ENSC M901: INTRODUCTION TO PHOTOVOLTAICS (PV)

Originator
rputnam

Co-Contributor(s)

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College
Moorpark College

Attach Support Documentation (as needed)
ENSC M901_state approval letter_CCC000620438.pdf

Discipline (CB01A)
ENSC - Environmental Science

Course Number (CB01B)
M901

Course Title (CB02)
Introduction to Photovoltaics (PV)

Banner/Short Title
Introduction to Photovoltaics

Credit Type
Noncredit

Start Term
Spring 2021

Catalog Course Description
Presents the sun as a resource in building design. Covers photovoltaics (PV) cells and modules, inverters, high-level PV system design, and the economics of PV.

Additional Catalog Notes
Aimed at the incumbent worker in the photovoltaics field who wishes to understand the underlying principles of photovoltaics. Safety in the photovoltaic workplace is covered in ENSC M903 OSHA 10 Construction Safety.

Taxonomy of Programs (TOP) Code (CB03)
0946.10 - *Energy Systems Technology

Course Credit Status (CB04)
N (Noncredit)

Course Transfer Status (CB05) (select one only)
C (Not transferable)

Course Basic Skills Status (CB08)
N - The Course is Not a Basic Skills Course

SAM Priority Code (CB09)
C - Clearly Occupational

Course Cooperative Work Experience Education Status (CB10)
N - Is Not Part of a Cooperative Work Experience Education Program

Course Classification Status (CB11)
L - Non-Enhanced Funding

Educational Assistance Class Instruction (Approved Special Class) (CB13)
N - The Course is Not an Approved Special Class

Course Prior to Transfer Level (CB21)
Y - Not Applicable

Course Noncredit Category (CB22)
J - Workforce Preparation

Funding Agency Category (CB23)
Y - Not Applicable (Funding Not Used)

Course Program Status (CB24)
2 - Not Program Applicable

General Education Status (CB25)
Y - Not Applicable

Support Course Status (CB26)
N - Course is not a support course

Field trips
Will not be required

Grading method
Pass/No Pass Grading

Does this course require an instructional materials fee?
No

Repeatable for Credit
Yes
Number of times a student may enroll in this course
Unlimited

Units and Hours

Carnegie Unit Override
No

Total in-Class (full semester or term)
Total Minimum Contact/In-Class Hours (for full semester or term; not weekly)
32
Total Maximum Contact/In-Class Hours (for full semester or term; not weekly)
32

Total Student Learning

Total Student Learning
Total Minimum Student Learning Hours
32
Total Maximum Student Learning Hours
32

Prerequisites
None

Corequisites
none

Advisories on Recommended Preparation
MATH M05 and MATH M06 or MATH M07

Requisite Justification

Requisite Type
Recommended Preparation

Requisite
MATH M05 and MATH M06 OR MATH M07

Requisite Description
Course not in a sequence

Level of Scrutiny/Justification
Content review

Student Learning Outcomes (CSLOs)

	Upon satisfactory completion of the course, students will be able to:
1	design a PV system using schematic and layout diagrams, that meets the annual electrical needs of a typical residence and takes advantage of all available financial incentives.

Course Objectives

	Upon satisfactory completion of the course, students will be able to:
1	quantify the solar resource for a given geographic location, collector orientation, and time of year.
2	describe the photovoltaic effects in terms of semiconductor device structure (p-n junction and doping) and physical principles; PV cells, modules and arrays.
3	characterize a PV module by observing its current-voltage characteristic at a level of irradiance and cell temperature.
4	design a PV system using high-level schematic and layout diagrams.
5	estimate the electrical energy production on a monthly and yearly basis, based on system power at Standard Test Conditions (STC), PV module orientation, system location, AC and DC losses, soiling and shading losses. Simulate performance using PVWatts or the CSI Solar Calculator
6	describe the elements of a utility bill using usage for the period, rate structure, and non-bypassable charges.
7	generate a customer cash flow analysis for a PV system purchase, lease or power purchase agreement; for purchase scenario, include break-even point, for PPA calculate internal rate of return (IRR) and/or net present value (NPR).
8	describe how the various California and Federal programs promote photovoltaics.
9	describe how financial incentives at the state and federal level promote photovoltaics.

Course Content

Lecture/Course Content

(10%) The Sun as a Resource.

The Sun's path through the sky as a function of season and latitude.

Monthly and annual solar resource for different locations (W/m^2), taking into account latitude, collector orientation and Typical Meteorological Year.

(10%) Local, State of California, and Federal Programs that promote photovoltaic installations

- Renewables Portfolio Standard
- Solar friendly utility tariffs
- Property Assessed Clean Energy financing
- Rebates

- Federal Tax Credits
- Accelerated depreciation
- Title 24

(10%) The photovoltaic effect

- The p-n junction
- Conversion of sunlight into electricity
- Cells and Modules
- I-V characteristic of a PV modules as a function of irradiance and temperature

(10%) Elements of Photovoltaic System Design

- STC power ratings of PV modules; Inverter efficiency
- Solar Resource (see 1., above)
- Modules orientation (azimuth and tilt)
- Electrical losses; soiling and shading losses
- Typical Meteorological Year

(20%) How to analyze a customer's 12-month electricity bill comparing and contrasting different rate structures (tariffs), usage and demand charges, and non-bypassable charges.

(10%) Utility rate tariffs:

- Flat rate
- Flat rate with tiers
- Time-of-Use
- Demand Charges
- Non-bypassable charges

(15%) How to calculate a customer's utility bill reduction given the PV system design. Adjust the design as needed to achieve 100% usage offset.

(15%) Calculate cash flow and return on investment for the following acquisition scenarios: purchase, lease and power purchase agreement.

Methods of Evaluation

Which of these methods will students use to demonstrate proficiency in the subject matter of this course? (Check all that apply):

Problem solving exercises
Skills demonstrations
Written expression

Methods of Evaluation may include, but are not limited to, the following typical classroom assessment techniques/required assignments (check as many as are deemed appropriate):

Computational homework
Essay exams
Group projects
Individual projects
Objective exams
Other (specify)
Problem-solving exams
Reports/papers
Skills demonstrations

Other

-Students will be graded based on frequent homework exercises (approximately eight in all).

-In addition, one term paper will be assigned, submitted in draft form and final form. Turnitin will be used to improve writing skills and prevent plagiarism.

Instructional Methodology

Specify the methods of instruction that may be employed in this course

Audio-visual presentations
Computer-aided presentations
Class activities
Class discussions
Case studies
Distance Education
Instructor-guided interpretation and analysis

Internet research
Laboratory activities
Lecture
Other (specify)

Specify other method of instruction

Following a presentation, orally question the students in class to assess comprehension
Instructor demonstrations in the use of electronic instrumentation and software tools

Describe specific examples of the methods the instructor will use:

1. use of the on-line NC State University DSIRE database www.dsireusa.org (https://www.dsireusa.org) to compare and contrast State and Local incentive programs for the installation of photovoltaic systems. Include both regulatory policy (building standards, net metering, renewables portfolio standard) as well as financial incentives (tax credits).
2. use of PV module and inverter data sheets to design a typical (e.g. 5 kW_{DC}) PV system. Use PVWatts (https://pvwatts.nrel.gov/) and California Solar Incentive (www.gosolarcalifornia.ca.gov/ (https://www.gosolarcalifornia.ca.gov)) on-line calculators and equipment databases.
3. After assigning reading, ask questions and solicit student responses. All students must participate in these exercises and will be graded on level of participation and correctness of responses.
4. Using data manufacturer data sheets, compare and contrast PV modue perfromance (efficiency, temperature coefficient of power, annual degradation) .

Representative Course Assignments

Writing Assignments

1. Analyze in writing the monthly and annual solar resource for two major cities in the US (kWh/m^2/day) for a south facing PV array and latitude tilt. Pick two cities which differ by at least (i) 15 degrees latitude and (ii) 300 miles proximity to the Pacific/Atlantic oceans and the Gulf of Mexico.
2. Design and layout -- in a sketch -- the size, placement and orientation of a PV system that will eliminate the usage charges of specific customer's electricity bill over one year's time, using a instructor-provided roof plans and geographic location of customer.
3. Describe the historical trends of PV installations in the US over the period 2009-2019, in terms of W_{STC}. Calculate the percent rate of growth, over this period of time.
4. Describe the historical trends in PV module prices over the period 2009-2019, in terms of US Dollars per W_{STC} . Calculate the percent rate of growth, over this period of time.

Critical Thinking Assignments

1. Perform an energy audit of a home using instructor-provided MS Excel spreadsheet. Identify the power consumption and estimate usage of heating/cooling, lighting, appliances, communication and entertainment device -- in terms of power consumption and hours per day. Determine the Energy Efficiency level in terms of kilowatt-hours per square foot of living space per day. Identify areas where more efficient appliances could be retrofitted, without loss of performance.
2. Determine the "break-even point" for a PV system based on PV system production, applicable utility rates, and purchase price; calculate the net present value and internal rate of return for the same system using the expected utility rate escalation, inflation and the discount rate.

Reading Assignments

1. Read the 10th Edition of the Solar Jobs Census. Be prepared to answer questions posed by the instructor on the following topics
   - U.S. Domestic solar module production, 2011-2019
   - Demographic makeup of the solar workforce 2019
   - Solar workforce: skills and educational backgrounds required; worker occupations; hiring trends
   - Average hourly wage rates in terms of occupation and level of experience.

2. Read trade publications, provided by instructor. Discussing recent California trends -- in terms of policy and financial incentives -- promoting the PV installation industry.

Skills Demonstrations

1. *Determine how many PV modules can be installed on a roof, given the module and mounting bracket dimensions, the roof dimensions, and the set-backs mandated by applicable building codes.*
2. *Given 12 months' of electrical utility bills, determine the number of PV modules (with a given peak power rating) and inverter (with a maximum AC power rating) that will offset all of the customer's usage from the utility for the same 12 months. This will require access to the following on-line simulator: CSI Standard PV Incentive Calculator.see http://www.csi-epbb.com/Default.aspx?referer=www.clickfind.com.au*
3. *The following are twelve examples of Personal Protective Equipment (PPE). Choose four examples of PPE which are most appropriate for use in installing a roof-top PV system*

Other assignments (if applicable)

1. Interview a minimum of three families in your neighborhood that have "rooftop solar". Determine the most important factors that convinced them to go solar. Ask them if the installing company offered any guidance or guarantees regarding monthly/annual energy production; and was the guidance or guarantees met.

Outside Assignments

Representative Outside Assignments

1. Reading assigned material in textbook, periodicals, and white papers on design of photovoltaic systems
2. Reading manufacturers' data sheets, product specifications, and installation manuals.

Articulation

Equivalent Courses at other CCCs

College	Course ID	Course Title	Units
no comparable course (noncredit) found in ASSIST			

Textbooks and Lab Manuals

Resource Type

Textbook

Description

Dunlop, James P. *Photovoltaic Systems*. 3rd ed., American Technical Publishers, 2012.

Resource Type

Textbook

Description

Solar Energy International. *Solar Electric Handbook: Photovoltaic Fundamentals and Applications*. 2nd ed., Pearson, 2013.

Resource Type

Other Resource Type

Description

PVWatts Calculator. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, National Renewable Energy Laboratory, n.d., https://pvwatts.nrel.gov/index.php.

PV System energy estimation tool provided online by the National Renewable Energy Laboratory (NREL).

Resource Type

Other Resource Type

Description

System Advisory Model. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, National Renewable Energy Laboratory, n.d., https://sam.nrel.gov/.

Solar energy production simulator and cost modeling software provided online by the National Renewable Energy Laboratory (NREL).

Resource Type

Other Resource Type

Description

Salesforce. 2020, www.salesforce.com/ (http://www.salesforce.com).

A customer relationship management platform focusing on marketing, sales, and customer service.

Resource Type
Other Resource Type

Description
MS Excel spreadsheet templates from the EPA on energy auditing and PV system production verification.

Resource Type
Websites

Description
Online periodical resources, such as:
SolarPro. https://solarprofessional.com
Home Power Magazine. https://homepower.com
Solar Industry. https://solarindustrymag.com

Resource Type
Textbook

Classic Textbook
Yes

Description
Peter T. Parrish. *Photovoltaic Laboratory: Safety, Code-Compliance, and Commercial Off-the-Shelf Equipment.* CRC Press, 2016.

Resource Type
Other Resource Type

Description
SunEye 210 by Solmetric: hand-held shade measurement tool for solar site assessment. This tool will be available for short-term loan.

Library Resources

Assignments requiring library resources
Research by locating periodical articles from the Library's online databases.

Sufficient Library Resources exist
Yes

Example of Assignments Requiring Library Resources
Research using the Library databases such as, Elsevier ScienceDirect, to locate periodicals/academic journal articles on the subject of design of photovoltaic systems.

Distance Education Addendum

Definitions

Distance Education Modalities
100% online

Faculty Certifications

Faculty assigned to teach Hybrid or Fully Online sections of this course will receive training in how to satisfy the Federal and state regulations governing regular effective/substantive contact for distance education. The training will include common elements in the district-supported learning management system (LMS), online teaching methods, regular effective/substantive contact, and best practices.
Yes

Faculty assigned to teach Hybrid or Fully Online sections of this course will meet with the EAC Alternate Media Specialist to ensure that the course content meets the required Federal and state accessibility standards for access by students with disabilities. Common areas for discussion include accessibility of PDF files, images, captioning of videos, Power Point presentations, math and scientific notation, and ensuring the use of style mark-up in Word documents.

Yes

Regular Effective/Substantive Contact

100% online Modality:

Method of Instruction	Document typical activities or assignments for each method of instruction
Synchronous Dialog (e.g., online chat)	On-line chat will be used by instructor to (i) encourage student comments and questions, (ii) general Q&A, (iii) general class discussion, (iv) demonstrate skills, (v) address problems, and (vI) review asynchronous lectures; to facilitate student outcomes. Participation is strongly encouraged and students will be graded based on their participation. Synchronous sessions may also be used for students to work on problem sets together. The platform for such sessions may include ConferZoom or any other approved medium for synchronous dialog.
Asynchronous Dialog (e.g., discussion board)	Regular Asynchronous discussion boards will be used to encourage discussion among students where they can compare and contrast/ discuss /identify and analyze elements of course outcomes. E.g. - Students will use the discussion board in Canvas to compare and contrast the use of microinverters, PV optimizers and string inverters.
E-mail	Email, class announcements and tools such as “Message Students Who” and “Assignment Comments” in Canvas will be used to regularly communicate with all students to clarify class content, remind of upcoming assignments, and provide immediate feedback to students on coursework to facilitate student learning outcomes. Students will be given multiple ways to email instructor through Canvas inbox and faculty provided email account through their own canvas email and school email.
Other DE (e.g., recorded lectures)	Faculty will use a variety of tools and media integrated within the LMS to help students reach SLO such as: o Recorded Lectures, Narrated Slides, Screencasts o Instructor created content (Excel-based calculators) o MC Online Library Resources (PV module, inverter data and racking datasheets) o Canvas Peer Review Tool o Canvas Student Groups (Assignments, Discussions) o Websites and Blogs o Multimedia (YouTube, Films on Demand, 3CMedia, Google Earth, California Solar Initiative PV Calculator)

Primary Minimum Qualification

ENVIRONMENTAL TECHNOLOGIES

Additional Minimum Qualifications

Minimum Qualifications
Vocational (short-term): Noncredit (per 5 CCR 53412(j))

Review and Approval Dates

Department Chair

04/24/2020

Dean

04/28/2020

Technical Review
09/03/2020

Curriculum Committee
09/15/2020

DTRW-I
10/08/2020

Curriculum Committee
MM/DD/YYYY

Board
11/10/2020

CCCCO
12/04/2020

Control Number
CCC000620438

DOE/accreditation approval date
MM/DD/YYYY