RC205

Introduction to Solar Energy

3 Credits

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Introduction to Solar Energy

Calendar Description

This is an introductory course that examines the effective use of solar energy for supplementing heat and electricity demands in buildings. Topics include solar system components, general system planning, design considerations, and safe installation guidelines.

Rationale

This is a required course for the Renewable Energy and Conservation program. The Sun is considered the ultimate source of energy for the earth as all energy sources that we use have their origins in solar energy. The interest in solar energy is not just a passing fad but is a mature industry with many reliable products on the market. Often a lack of understanding of the available solar resource and how systems are designed to work can lead to overstated claims of performance. This course is intended to provide information and procedures to ensure that systems are designed and installed correctly and that accurate assessments are done to predict performance. This course will concentrate on the two most popular uses of solar energy, solar domestic hot water and solar photovoltaic systems. Solar energy for space heating will be introduced.

Prerequisites

RC200 Basic Energy Principles is a prerequisite for taking RC204, RC205 or RC206. An aptitude for electricity, heat energy, energy movement, energy storage, fluid flow, and the types of calculations commonly used in the related industries is an asset.

Co-Requisites

None

Course Learning Outcomes

Upon successful completion of this course, students will be able to

1. use knowledge of the solar energy resource to assess the energy generation potential of a given site and predict the solar energy that can be harvested.

2. describe the equipment used to harvest solar energy for electricity and direct-use heat using the correct terminology.
3. describe the principle of operation of all the components of solar photovoltaic, solar domestic hot water and solar air heating systems.
4. perform basic design calculations for solar photovoltaic and solar thermal systems.
5. identify the safety hazards present when working around solar equipment and discuss methods to mitigate the risks.

As part of achieving the general course outcomes above, students will be able to perform the following task objectives:

1. define terms used to describe solar energy and equipment used to capture this energy.
2. calculate the ideal angle to mount a solar collector for a given location.
3. perform a shade analysis at a given site using appropriate tools.
4. use solar resource maps and data to predict potential of solar energy at a particular site.
5. describe significant events in the history of photovoltaic development.
6. describe various ways solar PV can be implemented including building integrated PV and solar concentrators.
7. explain how technical advancements and increased production have led to the reduction in the cost of PV components.
8. interpret current-voltage curves for solar modules to describe how a module or combination of modules might perform in real-world service.
9. discuss how PV cell temperature and environmental conditions affect performance and system design.
10. interpret manufacturer's specifications and literature.
11. explain the effects of shading on the performance of solar modules.
12. interpret qualification tests and standards for solar modules describing standard test conditions.
13. explain the purpose and principle of operation of major solar PV components including inverters, charge controllers and batteries.
14. describe the function of balance of system components for PV systems including conductors, conduit and raceway systems, combiner boxes and over current protection.
15. describe an example of the regulatory requirements for connecting solar PV systems to the grid.
16. determine battery capacity and correct charge settings for a given battery and charge controller combination.
17. perform an analysis of the electrical loads to estimate the required capacity of a PV array (kW) for an off-grid solar PV system.
18. draw a single line diagram of a solar PV system showing all required components.
19. size key system components in a PV system including minimum and maximum number of modules allowed per string for a given inverter/module combination.
20. describe how software such as PVWatts are used to estimate the power generated and the payback of a solar PV or thermal system.
21. describe the main requirements of PV systems to meet the Canadian Electrical Code.
22. describe grounding and bonding requirements for solar PV installations.
23. list common failure points with PV systems to facilitate troubleshooting.

24. identify specific safety issues related to the installation and operation of a solar PV system including electrical hazards of operating and non-operating systems, arc flash and the use of personal protective equipment and fall safety equipment during installation.
25. identify the common ways solar systems are mounted and secured on the roof or ground and discuss criteria for selection and implementation of mounting systems.
26. discuss basic concepts of solar energy in the context of solar thermal systems.
27. describe the relationships between heat and temperature including a discussion of the flow of heat through solids, gasses and liquids.
28. use calculations to predict heat flow and storage.
29. interpret manufacturer data given for solar collectors.
30. interpret Solar Rating and Certification Corporation (SRCC) certification reports to help predict the performance of a solar thermal system.
31. correctly size a solar domestic hot water system (SDHWS) for a given application predicting its performance.
32. describe the characteristics of good and bad SDHWS installations.
33. describe procedures necessary to properly maintain SDHW systems.
34. describe troubleshooting techniques used to diagnose problems in SDHW systems.
35. discuss issues related to using solar energy for space heating of buildings.
36. describe basic solar hydronic or air systems used for space heating of buildings.

Resource Materials

***Required Text(s)*:**

The following e-book is required as a text, is included as part of the course fee and can be downloaded from the learning managed for registered students:

Warmke, J. 2021. Understanding Photovoltaics, an easy to follow study guide for solar electric certification programs. 8th ed., Philo, Ohio: BRS Press

Each learning activity in the course identifies on-line reading resources. Some of these resources include e-books available to registered Lakeland College students through our library databases. One such text is:

The German Solar Energy Society. 2006. Planning and installing solar thermal systems, a guide for installers, architects and engineers. London, UK: James & James / Earthscan.

***Reference Text(s)*:**

References are listed within course content documents. Reference texts are additional resources for advanced study.

Conduct of Course

This course consists of the equivalent of 45 hours of lecture delivered on-line using an online learning manager program. The course is delivered over a set 8-week period. Course content modules and links to assigned readings will be available on-line. A course facilitator will be available to guide the learner through the course, answer any questions, and grade assignments and exams. Learners are expected to participate in on-line discussion forums and synchronous conference discussions with other classmates and the course facilitator. Assignments will be submitted electronically through the learning manager program. Open book unit exams will be taken on-line. Exams and assignments will be marked by the instructor and returned to the student with a grade and comments in the learning manager program. Students can monitor their progress though the course using utilities available in the learning manager program. In order to complete the course on time, deadlines for assignments, exam, and projects will be enforced.

Evaluation Procedures

The student's final grade is an aggregate of the following components:

Exams	
Exam - Module 1	10%
Exam - Modules 2, 3 and 4	20%
Exam - Modules 5, 6 and 7	20%
Assessments	
Assessment 1.1 Solar Terminology	4%
Assessment 1.2 Sun Angles	5%
Assessment 1.3 Solar Irradiance	4%
Assessment 2.1 Solar Module Specifications	4%
Assessment 5.1 Solar Collector Specifications	4%
Assignments	
Assignment 2.1 Battery Specifications	5%
Assignment 3.1 Load Analysis	10%
Assignment 3.2 Software Tools	6%
Assignment 5.1 Heat Transfer Calculations	4%
Assignment 6.1 Sizing SDHWS	4%
TOTAL	100%

Grade Equivalents and Course Pass Requirements

A minimum grade of D (50%) (1.00) is required to pass this course.

Letter	F	D	D+	C-	C	C+	B-	B	B+	A-	A	A+
Percent Range	0-49	50-52	53-56	57-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-100
Points	0.00	1.00	1.30	1.70	2.00	2.30	2.70	3.00	3.30	3.70	4.00	4.00

Students must maintain a cumulative grade of C (GPA - Grade Point Average of 2.00) in order to qualify to graduate.

Attendance

Active participation is required in all courses within the Renewable Energy and Conservation certificate and diploma programs. Each facilitator designates these requirements through the use of tools within the management system and personal contact with learners.

These expectations can be given marks as part of the assessment process. Each course outlines these expectations within the course structure.

Learners will be asked to demonstrate their participation/attendance through discussion forums, sharing research results, contributing relevant information, submitting assignments, communicating with colleagues and the facilitator, and participating in synchronous meetings or asynchronous activities.

Attendance or participation is considered vital to the learning process. Students are expected to keep up with the set course schedule. If a student is unable to participate for an extended period of time, marks will not be given for material missed. With prior notice, the facilitator may allow extensions for missed assignments at his/her discretion.

NOTE: Any exceptions to the above attendance policy (e.g. family or work-related issues) **must** be approved in writing by the Department Chair **prior** to the beginning of the course.

Course Units/Topics

Module 1: Solar Energy Fundamentals
- 1.1: Introductions
- 1.2: Solar terminology
- 1.3: Movement of the Sun
- 1.4: Solar irradiance and predicting energy available from the Sun

Module 2: Solar PV Systems and System Components
- 2.1: History of PV Technology
- 2.2: Solar PV modules
- 2.3: Inverters
- 2.4: Batteries and charge controllers

Module 3: Solar PV System Sizing Considerations
- 3.1: Load analysis
- 3.2: Sizing Solar PV Components / string sizing
- 3.3: Introduction to Software Tools

Module 4: Installation Concepts for PV Systems
- 4.1: Site Survey and Shading Analysis
- 4.2: Planning Grid Connected Systems
- 4.3: Solar system mounting systems and mechanical design considerations
- 4.3: Installing Commissioning and Troubleshooting Systems
- 4.4: Safety during handling and installation of PV systems

Module 5: Solar Thermal Systems
- 5.1: Overview of solar thermal systems
- 5.2: Review of thermal principles and heat transfer
- 5.3: Solar Thermal Collectors
- 5.4: Balance of System Components

Module 6: Solar Domestic Hot Water Systems
- 6.1: Solar domestic hot water system configurations
- 6.2: System design and installation considerations
- 6.3: Inspecting and maintenance of solar hot water systems

Module 7: Solar Space Heating Systems
- 7.1: Building Heat Requirements
- 7.2: Solar Heating Systems

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