



**GREEN COLLAR**  
**ENERGY TECHNOLOGIES** **ZONE**



# Wind Energy Technologies



# Wind Energy Technician

This Green Collar Zone workstation will teach you the basic principles of wind power, as you acquire skills by performing hands-on activities. No prior knowledge of alternative energy trades is required as the Green Collar Zone curriculum will introduce you to professional tools and materials and provide step by step instructions to use them in skills practice.

Before working on the skill set activities, you will learn:

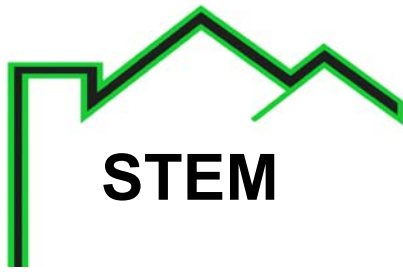
- The history of the wind power industry
- The career opportunities that exist in the alternative energy industry
- Fundamentals of electricity
- The components of a wind power system
- The difference between a grid tie and stand alone wind power system
- General safety tips followed by wind energy technicians

After you have learned about wind power systems, you will use industry grade materials to install and wire a wind turbine on a tower. You will use a wire stripper, side cutter, needle nose pliers, fish tape, electrical tape, screwdrivers and hex keys. You will use an electric drill and storage batteries to energize the wind power circuit. You will perform tests and make measurements with a voltmeter, ammeter, digital multimeter, and test light. You will connect a battery bank to a power inverter to tie into a residential electrical service panel.

## **WORKSTATION OVERVIEW**

You will complete the following tasks:

- Bench test a wind turbine
- Mount a wind turbine nacelle and rotor blades to a tower
- Run transmission wires from a turbine to a power center
- Connect power center meters, switches, and a circuit breaker
- Wire a power center to a battery storage station
- Connect storage batteries in a series/parallel combination circuit
- Test DC circuit for voltage and current
- Connect storage batteries to a power inverter
- Wire a power inverter to an electrical service panel
- Test AC circuit for voltage
- Disassemble wind energy circuit



Throughout the Wind Energy Technician curriculum you will see **STEM ENHANCEMENT** sections. These may be additional activities, projects, reading, or presentations that students can complete to strengthen their core skills in the areas of science, technology, mathematics and engineering.

**STEM ENHANCEMENT**

**S = Science concepts**

**T= Technology concepts**

**E= Engineering concepts**

**M= Mathematics concepts**

# SOLAR PANEL INSTALLER SKILLS OBJECTIVES

## Activity Day 1

- Define wind, wind energy, and wind power
- Define renewable and non-renewable energy
- List non-renewable energy sources
- List renewable energy sources
- Explain the advantages and disadvantages of wind power
- List the skills required of a wind energy technician

## Activity Day 2

- Draw and label a diagram of an atom
- Define the terms current, voltage, power, and resistance
- Describe the water analogy associated with current, voltage, power, and resistance
- Define the terms conductor and insulator
- Define circuit
- Describe how current flows in a circuit
- Define the term ground and state the purpose of a ground wire
- Explain the conditions necessary for electric shock to happen

## Activity Day 3

- Identify the components of a wind turbine
- Define rotor blade
- Differentiate between vertical and horizontal axis wind turbines
- Define nacelle and state its function
- Define tower
- Differentiate between three common types of wind turbine towers
- Use the wind power equation to solve for the wind power ratio of two different locations
- State the general rule for locating wind turbine towers around surrounding objects

## Activity Day 4

- Define power curve
- Identify the key components of a wind energy system on a circuit diagram
- Trace the complete circuit made by electrical current from a wind turbine through a wind energy system
- Define kinetic energy
- Define generator and state its function in a wind energy system
- Define voltage regulator and state its function in a wind energy system

### **Activity Day 4 continued...**

- Define bridge rectifier
- Define diode
- Define the terms brush and slip ring
- List the components of a power center and state their function in a wind energy system
- Define battery and state its function in a wind energy system
- Define inverter and state its function in a wind energy system
- List the three common types of wind energy systems
- Identify the components in the three types of wind energy systems

### **Activity Day 5**

- List safety tips specific to wind energy technicians
- Define bench test
- Perform a yaw wire bench test
- Define multimeter
- Identify the different parts of a multimeter
- List the steps for testing continuity, voltage, current, and resistance with a multimeter
- Safely use a multimeter to test a wind turbine's voltage and current

### **Activity Day 6**

- Define the terms hot, neutral, ground, and dead wires, and state their function in a circuit
- List the reasons wire size is important
- Explain how the distance between a wind turbine and the point of use of the electricity affect wire costs and wire size requirements
- List the main areas of a wind power system that must be grounded
- Define conduit
- Define fish tape
- Identify the different parts of a fish tape
- Safely use a fish tape to make a wire run
- Define hex key
- Use a hex key to drive socket head fasteners
- Distinguish between clockwise and counter-clockwise rotation

### **Activity Day 7**

- Define airfoil
- Define lift and drag
- Define fixed pitch blade and list its advantages and disadvantages
- Define variable pitch blade and list its advantages and disadvantages
- Define overspeed condition
- Define swept area
- State the mathematical relationship of rotor diameter to swept area and to power output

### **Activity Day 8**

- Define generator
- Define alternator
- Define permanent magnet alternator
- Define rotor
- Identify the different parts of a rotor
- Define the terms magnet, magnetic material, and magnetic field
- Describe the magnet orientation on a PMA rotor
- Define stator
- Identify the different parts of a stator
- Describe the coil directions on a stator
- Define air gap
- Define electromagnetic induction
- Describe how the movement of a north and south pole magnetic field across a stator winding produces a current in the form of a sine wave
- Define phase
- Distinguish between single phase and three phase alternators
- Define wild AC

### **Activity Day 9**

- Define bridge rectifier
- Define diode
- Distinguish between the three operating modes of a diode
- Define the terms forward bias and reverse bias
- Define half wave rectifier and describe its output voltage signal
- Define pulsating DC
- Define full wave rectifier and describe its output voltage signal
- Define three phase full wave bridge rectifier and describe its output voltage signal
- Interpret a three phase bridge rectifier circuit diagram, and identify the working diode pair at any given rotor angle

### **Activity Day 10**

- Define voltage regulator
- Identify the different parts of a voltage regulator
- List the five spinning conditions of a wind turbine
- State the function of each spinning condition of a wind turbine
- Locate voltage regulator components in a turbine

### **Activity Day 11**

- Define screwdriver
- Identify the different parts of a screwdriver
- Define paired wire
- Define tinning
- Define splicing
- Define wire nut
- Safely use a screwdriver to drive screws in terminal blocks
- Use a wire nut to connect wires

### **Activity Day 12**

- Define electric switch
- Define stop switch
- Identify the different parts of a stop switch
- Define pole
- Define throw
- Define SPDT and SPST
- Define break-before-make switch and state its advantage over other switch types
- Interpret an SPDT circuit drawing for each of its toggle positions
- Define meter
- Define ammeter
- Define analog
- Explain how an iron-vane meter works
- Define solenoid
- Define circuit breaker
- Explain how a bi-metal thermal self-resetting circuit breaker functions
- Define battery disconnect switch
- Interpret an SPST circuit drawing for each of its toggle positions
- Define voltmeter

### **Activity Day 13**

- Define lead acid battery
- Define rechargeable
- Define electrolyte
- Define cell
- Explain the electrochemical reaction when a battery is charging and discharging
- Define amp-hour
- State the difference between starter and deep cycle batteries
- Recognize series, parallel, and series/parallel combination battery connections
- Determine final voltage in a series connection
- Determine final amperage in a parallel connection

### **Activity Day 14**

- Connect a battery bank in a series/parallel combination
- Use a voltmeter to read a battery bank voltage
- Install a direct current light fixture and light bulb

### **Activity Day 15**

- Define drill
- Identify the different parts of a portable drill
- Complete testing of the wind turbine using LED observations and ammeter readings
- Safely use an electric drill to rotate the rotor shaft
- Use an ammeter to read a wind turbine current

### **Activity Day 16**

- Define inverter
- State the four main ways an inverter modifies low voltage current
- Define Hertz
- Use a multimeter and voltmeter to compare an inverter's input voltage to its output voltage

### **Activity Day 17**

- Define tape measure
- Identify the different parts of a tape measure
- Calculate the length of wire needed from one electrical box to another
- Define wire stripper
- Identify the different parts of a wire stripper
- Safely use a wire stripper to strip 14 gauge wire



### **Activity Day 18**

- Define side cutter
- Identify the different parts of a side cutter
- Define switch
- Identify the different parts of a switch
- Define receptacle
- Identify the different parts of a receptacle
- Safely use a side cutter to cut wires
- Install a switch and receptacle using hand tools

### **Activity Day 19**

- Define service panel
- Identify the different parts of a service panel
- Define entrance cable
- Define bus bar, and state the functions of hot, neutral, and ground bus bars
- Define circuit breaker
- Safely connect a ground wire to a ground bus bar and a neutral wire to a neutral bus bar
- Safely connect a hot wire to a circuit breaker
- Define test lamp
- Identify the different parts of a test lamp
- Safely use a test lamp to test for voltage in a receptacle outlet
- Check each component in an energized wind power system for proper functioning

### **Activity Day 20**

- Use basic math skills to calculate material and labor charges
- Safely use screwdrivers to remove electrical box covers and loosen terminal screws on electrical components
- Disconnect a circuit breaker
- Pull out wire runs
- Safely use side cutters to trim wire ends
- Use hex keys to disconnect and remove a nacelle

# Activity Day 6

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## Running Transmission Wire & Installing the Nacelle

### Wind Energy Technician Skills Objectives

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1. Define the terms hot, neutral, ground, and dead wires, and state their function in a circuit
2. List the reasons wire size is important
3. Explain how the distance between a wind turbine and the point of use of the electricity affect wire costs and wire size requirements
4. List the main areas of a wind power system that must be grounded
5. Define conduit
6. Define fish tape
7. Identify the different parts of a fish tape
8. Safely use a fish tape to make a wire run
9. Define hex key
10. Use a hex key to drive socket head fasteners
11. Distinguish between clockwise and counter-clockwise rotation

### Day 6 Activities

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1. Read the sections *Activity Introduction*, *Wire Sizes and Types*, *Wind Energy Wire Sizing*, *Ground Wires*, *Underground Wiring*, and *Using Fish Tape*.
2. Complete the step-by-step directions to run wire from the top of the tower to the junction box.
3. Read the sections *Using the Hex Key* and *Directional Symbols*.
4. Complete the step-by-step directions to mount the nacelle on the tower.
5. Complete the Activity Day 6 workbook questions.



## Activity Introduction

Your task is to run wire from the top of the tower to the junction box and to attach the wind turbine nacelle to the tower. Before you begin, you will learn about wire sizes and types. You will learn how to safely use a fish tape to run wires and how a hex key is used.

To run wires and install the nacelle, you'll need the tools pictured below. Each is either labeled in the tool module or is kept in the drawers at the base of the workstation. When you have finished using a tool, return it to the labeled tool holder.

Activity Day 6 Tools and Materials	
 <p><i>Safety Glasses</i></p>	 <p><i>Fish Tape</i></p>
 <p><i>Hex Keys</i></p>	



# Wire Sizes and Types

Electrical current flows in wires. Different wires are distinguished by color and by name. Copper wire used for electrical work is usually covered with plastic insulating material which provides the different colors. The common names for wires are *hot*, *neutral*, and *ground*. These terms denote the specific roles the wires play in allowing electricity to flow.

## Hot Wire

This wire is charged with voltage (it is **live**). The hot wire is connected to the power source, and either carries 120 or 240 volts. It is insulated with either black, red or blue insulation.

## Neutral Wire

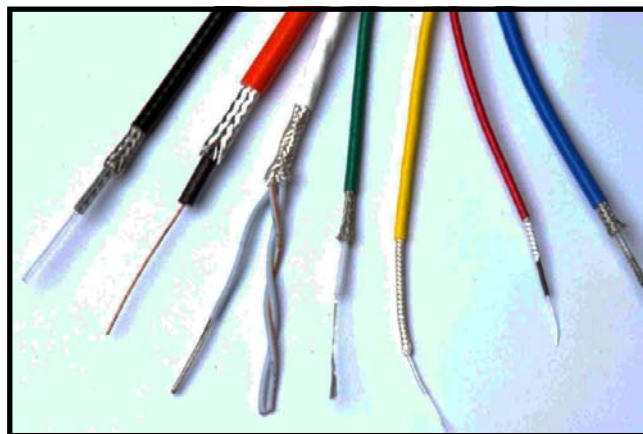
This wire completes a circuit by providing a path for electricity back to the panel and then ground. It does not carry any voltage when circuits are not in use, although there is still current in the wire. The neutral wire is always covered in either white or gray insulation.

## Ground Wire

This wire provides a safety system called grounding. It keeps every outlet and cover plate at zero voltage, and it carries no voltage or current. The ground wire is connected to the earth. It is normally a bare copper wire, but may be covered in green insulation.

## Dead Wire

This term refers to any wire with no voltage. This wire may be disconnected from the system or broken.



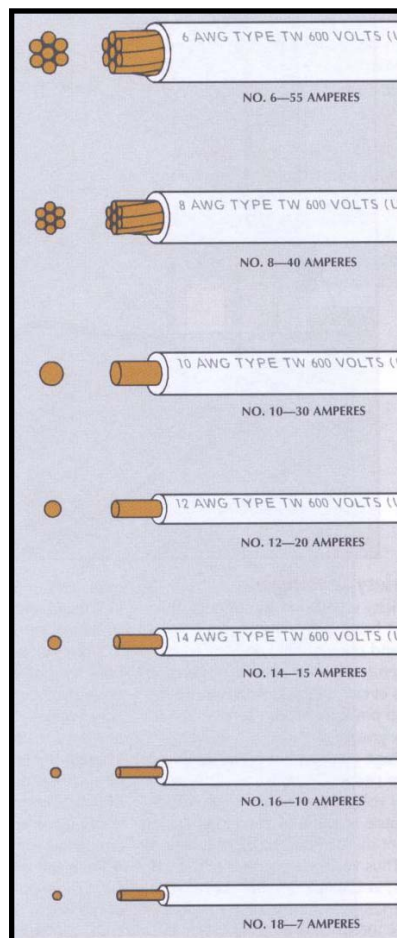
*Various Wires*

Copper wire is most commonly used in buildings and houses. Wire size is important for two reasons—the ability to carry current and voltage drop. When current flows through a wire, it creates some heat and loses some voltage (pressure) because of resistance to its flow in the wire. The heat produced and the voltage lost are kept low by using wire large enough to carry the current needed for the circuit.

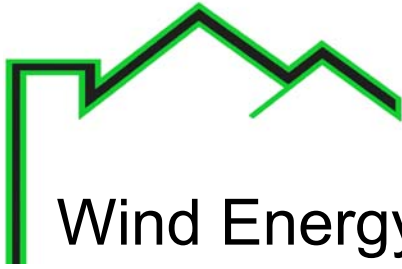
Copper wire sizes are indicated by number. The American Wire Gauge, or AWG, is the standard method of denoting diameter. The smaller the number, the greater the diameter. The smaller the wire, the greater its resistance to the flow of electricity. Wire size is printed on a wire's insulating jacket if there is enough space.

Solid wire consists of one strand, or wire. Stranded wire consists of several wires twisted together. Wires larger than #10 are stranded for flexibility during installation.

The highest voltage that can be applied to a wire or conductor in conformance with NEC standards is a wire's voltage rating. Typical voltage ratings for cables are 300V and 600V. This information is also printed on a wire's insulating jacket.



*Wire Size Chart — Not to Scale*



## Wind Energy Wire Sizing

Electric current from a wind turbine must be transmitted to the point of use before it can provide any benefit. The wires connecting the wind turbine to the batteries are important components of a wind energy system. Wire can be an expensive part of a system, especially when a long run of wire is required. Wire price increases with wire diameter (and therefore decreases with gauge number). However, using the smallest wire available is not necessarily the most economical option because of the greater loss of power due to resistance in a small wire.



*Wire*

Locating a wind turbine closer to the electricity's point of use will decrease wire costs and lower the voltage drop (the greater the wire length, the greater the resistance). Manufacturers specify the wire size and material for a range of distances between the wind turbine and the batteries that will allow their wind turbine to perform as designed. The Wind Energy Technician workstation turbine manufacturer recommends using #8 AWG copper wire for wire runs up to 30 feet from the turbine to the battery bank in this 12 volt system. The distance includes the tower. This wire size provides an energy loss of 5% or less.

Because the wire run is extremely short at the workstation, you will use #10 AWG copper wire in the wind energy circuit.



## Ground Wires

Wind turbine grounding systems are essential. Recall that ground wires carry current away when faulty conditions occur such as short circuits and electrical surges. These conditions can damage the electronics of a turbine by overloading them with high voltages or current. Wind energy technicians must understand and follow the grounding procedures that are listed in the turbine manufacturer's literature. They must also follow local and NEC grounding codes. There are three main areas on the DC side of a wind power system that must be grounded.

**Wind turbine components** are connected to a ground wire that runs down the inside of the tower and protects the components from damage should a short circuit occur. At the workstation, this ground wire is connected to the ground bus bar. In a working system, the wire would be connected to an earth ground located near the wind turbine. An earth ground is a conductor or rod that will dissipate large electrical currents into the earth.

**Wind turbine towers** are connected to a ground wire that runs down the outside of the tower and protects the tower and wind turbine from damage should lightning strike. The workstation does not feature a tower ground wire. In a working system, this ground wire would be connected to an earth ground located near the wind turbine.

**Batteries and direct current system components** such as meters and switches are connected to a black negative wire that runs up the inside of the tower to the turbine components. This negative wire is connected to a ground wire that protects the DC system components from damage should a short circuit occur. The workstation does not feature a DC component ground wire. In a working system, this ground wire would be connected to an earth ground located near the battery bank.

In addition, if a wind power system includes a **power center that is housed in a metal chassis** or box, it would be connected through a ground wire to the earth ground located near the battery bank.

There are two main areas on the AC side of a wind power system that must be grounded.

The **Service panel** is connected to a ground wire that runs from the ground bus bar out of the panel and protects the appliances that are hooked into a building's various circuits from damage should a short circuit occur. At the workstation, this ground wire is connected to the ground bus bar. In a working system, the wire would be connected to an earth ground located near the service panel.

The **inverter** is connected to a ground wire that runs out of the inverter and protects the inverter components from damage should a short circuit occur. At the workstation, this ground wire is connected to the ground bus bar. In a working system, this ground wire would be connected to the earth ground located near the service panel.



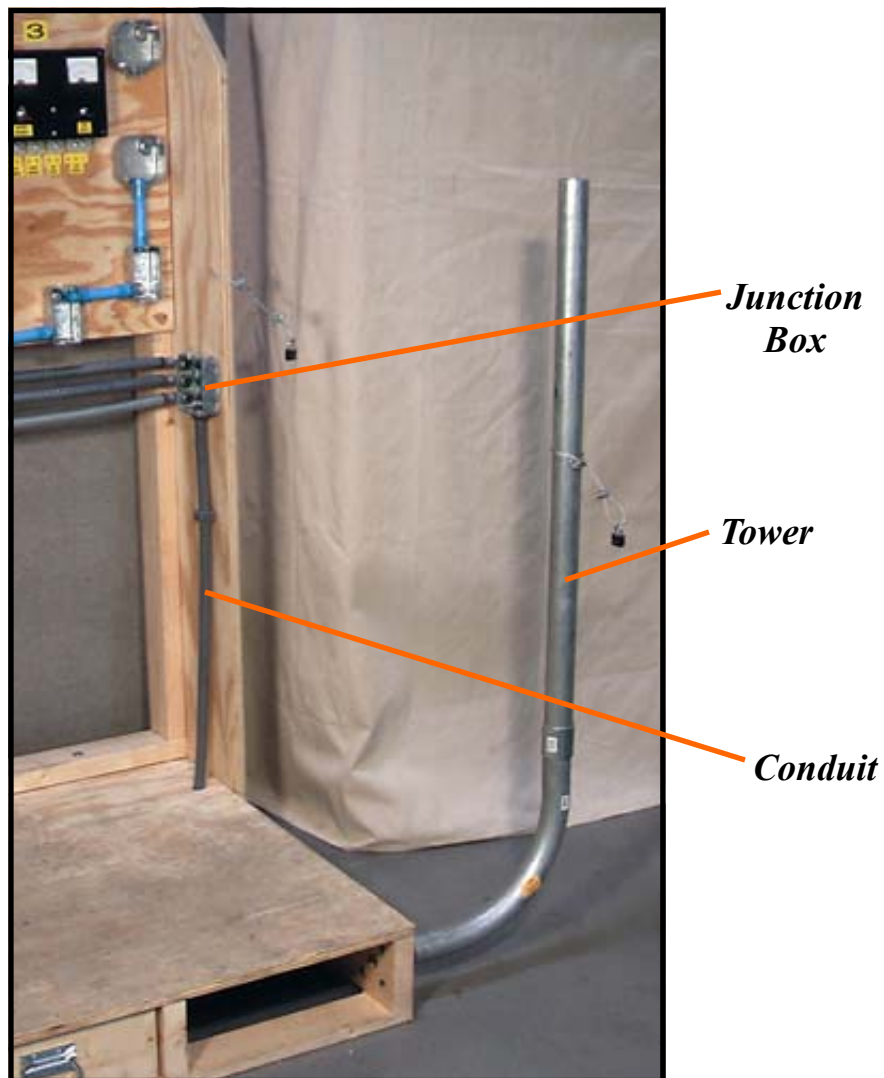
*Installing Wind Turbine Wires*





## Underground Wiring

Electric current flows from a wind turbine to its point of use through wires that must be physically protected from the elements. Wires leading to and from the turbine are run inside the tower. Wires running from the tower to the building are buried underground in conduit. Conduit is a protective cover for cables. At the workstation, 1/2" flexible watertight PVC conduit runs from the tower to a junction box to simulate underground wiring. A junction box is typically located where the wind turbine electrical wires enter a building. It allows the isolation of the buried electrical lines and a way to safely disconnect the building from the wind turbine.

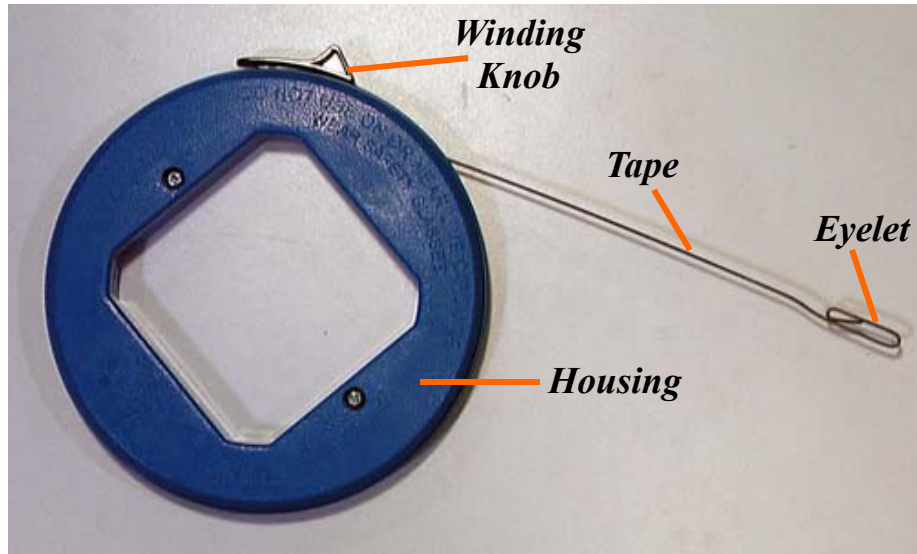


*Tower, Conduit, and Junction Box*



## Using Fish Tape

The parts of a fish tape and dispenser are called out below.





*Parts of a Fish Tape*

Fish tape is a tool for pulling, or fishing, wire through electrical conduit or behind walls or a ceiling. Fish tape, also known as draw tape or draw wire, is a thin, flat piece of steel wire with a hook or eyelet on one end. The tape is coiled in a plastic housing, or reel. Fish tape is flexible enough to go around corners and curves in conduit. It is strong enough to be pushed through a cable run without folding in on itself. And it is strong enough to pull cables back through a pipe without breaking. Fish tapes comes in various lengths, including 25, 50 and 100 feet.

To use fish tape, hold the housing and pull back the winding knob to release the tape from the housing. Push the tape through the cable run. Connect the wires securely to the tape. To attach wires to a fish tape that will run through a long length of conduit, strip off about six inches of insulation from the wires. Insert the bare wires through the eyelet on the end of the fish tape, and bend them back. Cover the splice with electrical tape so that it is smooth. The connection should be compact, no larger than the cable itself.

Pull the tape with the attached wires slowly back through the cable run in two to three foot intervals. Detach the wires from the fish tape, and push the winding knob forward to wind the tape back into the housing.

When using fish tape, follow these safety suggestions:

-  Always wear eye protection when using a fish tape
-  Do not use fish tape around live circuits
- Although the steel wire is both stout and flexible, do not use fish tape to pull an excessively heavy load
- Do not run power cables through a wall
- Don't sharply bend cables. This could affect their performance.
- Pulling too fast can nick the wires and pull your helper's fingers into a junction box

# Step-By-Step Instructions

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*To run wire through the tower and conduit:*

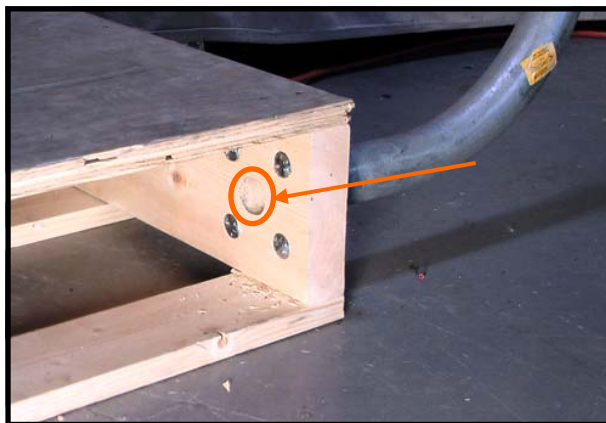


1. Put on your safety glasses.
2. Retrieve the fish tape and electrical tape. Open the wind turbine box, and retrieve the transmission wires as shown below.



*Transmission Wires*

3. Notice that each of the wires are stripped on one end and attached to a twist lock connection on the other end.
4. Locate the transmission wire entrance to the tower under the right front corner of the workstation.



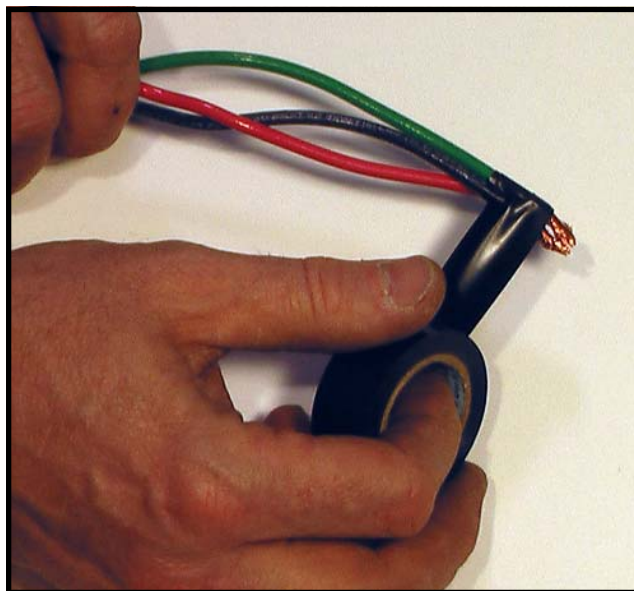
*Transmission Wire Entrance to Tower*

5. Pull back the winding knob on the fish tape dispenser to release the tape. Release about six feet of tape.
6. Start at the entrance hole. Push the tape from the hole up through the tower until it emerges at the top of the tower.



*Fish Tape Extending into Tower Pipe and Out the Top*

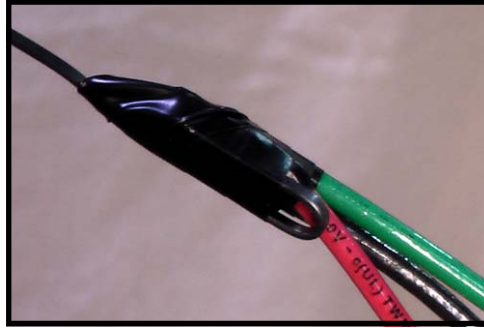
7. Gather together the stripped ends of the red positive wire, black negative wire, and the green ground wire. If the wires were to be pulled through a long distance, they would be stripped several inches to make a loop over the fish tape eyelet. However, these wires will not be fished through a long length of conduit, so they are stripped minimally.
8. Wrap electrical tape around the ends of the wires two or three times until the ends are completely covered with tape.



*Wrapping Wire Ends in Electrical Tape*

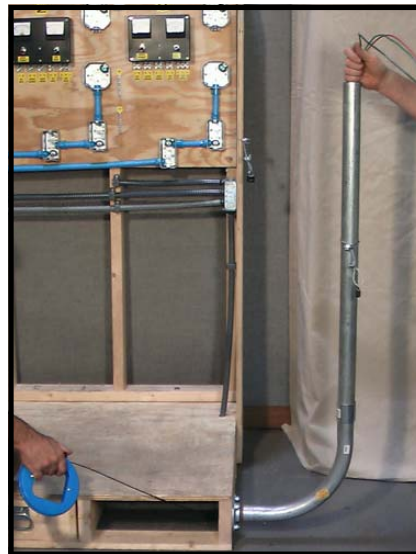


9. Continue wrapping the electrical tape around the fish tape eyelet to secure the wires to the fish tape. The wire ends should be completely covered in tape so that the connection does not catch on anything inside the conduit.



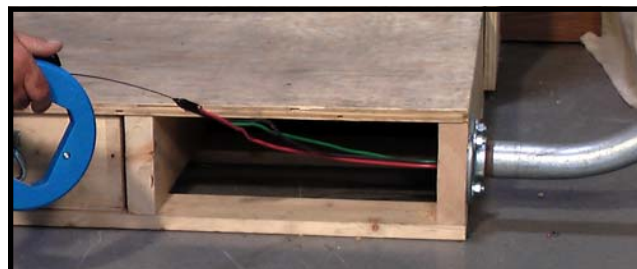
*Using Electrical Tape to Splice Wires to Fish Tape*

10. Slowly pull the fish tape back through the tower, with one student guiding the tape down through the tower and one student pulling it out of the entrance hole.



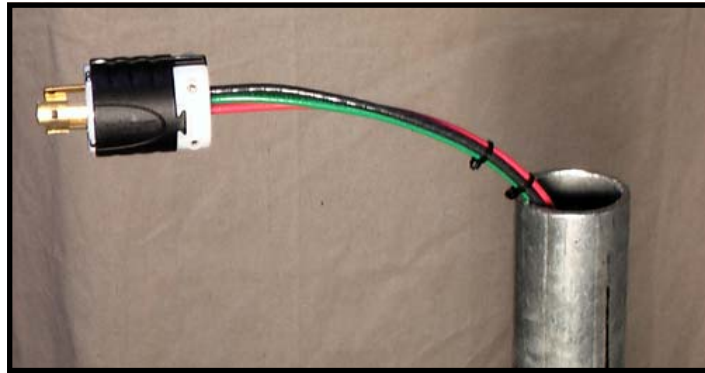
*Using Fish Tape to Pull Wires*

11. When the wires emerge from the entrance hole, remove the electrical tape from the wires and the fish tape eyelet. Push the winding knob forward on the tape dispenser to wind the fish tape back into its housing.



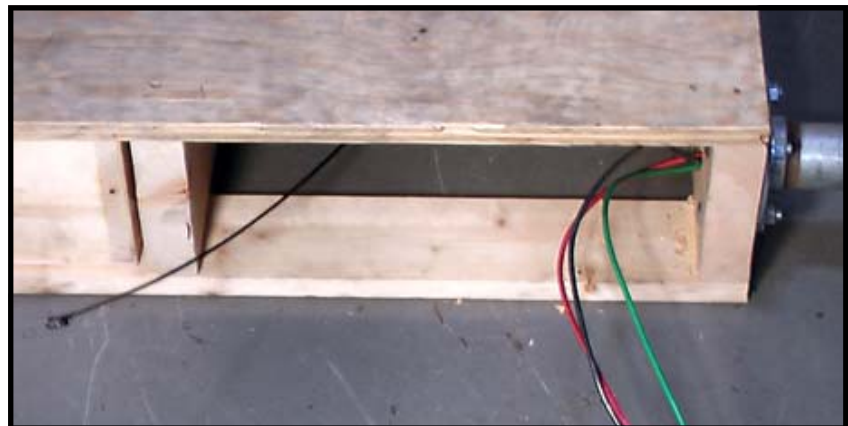
*Wires Emerging from Entrance Hole*

12. Pull the wires until the cable ties are just above the top of the tower pipe.



*Wires and Twist Lock Connection Extending from Tower*

13. Pull back the winding knob on the fish tape dispenser to release the tape. Release about six feet of tape. Start at the junction box. Push the tape through the hole in the bottom of the electrical box into the conduit. Push the tape down until it extends about one foot beyond the workstation.



*Fish Tape Extending into Junction Box and Out Bottom of Workstation*

14. Gather together the stripped ends of the transmission wires. Wrap electrical tape around the ends of the wires two or three times until the ends are completely covered with tape. Wrap the electrical tape around the fish tape eyelet to secure the wires to the fish tape.



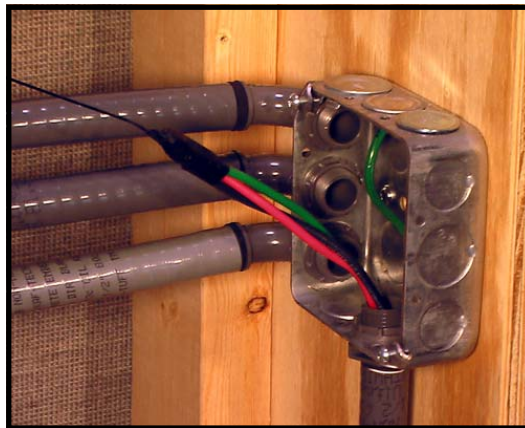
*Using Electrical Tape to Splice Wires to Fish Tape*

15. Slowly pull the fish tape through the conduit, with one student guiding the tape into the conduit and one student pulling it out of the junction box.



*Using Fish Tape to Pull Wires*

16. When the wires emerge into the junction box, remove the electrical tape from the wires and the fish tape eyelet. Push the winding knob forward on the tape dispenser to wind the fish tape back into its housing.



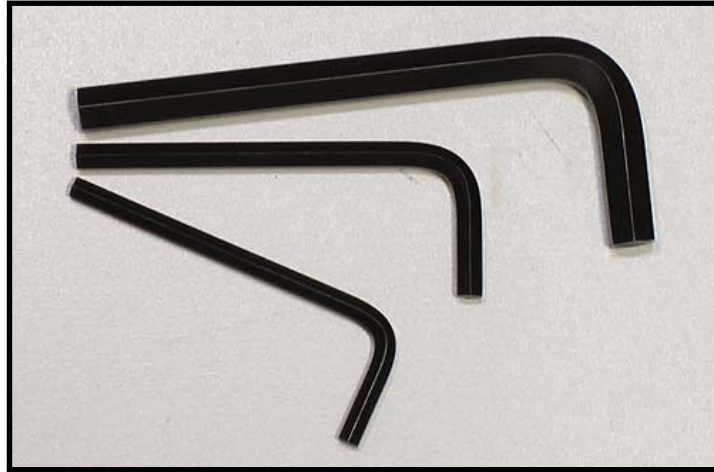
*Wires Emerging from Junction Box*

17. Pull the wires until six inches of each wire remain in the junction box. Tuck the extra wire neatly under the workstation.





## Using the Hex Key



*Hex Keys*

A hex key is a hand tool consisting of an L-shaped piece of metal with a hexagonal cross section used to install or remove fasteners that have a hexagonal socket in the head. It is also known as a hex wrench, Allen wrench, or hex-head.

Hex keys are available in many standard English and metric sizes. The workstation features 5/16", 3/16", and a 5/32" hex keys. Either end of the tool can be used, depending on whether reach or torque is needed. There are six contact surfaces between the key and the screw or bolt.

When using hex keys, follow these safety suggestions:



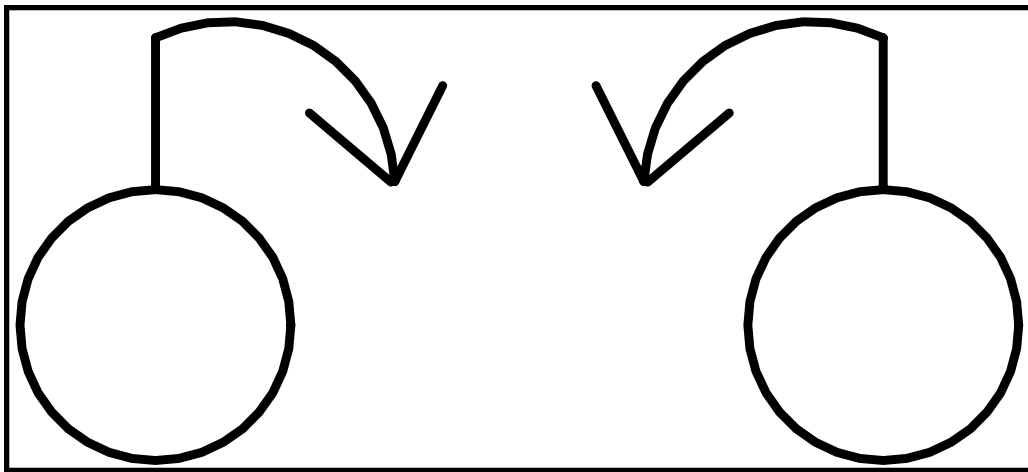
- Always wear safety glasses for eye protection
- Do not use hex keys that are too large or too small as this may damage the fastener
- Do not twist the hex key with pliers or a wrench
- Do not hold work in one hand while using the hex key on it with the other hand
- Do hold the hex key vertical to the screw or bolt head as you twist



## Directional Symbols

Some of the tools used by wind energy technicians in their daily work must be applied in two directions: clockwise and counter-clockwise.

Think about the way the hands of a clock turn—that is the clockwise direction. Counter-clockwise is the opposite direction—the hands of a clock turning backwards. The symbols for these two directions are below.



*Clockwise*

*Counter-clockwise*

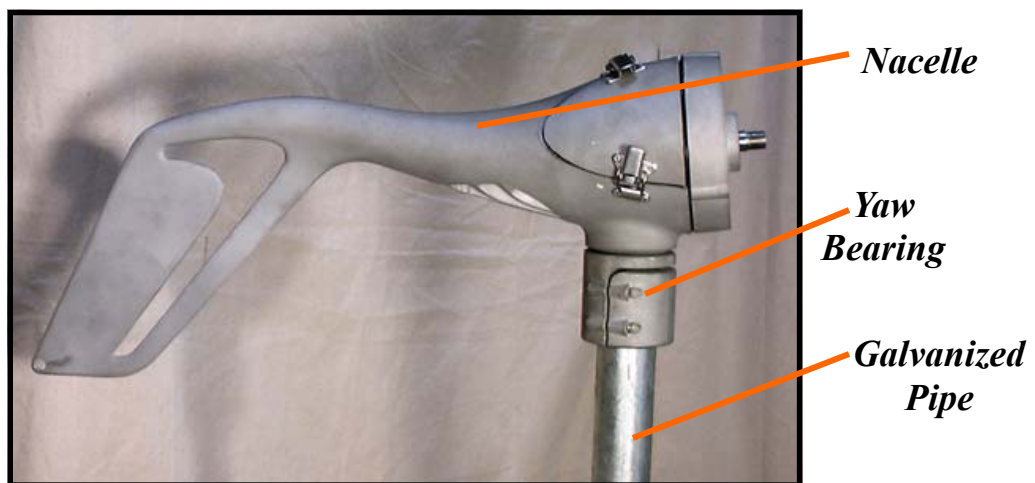
You will see these symbols in the workbook instructions whenever turning in a specific direction is required.

# Step-By-Step Instructions

*To mount the nacelle on the tower:*

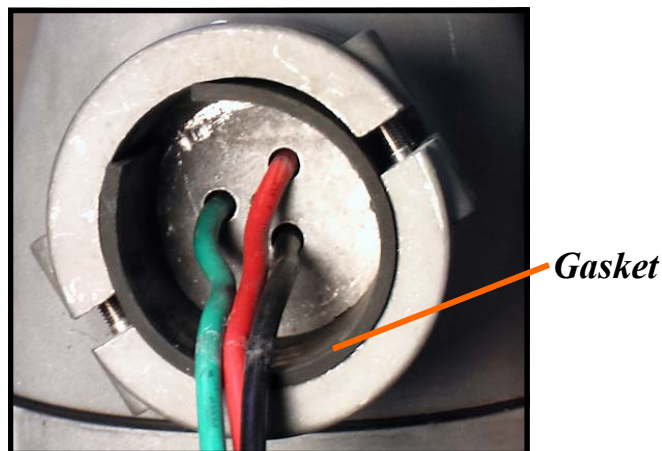


1. Put on your safety glasses.
2. You will mount the wind turbine nacelle onto a 1 1/2 inch diameter schedule 40 galvanized steel pole. A yaw bearing is a sealed bearing that supports the wind turbine as it swivels on its tower. The yaw bearing receives the pole.



*Mounting Components*

There is a rubber gasket inside the bearing that prevents the steel parts of the yaw bearing and the tower from contacting one another. The gasket provides a tight fit between the components and helps to dampen noise that could be transferred down the tower.



*Yaw Gasket*

3. One student should carefully lift the nacelle from its box and hold it close to the tower. The other student should connect the yaw wires to the transmission wires. Twist lock connectors used curved blades. Push the plug into the receptacle, and twist to lock the connection.



*Twist Lock Connector*

4. Feed the wires down into the tower.




*Feeding Yaw Wires into Tower*

5. Place the yaw bearing directly over the pole. Do not pinch the yaw wires between the bearing and the pole. Lower the yaw bearing completely onto the pole, then raise it 1/8 inch to prevent the bottom of the bearing from contacting the top of the pole.



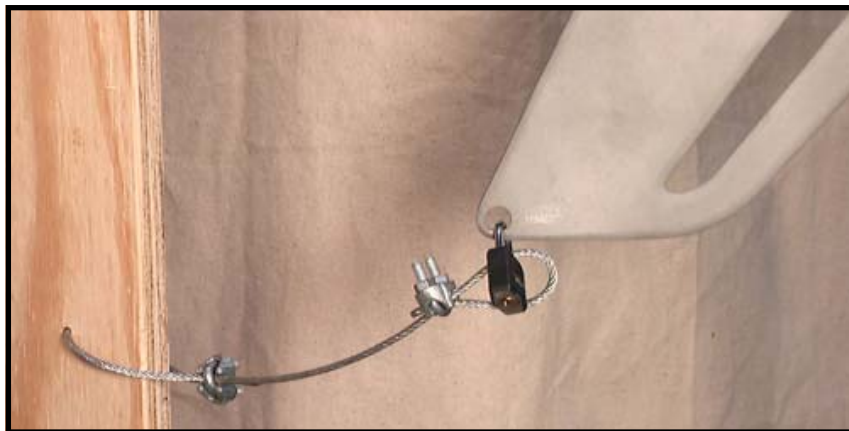
*Nacelle On Tower Pole*

- Retrieve the 5/32" hex key. Use the hex key to tighten the four mounting fasteners by turning them clockwise . Turn them until the fasteners are snug only.



*Tightening Mounting Fasteners with Hex Key*

- Ask your instructor whether you should disassemble the unit for the next class period or leave it assembled. If you are leaving the unit assembled, obtain a padlock from your instructor. Attach it to the tail of the nacelle and the cable extending from the workstation.



*Locking Wind Turbine Tail to Workstation*

- Return all tools and safety equipment to their places in the workstation. Clean up the workstation and put away unused materials.
- Locate Section 1 of the Questech Wind Energy Company work order. Enter today's date and the number of hours you worked on this job experience. You will use this information later to determine total job costs.



# Work Orders

Wind energy technicians use work orders to record information about a job and to prepare estimates of job charges.

See the work order example below. Work orders can give specific instructions and comments about the job to be done. In addition, the work order keeps a record of the time and materials used in completing the job so that the customer will be charged accurately.

Sign your name on your work order, and fill in the class period.

Name: _____		Class Period: _____	
<b>QUESTECH WIND ENERGY COMPANY: Work Order</b>			
Section 1: Wind Turbine Installation Labor Costs			
<b>Date</b>	<b>Hours Worked</b>	<b>Date</b>	<b>Hours Worked</b>
<b>Total Hours</b>			
<b>Per Hour</b>			
<b>Total Labor Cost</b>			
Section 2: Wind Power System Material Costs			
<b>Material</b>	<b>Unit Price in \$</b>	<b>Amount Used</b>	<b>Cost</b>
400 Watt Wind Turbine	800.00 ea		
1 1/2" Schedule 40 Pipe	2.72/ft		
6V Lead Acid Storage Battery	29.99 ea		
Power Center	50.00 ea		
Light Fixture	6.99 ea		
Service Panel	79.50		
Receptacles and Switches	1.99 ea		
<b>Material Cost</b>			
<b>6% Sales Tax</b>			
<b>Total Material Cost</b>			
Section 3: Wind Turbine Installation Total Job Cost			
<b>Total Labor Cost</b>			
<b>Total Material Cost</b>			
<b>Total Job Cost</b>			

*Wind Energy Technician Work Order*

**DO NOT WRITE ON THIS PAGE - ASK YOUR INSTRUCTOR FOR A COPY**

**Wind Energy Technician - Activity Day 6 Workbook Questions**

Match the wire type on the left with its function on the right.

- |                                  |  |
|----------------------------------|--|
| 1. Hot Wire _____                | A. Carries errant current away safely in case of faulty conditions             |
| 2. Neutral Wire _____            | B. Completes a circuit by providing a path for current to return to its source |
| 3. Ground Wire _____             | C. Carries current to various devices that use power                           |
| 4. To decrease wire costs: _____ |  |
|                                  | A. Increase the distance between the wind turbine and the battery bank         |
|                                  | B. Increase the wire diameter  |
|                                  | C. Increase the wire gauge   |
| 5. Define conduit.               |  |

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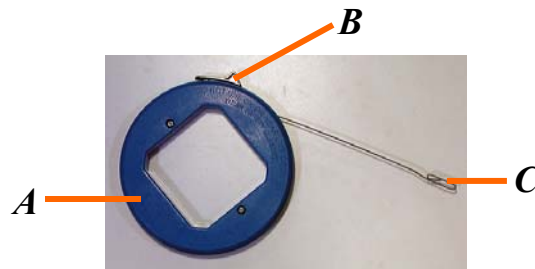
6. Define fish tape.

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Match the terms on the left with the parts of a fish tape.

- |                        |
|------------------------|
| 7. Housing _____       |
| 8. Eyelet / Hook _____ |
| 9. Winding Knob _____  |
| 10. Define hex key.    |



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## Optional STEM Activity

Use the following question or activity to strengthen your core skills in the areas of science, technology, engineering, and mathematics.

### STEM ENHANCEMENT

#### **STEM:**

**Often wire sizes are given in the unit of mils. A mil is one thousandth of an inch. A circular mil is the cross sectional area of a wire one mil in diameter. To calculate wire cross sectional area in circular mils, square a wire's diameter in mils.**

**Locate a wire size chart. Calculate the cross sectional area in circular mils for each of the following standard sizes:**

**#8, #10, #14, #22**