

# Seminar: PV 101: Entry Level PV Installations

Days 1 – 3

Traditional (in person) or Blended (online) Class:

## Introduction

### 1. Why Solar? Why Now?

- Fossil Fuel Consumption
- Renewables

### 2. Types of Solar Systems

- Grid-Tied PV Systems
- Off-Grid PV Systems
- Hybrid PV Systems
- PV Direct
- Solar Heating systems
- Section in Review

### 3. Safety

- Introduction
- Specific Hazards
  - Electricity
  - Heights
  - Slope
  - Heat
  - Wind
  - Weight

- OSHA
- Electricity
- Heights
- Other Hazards
- Tool Safety
- Roof Surfaces

### 4. Basics of Electricity

- Direct Current (DC) Electricity
- Alternating Current (AC) Electricity
- Frequency
- Current
- Voltage
- Resistance
- Electrical Circuit
- Voltage, Current, and Resistance Relationship

- Power
- Voltage Drop
- Power Loss
- Net Power
- Wire Sizing
- Energy
- Section in Review
- Key Concepts

## **5. How Solar Electricity Works**

- Converting Sunlight to Energy
- Silicon Cells
- PV Cell Types
- The Photovoltaic Solar Advantage
- Solar Modules
- Solar Array
- Module String
- Section in Review

## **6. Solar Modules**

- Output from a Solar Module
- Standard Test Conditions
- I-V Curves
- Field Conditions
- Effects of Irradiance on Output
- Effects of Temperature on Output
- Section in Review
- Key Concepts

## **7. Connecting Modules**

- Wiring in Series
- Wiring in Parallel
- Wiring in Parallel/Series
- Advantages and Disadvantages
- Module Matching
- Section in Review

## **8. Site Assessments – an Overview**

- Glossary of Terms
- Project Address and Property Layout
- Locations and Layouts of Buildings
- Potential Sites for Installing Solar
- Potential Shading Issues
- Truss / Rafter Spacing for Roof Mounted Systems
- Objects Interfering with the Array Layout
  - Location and Size of Service Entrance, Service Panel, and SubPanels
  - Load Side Taps

- Line Side Taps
- Wiring Plan
- Roof Condition
- Section in Review

## **9. Assembling a PV System**

- PV Array Mounting
  - Roof Mounts
  - Ground Mounts
  - Other Attachments
- Mounting Hardware
  - Roof Attachment
- Racking System
  - Rail
    - Attaching to the Rail
  - Clamps
- Electrical Attachments
  - Grounding
  - MC Connectors
  - Junction Box (J Box)
  - Combiner Box
  - Conduit
  - DC Disconnect
  - AC Disconnect
- Inverter
  - Low Voltage Inverters
  - String Inverters
  - Micro-Inverters
- Charge Controller
- Deep Cycle Batteries
- Section in Review

## **10. Sample Systems**

### **11. Orientation**

- Effect of Tilt on Production
- Effect of Azimuth on Production
- Effect of Tilt on East and West Facing Arrays
- Analyzing Azimuth and Tilt
- Section in Review
- Key Concepts

### **12. Determining Tilt and Azimuth**

- Tilt
- Azimuth
  - True North vs. Magnetic North
  - Magnetic Declination
  - True Bearing vs. Magnetic Bearing

Determining Declination  
Section in Review

### **13. Shading Analysis**

- Shading Analysis
- Components of the Solar Pathfinder
  - Solar Pathfinder Details
  - Reading the Shadows on a Solar Pathfinder
  - Helpful Hints about Using the Solar Pathfinder
- Procedure for Shade Analysis
- Effect of Shading on Production
- Solutions to Some Shading Issues

### **14. Electric Consumption**

- Terms
- Electric Supply
- The Electrical Grid
- Balancing the Grid
- Downside of Centralized Production
- Residential PV Systems Reduce Line Loss
- Components of an Electric Bill
  - Energy (kWh) Use
  - Rate Schedules
  - Example of TOU / Tiered Rate Billing
  - Example of Fixed Rate Schedule
- Estimating Gross Electric Consumption
  - Evaluating Electric Bills
  - New Construction
  - Lifestyle Dwelling Changes
- PV's Effects on Net Utility Consumption
  - Interconnection Agreement
  - Solar Production
  - Net Metering
  - Feed in Tariff

### **15. Estimating PV Production**

- System Sizing
- Production Estimating Methodology
- Estimating Methods
  - Sun Hour Method
  - Sun Chart Method
  - PVWatts Estimating Method
  - Summary of Results from Different Methods
- The De-Rating Factor

### **16. Sizing PV Arrays**

- Calculating Array Size with the Sun Hour Method
- Calculating Array Size with the Sun Chart Method

Calculating Array Size with PVWatts  
Summary of Results from Different Methods  
Sizing Arrays for an Off Grid System

## **17. Introduction to Inverters**

- System Design
  - Introduction to Inverters
    - Sine Waves
    - Modified Sine Waves
    - “True” Sine Waves
- System Safety
  - Working Safely with Inverters
  - Maximum Power Point Tracking (MMPT)
  - Maximum Voltage and Current Inputs
  - Inverter Efficiency

## **18. Micro Inverters**

- Introduction
- Micro Inverter Installation Steps
- Micro Inverter Future

## **19. String Inverter Theory**

- String Inverters Theory
- String Inverter Specification
- Inverter / Array Matching
  - Maximum DC Input Voltage
  - Minimum DC Input Voltage
  - Start Voltage
  - Maximum DC Input Current
  - Application of DC Input Calculations

## **20 String Inverter Configurators**

- Fronius Inverter Online Configurator
- SMA Inverter Online Configuration Tool
- Section in Review

## **21. Array Layout**

- Layout Goals
- Layout Pattern
- Layout Considerations
  - Flat Roof Applications
  - Ground Mount Considerations

## **22. Array Grounding**

- Array and Racking Grounding Equipment
  - Grounding Lugs
  - Ground Lugs and Clips
- Bonding Securely

## Completing the Grounding Path

### **23. Wiring & NEC**

- Introduction
- National Electric Code
  - Applying the Code
  - Understanding Solar Code
- BOS – Wiring to Inverter
  - Exposed Wiring
  - Junction Box
  - DC Combiner Box
- DC Disconnect
  - DC Disconnect Location
  - DC Disconnect Wiring
- AC Combiner
- AC Disconnect

### **24. Grid Connection**

- Sizing Circuit Breakers and Fuses
- Load Side Tap
  - Location of the Breaker
- Line Side Tap
- Labels

### **25. Racking Design and Components**

- Contractor's Responsibility
- Racking Equipment
- Racking Goals
  - Supporting the Modules
  - Distributing the Load
  - Aesthetic Requirements
  - Cost Requirements
- Types of Racking Systems
  - Flush Mounted Systems
  - Tilt Mounted Arrays
  - Ballasted Arrays
  - Ground Mounted Systems
  - BIPV

### **26. Ground Mounts – Hands on**

- Introduction
- System Design
- Tools
- Layout
- Equipment and Materials – 'Ground Trac' System
- Foundations
- Rail
- Grounding Lugs

Module Clamps  
End Caps

## **27. Commissioning, Troubleshooting, Maintenance**

Commissioning  
    Commissioning Steps for a Grid-Tied System  
Troubleshooting  
Preventive Maintenance

## **28. Diagramming – examples**

### **Days 4 – 5 (for both Traditional and Blended):**

The two final course days are where all the PV learning comes together. At least one instructor and one assistant work with teams of students to fully assemble, mount, wire, test, commission and troubleshoot three separate PV systems.

Teams will work also on the skills needed to properly site, situate, and size systems for maximum return.

This two day, hands on portion of the class is required for any student wishing to receive complete SSI Certification and/or to qualify to take the NABCEP Entry Level PV Installer exam.

#### **Familiarization with and use of safety equipment, including**

- fall prevention systems
- use of ladders
- securing a site
- use of electrical equipment.

#### **Hands on Installation:**

- assembling an eight panel ground mount system
- assembling racking on roof mounted systems, working with four different roofing materials
- wiring two different grid tied string inverters
- wiring a micro inverter system
- Testing, commissioning and troubleshooting systems.

#### **Practice siting and sizing systems, and documenting results:**

- hands on experience with tilt and azimuth
- hands on with Solar Pathfinder
- diagramming PV solar systems.