Introduction to Wind Energy

Module 58101-11

Annotated Instructor's Guide

Module Overview

This module introduces students to wind energy and the rapidly expanding world of wind-generated power. It covers the basic principles of capturing wind energy as well as the past, present, and future of the industry. The module also introduces trainees to wind turbine construction and the key components of horizontal axis units. To complete the industry introduction to future wind energy technicians, an overview of the wind farm environment and a description of the career field are presented.

Prerequisites

Prior to training with this module, it is recommended that the trainee successfully complete *Power Industry Fundamentals*.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Evaluate the advantages and disadvantages of wind power technology.
2. Identify the important events, people, and organizations in the history of wind power to date.
3. Describe wind energy concepts and how the energy is captured.
4. Identify the basic functions and classifications of wind turbines.
5. Identify major horizontal-axis wind turbine (HAWT) components and their function.
6. Describe the wind farm environment and characteristics of the wind energy maintenance technician.

Performance Task

This is a knowledge-based module; there are no performance tasks.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Wind Turbine Maintenance Technician Level One, Volume One PowerPoint® Presentation Slides (ISBN 978-0-13-272054-0)
Multimedia projector and screen
Computer
Appropriate personal protective equipment
Module Examinations*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly if any time will be spent in contact with systems or components. Review safety guidelines associated with working on electrical or mechanical systems and equipment. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Introduction To Wind Principles. Thomas E. Kissell. Pearson Education, publishing as Prentice Hall.
Wind Power. Paul Gipe. White River Junction, VT: Chelsea Green Publishing Company.
American Wind Energy Association (AWEA). www.awea.org.
U.S. Department of Energy, Wind Powering America Program. www.windpoweringamerica.gov.

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Introduction To Wind Energy*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; The History of Wind Power	
A. Introduction	_____
B. The History of Wind Power	_____
Session II. The Wind Industry Today; A Study in Wind Energy	
A. The Wind Industry Today	_____
B. A Study in Wind Energy	_____
1. The Power of the Wind	_____
2. More About Wind Speed	_____
3. Wind Speed and Height	_____
4. Wind Data Acquisition and Use	_____
Session III. Intercepting Wind Energy; Wind Turbines	
A. Intercepting Wind Energy	_____
1. The Betz Limit	_____
B. Wind Turbines	_____
1. HAWTs and VAWTs	_____
2. Blade Count	_____
3. Blade Size and Construction	_____
4. HAWT Yaw and Pitch	_____
5. Supervisory Control and Data Acquisition (SCADA)	_____
Session IV. HAWT Turbine Systems	
A. HAWT Turbine Systems	_____
1. Wind Turbine Towers	_____
2. Nacelles	_____
3. Electric Power Components	_____

Session V. HAWT Turbine Systems; The Wind Farm; The Wind Energy Technician

A. HAWT Turbine Systems _____

1. Drive System Components _____

B. The Wind Farm _____

1. Wind Farm Maintenance _____

C. The Wind Energy Technician _____

Session VI. Review and Testing

A. Module Review _____

B. Module Examination _____

1. Trainees must score 70 percent or higher to receive recognition from NCCER.
2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.

Introduction to Wind Turbine Safety
Annotated Instructor's Guide

Module 58102-11

Module Overview

This module provides basic safety training specific to the wind turbine industry. Trainees will gain a deeper understanding of the OSHA 10-hour General Industry safety program. Job and task safety analysis processes are also covered. The module provides safe work practices for confined spaces, electrical systems, and rigging specific to the service of wind turbine systems. An overview of safe driving techniques in the wind farm environment is also included. The instruction concludes with coverage of aerial work platforms and safe operating practices.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Power Industry Fundamentals* and *Wind Turbine Maintenance Technician Level One, Volume One*, Chapter One.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Describe the purpose and value of the Occupational Safety and Health Administration (OSHA) 10-hour General Industry guidelines.
2. Describe the purpose of Job Safety Analysis (JSA) meetings as it relates to the wind turbine environment.
3. Prepare a JSA.
4. Describe confined spaces as they relate to the wind turbine.
5. Identify electrical system safety guidelines for wind turbine service.
6. Identify safe rigging practices in the wind turbine environment.
7. Describe wind energy site safe driving techniques.
8. Identify various aerial work platforms and their operating characteristics.

Performance Task

Under the supervision of the instructor, the trainee should be able to do the following:

1. Prepare a JSA.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Wind Turbine Maintenance Technician Level One, Volume One PowerPoint® Presentation Slides (ISBN 978-0-13-272054-0)
Multimedia projector and screen
Computer
Appropriate personal protective equipment
Multimeter
Lockout devices and keyed locks
Lockout tags
Available equipment to practice lockout/tagout procedures
A sufficient number of sample Job Safety Analysis forms (found in the *Appendix*)
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly if any time will be spent in contact with systems or components. Review safety guidelines associated with working on electrical or mechanical systems and equipment. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

OSHA Standard 1926, Safety and Health Regulations for Construction, available at www.osha.gov.

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 12½ hours are suggested to cover *Introduction To Wind Turbine Safety*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; OSHA And The Wind Turbine Environment; Job Safety Analysis

A. Introduction _____
B. OSHA and the Wind Turbine Environment _____
C. Job Safety Analysis _____
D. Laboratory _____

Provide trainees with a simulated or actual job to be done and have them complete a JSA through a group effort. This laboratory corresponds to Performance Task 1.

Sessions II. and III. Confined Spaces; Electrical Safety

A. Confined Spaces _____
   1. Permit-Required Confined Spaces _____
   2. Worker Responsibilities in Confined Spaces _____
   3. Wind Turbine Confined Spaces _____
B. Electrical Safety _____
   1. Shock Hazard _____
   2. Step and Touch Potentials _____
   3. Arc Flash and Arc Blast _____
   4. Hazard Boundaries _____
   5. De-Energized Equipment _____
   6. Lockout/Tagout _____
C. Laboratory _____

Have trainees practice a simple lockout/tagout application and removal procedure. Point out the various electrical boundaries during the exercise.

Session IV. Rigging; Safe Driving; Aerial Work Platforms

A. Rigging _____
   1. Hoists _____
   2. Lift Planning _____
   3. Critical Lifts _____
   4. Lift Plan Implementation _____

B. Safe Driving _____
   1. Driving Company Vehicles _____
   2. Off-Road and Inclement Weather Driving _____

C. Aerial Work Platforms _____
   1. Scissor Lifts _____
   2. Boom Lifts _____

Session V. Review and Testing

A. Review _____

B. Module Examination _____
   1. Trainees must score 70 percent or higher to receive recognition from NCCER.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.

Introduction to Electrical Circuits
Annotated Instructor's Guide

Module 26103-11

Module Overview

This module introduces the trainee to electrical circuits. It offers a general introduction to electrical concepts used in Ohm's law. It includes atomic theory, electromagnetic force, resistance, and electric power equations. It also covers series, parallel, and series-parallel circuits.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One,* Modules 26101-11 and 26102-11.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Define voltage and identify the ways in which it can be produced.
2. Explain the difference between conductors and insulators.
3. Define the units of measurement that are used to measure the properties of electricity.
4. Identify the meters used to measure voltage, current, and resistance.
5. Explain the basic characteristics of series and parallel circuits.

Performance Tasks

This is a knowledge-based module. There are no performance tasks.

Materials and Equipment

Multimedia projector and screen
Electrical Level One
  PowerPoint® Presentation Slides
  (ISBN 978-0-13-257126-5)
Computer
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Sample schematics
Basic electrical circuit, including:
  Battery/power source
  Wiring
  Loads
  Switches
Examples of conductors, insulators, and
  color-coded resistors
Magnets
Simple electromagnet
Metal sheet
Iron filings
Various types of meters, including:
  Multimeter
  Voltmeter
  Clamp-on ammeter
  Ohmmeter
  Continuity tester
  Voltage tester
Module Examination*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees may work with electrical test equipment. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize electrical safety.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Electronics Fundamentals: Circuits, Devices, and Applications, Thomas L. Floyd. New York: Prentice Hall.
Principles of Electric Circuits, Thomas L. Floyd. New York: Prentice Hall.

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover *Introduction to Electrical Circuits.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction to Electrical Theory	
A. Introduction	_____
B. Atomic Theory	_____
C. Electrical Power Generation and Distribution	_____
D. Electric Charge and Current	_____
Session II. Ohm's Law; Schematics; Measurements	
A. Ohm's Law	_____
B. Schematic Representation of Circuit Elements	_____
C. Resistors	_____
D. Electrical Circuits	_____
E. Electrical Measuring Instruments	_____
Session III. Power Equations; Review and Testing	
A. Electrical Power	_____
B. Module Review	_____
C. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from NCCER.	
2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.	

Electrical Theory
Annotated Instructor's Guide

Module 26104-11

Module Overview

This module introduces trainees to circuit calculations involving the application of Ohm's and Kirchoff's laws.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One,* Modules 26101-11 through 26103-11.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Explain the basic characteristics of combination circuits.
2. Calculate, using Kirchhoff's voltage law, the voltage drop in series, parallel, and series-parallel circuits.
3. Calculate, using Kirchhoff's current law, the total current in parallel and series-parallel circuits.
4. Using Ohm's law, find the unknown parameters in series, parallel, and series-parallel circuits.

Performance Tasks

This is a knowledge-based module. There are no performance tasks.

Materials and Equipment

Electrical Level One
PowerPoint® Presentation Slides
(ISBN 979-0-13-257126-5)
Multimedia projector and screen
Computer
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Module examination*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees may work with electrical test equipment. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize electrical safety.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Electronics Fundamentals: Circuits, Devices, and Applications, Thomas L. Floyd. New York: Prentice Hall.
Principles of Electric Circuits, Thomas L. Floyd. New York: Prentice Hall.

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover *Electrical Theory.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	Planned Time
Session I. Introduction; Resistive Circuits	
A. Introduction	_____
B. Resistances in Series	_____
C. Resistances in Parallel	_____
D. Series-Parallel Circuits	_____
Session II. Applying Ohm's Law to Resistive Circuits	
A. Voltage and Current in Series Circuits	_____
B. Voltage and Current in Parallel Circuits	_____
C. Voltage and Current in Series-Parallel Circuits	_____
Session III. Kirchhoff's Law; Review and Testing	
A. Kirchhoff's Law	_____
B. Module Review	_____
C. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from NCCER.	
2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.	

Electrical Test Equipment
Annotated Instructor's Guide

Module 26112-11

Module Overview

This module introduces the trainee to electrical test equipment. It explains the purpose and use of voltmeters, ohmmeters, clamp-on ammeters, multimeters, megohmmeters, and motor and phase rotation testers. It also covers basic safety and explains category ratings.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One,* Modules 26101-11 through 26111-11.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Explain the operations of and describe the following pieces of test equipment:
   - Voltmeter
   - Ohmmeter
   - Clamp-on ammeter
   - Multimeter
   - Megohmmeter
   - Motor and phase rotation testers
2. Select the appropriate meter for a given work environment based on category ratings.
3. Identify the safety hazards associated with the various types of test equipment.

Performance Tasks

Under the supervision of the instructor, the trainee should be able to do the following:

1. Under instructor supervision, measure the voltage in your classroom from line to neutral and neutral to ground.
2. Under instructor supervision, use an ohmmeter to measure the value of various resistors.

Materials and Equipment

Multimedia projector and screen
Electrical Level One
PowerPoint® Presentation Slides
(ISBN 978-0-13-257126-5)
Computer
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Analog meter
Continuity tester
Resistors
Copy of the latest edition of the *National Electrical Code®*
Examples of the following test instruments with their operator's manuals:
Voltmeter
Voltage tester
Ohmmeter
Clamp-on ammeter
Multimeter
Megohmmeter
Motor and phase rotation testers
Safety video/DVD (*optional*)
TV/Video/DVD player (*optional*)
Module Examination*
Performance Profile Sheet*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to work with electrical test equipment. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize electrical safety.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

ABCs of Multimeter Safety, Everett, WA: Fluke Corporation.
ABCs of DMMs, Multimeter Features and Functions Explained, Everett, WA: Fluke Corporation.
Clamp Meter ABCs, Everett, WA: Fluke Corporation.
Electronics Fundamentals: Circuits, Devices, and Applications, Thomas L. Floyd. New York: Prentice Hall.
Power Quality Analyzer Uses for Electricians, Everett, WA: Fluke Corporation.
Principles of Electric Circuits, Thomas L. Floyd. New York: Prentice Hall.

Teaching Time for this Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 2½ hours are suggested to cover *Electrical Test Equipment.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Electrical Test Equipment	
A. Introduction	_____
B. Voltmeter	_____
C. Laboratory Have trainees practice measuring voltage. This laboratory corresponds to Performance Task 1.	_____
D. Ohmmeter	_____
E. Laboratory Have trainees practice using an ohmmeter. This laboratory corresponds to Performance Task 2.	_____
F. Ammeter and Multimeter	_____
G. Megohmmeter and Other Instruments	_____
H. Category Ratings and Safety	_____
I. Review	_____
J. Module Examination 1. Trainees must score 70% or higher to receive recognition from NCCER. 2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.	_____
K. Performance Testing 1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements. 2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.	_____

Electrical Wiring
Annotated Instructor's Guide

Module 58104-11

Module Overview

This module introduces trainees to the electrical wiring associated with wind turbines. The selection process for various conductors is reviewed, as well as the identification of conductors through cable and wire markings. Coverage of the specific types of conductors used in wind turbine systems is provided. The conductors presented include data and power-limited cabling. Trainees will learn how to prepare and terminate low-voltage conductors and cables.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Power Industry Fundamentals* and *Wind Turbine Maintenance Technician Level One, Volume On*e, Chapters One through Six.

Objectives

Upon completion of this module, the trainee will be able to do the following:

1. Interpret cable and wire markings to determine the physical and functional properties of wire and cable.
2. Select the appropriate conductor based on the ampacity, insulation type, and temperature rating using the *National Electric Code*® tables.
3. Describe types of conductors and cables used in wind turbine installations based on the application.
4. Identify the various types of data cable used in wind turbine systems.
5. Prepare and terminate various low-voltage conductors and cables.

Performance Tasks

Under the supervision of the instructor, the trainee should be able to do the following:

1. Prepare and terminate various low-voltage conductors and cables.
2. Select the appropriate conductor based on the ampacity, insulation type, and temperature rating using the *NEC*® tables.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Wind Turbine Maintenance Technician Level One, Volume One PowerPoint® Presentation Slides (ISBN 978-0-13-272054-0)
Copy of the latest edition of the *National Electrical Code*®
Multimedia projector and screen
Computer
Safety glasses
Appropriate personal protective equipment
Wire strippers appropriate for chosen wire size and type
Hand crimpers
Power crimping tools and dies
Heat-shrink insulators
Heat gun for heat-shrink insulators
Assorted sizes of wire and cable
Assorted sizes and types of crimp connectors
Assorted sizes and types of mechanical compression connectors
Assorted wire nuts
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review all safety guidelines associated with the use of hand and power tools to strip and terminate wire and cable. Emphasize the importance of proper housekeeping and organization as an important measure to avoid hazards and prevent injuries in the workplace.

Teaching Time for This Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 12½ hours are suggested to cover *Electrical Wiring*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; Properties of Conductors and Cables

A. Introduction _____

B. Properties of Conductors and Cables _____

1. Physical Size _____
2. Conductor Material _____
3. Insulating Material _____
4. Conductor Temperature Rating _____
5. Ampacity Rating _____

C. Laboratory _____

Have trainees practice selecting the appropriate conductor based on the ampacity, insulation type, and temperature rating using the *National Electrical Code®* tables. This laboratory corresponds to Performance Task 2.

Session II. Applications of Conductors and Cables; Cable Connectors and Conductor Terminations, Part One

A. Applications of Conductors and Cables _____

1. Data and Communications Cables _____
2. Low-Voltage Power Conductors or Cables _____
3. Medium-Voltage Cables _____

B. Cable Connectors and Conductor Terminations _____

1. Stripping and Cleaning Conductors _____

Sessions III and IV. Cable Connectors and Conductor Terminations, Part Two

A. Wire Connections Under 600 Volts _____

1. Dissimilar Metal Conductors and Connections _____
2. Heat-Shrink Insulators _____
3. Control and Sensor Cables _____
4. Low-Voltage Connectors and Terminals _____
5. Installing Compression Connectors _____

B. Laboratory _____

Have trainees practice stripping wire, installing various electrical connectors with manual and powered tools, and applying heat-shrink. This laboratory corresponds to Performance Task 1.

Session V. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70 percent or higher to receive recognition from NCCER.
2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Training Report Form 200, and submit the results to the Training Program Sponsor.