**RENRG 156 Course Outline as of Fall 2019**

# CATALOG INFORMATION

Dept and Nbr: RENRG 156 Title: PHOTOVOLTAIC SYSTEMS
Full Title: Photovoltaic Systems Design and Installation
Last Reviewed: 1/28/2019

| Units | | Course Hours per Week | | Nbr of Weeks | Course Hours Total | |
|---|---|---|---|---|---|---|
| Maximum | 3.00 | Lecture Scheduled | 2.00 | 17.5 | Lecture Scheduled | 35.00 |
| Minimum | 3.00 | Lab Scheduled | 3.00 | 8 | Lab Scheduled | 52.50 |
| | | Contact DHR | 0 | | Contact DHR | 0 |
| | | Contact Total | 5.00 | | Contact Total | 87.50 |
| | | Non-contact DHR | 0 | | Non-contact DHR | 0 |

Total Out of Class Hours: 70.00 Total Student Learning Hours: 157.50

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| Title 5 Category: | AA Degree Applicable |
| Grading: | Grade Only |
| Repeatability: | 00 - Two Repeats if Grade was D, F, NC, or NP |
| Also Listed As: | |
| Formerly: | ELEC 156 |

**Catalog Description:**
Introduction to photovoltaic technology and its practical application. Focus is on residential and small commercial photovoltaic systems: how they work, the equipment required, and maximizing energy harvest in both utility interactive and off-grid applications. Provides the basic understanding required to size, site, design, and install code-compliant solar energy systems. Course is registered provider of the NABCEP Entry Level Certificate of Knowledge Exam (optional at end of semester).

**Prerequisites/Corequisites:**
Course Completion or Current Enrollment in ELEC 51A

**Recommended Preparation:**
Course Completion of MATH 150A OR MATH 150

**Limits on Enrollment:**

**Schedule of Classes Information:**
Description: Introduction to photovoltaic technology and its practical application. Focus is on residential and small commercial photovoltaic systems: how they work, the equipment required, and maximizing energy harvest in both utility interactive and off-grid applications. Provides the

basic understanding required to size, site, design, and install code-compliant solar energy systems. Course is registered provider of the NABCEP Entry Level Certificate of Knowledge Exam (optional at end of semester). (Grade Only)
Prerequisites/Corequisites: Course Completion or Current Enrollment in ELEC 51A
Recommended: Course Completion of MATH 150A OR MATH 150
Limits on Enrollment:
Transfer Credit:
Repeatability: Two Repeats if Grade was D, F, NC, or NP

## ARTICULATION, MAJOR, and CERTIFICATION INFORMATION:

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|---|---|---|---|
| **AS Degree:** | **Area** | Effective: | Inactive: |
| **CSU GE:** | **Transfer Area** | Effective: | Inactive: |
| **IGETC:** | **Transfer Area** | Effective: | Inactive: |

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| **CSU Transfer:** | Effective: | Inactive: |
| **UC Transfer:** | Effective: | Inactive: |

**CID:**

**Certificate/Major Applicable:**
Certificate Applicable Course

## COURSE CONTENT

**Student Learning Outcomes:**
At the conclusion of this course, the student should be able to:
1. Explain photovoltaic module characteristics, specifications, and response to the Sun.
2. Conduct a solar site evaluation for installation of a photovoltaic system.
3. Optimally size utility interactive and off-grid photovoltaic systems to electrical demand.
4. Select appropriate inverters and balance of system components.
5. Perform a basic National Electrical Code (NEC) compliant photovoltaic (PV) array installation.

**Objectives:**
At the conclusion of this course, the student should be able to:
1. Discuss the history of photovoltaic technology.
2. Use current-voltage curves (IV curves) to interpret photovoltaic response to sunlight and temperature.
3. Read a sun chart and understand Earth’s movements around the Sun.
4. Chose appropriate personal protection equipment when working with PV.
5. Use standard industry tools to determine a site’s shading and to measure the total solar resource fraction available.
6. Perform a load analysis for both utility interactive and off-grid system sizing.
7. Match PV modules to inverter by using both manual string sizing calculations and manufacturer’s string sizing tools.
8. Select appropriate racking and balance of system components for roof and ground mounted arrays.

**Topics and Scope:**

I. Energy Overview
   A. Production
   B. Uses
   C. Conservation
II. Photovoltaic History, Applications, Types of Systems
   A. Photovoltaics cell development: 1839--today
   B. Early applications
   C. Technology uses today
III. Photovoltaics Economics and Political Environment
   A. Net-metering vs. feed-in-tariffs
   B. Federal incentives
   C. State incentives
IV. Electricity and PV
   A. Voltage, current, resistance
   B. Ohm's Law
   C. Alternating current (AC) & direct current (DC)
   D. Power vs. energy
   E. Digital multimeter use
V. Photovoltaic Safety
   A. Electricity physiology
   B. Lock out/tag out procedures
   C. Fall safety
   D. Personal protection equipment
   E. Battery safety
   F. NEC regulations
VI. Photovoltaic Modules
   A. Mono & poly crystalline
   B. Amorphous & thin film
   C. IV curve irradiance response
   D. IV curve temperature response
   E. Test conditions: STC (factory standard test conditions) & PTC (PV USA test conditions)
VII. Solar Resource
   A. Peak sun hours
   B. Units of irradiation & insolation
   C. Azimuth, tilt, and latitude
   D. Sun charts
   E. Seasons
VIII. Load Analysis
   A. Rate schedule tiers
   B. Time-of-use
   C. Energy requirements (kWhrs)
   D. Critical loads
IX. System Sizing
   A. DC vs. AC kWhrs
   B. Derate factors
X. Site Review
   A. Compass declination
   B. Shade evaluation tools: PathFinder, SunEye, Protractor
   C. Mounting azimuth & tilt
   D. Utility service panel
XI. Equipment Selection

A. Modules
B. Inverters
C. Racking

XII. Design
A. Layout
B. Row spacing
C. Roof vs. ground

XIII. Permitting
A. Site plans
B. Layouts
C. Line diagrams

XIV. Installation
A. Structural requirements
B. Mounting
C. Roof types
D. Wire runs

XV. Off-Grid System Design
A. Load analysis - amp hours & watts
B. System voltages
C. Batteries
D. Charge controllers
E. Array sizing

XVI. Performance Analysis and Troubleshooting
A. Expected output
B. Diagnostic measurements
C. Failure modes & causes

All topics covered in both the lecture and lab portions of the course.

**Assignment:**

Lecture-Related Assignments:
1. Read approximately one textbook chapter per week
2. Weekly problem sets
3. Quizzes (5-10)
4. Midterm
5. Final exam

Lab-Related Assignments:
1. Weekly lab activities
2. PV system design project

**Methods of Evaluation/Basis of Grade:**

**Writing:** Assessment tools that demonstrate writing skills and/or require students to select, organize and explain ideas in writing.

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| None, This is a degree applicable course but assessment tools based on writing are not included because problem solving assessments are more appropriate for this course. | Writing<br>0 - 0% |

**Problem Solving:** Assessment tools, other than exams, that demonstrate competence in computational or non-computational problem solving skills.

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| Problem sets | Problem solving<br>10 - 40% |

**Skill Demonstrations:** All skill-based and physical demonstrations used for assessment purposes including skill performance exams.

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| Lab assignments; PV system design project | Skill Demonstrations<br>20 - 50% |

**Exams:** All forms of formal testing, other than skill performance exams.

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| Quizzes, midterm, final exam: multiple choice, completion, true-false | Exams<br>20 - 40% |

**Other:** Includes any assessment tools that do not logically fit into the above categories.

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| None | Other Category<br>0 - 0% |

**Representative Textbooks and Materials:**
Photovoltaic Systems. 3rd ed. National Joint Apprenticeship and Training. American Technical Publishers. 2012 (classic)
Solar Energy International: Photovoltaics Design and Installation Manual, New Society Publishers. 2004 (classic)
Instructor prepared materials