

Halsey Street Green Solutions Solar PV Entry Level Training Program (SPITP)

Syllabus Table of Contents

1. [Course Description](#)
2. [Text Books & Other Course Materials](#)
3. [Grading](#)
4. [Detailed Solar Panel Installer Training Course Activities](#)
5. [PV Lesson & Lab Activity Alignment Menu](#)
6. [Other Reference Materials](#)
7. [Solar PV Course Lab Budget](#)

Solar PV Entry Level Training Course (120) Classroom Contact Hours

Course Description:

The Solar Photovoltaic (PV) Training Program was created by Halsey Street Green Solutions HSGS). This curriculum was devised as an entry level course in the study of solar PV cells, modules, and system components; electrical circuits; PV system design and sizing for use on homes and businesses; understanding solar electric products and applications; understanding energy conversion from sunlight to electricity; and working with solar conversion equipment.

In addition, this course was designed to give participants the book knowledge and hands on experience they will need to gain a Solar PV Certificate of Completion in an entry level solar PV installer course. The lectures, lab activities, test and homework assignments taught in this 96 hour PV course are based on the learning objectives devised by the North American Board of Certified Energy Practitioners (NABCEP).

Finally, this course will be offered as a HSGS's Workforce Development course with the training to be provided at Technical Colleges in North and South Carolina; The 10 Educational Opportunity Centers in New York State; The Outsource Training Center in Buffalo, New York; The Computer Village in St. Louis Missouri; and at other locations to be announced.

Note: This course is not intended to meet or replace the requirements for a Licensed Electrician.

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Course Goals:

Upon completion of this course, the student will be able to...

1. Demonstrate knowledge and application of key solar electric system terms and concepts;
2. Size & design a simple photovoltaic system;
3. Mount, ground, position, install, wire, and troubleshoot a photovoltaic system;
4. Test voltage generated by photovoltaic modules, and
5. Pass the Halsey Street Green Solutions, "PV Certificate of Completion Exam". and

Course Learning Objectives:

Students who take this course will be able to;

- Estimate the power and energy a PV system will need to produce to meet a homeowner's goals.
- Identify safety hazards of photovoltaic systems; identify sound practices and the protective equipment used during photovoltaic system installation and maintenance.
- Define basic electrical terms and calculate simple circuit values.
- Determine the functional requirements of PV system components.
- Estimate the solar resources available at a given location.
- Learn how to size, connect, and mount PV arrays.
- Determine and size the appropriate controller and inverter models.
- Select the proper equipment which is commercially available from the industry.
- Determine the cost of a PV system.
- Make a comparative economic analysis between alternative system designs.
- Properly design a PV power system for an appropriate application.
- Understand photovoltaic system electrical design.
- Understand photovoltaic system mechanical design.
- Measure photovoltaic system performance and troubleshoot problems.

Student Knowledge and Experience Assumptions:

No solar industry or electrical construction experience is assumed. Knowledge requirements include 7th grade reading level, basic math skills (addition, subtraction, multiplication, division, fractions, decimals, percentages, proportions, exponents, area calculations, use of formulas, basic algebra and word problems). In addition, students will be expected to use the Internet, a scientific calculator, hydrometer, digital multimeter, and a solar path finder as problem solving tools.

Halsey Street Green Solutions
Solar PV Entry Level Training Program (SPITP)

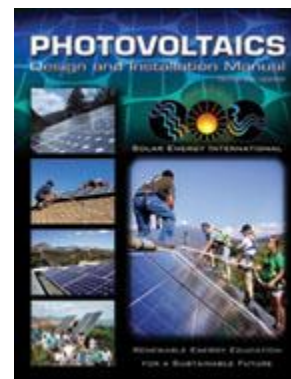
Course Syllabus (Continued)
Solar Electric Systems, Entry-Level

Required Text:

Text Books & Other Course Materials

Photovoltaics: Design & Installation Manual (\$60)
by SEI Solar Energy International

Solar Energy International's manual offers an overview of photovoltaic electricity, and a detailed description of PV system components, including PV modules, batteries, controllers and inverters. Electrical loads are also addressed, including lighting systems, refrigeration, water pumping, tools and appliances. The manual includes chapters on sizing photovoltaic systems, analyzing sites and installing PV systems. The manual also includes detailed appendices on PV system maintenance, troubleshooting, and insolation data for over 300 sites around the world.



Additional required course reading and viewing assignments will also be made available via this Solar Panel Installer Training Course DVD. The DVD includes: Web based references to PV information articles, [power point lectures](#), [a solar glossary](#), [rapid fire round robins](#), construction safety tips, video clips and exercises related to basic electricity, photovoltaic systems, and alternative energy careers. (See [course activities schedule](#) for details).

[Home Power Magazine](#) - Independently published since 1987, *Home Power magazine* is the premier information resource for small-scale renewable energy and energy efficiency projects.

Grading

- 40% - Quizzes
- 10% - Solar Panel Lab Assignments
- 50% - Final Certificate of Completion Examination

Daily Activity Schedule for Week 1 & Week 2

8:00 – 9:15	Lesson Objectives & Review
9:15 – 12:00	Daily Lecture
12:00 – 12:59	Break & Lunch
1:00 – 4:00	Lab Activity
4:00 – 4:30	Wrap Up
4:30	Class Dismissal

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Detailed – Course Activity Schedule

Week #1 - (TOC)

Lesson #1

Date	Topic Description	Readings, Web Sites & Videos	Lab Assignments
Day 1	<p>Lecture – Introduction to PV – History & Developments:</p> <p>Photovoltaic systems (PV) are solar energy systems that produce electricity directly from sunlight. Photovoltaic systems produce clean, reliable energy without consuming fossil fuels and can be used in a wide variety of applications. In this lesson students will explore the history, applications, employment opportunities, advantages, disadvantages, and components of PV systems.</p>	<p>Reading(s): Text Book - Chapter 1</p> <ul style="list-style-type: none"> Solar Panel Systems Explained Solar Energy Basics Finding Your Dream Job in Solar Solar Jobs – NY Times Article Charting Your Solar Course Solar Glossary of Terms <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> Solar Power 101 - Explained Solar Panels – How They Work Thin Film Solar Solar PV System Components 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz 1</p> <p>Aspirational Ex</p> <p>Home Work:</p> <p>Solar Review</p> <p>Cheat Sheet</p> <p>NABCEP</p>

Lesson #2

Day 2	<p>Lecture – Electrical Circuits & Ohms Law:</p> <p>Electricity is the flow of electrons through a circuit. The force or pressure of moving electrons in a circuit is measured as voltage. The flow rate of electrons is measured as amperage. The power of a system is measured as watts. This lesson focuses on photovoltaic terminology and workings of electricity in series and parallel electrical circuits.</p> <p>Lecture Two - Ohm's Law - Using Ohm's law to construct, and troubleshoot parallel and series circuits. Examining the theory behind the operation of electric motors and generators. Determining the physical and electrical characteristics of capacitors and inductors. Construct, and troubleshoot series and parallel capacitive circuits.</p>	<p>Reading(s): Text Book - Chapter 2</p> <ul style="list-style-type: none"> Electricity Basics Electricity – An Analogy Watt Hour Unit of Energy Circuits Electrical Path Series Linked Together in One Electrical Path Parallel—Side by Side Ohm's Law - DC v. AC <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> Introduction to Ohm's Law Part1 – Units & Quantities Part 2 –Simple Circuits Parallel Circuits Series Circuits Basic Circuit Analysis Electric Power Formula Lab Virtual Ohm's Lab Law Solar Panels Wiring Explained DC Circuit Analysis 	<p>Exercise(s):</p> <p>Quiz 2</p> <p>Solar Kit Lab</p> <p>Home Work:</p> <p>Wiring Exercise</p> <p>Cheat Sheet</p> <p>NABCEP</p>
--------------	---	--	--

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Week #1 - (TOC)

Lesson #3

Day 3	<p>Lecture – The Solar Resource:</p> <p>This lesson will focus on solar radiation fundamentals, gathering site data for a PV installation and completing a solar site analysis.</p> <p>The term for solar radiation striking a surface at a particular time and place is insolation. When insolation is described as power, it is expressed as a number of watts per square meter and usually presented as an average daily value for each month.</p> <p>On a clear day, the total insolation striking the earth is about 1,000 watts per square meter. However, many factors determine how much sunlight will be available at a given site, including atmospheric conditions, the earth's position in relation to the sun, and obstructions at the site.</p>	<p>Reading(s): Text Book - Chapter 3</p> <ul style="list-style-type: none"> • PV Orientation!!!! • Array Orientation • How to Mount PV Modules • Pole-Mounted Solar- Array • The Solar Radiation Data Averages • First Steps in Renewable Energy • Sun Chart Graphs • Load-Analysis-Site-Survey • PV Watts Calculator • Atmospheric Science Data Center • Using Arial Images for Site Prep <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Installing Solar Panels Part 1 • Installing Solar Panels Part 2 • Installing Solar Panels Part 3 • NJIT Solar Panel Installation • Using A Solar Path Finder • Smart Rack TM Adhesive Clamps 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Exercise 2</p> <p>Exercise 3</p> <p>Exercise 4</p> <p>Exercise 5</p> <p>Quiz 3</p> <p>Path Finder Lab</p> <p>Home Work</p> <p>Cheat Sheet</p> <p>NABCEP</p>
--------------	--	---	--

Lesson #4

Day 4	<p>Lecture – Photovoltaic Modules:</p> <p>Photovoltaic modules and arrays have proven to be a reliable source of electrical energy, but they must be properly designed as a reliable system to be effective.</p> <p>This lesson focuses on the basic physical characteristics of photovoltaic modules and explains how some climate and site-specific factors will affect their performance. System designers and users should be aware of these factors when choosing panels and designing photovoltaic systems.</p>	<p>Reading(s): Text Book – Chapter 5, Chapter 12 – Solar PV Kit Manual</p> <ul style="list-style-type: none"> • Solar-Electric-Module-Guide • DynoRaxx Flat Roof System • Grid Connected PV • A Peek Inside a PV Cell • How Photovoltaic Cells Work • PV Testing & Rating • Thin Film Solar - Crystalline Silicon Solar Cells • Building Integrated PV <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Thin Film versus Silicon Panels • Thin Film Solar Cells • DynoRaxx Flat Roof System • Silicon Solar Panels & Collector All in One • Thin Film Solar Panel and Collector All in One • Mounting Panels to the Roof 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Exercise 2</p> <p>Exercise 4</p> <p>Quiz 5</p> <p>Mounting Lab</p> <p>Home Work</p> <p>Assignment 1</p> <p>Cheat Sheet</p> <p>NABCEP</p>
--------------	--	---	---

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Week #2 - (TOC)

Lesson #5

Day 5	<p>Lecture 1 – Battery Types & Characteristics:</p> <p>Batteries store direct current electrical energy in chemical form for later use.</p> <p>Since a photovoltaic system’s power output varies throughout any given day, a battery storage system can provide a relatively constant source of power when the PV system is producing minimal power during periods of reduced insolation.</p> <p>This lesson will focus on battery types, sizing and safety in a PV systems.</p>	<p>Reading(s): Text Book - Chapter 6</p> <ul style="list-style-type: none"> • Lead Acid Battery • A Guide to Lead Acid Batteries • Top 10 Battery Blunders • Battery Box • Battery Safety Tips • Battery Sizing Worksheet <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Batteries & Controllers • Battery Bank Designer • Battery Bank for Solar System • Converting –Watts-Amps-Volts • Testing Battery Voltage 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz 6</p> <p>Battery Lab</p> <p>Home Work</p> <p>Assignment 1</p> <p>Cheat Sheet</p> <p>NABCEP</p>
--------------	---	---	--

Lesson #6 & #7

Day 6	<p>Lecture 1 – PV Controllers:</p> <p>The photovoltaic controller works as a voltage regulator. The primary function of a controller is to prevent the battery from being overcharged by the PV array. Lesson Two will focus on controller types, features, and sizing a PV system for the appropriate controller.</p>	<p>Reading(s): Text Book - Chapter 7, Chapter 8</p> <ul style="list-style-type: none"> • What is a Charge Controller? • Controller Sizing Worksheet • Choosing an MPPT Controller • What is an Inverter? • How Inverters Work • Choosing An Inverter • Grid Tied Inverters • Charge Controllers for Whole House System • New Generation of Grid Tied Inverters • Microinverters <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Solar Inverters – DC to AC • ProStar Charge Controller • Manson Charge Controller • Measuring Volts & Amps • Battery & Controller Work Station 	<p>Exercise(s):</p> <p>Controller:</p> <p>Exercise 1</p> <p>Exercise 2</p> <p>Quiz 7</p> <p>Controller Lab</p> <p>Home Work</p> <p>Controller CS</p> <p>NABCEP</p> <p>Inverter:</p> <p>Exercise 3</p> <p>Quiz 8</p> <p>Tools Lab</p> <p>Home Work</p> <p>Inverter CS</p> <p>NABCEP</p>
Day 7	<p>Lecture 2 – Inverters:</p> <p>Recent improvements in inverters and appliances have reduced this penalty and made inverters a viable “bridge” between direct current power sources and alternating current load requirements. This lesson will focus on the, who, what, when, where, how and why of the latest inverter technology.</p>		

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Week #2 - (TOC)

Lesson #8

Day 8	<p>Lecture – Photovoltaic System Wiring:</p> <p>Like an electron highway, wire is the path between system components in a PV system. Properly sized and installed wire will safely and efficiently conduct electricity. This lesson will delve into electrical concepts and terminology, conductor types and color coding, wire selection criteria, and a wire sizing guide for PV source and inverter output circuits. This lesson is designed to be used in conjunction with the <i>NEC®.2005</i></p> <p>Lecture – System Grounding:</p> <p>One of the confusing topics in the PV industry, grounding is a very important concept and installation practice. This lesson will introduce the main purposes of grounding systems and equipment, the correct and pertinent terminology, and commonly accepted grounding practices.</p>	<p>Reading(s): Text Book – Chapter 9</p> <ul style="list-style-type: none"> Configuring Your PV Array PV Module Wiring 101 PV Array Grounding PV Systems How to Read A Wiring Diagram Types of Household Wiring How to Build a Combiner Box Electric Wiring Color Coding PV System Design Challenges Working Safely with PV Sample Wiring Exercise <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> Wiring Solar Panels Installing & Grounding Panels Testing Electrical Wiring Electrical Circuit Testers Wire Size Calculator 	<p>Exercise(s):</p> <p>System Wiring</p> <p>Exercise 1 Quiz 9 Wiring Lab</p> <p>Home Work</p> <p>Cheat Sheet NABCEP -----</p> <p>Grounding</p> <p>Ground Quiz 1 Ground Quiz 2 Grounding Lab *</p> <p>Home Work</p> <p>Cheat Sheet NABCEP</p>
--------------	---	--	---

Week #3 - (TOC)

Lesson #9

Day 9	<p>Lecture – Sizing Stand Alone PV Systems:</p> <p>Sizing a residential photovoltaic power system is not particularly complex. This lesson illustrates a six-step process to accurately sizing a system based on the user's projected needs, goals, and budget. Sizing a system includes the following steps:</p> <ol style="list-style-type: none"> 1. Estimating electric loads. 2. Sizing and specifying batteries. 3. Sizing and specifying an array. 4. Specifying a controller. 5. Sizing and specifying an inverter. 6. Sizing system wiring. 	<p>Reading(s): Text Book – Chapter 10</p> <ul style="list-style-type: none"> Doing A Load Analysis Electricity Bill Made Easy Stand Alone PV System Text Book Stand Alone PV Stand Alone PVMaintenance Solar Comfort in Idaho Pole-Mounted-Solar-Array-Part2 NABCEP Exam Study Guide <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> Stand Alone PV System Components Solar PV Wiring Diagram Installing a Stand-Alone PV System 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz 10</p> <p>Flat Roof PV System Lab</p> <p>Home Work</p> <p>Cheat Sheet</p> <p>Stand Alone Quiz</p> <p>Tool Cheat Sheet</p> <p>NABCEP</p>
--------------	---	---	---

Halsey Street Green Solutions

Solar PV Entry Level Training Program (SPITP)

Week #3 - (TOC)

Lesson #9

Day 9	<p>Lecture - Overcurrent Protection and Disconnects Lesson:</p> <p>Both common sense and the National Electrical Code (NEC) tell us that in all electrical systems, including PV, there should be safeguards in place to protect us, conductors, and equipment. Overcurrent protection and disconnects are critical components in PV systems, and it is important to understand their purpose and function. This lesson will also cover proper procedures for basic overcurrent protection sizing, selection, and location in the system.</p>	<p>Reading(s): Text Book – Chapter 9</p> <ul style="list-style-type: none"> • The Why & Where of Disconnects • Overcurrent Devices • To Fuse Or Not To Fuse • NABCEP Exam Study Guide <p>Videos & Web Sites:</p>	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz</p> <p>Home Work</p> <p>Cheat Sheet</p>
--------------	--	--	---

Lesson #9B

Day 10	<p>Lecture - Installation, Commissioning, and Safety Lesson:</p> <p>While proper design and installation of a PV system are important for efficient, long-term reliability, safety always comes first. System commissioning (start-up) and shut-down procedures must be followed carefully to ensure proper system operation as well as a safe working environment. Failure to adhere to these procedures can lead to equipment damage, injury, and even death.</p>	<p>Reading(s): Text Book – Chapter 16</p> <ul style="list-style-type: none"> • Electrical Tools • Lockout/Tagout Safety • Smart Testing • NABCEP Safety Guide <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Ladder Safety • Using a Fire Extinguisher • Using a Safety Harness • Using Power Tools 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz</p> <p>Pitched Roof PV System Lab</p> <p>Home Work</p> <p>Cheat Sheet</p> <p>NABCEP</p>
---------------	--	--	---

Halsey Street Green Solutions Solar PV Entry Level Training Program (SPITP)

Week #3 - (TOC)

Lesson #10

Day 11	<p>Lecture – Grid-tied PV Systems:</p> <p>In this lesson and the next, students will be introduced grid-tied system types, the advantages of grid-tied systems, system sizing, obtaining an interconnection agreement and net metering.</p> <p>Grid-tied systems, also called utility-connected, grid-tied, or line-tied systems, are solar-based energy systems installed on homes or commercial buildings connected to an electric utility. Advances in solar power electronics make it relatively easy to connect a solar electric system to the utility. Energy generated by such a system is first used within the home, and surplus power is “pushed” onto the utility’s wires. In most US states, local utilities are required by law to allow “spinning the meter backward” when the electricity being produced by the PV system is greater than what is being used in the home.</p>	<p>Reading(s): Text Book – Chapter 11</p> <ul style="list-style-type: none"> • Home Blackout Protection • Monitoring PV-Systems • Hassle Free Urban PV • Practical Solar From the Ground Up • Solar Putting it all Together • Making Sense of Solar Cost • Interconnection Systems • NEC Standards for Grid-Tied PV • NABCEP Exam Study Guide • Look at RE incentives for different US states • Solar Glossary of Terms <p>Videos & Web Sites:</p> <ul style="list-style-type: none"> • Grid Tied Systems 101 • Grid Tied PV Systems • Solar & Wind Grid Tied Systems 	<p>Exercise(s):</p> <p>Exercise 1</p> <p>Quiz 11</p> <p>Quiz 12</p> <p>Quiz 13</p> <p>Quiz 14</p> <p>Quiz 15</p> <p>Grounding A PV System Lab</p> <p>Home Work</p> <p>Cheat Sheet</p> <p>SOLAR PV COURSE/Exercise-Grid-Tied-Putting-It-All-Together-Lab.doc</p>
Day 11	<p>NABCEP PV Entry Level Examination Review Session: PV Markets – Basic Electricity – Solar Energy Fundamentals - PV Fundamentals – Batteries- Controllers – Inverters – PV Wiring – Grounding – Safety - Troubleshooting</p>	<ul style="list-style-type: none"> • NABCEP PV Exam Overview 	<p>400 NABCEP Questions</p>

Week #3 - (TOC)

Lesson #12 (Class Rap-up Activity)

Day 12	<p>Final Exam – HSGS 60 Question NABCEP Photovoltaic (PV) Entry Level Test Preparation Exam</p> <p>Final Course Evaluation</p> <p>Field Trip to solar PV installation construction site</p>	<p>Reading(s):</p>	<p>Exercise(s):</p> <p>Final Exam</p> <p>Final Evaluation</p>
---------------	---	---------------------------	--

Halsey Street Green Solutions Solar PV Entry Level Training Program (SPITP)

Solar Panel Installer Training Course Forms	
• Daily Attendance Sheet – Summary Sheet –AG	• HSGS Payment Verification Form
• Weekly Evaluation Form	• Course Evaluation Form
• HSGS Solar Panel Course Grading Sheet	• NABCEP Test Registration Form
• Student Liability Waiver Form	• Rapid Fire Round Robin Scoring Sheet
Green Job Reading Material	
• Preparing the Workforce for “Green Jobs”	• Sun & Wind Solar Electric Store
• HSGS Projects & Training Programs	• Green Collar Jobs in American Cities
• Community Owned Energy Enterprises	• Green Jobs – Toward a Sustainable World
• Green Job Careers & Salaries in California	• Solar Installation Field Inspection Guide
• A Guide to PV System Design & Installation	• Working Safely with PV Systems
• Stand Alone PV Systems	• Maintenance of Stand Alone PV Systems
• PV Systems & the National Electrical Code	• NABCEP Preparation Test Questions
• Solar System Design Quick Review	• Solar Glossary of Terms

Lab Activity Materials & Videos	
• Setting Up the Solar Panel Training Kit	• Orientating the Panels for a Thin Film System
• Installing Panels in Series & Parallel	• Sizing the Staple Center for Solar Panels
• Sizing & Connecting Batteries for Solar	• Electricity Basics - Ohm’s Law Overview
• All About Circuits	• Free Sun Power – Solar Panel Tutorials
• Solar Course Hardware & Software Budget	• Solar Toolkit Components
• PV Lesson & Lab Activity Alignment Menu	• NREL PV Watts Solar Calculator

Solar System Cheat Sheets	
• Introduction to PV Systems Cheat Sheet	• Solar Radiation Cheat Sheet
• Solar Panel Cheat Sheet	• Site Survey & Preparation Cheat Sheet
• Charge Controller Cheat Sheet	• Stand Alone PV System Cheat Sheet
• Batteries Cheat Sheet	• Grid Tied PV System Cheat Sheet
• Inverter Cheat Sheet	• Electrical Integration Cheat Sheet
• Mechanical Integration Cheat Sheet	• Performance & Troubleshooting Cheat Sheet
• Grounding Cheat Sheet	• Site Safety Cheat Sheet