Course Number & Name: UTI 113 Solar Installation Technology

Credit Hours: 3.0          Contact Hours: 4.0          Lecture: 2.0          Lab: 2.0          Other: N/A

Prerequisites: Grade of “C” or better in UTI 111

Co-requisites: None          Concurrent Courses: None

Course Outline Revision Date: Fall 2010

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

Course Goals: Upon successful completion of this course, students should be able to do the following:

1. discuss the basic principles of photovoltaic (PV) 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 systems design for mechanical/electrical design;
6. install a PV system and components at the site;
7. perform a system checkout and inspection; and
8. maintain and troubleshoot a system.

Measurable Course Performance Objectives (MPOs): Upon successful completion of this course, students should specifically be able to do the following:

1. Discuss the basic principles of photovoltaic systems:
   1.1 describe the development of photovoltaics over time;
   1.2 discuss current and emerging opportunities in photovoltaic technology;
   1.3 discuss the advantages and disadvantages of photovoltaic technology;
   1.4 identify and describe environmental, health, and safety issues related to photovoltaic technology; and
   1.5 identify and describe the components of and types of photovoltaic systems
Measurable Course Performance Objectives (MPOs) (continued):

2. Work safely with photovoltaic systems:
   2.1 maintain safe work habits and keep a clean, orderly work area;
   2.2 demonstrate safe and proper use of required tools and equipment;
   2.3 demonstrate safe and accepted practices for personnel protection;
   2.4 discuss safety hazards and explain how to avoid them;
   2.5 demonstrate proficiency in basic first aid and CPR;
   2.6 identify and implement appropriate codes and standards concerning installation, operation and maintenance of PV systems and equipment; and
   2.7 discuss personal safety hazards associated with PV installations

3. Conduct a site assessment for solar PV installation:
   3.1 identify and demonstrate safe and proper use of typical tools and equipment required for conducting site surveys for PV installations;
   3.2 establish a suitable location with proper orientation, sufficient area, adequate solar access and structural integrity for installing the PV array;
   3.3 establish suitable locations for installing inverters, control, batteries and other balance-of-system components;
   3.4 diagram possible layouts and locations for array and equipment including existing building or site features.
   3.5 identify and assess any site-specific safety hazards or other issues associated with installation of the system;
   3.6 obtain and interpret solar radiation and temperature data for site for purposes of establishing performance expectations and use in electrical system calculations;
   3.7 evaluate (quantify) the customer electrical load and energy use through review of utility bills, meter readings, measurements and/or customer interview;
   3.8 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;
   3.9 determine requirements for installing additional sub-panels and interfacing PV system with utility service and/or other generation sources as applicable; and
   3.10 determine opportunities for the use of energy-efficient equipment/appliances, conservation and energy management practices as applicable

4. Select an appropriate systems design:
   4.1 identify appropriate system designs/configurations based on customer needs, expectations and site conditions;
   4.2 estimate sizing requirements for major components based on customer load, desired energy or peak power production, autonomy requirement, size and costs as applicable;
   4.3 identify and select major components and balance-of-system equipment required for installation; and
   4.4 estimate time, materials and equipment required for installation and determine the installation sequence to optimize use of time and materials
Measurable Course Performance Objectives (MPOs) (continued):

5. Adapt the systems design for mechanical/electrical design:
   5.1 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;
   5.2 identify appropriate module/array layout, orientation and mounting method for ease of installation, electrical configuration and maintenance at the site;
   5.3 determine the design currents for any part of a PV system electrical circuit;
   5.4 select appropriate conductor types and ratings for each electrical circuit in the system based on the application;
   5.5 determine the derated ampacity of system conductors and select appropriate sizes based on design currents;
   5.6 determine the appropriate size, ratings and locations for all system over-current and disconnect devices;
   5.7 determine the appropriate size, ratings and locations for grounding, surge suppression and associated equipment;
   5.8 determine voltage drop for any electrical circuit based on size and length of conductors;
   5.9 assess whether the array-operating voltage range is within acceptable operating limits for power conditioning equipment including inverters and controllers; and
   5.10 select an appropriate utility interconnection point and determine the size, ratings and locations for over-current and disconnect devices

6. Install a PV System and components at the site:
   6.1 utilize and follow drawings, schematics, instructions and recommended procedures in installing equipment;
   6.2 implement all applicable personnel safety and environmental protection measures;
   6.3 visually inspect and quick test PV modules;
   6.4 assemble modules, panels and support structures as specified by module manufacturer or design;
   6.5 install the module array interconnect wiring and implement measures to disable the array during installation;
   6.6 complete final assembly, structural attachment and weather sealing of the array to building or other support mechanism;
   6.7 install and provide required labels on inverters, controls, disconnects and over-current devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware;
   6.8 label, install and terminate electrical wiring being sure to verify proper connections, voltages and phase/polarity relationships;
   6.9 verify continuity and measure impedance of grounding system cognitive; and
   6.10 program, adjust and/or configure inverters and controls for desired set points and operating modes

7. Perform a system checkout and Inspection:
   7.1 visually inspect the entire installation, identifying and resolving any deficiencies in materials or workmanship;
   7.2 check the system mechanical installation for structural integrity and weather sealing;
Measurable Course Performance Objectives (MPOs) (continued):

7.3 check the electrical installation for proper wiring practice, polarity, grounding and integrity of terminations;
7.4 activate the system and evaluate the overall system functionality and performance as compared to expectations;
7.5 demonstrate procedures for connecting and disconnecting the system and equipment from all sources;
7.6 identify and verify all required markings and labels for the system and equipment;
7.7 identify and explain all safety issues associated with operation and maintenance of the system; and
7.8 identify the documentation that is required to be provided to the PV system owner/operator by the installer

8. Maintain and troubleshoot a system:

8.1 identify and demonstrate safe and proper use of tools and equipment required for maintaining and troubleshooting PV systems;
8.2 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;
8.3 measure system performance and operating parameters comparing them with specifications and expectations and assess the operating condition of the system and equipment;
8.4 perform diagnostic procedures and interpret the results;
8.5 identify performance and safety issues and implement corrective measures;
8.6 verify and demonstrate complete functionality and performance of the system, including start-up, shut-down, normal operation and emergency/bypass operation; and
8.7 compile and maintain records of the system operation, performance, and maintenance

Methods of Instruction: Instruction will consist of a combination of lectures, class discussions, classroom demonstrations, laboratory experiments, board work, group work and individual study.

Outcomes Assessment: Test and exam questions are blueprinted to course objectives. Checklist rubrics are used to evaluate the laboratory reports and corresponding oral presentation for the presence of course objectives. Data is collected and analyzed to determine the level of student performance on these assessment instruments in regards to meeting course objectives. The results of this data analysis are used to guide necessary pedagogical and/or curricular revisions.

Course Requirements: All students are required to:

1. Maintain regular attendance.
2. Complete homework assignments and laboratory reports.
3. Sit for all quizzes, tests, and exams.
4. Read all assigned textbook pages.
5. Participate in classroom discussions.
**Methods of Evaluation:** Final course grades will be computed as follows:

<table>
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<tr>
<th>Grading Components</th>
<th>% of final course grade</th>
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<tbody>
<tr>
<td><strong>Homework, Quizzes, Class Participation, and Attendance</strong>&lt;br&gt;A perusal of homework problems and quizzes and an analysis of class discussion will indicate the extent to which students master course objectives. Attendance may also be counted toward the student’s final course grade.</td>
<td>25 – 30%</td>
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<td><strong>Laboratory Reports</strong>&lt;br&gt;Students will be expected to show that they have read assigned lab manual sections, can follow written procedures, measure and record data, perform calculations and write reports including all specified components, which will provide evidence of mastery of course objectives.</td>
<td>20 – 30%</td>
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<td><strong>3 or more Tests</strong>&lt;br&gt;(dates specified by the instructor)&lt;br&gt;Tests will show evidence of the extent to which students meet course objectives, including but not limited to identifying and applying concepts, analyzing and solving problems, estimating and interpreting results and stating appropriate conclusions using correct terminology.</td>
<td>25 – 30%</td>
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<td><strong>Final Exam</strong>&lt;br&gt;(comprehensive)&lt;br&gt;The same objectives apply as with tests, but it is anticipated that students will provide increased evidence of synthesizing a combination of concepts.</td>
<td>20 – 30%</td>
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**NOTE:** The instructor will provide specific weights, which lie in the above-given ranges, for each of the grading components at the beginning of the semester.

**Academic Integrity:** Dishonesty disrupts the search for truth that is inherent in the learning process and so devalues the purpose and the mission of the College. Academic dishonesty includes, but is not limited to, the following:

- **plagiarism** – the failure to acknowledge another writer’s words or ideas or to give proper credit to sources of information;
- **cheating** – knowingly obtaining or giving unauthorized information on any test/exam or any other academic assignment;
- **interference** – any interruption of the academic process that prevents others from the proper engagement in learning or teaching; and
- **fraud** – any act or instance of willful deceit or trickery.

Violations of academic integrity will be dealt with by imposing appropriate sanctions. Sanctions for acts of academic dishonesty could include the resubmission of an assignment, failure of the test/exam, failure in the course, probation, suspension from the College, and even expulsion from the College.
**Student Code of Conduct:** All students are expected to conduct themselves as responsible and considerate adults who respect the rights of others. Disruptive behavior will not be tolerated. All students are also expected to attend and be on time for all class meetings. No cell phones or similar electronic devices are permitted in class. Please refer to the Essex County College student handbook, *Lifeline*, for more specific information about the College’s Code of Conduct and attendance requirements.

<table>
<thead>
<tr>
<th>Week</th>
<th>Content/Topics</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to the course; Photovoltaic (PV) technology (ch 1); PV system components and PV system types (ch 1)</td>
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<td>2</td>
<td>Volt, amp, AH, watt, watt-hour, series &amp; parallel wiring exercises (ch 2); Solar radiation, solar site analysis (ch 3)</td>
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<td>3</td>
<td>Electrical load requirements, calculating load estimates (ch 4); Safe PV installation, safe work habits, safety hazards, first aid (ch 16)</td>
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<tr>
<td>4</td>
<td>Characteristics of PV modules (ch 5); <strong>Test 1</strong>; Factors of PV module performance (ch 5)</td>
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</table>
| 5    | Lab #1: PV Module Performance  
Battery types and operation (ch 6) |
| 6    | Battery specification and safety, battery wiring configuration (ch 6);  
Lab #2: Battery Wiring |
| 7    | PV controller types and features (ch 7); **Test 2**; Specifying PV controller (ch 7) |
| 8    | Lab #3: PV Controllers  
Inverter operating principles (ch 8) |
| 9    | Inverter types and features, inverter sizing exercises (ch 8);  
Lab #4: Inverters |
| 10   | Wire types, ampacity, cable types, voltage drop (ch 9); System wiring exercise, disconnects, grounding, surge suppression (ch 9) |
| 11   | Lab #5: PV System Wiring  
Sizing stand-alone PV systems (ch 10); **Test 3** |
| 12   | Grid-tied PV system (ch 11); Mounting PV modules (ch 12) |
| 13   | PV system installation (ch 14); Maintaining and troubleshooting a system (ch 15) |
| 14   | Lab #6: Troubleshooting a System |
| 15   | Review and **Final Exam** |