# COURSE OUTLINE

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<td>ERG113</td>
<td>Solar installation Technology</td>
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Hours: 2/2 lecture/Lab/Other

Co- or Pre-requisite: Revised: Spring 2014

## Course description:

Introduction to the Solar PV industry. Includes system types and efficiencies, solar site evaluation, differences between grid intertie and off-grid systems and associated components. Students use materials and tools used in solar panel installation. Safety on the job is emphasized.

2 lecture/2 laboratory

## Required texts/other materials:


## Revision date:

Spring 2014

## Course Coordinator:

Garry Perryman, 3357, perryg@mccc.edu

## Other learning resources:

**Course Competencies/Goals:**

1. Understand the basic principles of Photovoltaic systems.
2. Work safely with photovoltaic systems.
3. Conduct a site assessment for solar PV installation.
4. Select an appropriate systems design.
5. Adapt the design for mechanical / electrical design.
6. Install PV System and components at the site.
7. Perform a system checkout and Inspection.
8. Maintain and troubleshooting a system.
9. Read and interpret plans and specifications.
10. Read and interpret codes and standards.
11. Use basic mathematics and some trigonometry (addition, subtraction, multiplication, division, calculations of area and volume, fractions, decimals, percentages, calculating the sides of triangles, square roots, powers of numbers, and solving simple algebraic equations for unknown variables).

**Course-specific General Education Knowledge Goals and Core Skills**

**General Education Knowledge Goals**

**Goal 1. Communication.** Students will communicate effectively in both speech and writing.

**Goal 2. Mathematics.** Students will use appropriate mathematical and statistical concepts and operations to interpret data and to solve problems.

**Goal 3. Science.** Students will use the scientific method of inquiry, through the acquisition of scientific knowledge.

**Goal 4. Technology.** Students will use computer systems or other appropriate forms of technology to achieve educational and personal goals.

**Goal 5. History.** Students will understand historical events and movements in World, Western, non-Western or American societies and assess their subsequent significance.

**Goal 6. Diversity.** Students will understand the importance of a global perspective and culturally diverse peoples.

**Goal 7. Ethical Reasoning and Action.** Students will understand ethical issues and situations.

**MCCC Core Skills**

**Goal A. Written and Oral Communication in English.** Students will communicate effectively in speech and writing, and demonstrate proficiency in reading.

**Goal B. Critical Thinking and Problem-solving.** Students will use critical thinking and problem solving skills in analyzing information.

**Goal C. Ethical Decision-Making.** Students will recognize, analyze and assess ethical issues and situations.

**Goal D. Information Literacy.** Students will recognize when information is needed and have the knowledge and skills to locate, evaluate, and effectively use information for college level work.

**Goal E. Computer Literacy.** Students will use computers to access, analyze or present information, solve problems, and communicate with others.

**Goal F. Collaboration and Cooperation.** Students will develop the interpersonal skills required for effective performance in group situations.
Units of study in detail.

Unit I  [Overview of Photovoltaic's]

**Learning Objectives:**

*The student will be able to…*

- Understand the development of Photovoltaic’s over time. (Course Competencies 1; Gen Ed Goals 2, 3 & 4; Core Skills B & D.)
- Understand current and emerging opportunities in Photovoltaic Technology. (Course Competencies 1 & 4; Gen Ed Goals 2, 3 & 4; Core Skills B, & D.)
- Describe the advantages and disadvantages of Photovoltaic Technology. (Course Competencies 1 & 4; Gen Ed Goals 3 & 4; Core Skills B, & D.)
- Identify Environmental, Health, and Safety Issues. (Course Competencies 1 & 2; Gen Ed Goals 1, 2 & 3; Core Skills A, B, & D.)
- Identify Photovoltaic System Components and Photovoltaic System Types. (Course Competencies 4, 5 & 8; Gen Ed Goals 2, 3 & 4; Core Skills A, B, & D.)

Unit II  [Safety and PV Installations]

**Learning Objectives:**

*The student will be able to…*

- Maintain safe work habits and a clean, orderly work area. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)
- Demonstrate safe and proper use of required tools and equipment. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)
- Demonstrate safe and accepted practices for personnel protection. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)
- Demonstrate awareness of safety hazards and how to avoid them. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)
- Demonstrate proficiency in basic first aid and CPR. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)

Unit III  [Electrical and non-electrical hazards safety and PV Installations]

**Learning Objectives:**

*The student will be able to…*

- Identify and implement appropriate codes and standards concerning installation, operation and maintenance of PV systems and equipment. (Course Competencies 1, 3, 7, 8 & 10; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B, D 7 E.)
- Identify personal safety hazards associated with PV installations. (Course Competencies 2; Gen Ed Goals 1 & 4; Core Skills A.)

Unit IV  [Conducting a site assessment]

**Learning Objectives:**

*The student will be able to…*

- Identify typical tools and equipment required for conducting site surveys for PV installations, and demonstrate proficiency in their use. (Course Competencies 2, 3, 6 & 7; Gen Ed Goals 1 & 4; Core Skills A.)
- Establish suitable location with proper orientation, sufficient area, adequate solar access and structural integrity for installing PV array. (Course Competencies 1, 3, 4, 6 & 9; Gen Ed Goals 1, 3 & 4; Core Skills A, B, &D.)
- Establish suitable locations for installing inverters, control, batteries and other balance-of-system components. (Course Competencies 3, 4, 6 & 9; Gen Ed Goals 1, 3 & 4; Core Skills A, B & D.)
- Diagram possible layouts and locations for array and equipment, including existing building or site features. (Course Competencies 1, 3, 4, 5, 6 & 9; Gen Ed Goals 1 & 4; Core Skills B & D.)
- Identify and assess any site-specific safety hazards or other issues associated with installation of system. (Course Competencies 2, 3 & 5; Gen Ed Goals 1 & 4; Core Skills B & D.)
- Obtain and interpret solar radiation and temperature data for site for purposes of establishing performance expectations and use in electrical system calculations. (Course Competencies 5, 9 & 11; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B & D.)
- Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements and/or customer interview. (Course Competencies 11; Gen Ed Goals 2, 3 & 4; Core Skills A, B & D.)
- Estimate and/or measure the peak load demand and average daily energy use for all loads directly connected to inverter-battery systems for purposes of sizing equipment, as applicable. (Course Competencies 11; Gen Ed Goals 2, 3 & 4; Core Skills A, B & D.)
- Determine requirements for installing additional subpanels and interfacing PV system with utility service, and/or other generation sources as applicable. (Course Competencies 2, 5, 6, 7, 9 & 10; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B & D.)
- Identify opportunities for the use of energy efficient equipment/appliances, conservation and energy management practices, as applicable. (Course Competencies 2, 5, 6, 7, 9 & 10; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B & D.)

**Unit V  [Selecting a System Design]**

*Learning Objectives:*
*The student will be able to…*

- Identify appropriate system designs/configurations based on customer needs, expectations and site conditions. (Course Competencies 4, 5, 9 & 11; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B, C, D & F.)
- Estimate sizing requirements for major components based on customer load, desired energy or peak power production, autonomy requirement, size and costs as applicable. (Course Competencies 11; Gen Ed Goals 2 & 3; Core Skills B, D & E.)
- Identify and select major components and balance of system equipment required for installation. (Course Competencies 11; Gen Ed Goals 2 & 3; Core Skills B, D & E.)
- Estimate time, materials and equipment required for installation, determine installation sequence to optimize use of time and materials. (Course Competencies 4, 5, 9 & 11; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B, C, D & F.)

**Unit VI  [Adapting the Mechanical Design]**

*Learning Objectives:*
*The student will be able to…*

- Identify a mechanical design, equipment to be used and installation plan that is consistent with the environmental, architectural, structural, code requirements and other conditions of the site. (Course Competencies 4, 5, 8, 9 & 10; Gen Ed Goals 1, 2, 3 & 4; Core Skills A, B, D & E.)
- Identify appropriate module/array layout, orientation and mounting method for ease of installation, electrical configuration and maintenance at the site. (Course Competencies 4, 5, 6 & 7; Gen Ed Goals 3 & 4; Core Skills B, D & E.)

**Unit VII  [Adapting the Electrical Design]**

*Learning Objectives:*
*The student will be able to…*

- Determine the design currents for any part of a PV system electrical circuit. (Course Competencies 2, 4, & 5; Gen Ed Goals 3 & 4; Core Skills B.)
- Select appropriate conductor types and ratings for each electrical circuit in the system based on application. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Determine the derated ampacity of system conductors, and select appropriate sizes based on design currents. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Determine appropriate size, ratings and locations for all system overcurrent and disconnect devices. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Determine appropriate size, ratings and locations for grounding, surge suppression and associated equipment. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Determine voltage drop for any electrical circuit based on size and length of conductors. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Verify that the array operating voltage range is within acceptable operating limits for power conditioning equipment, including inverters and controllers. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Select an appropriate utility interconnection point, and determine the size, ratings and locations for over current and disconnect devices. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)

**Unit VIII** [Installing Subsystems and Components at the site]

**Learning Objectives:**
The student will be able to…

- Utilize drawings, schematics, instructions and recommended procedures in installing equipment. (Course Competencies 4, 5 & 9; Gen Ed Goals 1 & 4; Core Skills A.)
- Implement all applicable personnel safety and environmental protection measures. (Course Competencies 2 & 4; Gen Ed Goals 1; Core Skills B & D.)
- Visually inspect and quick test PV modules Psychomotor Important. (Course Competencies 1, 2 & 7; Gen Ed Goals 3 & 4; Core Skills B & F.)
- Assemble modules, panels and support structures as specified by module manufacturer or design. (Course Competencies 2, 6 & 7; Gen Ed Goals 3 & 4; Core Skills B, D & F.)
- Install module array interconnect wiring, implement measures to disable array during installation. (Course Competencies 2, 6 & 7; Gen Ed Goals 3 & 4; Core Skills B, D & F.)
- Complete final assembly, structural attachment and weather sealing of array to building or other support mechanism. (Course Competencies 2, 6 & 7; Gen Ed Goals 3 & 4; Core Skills B, D & F.)
- Install and provide required labels on inverters, controls, disconnects and overcurrent devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Label, install and terminate electrical wiring; verify proper connections, voltages and phase/polarity relationships. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Verify continuity and measure impedance of grounding system cognitive. (Course Competencies 2, 4, & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)
- Program, adjust and/or configure inverters and controls for desired set points and operating modes. (Course Competencies 2, 4 & 5; Gen Ed Goals 3, 4 & 9; Core Skills B.)

**Unit IX** [Performing System Checkout and Inspection]

**Learning Objectives:**
The student will be able to…

- Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship. (Course Competencies 2, 7, 8 & 9; Gen Ed Goals 3 & 4; Core Skills B, D & E.)
- Check system mechanical installation for structural integrity and weather sealing. (Course Competencies 2, 7, 8 & 9; Gen Ed Goals 3 & 4; Core Skills B, D & E.)
- Check electrical installation for proper wiring practice, polarity, grounding and integrity of terminations. (Course Competencies 2, 4, & 5; Gen Ed Goals 3 & 4; Core Skills B.)

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• Activate system and verify overall system functionality and performance, compare with expectations. (Course Competencies 7, 8 & 10; Gen Ed Goals 1, 3 & 4; Core Skills B, C, D & E.)
• Demonstrate procedures for connecting and disconnecting the system and equipment from all sources. (Course Competencies 2, 4, & 5; Gen Ed Goals 3 & 4; Core Skills B)
• Identify and verify all required markings and labels for the system and equipment. (Course Competencies 9; Gen Ed Goals 1 & 4; Core Skills A.)
• Identify and explain all safety issues associated with operation and maintenance of system
• Identify what documentation is required to be provided to the PV system owner/operator by the installer. (Course Competencies 9; Gen Ed Goals 1 & 4; Core Skills A.)

Unit X [Maintaining and Troubleshooting a System]

Learning Objectives: The student will be able to…

• Identify tools and equipment required for maintaining and troubleshooting PV systems; demonstrate proficiency in their use. (Course Competencies 7 & 8; Gen Ed Goals 1 & 4; Core Skills A & B.)
• Identify maintenance needs and implement service procedures for modules, arrays, batteries, power conditioning equipment, safety systems, structural and weather sealing systems, and balance of systems equipment. (Course Competencies 7 & 8; Gen Ed Goals 1 & 4; Core Skills A & B.)
• Measure system performance and operating parameters, compare with specifications and expectations, and assess operating condition of system and equipment. (Course Competencies 7; Gen Ed Goals 1 & 4; Core Skills A & F.)
• Perform diagnostic procedures and interpret results. (Course Competencies 7 & 8; Gen Ed Goals 1, 3 & 4; Core Skills A, B & F.)
• Identify performance and safety issues, and implement corrective measures. (Course Competencies 2 & 7; Gen Ed Goals 1 & 4; Core Skills A & F.)
• Verify and demonstrate complete functionality and performance of system, including start-up, shut-down, normal operation and emergency/bypass operation. (Course Competencies 2, 7, 8, 9 & 10; Gen Ed Goals 1,3, 4 & 7; Core Skills A, B, C, D, E, C & F.)
• Compile and maintain records of system operation, performance and maintenance. (Course Competencies 1 & 7; Gen Ed Goals 1,3, 4 & 7; Core Skills A, B, C, D, E, C & F.)

Method of Instruction:

Lecture will be used as the primary method of information delivery. Extensive use of PowerPoint explaining theories and working examples will form the base from which numerous homework problems and lab exercises to yield student proficiency. The lecture, problems, and laboratory work will emphasize the practical application of theories and formula. The laboratory work will follow the lecture as close as practicable. Experiment will emphasize and reinforce the theories discussed in the classroom and will yield much practical experience in using flow measuring devices and constructing proper circuits to obtain correct measurements with these devices.

Evaluation of student learning:

20% Homework
30% Five one-hour tests, scheduled normally at the conclusion of each unit and encompassing all work covered in the course prior to the test date.
30% Lab reports will be graded on their comprehensive content, correctness, neatness, and general approach to the problem.
20% Final comprehensive exam
**Academic Integrity Statement:**

Students are expected to comply with the college-wide requirements for academic integrity. Mercer County Community College is committed to Academic Integrity—the honest, fair, and continuing pursuit of knowledge, free from fraud or deception. This implies that students are expected to be responsible for their own work. Presenting another individual’s work as one’s own and receiving excessive help from another individual will qualify as a violation of Academic Integrity. The entire policy on Academic Integrity is located in the Student handbook and is found on the college website (http://www.mccc.edu/admissions_policies_integrity.shtml).

**Students with Disabilities:**

Any student in this class who has special needs because of a disability is entitled to receive accommodations. Eligible students at Mercer County Community College are assured services under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973. If you believe you are eligible for services, please contact Arlene Stinson, the Director of Academic Support Services. Ms. Stinson’s office is LB221, and she can be reached at (609) 570-3525.