Course Number and Title: NRG 201 Photovoltaic Systems I

Campus Location:
Georgetown, Dover, Stanton

Effective Date:
2018-51

Prerequisite:
NRG 154, MAT 153, ELC 125 or concurrent

Co-Requisites:
none

Course Credits and Hours:
4.00 credits
3.00 lecture hours/week
2.00 lab hours/week

Course Description:
This course covers the fundamentals of photovoltaic (PV) modules, including how a solar cell converts sunlight into electricity. The system components of a PV system (including the role of modules, inverters, and charge controllers) are discussed. Students size PV systems for a variety of uses.

Required Text(s):
Obtain current textbook information by viewing the [campus bookstore - https://www.dtcc.edu/bookstores](https://www.dtcc.edu/bookstores) online or visit a campus bookstore. Check your course schedule for the course number and section.

Additional Materials:
None

Schedule Type:
Classroom Course

Disclaimer:
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Core Course Performance Objectives (CCPOs):

1. Engage in professional behavior. (CCC 1, 3, 4, 5)
2. Define basic solar energy terminology, and describe the sun's movement in the sky. (CCC 1, 2, 3, 6; PGC 6)
3. Identify factors that reduce or enhance the amount of solar energy collected by a PV array. (CCC 1, 2, 5, 6; PGC 6, 7)
4. Use instruments and procedures for measuring and calculating solar power and solar energy. (CCC 1, 2, 5, 6; PGC 1, 6,7)
5. Analyze local, regional, and national factors that impact site-specific PV applications. (CCC 1, 2, 5; PGC 5)
6. Explain the fundamentals of PV modules. (CCC 1, 2, 5, 6; PGC 5, 7)
7. Describe basic system components associated with PV systems. (CCC 1, 2, 5, 6; PGC 6)

See Core Curriculum Competencies and Program Graduate Competencies at the end of the syllabus. CCPOs are linked to every competency they develop.

Measurable Performance Objectives (MPOs):
Upon completion of this course, the student will:

1. Engage in professional behavior.
   1. Demonstrate punctuality when attending class, participating in off-site projects, and submitting assignments.
   2. Communicate using industry-appropriate language in presentations, reports, and homework.
   3. Demonstrate appropriate professional behavior when working with others.
2. Define basic solar energy terminology, and describe the sun's movement in the sky.
   1. Define basic solar energy terminology.

   2. Define *solar window*.
   3. Describe the ecliptic plane, equatorial plane, and solar time.
   4. Diagram the sun's apparent movement across the sky over any given day and over an entire year at any given latitude.
   5. Identify the sun's position using sun path diagrams for given dates.
   6. Describe equinox and solstice, and identify when they occur.
   7. Determine when direct solar radiation strikes the north, east, south, and west walls and horizontal surfaces of a building.
   8. Calculate the following angles, and define them as they relate to the sun's movement: solar altitude angle, solar azimuth angle, incidence angle, array tilt angle, array azimuth angle, and solar incidence angle.
3. Identify factors that reduce or enhance the amount of solar energy collected by a PV array.
   1. Examine the consequences of array shading.
   2. Identify best practices for minimizing shading and preserving array output.
   3. Identify rules of thumb for spacing distances required to avoid inter-row shading from adjacent sawtooth rack-mounted arrays at specified locations between 9:00 a.m. and 3:00 p.m. solar time throughout the year.
4. Use instruments and procedures for measuring and calculating solar power and solar energy.
   1. Demonstrate the use of a standard compass, and determine true geographic south from magnetic south at any given location given a magnetic declination map.
   2. Demonstrate the use of equipment and software tools to evaluate the solar window and shading at given locations, and quantify the reduction in solar energy received.
   3. Measure thermal radiation using a pyrometer.
   4. Obtain shade and solar data and information at a site using tools such as the Sun Eye and Solar Pathfinder.
   5. Use computer software tools to obtain shade and solar data for a site analysis.
   6. Use solar energy databases and computer software to determine the effect of tilt angle orientation.
5. Analyze local, regional, and national factors that impact site-specific PV applications.
   1. Identify key contributions to the deployment of PV technology such as the solar renewable energy credits (SRECs), Renewable Portfolio Standards (RPS), feed-in-tariffs (FITs), cost of modules, and research and development.
   2. Identify common types of PV system applications for both standalone and utility interactive systems with and without energy systems.
   3. Describe key features and benefits of specific types of PV systems for residential, commercial, building integrated, concentrated PV, and utility applications.
   4. List the advantages and disadvantages of PV systems compared to alternative electricity generation sources.
   5. Describe the benefits and features of a PV system that operates on and off the grid.
   6. Describe the roles of various segments of the PV industry, and explain how they interact with one another.
   7. Identify opportunities for both grid-tied and stand-alone PV system applications.
   8. Discuss the importance of conservation and energy efficiency as they relate to PV system applications.
6. Explain the fundamentals of PV modules.
   1. Explain how a solar cell converts sunlight into electrical power.
   2. Distinguish among PV cells, modules, panels, and arrays.
   3. Differentiate among mono-crystalline, poly-crystalline, and amorphous types of PV modules, listing their key features, typical efficiencies, and applications.
   4. On a current-voltage (I-V) curve, identify and label key electrical output parameters such as open current voltage (V_{oc}), short circuit current (I_{sc}), maximum power voltage (V_{mp}), current at maximum power (I_{mp}), and maximum power (P_{mp}) for PV modules using manufacturers' literature.
   5. Determine the operating point on a given I-V curve given the electrical load.
   6. Identify how temperature affects the output power of a PV module.
   7. Describe the effects of connecting similar or dissimilar PV modules in series and in parallel on electrical output, and identify the resulting I-V curve.
   8. Describe various performance rating and measurement conditions for PV modules and arrays, such as standard test conditions (STC), standard operating conditions (SOC), nominal operating cell temperature (NOCT), and PV USA test conditions (PTC).
   9. 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.
   10. Calculate efficiency and power output per unit area, given a surface area, incident solar irradiance, and electrical power output for a PV cell.
   11. Discuss the significance and consequences of PV modules being current-limited sources.
   12. Explain the purpose and operation of bypass diodes.
   13. Identify the standards and design qualification testing that help ensure the safety and reliability of PV modules.
   14. Differentiate how PV modules are configured in a series and parallel to provide voltage, current, and power output for interfacing with other equipment.
   15. Apply Ohm's law and conductor properties to calculate voltage drop for simple PV source circuits.
   16. Discuss key articles of the National Electric Code, including Article 690 on solar photovoltaic systems.
7. Describe basic system components associated with PV systems.
   1. Describe the purpose and principles of operation for the following major PV system components: PV modules and arrays, inverters and chargers, charge controllers, and energy storage.
   2. Describe the functions of the following balance of system components in a PV system: conductors, conduit and raceway systems, overcurrent protection, switch gear, junction and combiner boxes, and terminations and connectors.
   3. Identify the functions, features, specifications, settings, and performance indicators associated with the following PV system power processing equipment: inverters, chargers, charge controllers, and maximum power point trackers.

4. Identify the basic types of PV systems, their major subsystems and components, and the electrical and mechanical balance of system components required.
5. Create one-line electrical schematics for interactive and standalone PV systems showing all major components and subsystems, and indicate the locations of the PV source and output circuits, inverter input and output circuits, charge controller and battery circuits, as applicable; mark the directions of power flows through the system under various load conditions.
6. Select important information from the nameplate specifications on PV modules, inverters, and related equipment.
7. Determine allowable system voltage limits, type and size of conductors, overcurrent protection devices, disconnect means, and wiring methods.

Evaluation Criteria/Policies:
Students must demonstrate proficiency on all CCPOs at a minimal 75 percent level to successfully complete the course. The grade will be determined using the Delaware Tech grading system:

92	–	100	=	A
83	–	91	=	B
75	–	82	=	C
0	–	74	=	F

Students should refer to the Student Handbook - https://www.dtcc.edu/handbook for information on the Academic Standing Policy, the Academic Integrity Policy, Student Rights and Responsibilities, and other policies relevant to their academic progress.

Core Curriculum Competencies (CCCs are the competencies every graduate will develop):

1. Apply clear and effective communication skills.
2. Use critical thinking to solve problems.
3. Collaborate to achieve a common goal.
4. Demonstrate professional and ethical conduct.
5. Use information literacy for effective vocational and/or academic research.
6. Apply quantitative reasoning and/or scientific inquiry to solve practical problems.

Program Graduate Competencies (PGCs are the competencies every graduate will develop specific to his or her major):

1. Utilize building system and energy technology hardware and software to gather data on building lighting systems operation and energy consumption.
2. Calculate, analyze, and verify the energy use of buildings based upon the interaction of energy consuming building systems.
3. Evaluate residential buildings and make recommendations for optimized building performance and occupant comfort.
4. Prepare and present technical reports.
5. Analyze the economic, environmental, and business implications of potential energy measures.
6. Perform preliminary and in depth site and customer suitability evaluation of potential applications for solar use.
7. Design and calculate the output of an optimal site-specific array by deriving panel configuration and specifying components.

Disabilities Support Statement:
The College is committed to providing reasonable accommodations for students with disabilities. Students are encouraged to schedule an appointment with the campus Disabilities Support Counselor to request an accommodation needed due to a disability. A listing of campus Disabilities Support Counselors and contact information can be found at the disabilities services - https://www.dtcc.edu/disabilitysupport web page or visit the campus Advising Center.