SOL 220
Solar Photovoltaic Design and Installation

Course Description
This course is a study of solar photovoltaic (PV) specific design, code compliance, sizing calculations, cost analysis, inverter applications, safety issues, and associated component selections.
Prerequisites: SOL 201 or instructor approval.

Course Focus
This course is a study of solar photovoltaic (PV) specific design, code compliance, sizing calculations, cost analysis, inverter applications, safety issues, and associated component selections as well as battery based systems.

Text and References
SKU: ISBN -1256701661

Course Goals
The following list of course goals will be addressed in the course. These goals are directly related to the performance objectives.

1. Identify the various safety hazards associated with both operating and non-operating PV systems and components
2. List different types of personal protective equipment (PPE) commonly required for installing and maintaining PV systems
3. List different methods and identify safe practices for hoisting and rigging, the use of ladders, stairways and guardrails, the use of head, feet, hearing and face protection, the use of power tools, and the use of the appropriate fall protection, including the requirements for personal fall arrest and safety-monitoring systems according to OSHA standards
4. Recognize the principal electrical safety hazards associated with PV systems, including electrical shock and arc flash.
5. Understand the meaning of basic electrical parameters including electrical charge, current, voltage, power and resistance, and relate these parameters to their hydraulic analogies (volume, flow, pressure, hydraulic power and friction)
6. Explain the difference between electrical power (rate of work performed) and energy (total work...
7. Describe the function and purpose of common electrical system components, including conductors, conduits/raceways and enclosures, overcurrent devices, diodes and rectifiers, switchgear, transformers, terminals and connectors, grounding equipment, resistors, inductors, capacitors, etc.
8. Identify basic electrical test equipment and its purpose, including voltmeters, ammeters, ohmmeters and watt-hour meters.
9. Demonstrate the ability to apply Ohm’s Law in analyzing simple electrical circuits, and to calculate voltage, current, resistance or power given any other two parameters.
10. Understand the fundamentals of electric utility system operations, including generation, transmission, distribution and typical electrical service supplies to buildings and facilities
11. Define basic terminology, including solar radiation, solar irradiance, solar irradiation, solar constant, air mass, ecliptic plane, equatorial plane, pyranometer, solar declination, solstice, equinox, solar time, solar altitude angle, solar azimuth angle, solar window, array tilt angle, array azimuth angle, and solar incidence angle
12. Diagram the sun’s apparent movement across the sky over any given day and over an entire year at any given latitude, and define the solar window
13. For given dates, times and locations, identify the sun’s position using sun path diagrams, and determine when direct solar radiation strikes the north, east, south and west walls and horizontal surfaces of a building
14. Differentiate between solar irradiance (power), solar irradiation (energy), and understand the meaning of the terms peak sun, peak sun hours, and insolation
15. Identify factors that reduce or enhance the amount of solar energy collected by a PV array
16. Demonstrate the use of a standard compass and determine true geographic south from magnetic south at any location given a magnetic declination map
17. Quantify the effects of changing orientation (azimuth and tilt angle) on the amount of solar energy received on an array surface at any given location using solar energy databases and computer software tools
18. Understand the consequences of array shading and best practices for minimizing shading and preserving array output.
19. Demonstrate the use of equipment and software tools to evaluate solar window obstructions and shading at given locations, and quantify the reduction in solar energy received
20. Identify rules of thumb and spacing distances required to avoid inter-row shading from adjacent sawtooth rack mounted arrays at specified locations between 9 am and 3 pm solar time throughout the year
21. Define the concepts of global, direct, diffuse and albedo solar radiation, and the effects on flat-plate and concentrating solar collectors
22. Identity the instruments and procedures for measuring solar power and solar energy
23. Explain how a solar cell converts sunlight into electrical power
24. Distinguish between PV cells, modules, panels and arrays
25. Identify the five key electrical output parameters for PV modules using manufacturers’ literature (Voc, Isc, Vmp, Imp and Pmp), and label these points on a current-voltage (I-V) curve
26. Understand the effects of varying incident solar irradiance and cell temperature on PV module electrical output, illustrate the results on an I-V curve, and indicate changes in current, voltage and power
27. Determine the operating point on a given I-V curve given the electrical load
28. Explain why PV modules make excellent battery chargers based on their I-V characteristics
29. Understand the effects of connecting similar and dissimilar PV modules in series and in parallel on electrical output, and diagram the resulting I-V curves
30. Define various performance rating and measurement conditions for PV modules and arrays, including STC, SOC, NOCT, and PTC
31. Compare the fabrication of solar cells from various manufacturing processes
32. Describe the components and the construction for a typical flat-plate PV module made from crystalline
silicon solar cells, and compare to thin-film modules
33. Given the surface area, incident solar irradiance and electrical power output for a PV cell, module or array, calculate the efficiency and determine the power output per unit area
34. Discuss the significance and consequences of PV modules being limited current sources
35. Explain the purpose and operation of bypass diodes
36. Identify the standards and design qualification testing that help ensure the safety and reliability of PV modules.
37. Describe the purpose and principles of operation for major PV system components, including PV modules and arrays, inverters and chargers, charge controllers, energy storage and other sources
38. List the types of PV system balance of system components, and describe their functions and specifications, including conductors, conduit and raceway systems, overcurrent protection, switchgear, junction and combiner boxes, terminations and connectors
39. Identify the primary types, functions, features, specifications, settings and performance indicators associated with PV system power processing equipment, including inverters, chargers, charge controllers, and maximum power point trackers
40. Understand the basic principles, rationale and strategies for sizing stand-alone PV systems versus utility-interactive PV systems
41. Given the power usage and time of use for various electrical loads, determine the peak power demand and energy consumption over a given period of time
42. Beginning with PV module DC nameplate output, list the de-rating factors and other system losses, and their typical values, and calculate the resulting effect on AC power and energy production, using simplified calculations, and online software tools including PVWATTS
43. For a specified PV module and inverter in a simple utility-interactive system, determine the maximum and minimum number of modules that may be used in source circuits and the total number of source circuits that may be used with a specified inverter, depending upon the expected range of operating temperatures, the inverter voltage windows for array maximum power point tracking and operation, using both simple calculations and inverter manufacturers’ online string sizing software tools
44. Given a stand-alone application with a defined electrical load and available solar energy resource, along with PV module specifications, size and configure the PV array, battery subsystem, and other equipment as required, to meet the electrical load during the critical design period.

Student Contributions
The student is expected to be prepared for class and to be in class on time. Cell phones are not allowed to be used in the classroom. This includes texting. All electronic devices including cell phones, pagers, computers, iPods, iPads must be turned off during class.

ADA STATEMENT
The Technical College of the Lowcountry provides access, equal opportunity and reasonable accommodation in its services, programs, activities, education and employment for individuals with disabilities. To request disability accommodation, contact the counselor for students with disabilities at (843) 525-8228 during the first ten business days of the academic term.

ACADEMIC MISCONDUCT
There is no tolerance at TCL for academic dishonesty and misconduct. The College expects all students to conduct themselves with dignity and to maintain high standards of responsible citizenship.

It is the student’s responsibility to address any questions regarding what might constitute academic misconduct to the course instructor for further clarification.
The College adheres to the Student Code for the South Carolina Technical College System. Copies of the Student Code and Grievance Procedure are provided in the TCL Student Handbook, the Division Office, and the Learning Resources Center.

ATTENDANCE
The College’s statement of policy indicates that students must attend ninety percent of total class hours or they will be in violation of the attendance policy.

- Students not physically attending class during the first ten calendar days from the start of the semester must be dropped from the class for NOT ATTENDING.
- Students taking an online/internet class must sign in and communicate with the instructor within the first ten calendar days from the start of the semester to indicate attendance in the class. Students not attending class during the first ten calendar days from the start of the semester must be dropped from the class for NOT ATTENDING.
- Reinstatement requires the signature of the division dean.

In the event it becomes necessary for a student to withdraw from the course OR if a student stops attending class, it is the student’s responsibility to initiate and complete the necessary paperwork. Withdrawing from class may have consequences associated with financial aid and time to completion.

When a student exceeds the allowed absences, the student is in violation of the attendance policy. The instructor MUST withdrawal the student with a grade of “W”, “WP”, or “WF” depending on the date the student exceeded the allowed absences and the student’s progress up to the last date of attendance or under extenuating circumstances and at the discretion of the faculty member teaching the class, allow the student to continue in the class and make-up the work. This exception must be documented at the time the allowed absences are exceeded.

Absences are counted from the first day of class. There are no "excused" absences. All absences are counted, regardless of the reason for the absence.

- A student must take the final exam or be excused from the final exam in order to earn a non-withdrawal grade.

A copy of TCL’s STATEMENT OF POLICY NUMBER: 3-1-307 CLASS ATTENDANCE (WITHDRAWAL) is on file in the Division Office and in the Learning Resources Center.

HAZARDOUS WEATHER
In case weather conditions are so severe that operation of the College may clearly pose a hardship on students and staff traveling to the College, notification of closing will be made through the following radio and television stations: WYKZ 98.7, WGCO 98.3, WGZO 103.1, WFXH 106.1, WWVV 106.9, WLOW 107.9, WGRZ 104.9, WFXH 1130 AM, WLVM 101.1, WSOK 1230 AM, WAEV 97.3, WTOC TV, WTGS TV, WJWJ TV, and WSAV TV. Students, faculty and staff are highly encouraged to opt in to the Emergency Text Message Alert System.

Emergency Text Message Alert
Students, faculty and staff are highly encouraged to opt in to the Emergency Text Message Alert System. Participants receive immediate notification of emergency events and weather cancelations via text messaging on their cell phones. Participants can also opt in to receive non-emergency news and announcements. Go to www.tcl.edu. On the homepage, click on “emergency TextAlert at TCL” and fill out the form or go to www.tcl.edu/textalert.asp
**Broadcast Learning Format:** This class is being taught in a broadcast learning format. Images and word of class participants may be transmitted live or on a delayed basis to other locations. Classes may be rebroadcast due to extenuating circumstance.

**Course Evaluation**
The grading scale is as follows:
- 90 - 100 = A
- 80 - 89 = B
- 70 - 79 = C
- 60 - 69 = D
- Below 60 = F

**Course Schedule/Outline**
The class meets for 1 lecture/presentation hours per week for a total of 16 weeks during fall and spring semesters.

**Syllabus Safety Addendum**

**Purpose**
The purpose of this safety addendum is to provide each student with safety guidelines during an incident, emergency, or disaster at TCL. In addition, it provides students guidelines for lockdown procedures, evacuation procedures, and active shooter.

**Definition**

**An incident** is any event, potential or actual, that may impact normal operations but has no immediate health or life threatening consideration or serious effect on the overall functional capacity of the College. An event of this nature should be reported to the Office of the Vice President for Administrative Services. Also notify the off-site campus administrator if applicable.

**An emergency** is any incident, potential or actual, which may endanger life or health or which affects an entire building or buildings, and will disrupt the overall operations of the College. Outside emergency services will probably be required, as well as major efforts from campus support services. Major policy considerations and decisions will usually be required from the college administration during times of crises. An emergency should be reported immediately by directly using 911 if life or health/injury considerations exist and then to the Office of the President or Vice President for Administrative Services as quickly as possible. Also notify the off-site campus administrator if applicable.

**A disaster** is any event or occurrence that has taken place and has seriously impaired or halted the operations of the College. In some cases, mass personnel casualties and severe property damage may be sustained. A coordinated effort of all campus-wide resources is required to effectively control the situation. Outside emergency services will be essential. In all cases of disaster, an Emergency Control Center will be activated, and the appropriate support and operational plans will be executed. The disaster should be immediately reported, first by calling 911 and then to the Office of the President or Vice President for Administrative Services. Also notify the off-site campus administrator if applicable.

**Types of Emergencies**
- Hurricane
- Tornado
- Fire
- Biochemical or Radiation Spill
- Explosion/Bomb
- Downed Aircraft (crash which directly impacts campus operations)
- Utility Failures
- Violent or criminal behavior
- Psychological Crisis

**Procedures**

**Active Shooter**

**Building Evacuation**
1. Building evacuations occur when an alarm sounds and/or upon notification by Security or the Emergency Director.

2. When the building evacuation alarm is activated during an emergency, individuals should exit according to the building evacuation plan and alert others to do the same.

3. Once outside, individuals should proceed to a clear area that is at least 500 feet away from the affected building. Streets, fire lanes, hydrant areas and walkways should be kept clear for emergency vehicles and personnel.

4. Individuals should not return to an evacuated building unless told to do so by Security or the Emergency Director.

5. Individuals should assist persons with disabilities in exiting the building. Elevators are reserved for disabled persons.

**Campus Evacuation**
1. A uniformed Security Guard, the Emergency Director, or an Emergency Resource Team member will announce evacuation of all or part of the campus grounds.

2. All persons (students and staff) are to immediately vacate the campus, or in the case of a partial evacuation relocate to another part of the campus grounds as directed.

**Lockdown**
1. Clear the halls
2. Report to the nearest classroom/office
3. Assist those needing special assistance
4. Ensure classroom/office doors are closed and locked
5. Turn off lights
6. Stay away from doors and windows (out of the line of sight)
7. BE QUIET and follow instructor’s directions
8. Silence cell phones
9. Wait for the “All Clear” before leaving

Developed/Revised: October 7, 2019