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Northeast Wisconsin Technical College

10-482-133 059263 Photovoltaics-Advanced

Course Outcome Summary

Course Information

Description	10-482-133 PHOTOVOLTAICS-ADVANCED ...topics include batteries, wiring configurations, system diagramming, National Electrical code, component selection, wiring, safety and system maintenance. (Prerequisites: 10-482-126 Intro to Solar; 10-660-104, DC 1: Intro; 10-660-105, DC 2: Circuits; 10-620-107, AC 1: Properties)
Total Credits	4
Total Hours	90

Course History

Last Revision Date	2/27/2017

Employability Skills

Communicate Effectively

Demonstrate Community and Global Accountability

Demonstrate Personal Accountability

Solve Problems Effectively

Think Critically and Creatively

Value Individual Differences and Abilities

Work Cooperatively and Professionally

Program Outcomes

TSA1 - Evaluate renewable, fossil and other energy resources in context of sustainability, environment, society and economics

TSA2 - Evaluate building performance and energy use

TSA3 - Recommend building/site solutions to optimize performance

TSA4 - Install equipment and materials to optimize performance

TSA5 - Service equipment and systems

Course Competencies

1. Explore the basics of Grid tied and Stand alone PhotoVoltaic systems.

Assessment Strategies
Through participation in classroom discussions
On a written exam.

Learning Objectives
1.a. Differentiate between interactive and stand alone systems.
1.b. Explore the use of the Flat-plate collector for Photovoltaic applications over concentrating collectors.
1.c. Identify remote applications for Photovoltaic systems.
1.d. List the typical componets required to complete a Photovoltaic installation.

Criteria

Your performance will be successful when:

you can differentiate between interactive and stand alone Photovoltaic systems.
you idenify remote applications for Photovoltaic systems.
you can list the typical components required for a complete Photovoltaic installation.
you list the use of flat plate Photovoltaic collectors over concentrating collectors.

2. Explore the solar radiation data and measurements in our lab setting for sizing a PhotoVolatic system.

Assessment Strategies
Through participation in classroom discussions
On a written exam.

Learning Objectives
2.a. Calculate maximum average daily solar radiation for given locations and month of the year.
2.b. Analyze the radiation data to determine the average amount of energy for given Photovoltaic systems.
2.c. Measure the radiation for our lab location.
2.d. Compare your measured radiation to your calculated values.

Criteria

Your performance will be successful when:

you can calculate maximum average daily radiation levels.
from radiation data you can determine average amount of energy for a photovoltaic system.
you can measure radiation levels
your measued values compare favorably to your calculated values.

3. Analyze the OSHA safety requirements for typical PhotoVoltaic installations.

Assessment Strategies
Through participation in classroom lecture
On a written exam

Learning Objectives
3.a. Review OSHA CFR 1910 as is applies generally to PV installations
3.b. Review OSHA CFR 1926 as it applies to construction safety

Criteria

Your performance will be successful when:

you can identify optimal tilt angles for PV panels to maximize solar radiation received.
based on site considerations you can determine the placement of Photovoltaic panels
based on structural limitations you can determine the placement of Photovoltaic panels.

4. Analyze the NFPA 70E requirements for typical PhotoVoltaic installations.

Assessment Strategies
Through participation in classroom lecture
On a written exam

Learning Objectives

4.a. List the hazards involved when working with electricity
4.b. Differentiate between Arc blast and Arc Flash
4.c. Apply NFPA 70E to the electrical installation in our lab setting
4.d. List the OSHA requirements relating to NFPA 70E

Criteria

Your performance will be successful when:

you can list the types of batteries used in Photovoltaic systems
you can differentiate between the types and classifications of batteries used in photovoltaice systems
you can articulate the difference between series and parallel connections
you can relate the National Electrical Code articles and sections as they apply to battery installations
you list the maintenance and troubleshooting procedures for a bank of batteries.

5. Design an interactive (Grid Tied) and stand alone PhotoVoltaic system.

Assessment Strategies

By participating in your instructors lecture
On a written exam
Oral Presentation

Learning Objectives

5.a. Determine the load(s) to be served by the Photovoltaic system.
5.b. Calculate the hours of demand for the loads served by the Photovoltaic systems.
5.c. Select the required inverter for your installation.
5.d. Determine the required array output for your installation.

Criteria

Your performance will be successful when:

you can determine loads that will be served by the photovoltaic system
you can calculate the hours of demand to be served by the photovoltaic system
you select the proper inverter for the installation
you determine the array necessary for the loads to be served

6. Determine the typical procedures for mounting the PhotoVoltaic panels.

Assessment Strategies

when you participate in your instructors focused lecture
on a written exam

Learning Objectives

6.a. List the construction considerations integrating arrays on buildings.
6.b. Identify the various types of mounting configuations available for Photovolatic arrays.
6.c. Identify the different types of attachments methods available for Photovolatic arrays.
6.d. Identify the structural loads that will be placed on a Photovoltaic array.

Criteria

Your performance will be successful when:

you list the construction concerns when integrating PV arrays on a building
you identify the correct mounting configurations available for PV arrays
you list the different methods available to attach PV arrays
you can state the structural loads that a PV array will encounter

7. Access the electrical and building requirements and codes pertaining to typical PhotoVoltaic installations.

Assessment Strategies

by participating in your instructors lecture
on a written exam

Learning Objectives

7.a. Select the conductors for Photovoltaic systems.

7.b. Select the overcurrent device for Photovoltaic systems.
7.c. Identify the applicable articles of the National Electrical Code that apply to Photovoltaic installations.
7.d. Review the requiements for the grounding of Photovoltaic systems.
7.e. List the locations and size of the required disconnecting means for Photovoltaic systems.
7.f. Detail the requirements for installers of the electrical components for Photovoltaic systems.

Criteria

Your performance will be successful when:

you can select the proper conductors for the PV system
you select the correct overcurrent protection device for the system
you utilize article 690 from National Electrical Code rules correctly for the PV installation
you can state the grounding requirements for the PV system
you can list the required locations and sizes of the disconnecting means for the PV system
you state the requirements necessary to do the electrical installions in Wisconsin.

8. Determine the typical maintenance, troubleshooting, and installation concerns for typical Photovoltaic installations.

Assessment Strategies

by participating in your instructors lecture
on a written exam

Learning Objectives

8.a. Analyze the steps necessary for inspection of the entire installation.
8.b. Discuss installations on asphalt roofing when the ambient temperatures are high and low
8.c. List the tasks involved with the typical maintenance of the Photovoltaic array.
8.d. Determine the required electrical test equipment necessary to troubleshoot a Photovoltaic system.
8.e. Detail the steps to systematically troubleshoot an Photovoltaic installation.

Criteria

Your performance will be successful when:

you list the steps necessary for inspection of the PV installation
you state all tasks involved with maintaining a PV array.
you list the electrical testing tools required to troubleshoot a PV installation
you create a list of the required steps necessary to efficiently troubleshoot a PV system

9. Install a typical photovoltaic system in the lab or out in the field.

Assessment Strategies

by participation in your instructors focused lecture
by successfully completion of your project in the lab

Learning Objectives

9.a. Construct a Photovoltaic system that meets all applicable codes and standards.
9.b. Verify the operation of your Photovoltaic installion by connecting it to the grid.

Criteria

Your performance will be successful when:

you have constructed a Photovoltaic system in the lab that meets all applicable codes and standards.
your lab project successfully produces voltage in the correct manner.

10. Determine correct wire type and size for PV systems.

Assessment Strategies

Demonstration
Project
Presentation

Learning Objectives

10.a. Select correct wire types for various aspects of PV applications.
10.b. Determine the current / amp flow requirements for both DC and AC PV wiring applications.
10.c. Determine the correct wire size based on current requirements, voltage drop, temperature, conduit fill,

and NEC requirements for PV applications, including rooftop applications.

Criteria

you understand the different wire types and their applications
you can select the proper wire type for the application.
you can calculate the current / amp requirements for PV systems wire runs.
you can calculate voltage drop for wire runs.
you can select the proper wire size for the application.
you can adjust wire ampacity rating based on conduit fill.
you can adjust wire ampacity rating based on ambient temperature.
you can adjust wire ampacity rating based on roof top wire runs in conduit at certain distances off the roof.

11. Interpret & understand Section 690, and other applicable sections, in the current National Electric Code

Assessment Strategies

Project
Presentation
Written Product

Learning Objectives

11.a. Describe the purpose of the National Electric Code, NEC.
11.b. Articulate the requirements of being "Code Compliant".
11.c. Explain the major components of NEC Section 690, Solar Photovoltaic (PV) Systems.
11.d. Elaborate on the requirements of NEC Section 250, Grounding and Bonding.
11.e. Apply the guidelines and tables of NEC Section 310, Conductors for General Wiring
11.f. Determine required locations and correctly size all disconnecting means required on PV systems.
11.g. Ascertain need, correct type and size of overcurrent protection devices.
11.h. Diagram correct bonding and grounding for all parts of a PV system.

Criteria

you can describe the purpose of the NEC
you describe what NEC compliant means.
you articulate the purpose of Section 690, Solar Photovoltaic (PV) Systems
you articulate the basics of Section 250, Grounding and Bonding.
you apply Section 310, Conductors for General Wiring.
you can calculate circuit requirements for AC modules and PV sources.
you can determine the need for and correctly size, overcurrent protection.
you explain what disconnecting means.
you identify bonding and grounding requirements.
you can determine what labeling is required for all PV system components.

12. Apply correct code compliant labeling for PV systems.

Assessment Strategies

Project
Skill Demonstration

Learning Objectives

12.a. Describe the labeling requirements per NEC for PV system installations
12.b. Explain equipment and PV module required labeling per NEC.
12.c. Describe PV AC & DC disconnect means labeling requirements.
12.d. Explain color coding requirement for the various categories of required labels.

Criteria

You will be successful when:

you know and can apply labeling requirements for PV systems.
you can describe the labeling requirement for PV systems wiring.
you can describe the labeling requirements in NEC Article 690 Part VI and Article 705 for equipment labeling.
you can describe the Fire Safety Label requirements for PV system disconnecting means.
you can describe PV array disconnect labeling requirements.
you can explain color coding requirements for the various types of labels required.