pass Level One written exam and hands-on assessment

OR

- OJT with an ETAI-approved employer for a minimum of 12 months
- Pass the Level One written exam

Upon completion of the above, submit your Photovoltaic OJT JTG package signed-off by your ETAI-approved trainer to ETAI.

#### **Level Two Specialist**

- Hold a Level 1 PV Apprentice certification
- OJT with an ETAI-approved employer for a minimum of 18 months
- Pass the ETAI EM1-DC, EM2-AC, and the Level Two written exams
- Show proof of being either a licensed or journeyman electrician (or its equivalent or higher) as determined by the municipality, state or province in which you are employed

Upon completion of the above, submit your Photovoltaic OJT JTG package signed-off by your ETAI-approved trainer to ETAI.

#### **Level Three Technician**

- Hold a Level 2 PV Specialist certification
- OJT with an ETAI-approved employer for a minimum of 36 months
- Pass the ETAI Level Three exam

Upon completion of the above, submit your Photovoltaic OJT JTG package signed-off by your ETAI-approved trainer to ETAI.

	SCALE VALUE	PROFICIENCY CODE KEY
<b>TASK PERFORMANCE LEVELS</b>	<b>1</b>	Can do simple parts of the task. Needs to be told or shown how to do most of the task. <b>(EXTREMELY LIMITED)</b>
	<b>2</b>	Can do most parts of the task. Needs help only on hardest parts. <b>(PARTIALLY PROFICIENT)</b>
	<b>3</b>	Can do all parts of the task. Needs only a spot check of completed work. <b>(COMPETENT)</b>
	<b>4</b>	Can do the complete task completely and accurately. Can tell or show others how to do the task. <b>(HIGHLY PROFICIENT)</b>
<b>TASK KNOWLEDGE LEVELS</b>	<b>a</b>	Can name parts, tools, and simple facts about the task. <b>(NOMENCLATURE)</b>
	<b>b</b>	Can determine step-by-step procedures for doing the task. <b>(PROCEDURES)</b>
	<b>c</b>	Can identify why and when the task must be done and why each step is needed. <b>(OPERATING PRINCIPLES)</b>
	<b>d</b>	Can predict, isolate, and resolve problems about the task. <b>(ADVANCED THEORY)</b>
<b>SUBJECT KNOWLEDGE LEVELS</b>	<b>A</b>	Can identify basic facts and terms about the subject <b>(FACTS)</b>
	<b>B</b>	Can identify relationship of basic facts and state general principles about the subject. <b>(PRINCIPLES)</b>
	<b>C</b>	Can analyze facts and principles and draw conclusions about the subject. <b>(ANALYSIS)</b>
	<b>D</b>	Can evaluate conditions and make proper decisions about the subject. <b>(EVALUATION)</b>

\*A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. **(Examples: b and 1b)**

\*\* A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

— Not required for this Level.

+ Reserved for future use.

## **RENEWABLE ENERGY TECHNOLOGY - 2009 PHOTOVOLTAIC (PV) INSTALLER**

The following is a listing of the major categories and items considered necessary to be included in a course of study directed towards the education of workers needed in the photovoltaic installation industry.

The PV Installer will be required to properly perform the following:

- Identify major components of a Photovoltaic System
- Identify types of PV systems
- Identify panel types and characteristics
- Determine proper Installation Sequence for Array and BOS
- Install basic Array and BOS components
- Determine proper Array Orientation
- Understand Basic performance characteristics
- Understand basic systems sizing methods.
- Troubleshoot basic systems problems and installation errors.

Understand safe working practices for:

- Working aloft (ladder, roof, lanyard and harness)
- Working with hand and basic power tools
- Eye and ear protection
- Electrical safety

Certification examination questions and skill demonstrations (when required) are based on the topical outline provided in the ITEMS LIST. The specific COMPETENCIES are derived from the ITEMS LIST.

There are 11 general categories of required knowledge and skills. The ITEM LISTING defines the particular content areas in which the certification candidate must demonstrate proficiency.

## **PHOTOVOLTAIC (PV) INSTALLER**

### **MAJOR CATEGORIES:**

- 1.0 INTRODUCTION TO RENEWABLE ENERGY TECHNOLOGIES**
- 2.0 ADVANCEMENT OF PHOTOVOLTAIC TECHNOLOGY**
- 3.0 PHOTOVOLTAIC SAFETY**
- 4.0 TERMINOLOGY**
- 5.0 CODES AND STANDARDS**
- 6.0 THEORY OF OPERATION**
- 7.0 APPLIED CALCULATIONS AND FORMULAS**
- 8.0 ESTIMATING HOME ENERGY NEEDS**
- 9.0 PLANS AND BLUEPRINTS**
- 10.0 INSTALLATION**
- 11.0 PV SYSTEM MAINTENANCE PERFORMANCE AND TROUBLESHOOTING**

<b>1.0 INTRODUCTION TO RENEWABLE ENERGY TECHNOLOGIES</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
1.1 History and Background	A	A	A
1.1.1 Describe the evolution, uses, applications and function of the following renewable energy technologies:	A	A	A
1.1.1.1 Wind	A	A	A
1.1.1.2 Geothermal	A	A	A
1.1.1.3 Solar Thermal	A	A	A
1.1.1.4 Micro Hydro	A	A	A
1.1.1.5 Photovoltaic	A	A	A
1.1.1.6 Fuel Cells	A	A	A
<b>2.0 ADVANCEMENT OF PHOTOVOLTAIC TECHNOLOGY</b>			
2.1 Trace the evolution of photovoltaics.	A	A	A
2.2 Summarize the evolution of photovoltaic technology	A	A	A
2.3 Track the evolution of photovoltaic application	A	A	A
2.4 PV Effect	A	C	D
2.5 PV Principles	A	C	D
2.6 Active vs. Passive	A	C	D
<b>3.0 PHOTOVOLTAIC SAFETY</b>			
3.1 Basic Safety	D	D	D
3.1.1 Personal Protection Equipment:	D	D	D
3.1.1.1 Eyewear	D	D	D
3.1.1.2 Hardhat	D	D	D
3.1.1.3 Ear Protection	D	D	D
3.1.1.4 Respirator	D	D	D
3.1.1.5 Clothing and Sun Protection	D	D	D
3.1.1.6 Boots	D	D	D
3.1.1.6.1 Standard Work Boots	D	D	D
3.1.1.6.2 Special Roof Boots	D	D	D
3.2 Personal Safety	D	D	D
3.2.1 Personal safety devices	D	D	D
3.2.1.1 Voltage detection devices	D	D	D
3.2.1.2 Rubber gloves	D	D	D
3.2.2 Avoiding High Voltage	D	D	D

<b>3.0 PHOTOVOLTAIC SAFETY Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
3.2.3 Site Safety (working hazards)	D	D	D
3.2.4 First Aid	D	D	D
3.2.4.1 Sunburn	D	D	D
3.2.4.2 Electrocuting	D	D	D
3.2.4.3 CPR	D	D	D
3.3 Chemical Safety	D	D	D
3.4 Equipment	D	D	D
3.4.1 Power Tool Safety	D	D	D
3.4.2 Hand Tool Safety	D	D	D
3.5 Mounting Procedures	D	D	D
3.5.1 Roof Mounting	D	D	D
3.5.1.1 Structural Issues	D	D	D
3.5.2 Ground Mounting	D	D	D
3.5.3 Pole Mounting	D	D	D
3.6 Working Aloft	D	D	D
3.6.1 Ladder	D	D	D
3.6.1.1 Self supporting	D	D	D
3.6.1.2 Extension	D	D	D
3.6.2 Lanyard and Harness	D	D	D
3.6.3 Personal Fall-Arrest Systems (PFAS)	D	D	D
3.7 Battery Installation Safety	D	D	D
3.7.1 Special Personal Eyewear Protection	D	D	D
3.7.2 Acid Mitigation	D	D	D
3.8 Electrical Safety	D	D	D
3.8.1 Touch Potential	D	D	D
3.8.2 Grounding and Bonding	D	D	D
<b>4.0 TERMINOLOGY</b>			
4.1 Define the following <b>applications</b> :			
4.1.1 Building Integrated Photovoltaics	A	B	C
4.1.2 Battery Backup System	3b	4d	4d
4.1.3 Direct Coupled System	B	2b	4c

<b>4.0 TERMINOLOGY Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
4.1.4 Hybrid System	B	2b	3c
4.1.5 Grid-Tied Connected PV System (aka Grid Connected or Utility Connected)	2b	3c	4d
4.1.6 Seasonal loads (Biasing)	A	B	C
4.1.7 Small PV Applications	A	B	B
4.1.8 Autonomous Systems or Stand Alone System (aka Off Grid)	B	2b	3c
4.2 Define the following terms used in <b>solar panel</b> technology:			
4.2.1 I-V Curve	A	B	C
4.2.2 Maximum Power Point (MPP)	A	B	C
4.2.3 Mono-Crystalline Silicon	A	B	C
4.2.4 Normal Operating Cell temperature (NOCT)	B	C	D
4.2.5 Standard Test Conditions (STC)	B	C	D
4.2.6 Open Circuit Voltage (Voc or volts open circuit)	C	D	D
4.2.7 Polycrystalline Silicon	B	C	D
4.2.8 Ipm (aka Amps panel Max)	C	D	D
4.2.9 Amorphous / Thin Film	B	C	D
4.2.10 PVWATTS Test Conditions (PTC)	B	C	D
4.2.11 Vpm (aka Volts Panel Max)	C	D	D
4.2.12 Isc (aka Amp Short Circuit)	C	D	D
4.2.13 Blocking Diode	A	B	B
4.2.14 Bypass Diode	A	B	B
4.2.15 Concentrators	A	2b	3c
4.2.16 Single Junction Panel	A	A	A
4.2.17 Multi Junction Panel	A	A	A
4.3 Define the following terms for <b>energy storage</b> :			
4.3.1 Battery	B	2c	3c
4.3.1.1 Flooded Lead Acid	B	2c	3c
4.3.1.2 Sealed	B	2c	3c
4.3.1.3 Absorbed Glass Mat	B	2c	3c
4.3.2 Deep Cycle	C	C	C
4.3.3 Depth of Discharge (DOD)	C	C	C
4.3.4 Flywheel Storage	A	A	B
4.3.5 Kinetic Storage	A	A	B

<b>4.0 TERMINOLOGY Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
4.3.6 Overcharge	C	C	C
4.3.7 Thermal Masses	C	C	C
4.3.8 Battery Charging (Equalization, Float, Bulk and Absorption)	C	C	D
4.3.9 Amp Hour Capacity	B	C	C
<b>4.4 Define the following terms used in PV wiring:</b>			
4.4.1 Ampacity	C	C	C
4.4.2 Conductor	C	C	C
4.4.3 Grounded conductors	C	C	D
4.4.4 Load Resistance	C	C	D
4.4.5 Short Circuit Current	C	C	D
4.4.6 Type of Wiring (THWN THHN, RHW)	C	C	C
4.4.7 AWG	A	A	D
4.4.8 Overcurrent Protection	B	C	D
<b>4.5 Define the following terms used in PV installation:</b>			
4.5.1 Bonding/Grounding	3c	4c	4c
4.5.2 Electrical Insulation	3c	4c	4c
4.5.3 Dual-axis tracking	B	2b	3c
4.5.4 Fixed Tilt Array	3b	4c	4c
4.5.5 Ground Mounting	3b	4c	4c
4.5.6 Roof Mounting	3b	4c	4c
4.5.7 Metal Non-conductors	B	C	C
4.5.8 One Axis Tracking	B	2b	3c
4.5.9 System Operating Voltage	B	C	C
4.5.10 Tracking Array	B	2b	3c
<b>4.6 Define the following terms for orientation:</b>			
4.6.1 Altitude	B	C	C
4.6.2 Azimuth	B	C	C
4.6.3 Direct Beam Radiation	B	C	C
4.6.4 Angle of Incidence (aka Incident Light)	B	C	C
4.6.5 Latitude	B	C	C
4.6.5.1 Equinox/Solstice	B	C	C

<b>4.0 TERMINOLOGY Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
4.6.6 Magnetic Declination	3b	3b	3b
4.6.7 Tilt Angle	B	C	C
4.6.8 Peak Sun Hours	A	A	A
4.6.8.1 Sun Path diagrams	3b	4c	4d
4.6.8.2 Shading	3b	4c	4d
4.6.8.3 Weather	3b	4c	4d
<b>4.7 Define the following <b>Balance of System (BOS)</b> terms:</b>			
4.7.1 Charge Controllers	B	C	C
4.7.1.1 Series charge controller	B	C	C
4.7.1.2 Shunt charge controller (aka Diversionary charge controller)	B	C	C
4.7.1.3 Pulse Width Modulation	B	C	C
4.7.1.4 Maximum Power Point Tracking	B	C	C
4.7.2 Inverter	B	C	C
4.7.2.1 Waveform	B	C	C
4.7.2.2 On-grid or Off-grid	B	C	C
4.7.2.3 Efficiency	B	C	C
4.7.3 Combiner Box	B	C	C
4.7.4 Generator	B	C	C
4.7.5 Voltage regulator	B	C	C
<b>4.8 Define the following <b>solar power</b> key terms:</b>			
4.8.1 Active Solar Energy	B	B	B
4.8.2 Insolation	C	C	C
4.8.3 Irradiance	C	C	C
4.8.4 Kilowatt-hours per square meter	B	C	C
4.8.5 Passive Solar Energy	B	B	B
4.8.6 Photon	A	A	A
4.8.7 Balance of System	B	C	C
4.8.8 Pyranometer (specialty tools)	2b	3c	4c
4.8.9 Pyroheliometer (specialty tools)	2b	3c	4c
4.8.10 Solar Constant	A	A	A
4.8.11 Solar noon	B	B	B
4.8.12 Solar Pathfinder	3b	4c	4c

<b>4.0 TERMINOLOGY Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
4.8.13 Zenith Angle	2b	3c	4c
4.8.14 Air Mass	B	B	B
4.8.15 Ambient Temperature	B	C	C
4.8.16 Cell Temperature	B	C	C
4.8.17 Days of Autonomy	B	B	B
4.8.18 Cloud Enhancement	A	A	A
4.8.19 Electromagnetic Power Spectrum	A	A	A
<b>5.0 CODES AND STANDARDS</b>			
5.1 Local State and National Codes	A	A	A
5.2 National Electrical Code	A	A	A
5.2.1 Article 250 Grounding and Bonding	A	B	C
5.2.2 Article 685 Integrated Electrical Systems	A	A	A
5.2.3 Article 690 Solar Photovoltaic Systems	A	B	C
5.2.4 Article 700 Emergency Systems	A	B	C
5.2.5 Article 100 General Wiring	A	B	C
5.2.6 Article 445 Generators	A	B	C
5.3 NFPA 5000, Building Construction and Safety Code	A	A	A
5.4 IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems	A	A	A
5.5 UL1703, Standard for Flat-plate Photovoltaic Modules and Panels	A	B	B
5.6 UL 1741 Standard for Static Inverters, Converters & Controllers for use in Independent Power Systems.	A	B	B
5.7 Interconnection Agreements	A	A	A
5.8 NREL -STC	A	A	A
5.9 Net Metering	A	B	B
5.10 PV USA -PTC	A	A	A
<b>6.0 THEORY OF OPERATION</b>			
6.1 Photovoltaic System Types	A	B	C
6.2 Photovoltaic Principles			
6.2.1 Series String	A	B	C
6.2.2 Parallel Strings	A	B	C
6.2.3 Series-Parallel Arrays	A	B	C

<b>6.0 THEORY OF OPERATION Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
6.3 Components of a Photovoltaic system	A	A	A
6.4 Module Characteristics and Functions	A	B	B
6.5 Photovoltaic Module Performance	A	A	A
6.5.1 Maximum Power Point (IV Curve)	A	B	B
6.5.2 Short Circuit Current	A	B	B
6.5.3 Open Circuit Voltage	A	B	B
6.5.4 Voltage Drop	A	B	B
6.5.5 Maximum Power (STC Rating)	A	B	B
6.5.6 Maximum Current	A	B	B
6.5.7 Volt Max Power	A	B	B
6.5.8 External Performance factors	A	A	A
6.5.8.1 Temperature	A	A	A
6.5.8.2 Dirt	A	A	A
6.5.8.3 Solar Intensity	A	B	C
6.5.8.4 Reflection/Refraction	A	B	C
6.5.8.5 Obstruction	A	B	C
6.6 System Installation	A	B	C
6.6.1 Site Selection	A	B	D
6.6.1.1 Solar Radiation	A	A	B
6.6.1.1.1 Solar Radiation Measurement	A	A	A
6.6.1.2 Gathering Site Data	A	A	B
6.6.1.2.1 Structural Data	A	A	B
6.6.1.2.2 Eligibility	A	A	B
6.6.1.3 Solar Site Analysis	A	A	B
6.6.2 PV Array Installation	A	B	C
6.6.2.1 Tracking	A	B	C
6.6.2.1.1 Single-axis tracking	A	B	C
6.6.2.1.2 Dual-axis tracking	A	B	C
6.6.3 Battery Installation	A	B	C
6.6.4 System Electronics	A	B	C
6.6.4.1 Controls	A	B	C
6.6.4.2 Inverter	A	B	C

<b>6.0 THEORY OF OPERATION Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
6.6.4.2.1 Theory of Operation	A	B	C
6.6.4.2.1.1 Waveforms	A	B	B
6.6.4.2.2 Types	A	B	B
6.6.4.2.3 Features	A	B	B
6.6.4.2.4 Sizing	A	A	A
6.6.4.2.5 Safety Issues	C	C	D
6.6.4.3 Charge Controller	A	A	A
6.6.4.3.1 Theory of Operation	A	A	A
6.6.4.3.2 Types – Series and Shunt	A	A	A
6.6.4.3.3 Features	A	A	A
6.6.4.3.4 Sizing	A	A	A
6.6.4.3.5 Safety Issues	A	B	C
6.6.5 PV System Wiring	A	B	C
6.6.5.1 Wire Sizing	A	B	C
6.6.5.1.1 Derating Factors	A	B	B
6.6.5.2 Over-current/Overload Protection	A	B	D
6.6.5.3 Separately Derived Systems	A	B	C
6.6.5.3.1 Disconnects	A	B	C
6.6.5.3.2 Grounding	A	B	D
6.6.5.3.3 Surge Suppression	A	B	D
6.6.6 Grid-Tied Systems	A	A	A
6.6.6.1 Types and Advantages	A	A	A
6.6.6.2 Generator Backup Systems	A	A	A
6.6.7 Stand-Alone Systems			
6.6.8 Hybrid Systems	-	A	2b
6.6.8.1 Solar/Wind Power	-	A	2b
6.6.8.3 Solar/Micro hydro	-	A	2b
<b>7.0 APPLIED CALCULATIONS AND FORMULAS</b>			
7.1 Ohms Law	A	A	A
7.2 Power Formulas	3c	4c	4c
7.3 Series and Parallel Calculations	3c	4c	4c
7.4 Kirchoff's Rules	A	A	B

<b>7.0 APPLIED CALCULATIONS AND FORMULAS Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
7.5 Raceway and Box Calculations	3c	4c	4c
7.6 Conductors Sizing and Protection Calculations	3c	4c	4c
7.7 Voltage-Drop Calculations	3c	4c	4c
7.8 Dwelling Unit Calculations	3c	4c	4c
7.9 Transformer Calculations	3c	4c	4c
7.10 System Size requirements	3c	4c	4c
7.10.1 # of panels	3c	4c	4c
7.10.2 Battery size (off Grid)	3c	4c	4c
7.10.3 Disconnect Size	3c	4c	4c
7.10.4 Wire Size	3c	4c	4c
<b>8.0 ESTIMATING HOME ENERGY NEEDS</b>			
8.1 Energy Conservation	A	C	C
8.1.1 Identify electrical appliances that may be replaced by more energy efficient ones	A	C	C
8.1.2 Explain the appliance Energy Star rating system	A	C	C
8.2 Electrical Load Requirements	A	C	C
8.2.1 Compiling Load Calculation Information	3c	4c	4c
8.2.1.1 Grid-Tied	3c	4c	4c
8.2.1.2 Off Grid	3c	4c	4c
8.2.2 Standard load calculation method	3c	4c	4c
8.2.3 Optional load calculation method	3c	4c	4c
8.2.4 Explain how to use a load summary worksheet	A	C	C
8.2.5 Identify peak consumption periods	A	C	C
8.2.6 Identify the maximum projected load (off grid only)	A	C	C
8.2.7 Calculate the whole home monthly and yearly projected load	3c	4c	4c
<b>9.0 PLANS AND BLUE PRINTS</b>			
9.1 Elevation drawings	A	B	C
9.2 Grid lines	A	B	C
9.3 Legend	A	B	C
9.4 Revision Block	A	B	C
9.5 Scale	A	B	C
9.6 Schematics	A	B	C
9.7 Sectional Drawings	A	B	C

<b>9.0 PLANS AND BLUE PRINTS Cont'd</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
9.8 Specifications	A	B	C
9.9 Structural drawings	A	B	C
9.10 Symbols	A	B	C
9.11 Title block	A	B	C
<b>10.0 INSTALLATION</b>			
10.1 Tools	3b	4c	4d
10.1.1 Specialty Tools	3b	4c	4d
10.1.1.1 Solar Path Finder	3b	4c	4d
10.1.1.2 Pyranometer	3b	4c	4d
10.1.1.3 Pyroheliometer	3b	4c	4d
10.1.2 Power Tools	3b	4c	4d
10.1.3 Hand Tools	3b	4c	4d
10.2 Mounting			
10.2.1 Ground Mounting	3b	4c	4d
10.2.1.1 Fixed Array	3b	4c	4d
10.2.1.2 Adjustable Array	3b	4c	4d
10.2.1.3 Trenching – Buried Wire	3b	4c	4d
10.2.2 Pole Mounting			
10.2.2.1 Fixed	3b	3c	4d
10.2.2.2 Trackers	3b	3c	4d
10.2.3 Roof Mounting			
10.2.3.1 Roof Area	3b	3c	4d
10.2.3.1 Wind load	B	C	D
10.2.3.2 Seismic Load	B	C	D
10.2.3.3 Snow Load	B	C	D
10.2.3.2 Roof Penetration	3b	3c	4d
10.2.3.3 Leak Prevention	3b	3c	4d
10.2.3.4 Hardware Mounting	3b	3c	4d
10.3 BOS Installation			
10.3.1 Inverters	3b	3c	4d
10.3.1.1 Indoor	3b	3c	4d
10.3.1.2 Outdoor	3b	3c	4d

<b>10.0 INSTALLATION Cont'd</b>			
10.3.1.3 Grounding/Overcurrent Protection	3b	3c	4d
10.3.2 Battery			
10.3.2.1 Room Ventilation	B	3c	4d
10.3.2.2 Disposal	B	3c	4d
10.3.3 Chargers	B	3c	4d
10.3.4 Disconnect Switches – AC and DC	3b	3c	4d
10.3.5 Ground Rod	3b	2c	4d
10.3.6 EMT (Electrometallic Tubing)	3b	4b	4b
10.3.7 Wiring	3b	4b	4b
10.3.7.1 Buried	3b	4c	4c
10.3.7.2 Handling	3b	4c	4c
10.3.8 Main Breaker Connections	A	B	C
10.3.9 Combiner Box	3b	4c	4c
10.3.9.1 PV Modules	3b	4c	4c
10.4 Connections Sequence	A	B	C
<b>11.0 PV SYSTEM MAINTENANCE PERFORMANCE AND TROUBLESHOOTING</b>			
11.1 Maintenance	B	C	D
11.1.1 Panel Cleaning and Soiling	2b	3c	3c
11.1.2 Battery Maintenance	B	3c	4d
11.1.2.1 Protection and Safety	B	3c	4d
11.2 Determining System Performance Problems	B	C	D
11.2.1 Trackers – Check for Directional True	B	3c	3c
11.2.2 Determining a Faulty Panel	B	4c	4c
11.2.3 Determining a Faulty Inverter	B	3c	4d
11.2.4 Wiring and Corrosion	B	3b	4d
11.2.5 Animal and Weather Damage	B	3b	4d
11.3 System Monitoring	A	C	D
11.3.1 Remote Inverter Monitoring	A	C	4c
11.3.2 Data Interpretation	A	C	4c
11.3.3 PV Meters	A	C	4c
<b>END OF PHOTOVOLTAIC (PV) INSTALLER COMPETENCIES</b>			

## RECOMMENDED STUDY MATERIALS

### PV INSTALLER - LEVEL 1

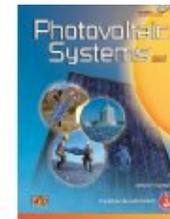
#### Photovoltaics Design and Installation Manual by Solar Energy International (SEI)

- **Paperback:** 336 pages
- **Publisher:** New Society Publishers (September 1, 2004)
- **Language:** English
- **ISBN-10:** 0865715203
- **ISBN-13:** 978-0865715202



#### Photovoltaic Systems, 2<sup>nd</sup> Edition, James Dunlop

- **Hardcover:** 464 pages
- **Publisher:** Amer Technical Pub; 2nd Edition edition (July 1, 2009)
- **Language:** English
- **ISBN-10:** 0826913083
- **ISBN-13:** 978-0826913081



#### Green Technology, Concepts and Practices by Jay and Annie Warmke

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- **Language:** English
- **ISBN-10:** 1581221118
- **ISBN-13:** 978-1581221114



## Mike Holt's Illustrated Guide to Understanding the NEC Requirements for Solar Photovoltaic Systems, 2011 NEC

- **Perfect Paperback:** 368 pages
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- **Language:** English
- **ISBN-10:** 1932685545
- **ISBN-13:** 978-1932685541

