ENERGY BIKE

The Energy Bike teaches students concepts of electricity with innovative, hands-on activities.

GRADE LEVEL

Intermediate

SUBJECT AREAS

Science
Math
Language Arts
Technology

NEED

2006-2007

Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Printed on Recycled Paper with Soy-Based Ink

TABLE OF CONTENTS

The Energy Bike booklet was developed by the Ohio Energy Project and has been revised and reprinted with permission.

WHAT IS THE ENERGY BIKE?

The Energy Bike is a woman's 21-speed bike. The rear wheel is stabilized so that the bike is stationary. A 12-volt motor is mounted against the rear wheel. The motor acts as a generator when driven by the roller that rests on the bike's rear tire. A cable runs from the generator to a display board with volt and amp meters and sockets and outlets where light bulbs and small appliances can be attached.

The Energy Bike is designed to demonstrate fundamental concepts of electricity, including current, voltage, wattage, resistance, capacitance, and power. Students take active roles in pedaling the bike to produce electricity for different explorations.

By following the activities in this booklet, you can use the Energy Bike to teach electricity in concrete terms that students can understand in a format that promotes long-term retention of knowledge. For example, when students ride the Energy Bike, they are able to see how much voltage and current are being produced and feel the difference between the energy required to light an incandescent bulb and a fluorescent bulb.

The Energy Bike can be used in many learning environments, including classrooms, science labs, professional development programs, assemblies, PTA programs, science fairs, and science nights.

HOW DOES THE ENERGY BIKE GENERATE ELECTRICITY?

On the back of the bike is a motor that acts like a generator. Motors and generators have the same physical construction—each consists of a copper coil, called an armature, which rotates in a magnetic field to create electricity. Motors are usually used to provide a mechanical advantage, for example, a motor causing the wheels of a car to turn.

Generators are used to produce electrical energy. In the generator, the armature spins in the magnetic field, causing electrons in the copper coil to flow along the surface of the copper wire, creating an electrical current. So, how is that current getting from the coil to the light bulb? It travels through the cord. Even though we can't see them, there are two wires in the cord, both of which are connected by brushes (sliding contacts) to the coil of the generator. The electricity flows to the light bulb through one wire and flows back to the generator through the other wire.

SETTING UP THE ENERGY BIKE

THE BICYCLE

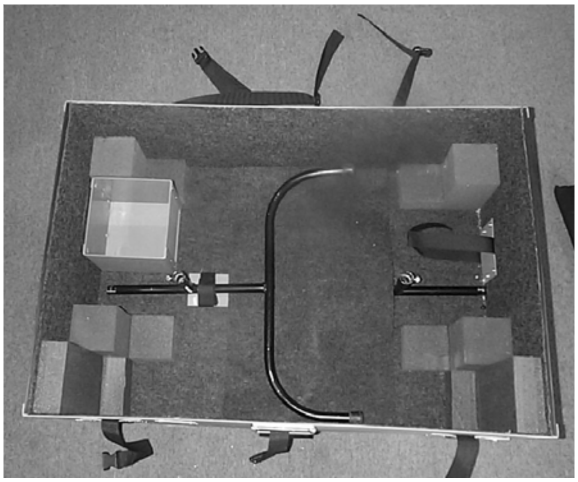
1. Set-up will take approximately 60 minutes and is more easily accomplished by two people.
2. Make sure you have the following materials:
   - ♦ Energy Bike with Odometer & 12-volt Motor
   - ♦ Bike Stand
   - ♦ Carrying case with:
     - Display Board
     - 4 Incandescent Lightbulbs (50W - 12V)
     - 4 CFLs & Ballasts (13W - 12V)
     - Fan
     - Radio/cassette Player
     - Beverage Warmer
     - Tool Kit
     - Hair Dryer
     - Digital Timer
     - 6 and 20 Amp Fuses
     - Adaptaplug
     - DC Power Adapter
     - Thermometer
     - DC Extension Cord
     - AC Power Inverter
     - 3 Spools of Wire
3. Set up the bike stand by separating the legs.
4. Turn the inner black knobs on the bike stand until they are flush with the outer black knobs.
5. Completely loosen the outer black knobs so that the silver cups are as far apart as possible.
6. Roll the rear wheel of the bike into the stand, keeping the front wheel straight.

7. Lift the rear wheel and prepare to secure it in the stand.
8. Guide one of the rear wheel's axle nuts into a slotted silver cup. Align the opposite axle nut with the other cup. Tighten the outer black knobs until the bolts support the wheel.
9. Adjust the outer black knobs until the wheel is centered in the stand. Approximately one-half inch of threaded rod should show on either side of the wheel.
10. Tighten the inner black knobs until they are flush with the stand braces.

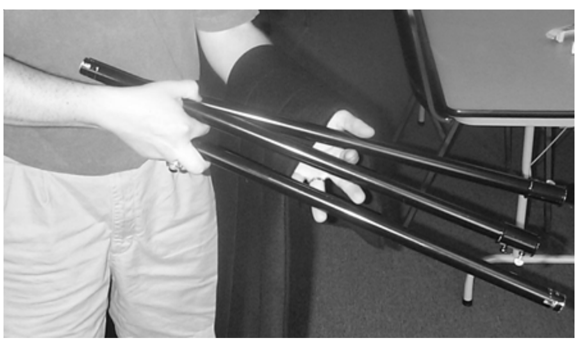
SETTING UP THE ENERGY BIKE

THE DISPLAY BOARD

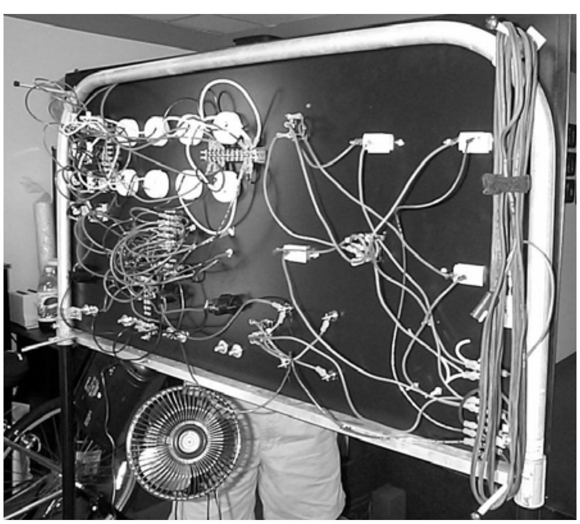
1. Remove the two display board bases from the case and set them aside.



2. Remove the three poles from the black bag.



3. The shorter pole has a set of connector bolts on each end. Use this pole to connect the two stand bases together. Tighten the bolts.
4. Attach the other two poles to the top of the bases and tighten the bolts.



5. Attach the display board to the top of the poles and tighten the bolts.
6. Connect the long black wire to the bike's generator. Use the Velcro straps on the bike stand to secure the wire to the stand and the bike.
7. Insert the four incandescent bulbs into the top row of sockets.

8. Insert the four ballasts into the bottom row of sockets, then insert the compact fluorescent bulbs.
9. Attach any additional appliances you need to the hooks and plug them into the sockets.

TEST DRIVE!

1. Make sure all wires and connections are secure.
2. Make sure the display board is stable and that all bolts are tightened.
3. Make sure the bike doesn't lean from side to side in the stand.
4. Put the bicycle in its highest gear while pedaling the bike, with the chain on the largest front sprocket and the smallest rear sprocket.
5. Ride the bike and test bulbs and appliances.
6. Experiment with different speeds and configurations.

SAFETY CONTRACT

The Energy Bike has potentially dangerous components. All participants should be aware of the potential for danger and agree to the following safety contract before participating in Energy Bike activities.

INSTRUCTORS

Make sure all riders have appropriate clothing and shoes.

Change the seat height for riders as needed.

Have riders get on the bike from the side away from the display board.

Hold the handlebars to stabilize the bicycle if needed, especially when riders are mounting and dismounting.

Be alert for over-exerted riders and immediately stop them from pedaling.

Avoid the rear wheel when the bike is in use.

Keep non-riders away from the rear wheel when the bike is in use.

Enforce all rider safety rules, making additional rules as needed.

Do not leave the bike unattended when on display.

RIDER QUALIFICATIONS

You must be able to keep your feet flat on the pedals when seated.

You must be wearing appropriate closed toe shoes.

You must be able to pedal at a consistent speed.

You must agree to follow all safety guidelines.

RIDERS

Tuck or gather loose clothing that could become caught in the spokes or chain.

Tie shoelaces.

Get on the bike from the side away from the display board.

Keep clear of all cords and wires.

Remain seated at all times.

Hold on to the handlebars at all times.

Keep the bike as steady as possible.

No showing off!

RIDER AGREEMENT

I, ___________________________, agree to the terms of the Safety Contract. I understand that the Energy Bike has potentially dangerous components, and I promise to follow the rules to insure my safety. Unsafe behavior will terminate my participation in the Energy Bike activities.

Signed:____________________________________ Date: ________________

ENERGIZING ACTIVITIES!

INTRODUCTION

This guide contains two introductory activities, ten Energy Bike Activities, three Extension Activities, and nine Discovery Activities, along with student Power Worksheets, transparency masters, Correlations to the Illinois Science Standards, an Answer Key, instructions for assembling, dismantling, and troubleshooting the Energy Bike.

The level of difficulty for the Energy Bike activities varies. Some of the concepts may be too simple or too advanced for your grade level. As you read through the activities, modify them to accomodate your class. You are also encouraged to develop your own lessons. The length of each activity will depend on your explanation of each concept and the number of riders you allow to participate. Each activity requires approximately fifty minutes.

ACTIVITY FORMAT

Overview: A brief outline describes each activity.

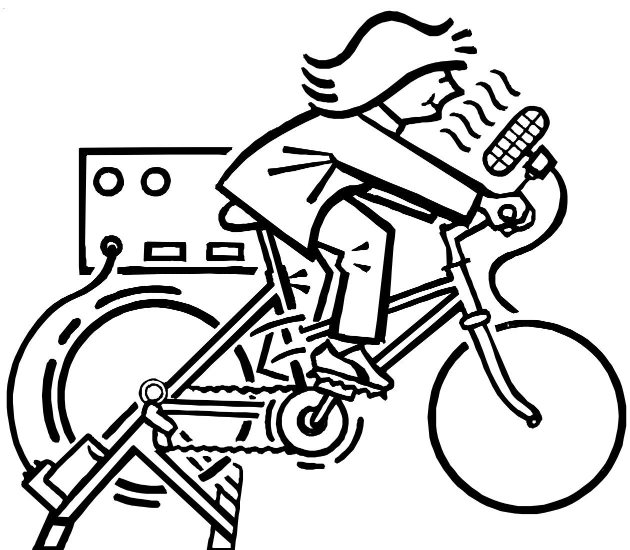
Outcomes: Concepts that students will learn are listed for the Energy Bike activities.

Materials: Materials needed to complete the activities are listed. Materials NOT included with the Energy Bike are designated with an asterisk*.

Get Ready, Set, Go: Preparation required and step-by-step directions for each activity.

Power Worksheets: Worksheets for students to complete during the activities.

Extension & Discovery Activities: Follow-up activities to reinforce the scientific concepts of the Energy Bike activities. Some of these require additional materials or must be completed at home.



****SUGGESTION****

We advise that you use the Energy Bike as a culminating activity after teaching the fundamentals of energy and electricity. NEED has extensive curriculum on the science and sources of energy, electricity, and energy conservation and efficiency. A valuable introductory electricity unit is NEED's **ElectroWorks Kit** (grades 4 through 7) that introduces students to basic concepts of electricity, circuits, and measurement. See NEED's website—**www.need.org**—for the NEED catalog that describes all of NEED's curriculum materials.

HELPFUL HINTS FOR ALL ENERGY BIKE ACTIVITIES

Instruct Energy Bike riders to pedal at a steady pace. This will enable consistent measurements on the volt and amp meters.

Instruct Energy Bike riders to keep pedaling until you tell them to stop.

To reinforce the scientific method, have more than one student ride the bike during each activity. You can also have additional students repeat parts of the activity to verify conclusions drawn from the activity. This will allow more volunteers to ride the Energy Bike.

When moving switches or inserting plugs into the receptacles, stabilize the display board with one hand holding the top of the board.

When inserting appliance plugs into the receptacles, do not rotate the plugs. Push the plugs straight in and pull them straight out.

And the most important hint – have fun!

ACTIVITY ONE: FORMS OF ENERGY

Overview

An introduction to the forms of energy and how energy is transformed from one form to another.

Outcomes

Students will:

- ♦ understand that energy is found in many forms.
- ♦ understand that energy can be changed from one form to another.
- ♦ understand the Law of Conservation of Energy—that energy is neither created nor destroyed; it is only transformed from one form to another.
- ♦ understand that once energy is transformed into heat, it is very difficult to capture and use again, because it quickly disperses.
- ♦ understand that electricity is an easy form of energy to transport and use.

Get Ready

Make transparencies of the Forms of Energy and Energy Transformations masters on pages 12-13.

Get Set

Set up an overhead projector.

Go

1. Use the Forms of Energy transparency to teach the students the forms of energy.
2. Discuss how energy is stored/found in each of the major energy sources.
3. Discuss the Law of Conservation of Energy.
4. Use the Energy Transformations transparency to show the energy transformations that take place to power the Energy Bike.
5. Discuss the energy tranformations involved with a car.
6. Discuss electricity as an energy carrier. Discuss what life would be like without electricity.

Reinforcement

Use NEED's **Science of Energy Kit** to reinforce concepts of energy transformations with hands-on experiments.

ACTIVITY TWO: SOURCES OF ENERGY

Overview

An introduction to the major renewable and nonrenewable energy sources we use in the United States today.

Outcomes

Students will:

- ♦ understand that a lot of energy is required to maintain the lifestyle they enjoy in the United States.
- ♦ be aware of the many energy sources used in the United States today and how they are used.
- ♦ understand the concepts of renewable and nonrenewable.

Get Ready

Make a transparency of the Sources of Energy transparency master on page 14.

Get Set

Set up an overhead projector.

Go

1. Discuss how students have used energy today and what kinds of energy they have used.
2. Introduce the terms renewable and nonrenewable. Renewable energy sources can be replenished by nature in a short time. Nonrenewable energy sources take millions of years to form.
3. Ask students to name as many renewable and nonrenewable energy sources as they can.
4. Use the Sources of Energy transparency to show the students the major energy sources we use and how they are used.
5. Ask the students what type of energy electricity is. Discuss the fact that electricity is a secondary source of energy—another source of energy must be used to generate electricity. Use the transparency to show how many different sources of energy are used to produce electricity.

Reinforcement

Use activities in NEED's **Games and Icebreakers** booklet and **Energy Infobooks** to reinforce information on the energy sources and electricity.

FORMS OF ENERGY

All forms of energy fall under two categories

POTENTIAL

Potential energy is stored energy and the energy of position (gravitational)

CHEMICAL ENERGY

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

STORED MECHANICAL ENERGY

Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

GRAVITATIONAL ENERGY

Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational potential energy. When the water is released to spin the turbines, it becomes motion energy.

KINETIC

Kinetic energy is motion - the motion of waves, electrons, atoms, molecules and substances

RADIANT ENERGY

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

THERMAL ENERGY

Thermal energy (or heat) is the internal energy in substances - the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

MOTION

The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

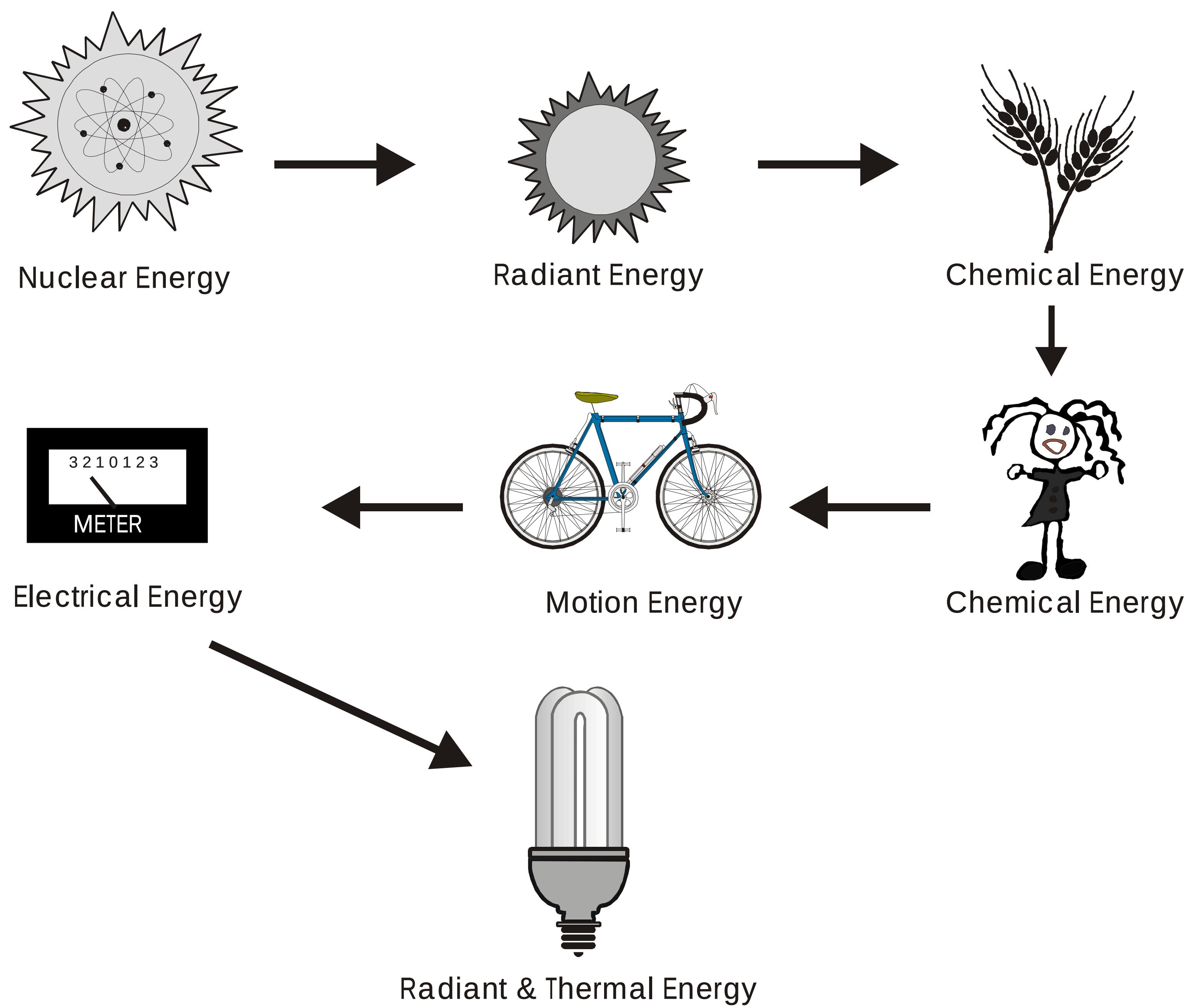
SOUND

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

ELECTRICAL ENERGY

Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

ENERGY TRANSFORMATIONS



U. S. ENERGY CONSUMPTION BY SOURCE

BIOMASS 3.0% *renewable* Heating, electricity, transportation	**PETROLEUM** 38.5% *nonrenewable* Transportation, manufacturing
HYDROPOWER 2.4% *renewable* Electricity	**NATURAL GAS** 22.9% *nonrenewable* Heating, manufacturing, electricity
GEOTHERMAL 0.3% *renewable* Heating, electricity	**COAL** 22.8% *nonrenewable* Electricity, manufacturing
SOLAR 0.1% *renewable* Light, heating, electricity	U235 **URANIUM** 8.2% *nonrenewable* Electricity
WIND 0.1% *renewable* Electricity	**PROPANE** 1.6% *nonrenewable* Manufacturing, heating
OTHER 0.1%	

LIGHT BULB OR HEAT BULB?

OVERVIEW

Compact fluorescent bulbs (CFLs) provide light more efficiently than incandescent bulbs. Incandescent lighting is used most often in homes because of availability and cost.

In this activity, students will use the Energy Bike to generate electricity and compare the two types of bulbs using their muscle power. They will read volt and amp meters to determine current and voltage, then calculate wattage and determine the economic advantage of using compact fluorescent bulbs.

OUTCOMES

Students will:

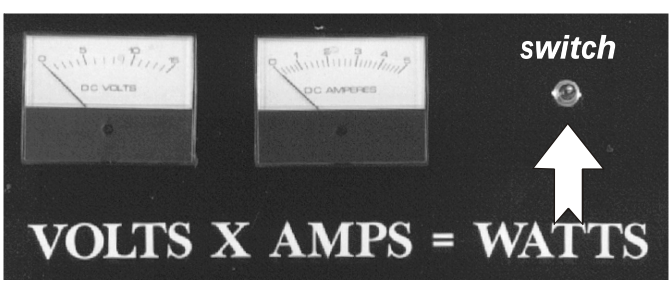
- understand that light bulbs convert electrical energy into radiant and thermal energy.
- compare the energy efficiency of compact fluorescent and incandescent bulbs.
- define electricity, volts, amps, and watts.
- understand the Law of Conservation of Energy.

GET READY

Make copies of the worksheets on pages 17-18.

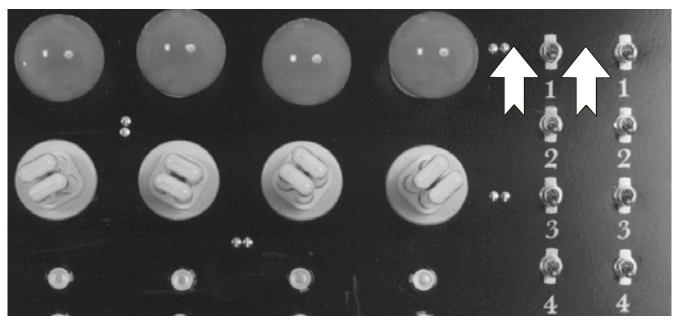
GET SET

1. Set up the Energy Bike and insert four incandescent and four compact fluorescent bulbs.
2. If any problems occur while testing the Energy Bike, refer to the troubleshooting section.
3. Flip the amp meter switch up as indicated in the picture below.



GO

1. Review the Safety Contract with your students.
2. Have your students predict which type of light bulb will be more energy efficient.
3. Describe the task: Students will generate electricity using the Energy Bike to compare incandescent bulbs and CFLs. They will observe and describe the muscle power required to light the incandescent and CFLs.
4. Define **electricity**: Electricity is the movement or flow of electrons.
5. Select a volunteer and ask him/her to get on the bike and begin pedaling. When the voltmeter reaches 12-13 volts, turn on one CFL.
6. After a few seconds, turn off the CFL, and light an incandescent bulb. Stop the rider and ask him/her to compare the amount of force required to light each bulb. *The rider should indicate that the CFL was easier to light.*



The Energy Bike has two columns of switches that power the incandescent and compact fluorescent bulbs (CFLs). The left column powers the incandescent bulbs, and the right column powers the CFLs.

7. Introduce the terms volts, amps, and watts as units of measurement of electricity.
8. Define **volts**: volts measure the energy available to move electrons—the electric potential.
9. Demonstrate volts by having the students stand in a circle and imagine they are electrons in a wire. Instruct them to put one hand on the shoulder of the person next to them and push gently. Explain that electrons push on one another as they move through a circuit, and that push is the energy available to move the electrons. Volts measure the potential energy of the electrons, so voltage is described as potential difference.
10. Define **amps**: amps measure the amount of electric **current**—the number of electrons flowing past a given point in a given time.

LIGHT BULB OR HEAT BULB?

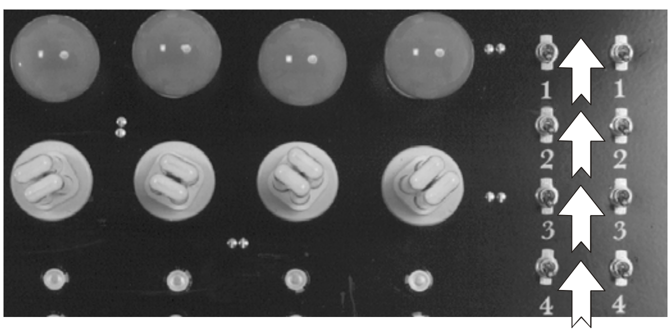
11. Using the same students, demonstrate amps by identifying a starting point in the circuit. Have the students begin to walk around the circle very quickly. As the students' pace increases, the starting point is passed more frequently. That increase in frequency represents an increase in amps. Amps measure the number of electrons that pass a certain point in the circuit per second. One amp is equal to 6.2×10^{18} electrons passing a point in one second.
12. Define **watts**: watts measure electrical power. Watts can be determined by multiplying volts (potential) by amps (current):

    Volts x Amps = Watts

13. Ask a volunteer to pedal the Energy Bike and light one incandescent bulb and one CFL. Have the class determine which type of bulb requires more electricity by reading the amp meter.

    CFL = 1 amp

    Incandescent bulb = 4 amps



14. Have a third volunteer pedal to compare the amount of muscle power required to light four CFLs versus one incandescent bulb. *The power required should feel equal.*
15. Using a fourth volunteer, first light an incandescent, then a CFL, one at a time. Ask the students to determine which bulb looks brighter. *Often they will answer CFL.*

    CFL = 12 watts

    Incandescent bulb = 48 watts

16. Since the incandescent bulb requires more power, it seems it should be brighter, even though they are producing the same amount of light (lumens). If the extra power is not being converted into light, to what other form of energy is it being converted? *It is being converted into thermal energy, or heat.*
17. While a student is pedaling, have several volunteers hold their hands near the incandescent bulb and then the compact fluorescent bulb. Instruct the students to take their hands away from the bulbs as soon as they begin to feel warm. Which bulb feels warmer? *The incandescent bulb should feel warmer.*

CFL energy =	*60% thermal energy*
	40% radiant energy
Incandescent energy =	*90% thermal energy*
	10% radiant energy

18. Which bulb is more energy efficient and cost efficient? *A fluorescent bulb requires 75% less energy and lasts up to 13 times longer. A compact fluorescent bulb uses approximately 1/4 the power of an incandescent bulb because it converts electrical energy into radiant energy more efficiently.*
19. Define the **Law of Conservation of Energy**: Energy is neither created nor destroyed; it is transformed from one form to another.

    Discuss how energy is tranformed with the Energy Bike in this activity—the cyclists' mechanical energy is transformed into electricity, which is transformed into light and heat by the light bulbs.

FLUORESCENT & INCANDESCENT BULBS

The filament of an incandescent bulb is a resistive element, similar to the wires in a toaster. The filament is a tungsten wire wound in a tight coil. It glows much more brightly than a heating element. Filaments can be up to 20 inches long and reach temperatures of 4,500°F! Due to a filament's high temperature, inert gases such as argon are placed inside the bulb to prevent the wire from burning. **Incandescence** is the emission of a glowing white light by an intensely heated material.

A fluorescent bulb has a glass tube, whose inner surface has a phosphor coating. In a compact fluorescent bulb, the tube is folded back on itself. The tube is filled with argon gas and a small amount of mercury vapor. Different gases produce different colored light. For example, neon gas produces red light and sodium gas makes yellow light. At the end of each tube are electrodes that emit electrons when heated by an electric current. When electrons strike the mercury vapor, the mercury atoms emit rays of ultraviolet (UV) light. When these invisible UV rays strike the phosphor coating, the phosphor atoms emit visible light. The conversion of one type of light into another is called **fluorescence**.

POWER WORKSHEET

LIGHT BULB OR HEAT BULB?

FUN FACT
The amount of electrical energy used to light a 100 watt incandescent bulb for 10 hours would be enough to run a color television for seven hours!

1. What is electricity?

2. What do volts measure?

3. What do amps measure?

4. What do watts measure?

5. Did the incandescent or compact fluorescent bulb require more power to light?

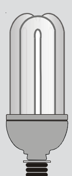
6. The Law of Conservation of Energy states:

7. When electricity flows through a light bulb, it is converted into what two forms of energy?

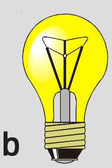
   a.

   b.

8. From your observation of the Energy Bike, which type of light bulb is more energy efficient and cost efficient, compact fluorescent or incandescent?



POWERFUL CALCULATIONS!



Compact Fluorescent Bulb

_____ Volts x _____ Amps = _____ Watts

Incandescent Light Bulb

_____ Volts x _____ Amps = _____ Watts

POWER WORKSHEET

Which Light Bulb Would You Use?

Use the chart below to solve the equations. For each step, write the answers for each bulb on the line above it. Round your answers to the nearest hundredth (two decimal places).

BULB SPECIFICS	Incandescent	CFL
Brightness	1180 lumens	1280 lumens
Power	75 watts	20 watts
Cost of Electricity	$0.08/kWh	$0.08/kWh
Life of Bulb	750 hours	10,000 hours
Price per Bulb	$0.50	$10.00

Amount of Electricity Used

Step 1. Multiply the power of the bulb by 10,000 hours.

____________ Incandescent   ____________ CFL

Step 2. Divide the answers above by 1000 kW to find out the amount of electricity used.

____________ Incandescent   ____________ CFL

Cost of Electricity for 10,000 Hours of Light

Step 3. Multiply the answers to Step 2 by the cost of electricity.

____________ Incandescent   ____________ CFL

Cost of Bulbs for 10,000 Hours of Light

Step 4. Divide 10,000 hours by the life of the bulb to determine the number of bulbs needed.

____________ Incandescent   ____________ CFL

Step 5. Multiply the number of bulbs by the price per bulb to determine cost.

____________ Incandescent   ____________ CFL

Total Cost for 10,000 Hours of Light

Step 6. Add the cost of the bulbs to the cost of electricity to determine the total cost of the light.

____________ Incandescent   ____________ CFL

DISCOVERY 1

BULB DETECTIVES

1. List locations in your school and identify the type and number of bulbs used in each room or location.

LOCATION	TYPE OF BULB	NUMBER OF BULBS
Main Lobby		
Office		
Trophy Case		
Cafeteria		
Gym		
Auditorium		
Art Room		
Exit Signs		

2. Discuss with your classmates the results of your survey. Did you find more compact fluorescent or more incandescent bulbs? Why do you think your school chooses to use the bulbs they do in each location? Would you recommend that they make any changes? Did you find other kinds of lighting?

3. Complete chart below for your home. Discuss with your family any changes you think should be made.

LOCATION	TYPE OF BULB	NUMBER OF BULBS
Kitchen		
Bedroom		
Basement		
Garage		

CFL vs. INCANDESCENT

OVERVIEW

Students will investigate the energy efficiency of incandescent bulbs and CFLs by determining which produces the most heat. Both bulbs will produce the same amount of light, but one will produce more heat, causing it to be less energy efficient. This activity works best as a class demonstration.

GET READY

1. Collect the following materials:
   - ♦ 60-watt incandescent bulb*
   - ♦ 25-watt incandescent bulb*
   - ♦ 100-watt incandescent bulb*
   - ♦ 12-watt compact fluorescent bulb*
   - ♦ Small lamp*
   - ♦ Scissors*
   - ♦ Laboratory thermometer*
   - ♦ Box large enough to cover the lamp without touching the bulb*
2. Have access to an electric outlet.
3. Make a transparency of the graph on page 21.

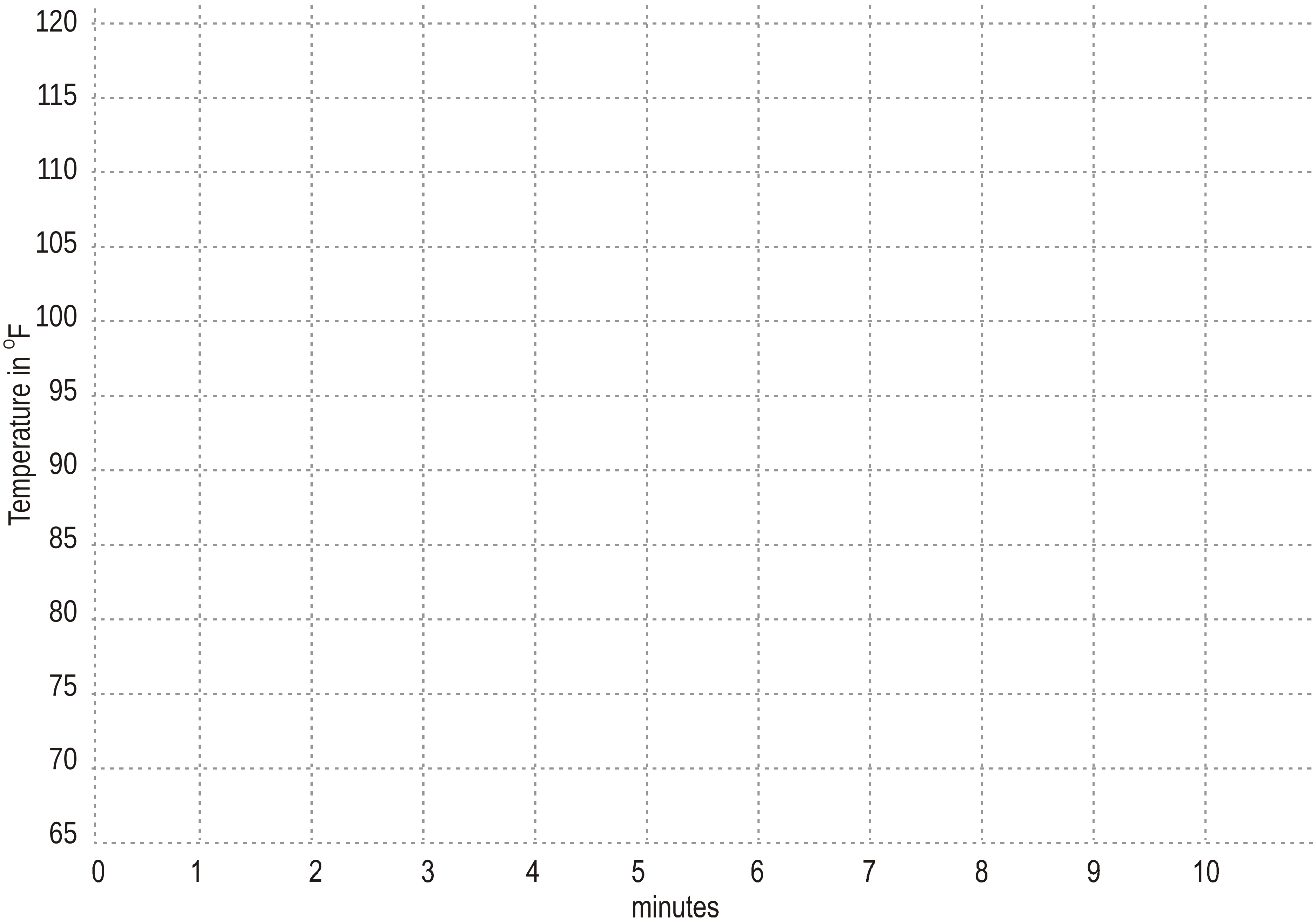
GET SET

1. Use scissors to make a hole in the bottom of the box for the electrical cord.
2. Cut a second hole about midway up the box for the thermometer.

GO

1. Place the lamp with the 60-watt incandescent bulb into the box. The bulb should not touch the box.
2. Measure the temperature of the air in the box before plugging in the lamp.
3. Turn on the lamp and take temperature readings every minute for 10 minutes.
4. Repeat the activity using the fluorescent bulb.
5. Plot the data from both trials on the graph transparency using different colored pens. Discuss the results. *The fluorescent bulb produces the same amount of light using less power. Fluorescent bulbs convert less electrical energy into heat energy than incandescent bulbs.*
6. Use the same procedure to compare the heat produced by a 25-watt incandescent bulb and a 100-watt bulb. Is it more energy efficient to use four 25-watt bulbs or one 100-watt bulb?

CFL vs. INCANDESCENT



MIGHTY MOTORS

OVERVIEW

In this activity, students use the Energy Bike to discover more about motors. They will calculate the power required to operate a fan and a hair dryer. The hair dryer requires 12 times more power than the fan because it contains a resistive heating element. Students will discover that it requires more power to start a motor than to keep it running by observing the amp meter. Energy efficiency will be discussed as it relates to turning off non-essential motors during a blackout.

OUTCOMES

Students will:

- ♦ understand that motors convert electrical energy into mechanical energy.
- ♦ determine that the Energy Bike converts mechanical energy into electrical energy.
- ♦ understand that more power is required to start a motor than to keep it running.
- ♦ be able to define inertia.
- ♦ understand how to prevent power surges following a blackout.

MATERIALS

- ♦ Fan
- ♦ Plastic bag*
- ♦ Hair dryer

GET READY

1. Gather the materials listed above. All of the materials except the plastic bag can be found in the Energy Bike carrying case.
2. Make class copies of the Power Worksheet on page 24.

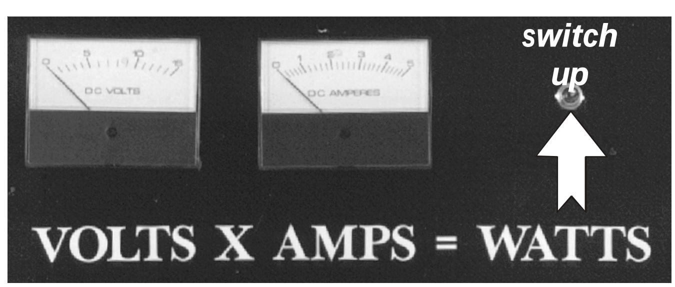
GET SET

1. Set up the Energy Bike. Plug the fan and hair dryer into the receptacles.
2. Test the Energy Bike. If you have a problem, refer to the troubleshooting section.
3. Flip the amp meter switch up as indicated in the picture to the right.

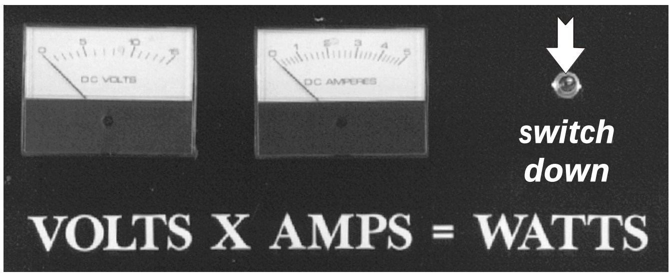
GO

1. Review the Safety Contract with your students.
2. Select a volunteer to ride the Energy Bike. As the volunteer pedals, slide the fan switch from OFF to SLOW. Ask the rider to describe the fan's air flow and the pedaling resistance.
3. While the student continues to pedal, slide the fan switch to FAST. The rider may feel an increase in the pedaling resistance, and will also be rewarded with more air flow.
4. Select two new volunteers, one to ride the Energy Bike and one to read the meters. While one student is pedaling, instruct the other to read the amp meter as you switch the fan from SLOW to FAST speed.

   SLOW = 0.6 amps FAST = 1.0 amp
5. Place the plastic bag over the fan so that it is stretched tightly over the grill.
6. Switch the fan to FAST and ask the rider to pedal until the volt-meter registers a steady 12-13 volts. Have the other volunteer observe the amp meter, and compare the previous experiment. The amount of current will be higher, because the fan must work harder to move air against the bag.
7. Remove the plastic bag for the next experiment. Have the rider continue to pedal while you switch the fan OFF, and wait until the fan stops. Switch the fan back on to FAST. By watching closely, students will see the amp meter surge to over one amp before settling down to one (1) amp.
8. Define **inertia**: Inertia is the resistance of an object to any change in its speed or direction.
9. Due to friction, more energy is required to start a motor than to keep it running. Relate this idea to real life by asking what can occur when an appliance with a larger motor, such as a vacuum cleaner or power tool, is turned on at home. The extra energy needed to start the larger motor may sometimes cause the lights to dim.



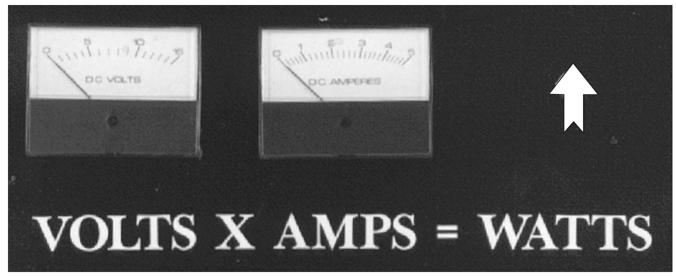
10. Have the class predict the number of amps the hair dryer will use based on their knowledge that the fan used one (1) amp on FAST speed.
11. Select a strong volunteer to ride the Energy Bike. Select another volunteer to read the meters.
12. Flip the switch down towards the 0-30 amp meter to accurately measure the number of amps used by the hair dryer.



13. Have the student begin to pedal. Once the volt-meter reaches 12-13 volts, turn on the hair dryer. How many amps does it require?

Hair Dryer = 12 amps

14. Which motor moved more air, the hair dryer or the fan? *Typically, the fan moves a much greater amount of air.*
15. Why does the hair dryer use so much more energy, yet produce less air? The hair dryer heats air with a resistive heating element, similar to the one found in a toaster or an incandescent bulb.
16. Once the student has 12-13 volts registered on the meter, turn on the hair dryer and place it near his or her wrist. It is amazing how much work is required to produce so little heat!
17. Discuss motors and generators, comparing and contrasting how generators and motors use mechanical and electrical energy. A generator converts mechanical energy to electrical energy; a motor converts electrical energy to mechanical energy.
18. Select a volunteer to pedal the Energy Bike. Flip the amp meter switch to the center (off) position.
19. Once the volunteer has 12-13 volts registered on the volt-meter, charge the capacitors by flipping the switch next to the capacitors in the upward position as indicated in the picture. *Note: More information about capacitors is found on page 33.*



20. Observe the 0-5 amp meter. The needle will gradually fall. After the needle stops falling, instruct the volunteer to stop pedaling. Ask the students to describe the energy conversions occurring between the cyclist and the capacitors. The capacitors' electrical energy is converted to mechanical energy, which spins the generator, the friction roller, and the wheel.
21. Discuss some of the uses of motors in our homes, including:
    a. Personal grooming (hair dryers and electric razors)
    b. Clothes washers and dryers
    c. Refrigerators and freezers
    d. Electric mixers, blenders, coffee grinders
    e. Fans, heaters, air conditioners
22. Define a **blackout**: A blackout is the loss of electrical supply to a power company's service area.
23. As learned in this activity, more energy is required to start a motor than to keep it running. After a blackout, when electricity returns to a power company's service area, huge electrical surges occur. This is a result of many motors trying to start at the same time.
24. You can reduce power surges by turning off non-essential motors during a blackout.
25. Discuss which motors are essential and which are non-essential in a home.

WORKSHEET

Mighty Motors

1. True or False? More energy is required to keep a motor running than to start it. If false, rewrite the statement to make it true.

2. What is inertia?

3. Does the hair dryer use more or less energy than a fan? Why?

4. A generator converts _______________ energy into _____________ energy.

5. A motor converts _______________ energy into _________________ energy.

6. List four motors in your home:

   a.

   b.

   c.

   d.

7. What is a blackout?

8. Look at your answers to question 6. Which motors could be turned off during a power outage?

POWERFUL CALCULATIONS

Fan - Low Speed:	_______	Volts	x	_______	Amps	=	_______	Watts
Fan - High Speed:	_______	Volts	x	_______	Amps	=	_______	Watts
Hair dryer:	_______	Volts	x	_______	Amps	=	_______	Watts

DISCOVERY 2

MOTOR SEARCH

How many motors are in your home? List the motors found in each room. Choose one motor from each room and record the number of amps and watts it uses. Typically, the numbers are found near the electrical wire running into the motor. In the United States, most motors use 120 volts.

Hint: Volts x Amps = Watts

Bedroom

Amps = ______ Watts = ______

Bathroom

Amps = ______ Watts = ______

Kitchen

Amps = ______ Watts = ______

Laundry Room

Amps = ______ Watts = ______

Family Room

Amps = ______ Watts = ______

Basement

Amps = ______ Watts = ______

Other

Amps = ______ Watts = ______

APPLIANCE ADVANTAGE

OVERVIEW

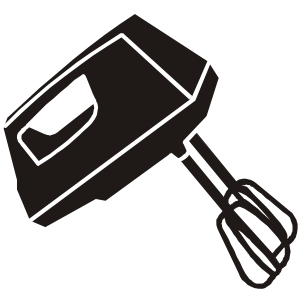
Students will compare the amount of time it takes to complete various tasks with manual tools and mechanical tools: human energy versus mechanical energy.

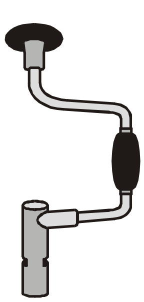
GET READY

1. Make a copy of the chart on the page 27 for each student.
2. Gather the following materials:
    - ♦ Electric drill & hand drill*
    - ♦ Block of wood*
    - ♦ Electric hand mixer & egg beater*
    - ♦ 2 Mixing bowls*
    - ♦ 4 Cups of flour*
    - ♦ 2 Cups of water*
    - ♦ Electric can opener & hand can opener*
    - ♦ 2 Empty cans*
    - ♦ Electric knife & standard carving knife*
    - ♦ 2 Bars of soap*
    - ♦ Cutting board*

GET SET

1. Measure two cups of flour and one cup of water into each mixing bowl.
2. Have access to an electrical outlet.





GO

1. Discuss the length of time it would take to walk to school compared to riding in a car or bus.
2. Demonstrate ways in which people use mechanical energy to save time and effort. Have the students record the amount of time that passes as you or student volunteers:
    - ♦ Cut a bar of soap in half with an electric knife, then with a standard knife.
    - ♦ Drill a hole in a block of wood with an electric drill, then with a hand drill.
    - ♦ Mix flour and water with an electric mixer, then with a hand mixer.
    - ♦ Open the bottom of an empty can with an electric can opener, then with a hand can opener.
3. Have the students graph each demonstration to illustrate the time saved using electrical appliances on the hand-out.
4. Discuss the advantages and disadvantages of using convenient electrical devices and how they affect our standard of living and quality of life.

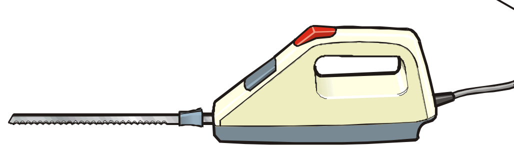
EXTENSION

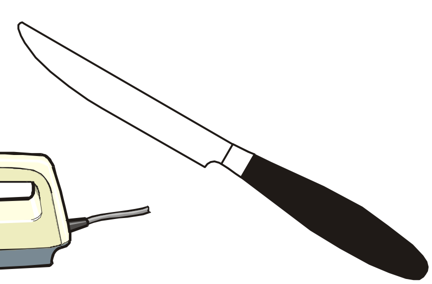
As a homework extension activity, have the students record the time it takes to dry their hair naturally, using an electric hair dryer on the hot setting, then using an electric hair dryer on the cool setting.

Instruct the students to record the wattage of their hair dryers. This information is typically found near the electrical wire as it enters the hair dryer.

Have the students calculate the wattage. (Most appliances in the U. S. use 120 volts.)

Volts x Amps = Watts





HOW MUCH TIME DO ELECTRICAL APPLIANCES SAVE?

TIME (seconds)	SOAP		WOOD BLOCK		FLOUR & WATER		METAL CANS	
160								
150								
140								
130								
120								
110								
100								
90								
80								
70								
60								
50								
40								
30								
20								
10								
Devices Used	Electric Knife	Standard Knife	Electric Drill	Hand Drill	Electric Mixer	Hand Mixer	Electric Can Opener	Hand Can Opener

THE BTU IS ONE HOT TOPIC

OVERVIEW

In this activity, a beverage warmer will be used to heat one pound of water. A team of six students will ride the Energy Bike for six minutes to power the beverage warmer. Another student will monitor the number of BTUs generated by the riders. The class will then calculate the number of BTUs per hour the Energy Bike is able to produce, and relate this data to real-life applications.

One British Thermal Unit (BTU) is the amount of heat energy required to raise one pound of water one degree Fahrenheit.

OUTCOMES

Students will:

- be able to define British Thermal Unit (BTU).
- know that a typical residential water heater uses 40,000 BTUs per hour.
- calculate the number of Energy Bikes required to operate a home water heater.

MATERIALS

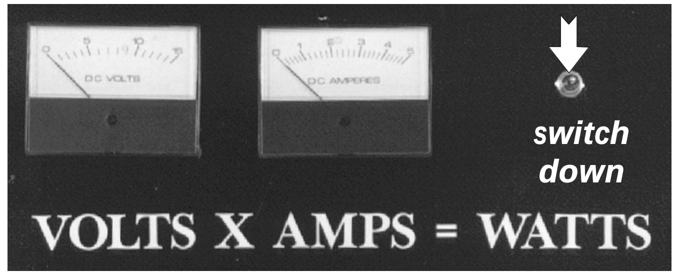
- Beverage warmer
- Thermometer
- Water*
- Timer
- Receptacle extension cord
- Graduated cylinder*

GET READY

1. Gather the materials listed. All of the materials are in the Energy Bike carrying case, except water.
2. Make copies of the Power Worksheet on page 30.

GET SET

1. Set up the Energy Bike. Plug the extension cord into a receptacle, and hang the beverage warmer on a hook. **Caution:** Do not plug the beverage warmer into the extension cord.
2. Test the Energy Bike. If any problems occur during testing, refer to the troubleshooting section.
3. Measure 16 ounces of water, and pour it into the beverage warmer. The result will be approximately one pound of water.
4. Set the timer to six minutes and clip it to the top of the display board.



5. Flip the amp meter switch down toward the 0-30 amp meter as shown in the picture above.
6. Place the thermometer in the water.

GO

1. Review the Energy Bike Safety Contract with your students.
2. Discuss the various ways that individuals and industries use hot water.
3. Define **British Thermal Unit (BTU)**: One BTU is the amount of energy required to raise the temperature of one pound of water one degree Fahrenheit.
4. Describe the task:
   - Five volunteers will take turns powering the Energy Bike for a total of six minutes. Each volunteer must give a signal when tired. At that point, pause the timer and have another volunteer pedal.
   - The Energy Bike will heat a beverage warmer, which will be used to raise the temperature of one pound of water.
   - A sixth volunteer will observe the temperature changes in the water using a thermometer.
   - Each time the temperature increases one degree, one BTU of heat energy has been added to the water.
5. Have your students predict how many degrees the water temperature will increase in six minutes on their Brain Power Worksheet.
6. Select five volunteers to ride the Energy Bike. Warn the students that this experiment requires strength equivalent to riding a bike uphill. They should expect some pedaling difficulty!
7. Select a sixth volunteer. This student will hold the beverage warmer, observe the thermometer and report temperature changes to the class.

8. Make sure the extension cord is plugged into the display board.
9. Have the first volunteer get on the bike and begin pedaling. When the volt-meter registers 12-13 volts, plug the extension cord into the beverage warmer.
10. After 15 seconds, set the timer at six minutes and start it. *It takes about 15 seconds for the beverage warmer to get hot.*
11. Have the student observing the beverage warmer call out "One BTU" each time the water temperature increases one degree Fahrenheit. The other students should keep track of the number of BTUs.
12. Observe the current on the amp meter and have the students calculate the number of watts needed to power the beverage warmer.

    VOLTS x AMPS = WATTS
13. When the first bike volunteer signals he/she is tired, stop the timer, and ask for the next rider. Once the volt-meter registers 12-13 volts, restart the timer.
14. Repeat the bike process until the entire six minutes have elapsed.

When the timer sounds, have the student with the beverage warmer stir the water carefully with the thermometer for 30 seconds to ensure that all of the heat is transferred to the water, then take a final reading.

15. Have the class calculate the number of BTUs generated per hour. Calculate the total BTUs per hour generated using the Energy Bike:

Equation: $$\frac{\text{BTU}}{\text{6 minutes}} \times \frac{\text{60 minutes}}{\text{1 hour}} = \text{BTU/hr}$$

Example: $$\frac{\text{15 BTU}}{\text{6 minutes}} \times \frac{\text{60 minutes}}{\text{1 hour}} = \text{150 BTU/hr}$$

16. Have the students calculate the number of Energy Bikes it would take to power a water heater. A home water heater requires 40,000 BTUs per hour to operate.

    ____ bikes X BTU/hr/bike = 40,000 BTU/hr

BTU & Y-O-U!

BTU stands for British Thermal Unit. A BTU is a measurement of heat energy. One BTU is the amount of heat energy required to raise one pound of water one degree Fahrenheit. The heating or cooling power of large appliances such as furnaces, water heaters, clothes dryers, air conditioners, and refrigerators is measured in BTUs. The rate at which heat energy is supplied or removed is expressed as BTUs per hour, or BTU/hr. The average home water heater supplies heat to the water in its tank at the rate of 40,000 BTU/hr.

A large city such as Boston uses about one quadrillion (1,000,000,000,000,000) BTUs per year! This is equal to 172 million barrels of oil, 980 billion cubic feet of natural gas, or 100 million tons of coal.

What does this all boil down to? Conservation! By taking shorter showers, using warm or cold water for laundry, and turning off the faucet between uses, you can reduce the amount of energy needed to heat the water in your home. Reducing your water consumption conserves energy resources.

POWER WORKSHEET

The BTU is One Hot Topic

1. What is a BTU?

2. What is the heating power of a typical home water heater?

3. What is the heating power of the beverage warmer?

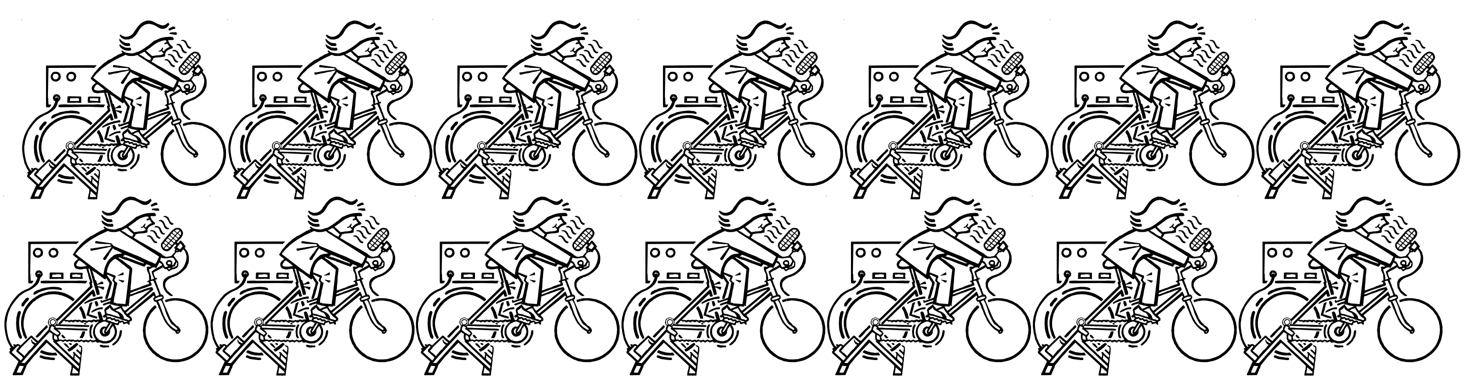
12 VOLTS x ________ AMPS = _________ WATTS

4. Predict how many BTUs the Energy Bike will generate in six minutes: ___________

5. Record how many BTUs were actually generated by the Energy Bike in six minutes: __________

6. Calculate how many BTUs per hour the Energy Bike can generate.

7. Calculate the number of Energy Bikes it would take to operate a typical home water heater.



DISCOVERY 3

Hot Stuff

1. Investigate the BTU rating of the water heaters in your home and school. They should be labeled on the water heaters. *If the water heater has a watt rating rather than a BTU/ hr rating, multiply the number of watts by 3.414 to get the BTU/ hr rating.*

   Record your answer:

   Home: ________________

   School: ________________

2. Based on the number of BTUs per hour your class generated using the Energy Bike, how many Energy Bikes would it take to power the water heaters you investigated?

   Home: ________________

   School: ________________

3. List five ways to reduce the amount of hot water used at school or at home.

   a.

   b.

   c.

   d.

   e.

DISCOVERY 4

IN HOT WATER

OVERVIEW
Students will calculate the approximate number of BTUs needed to heat water for a shower or bath.

GET READY
Gather the following materials:

- Stop watch or watch with a second hand*
- Empty 1-gallon container*
- Lab thermometer*
- Pencil*
- Shower head or bathtub faucet*

GO
1. Locate a cold water tap on the lowest floor of your home.
2. Let the water run for approximately two minutes, then measure its temperature. This will give you the water temperature as it flows into your house.

   Temperature = _______ °F

3. Turn on the bath tub faucet or the shower. Use the stopwatch to time how long it takes to fill the gallon container with water. This will give you the Flow Rate of the water. Hint: Convert the flow rate into a ratio of gallons per minute.

   Flow Rate = 1 gallon in _____ seconds

   Ratio: ______ gallons/minute

4. During your next shower or bath, use the thermometer to measure the temperature of the water at the showerhead or faucet.

   Temperature = ________ °F

5. Use the stopwatch to measure the amount of time the water runs for your bath or shower.

   Time = _________ minutes

6. Calculate how much the water heater changed the temperature of the water. Subtract the temperature of the water as it flows into your house from the temperature you recorded in Step 4.

   ______ °F -______ °F = ______ °F

7. How many gallons of water did you use? Multiply the amount of time the water ran for your bath or shower by the Flow Rate you calculated in Step 3.

   Minutes x Flow Rate = ______ Gallons

8. If one gallon of water weighs 8.3 pounds, calculate the number of pounds of water you used.

   _____Gallons x 8.3 lb/gal = ______ Pounds

9. Calculate the number of BTUs that were required for you to bathe. Multiply the pounds of water by the number of degrees your water heater raised the water temperature. Remember: One BTU is the amount of energy it takes to raise one pound of water one degree Fahrenheit.

   _____ Pounds x _____ °F = _____ BTUs

10. Calculate the number of hours it would take the Energy Bike to heat the water for your bath or shower.

CAPACITORS...The Energy Trap

OVERVIEW

Capacitors are devices used to store electrical energy. In this activity, students will compare and contrast capacitors and batteries. By riding the Energy Bike, a volunteer will store potential energy in the capacitors. Once the energy has been stored, the volunteer will relax while the stored energy powers a fan, radio, or tape player. Capacitors demonstrate potential energy being converted into kinetic energy. Common uses of capacitors will be discussed.

OUTCOMES

Students will:

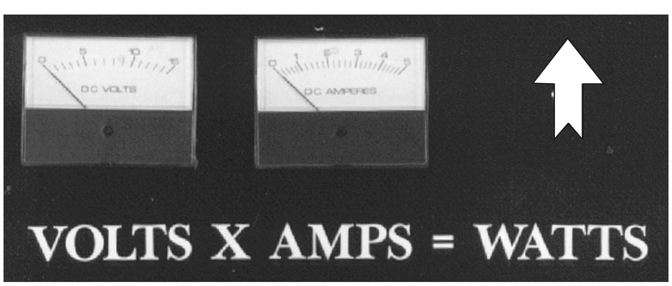
- ♦ be able to define and understand potential and kinetic energy.
- ♦ know the function of capacitors.
- ♦ understand the difference between a capacitor and a battery.
- ♦ list two uses of capacitors.

GET READY

Make copies of the Power Worksheet on page 36.

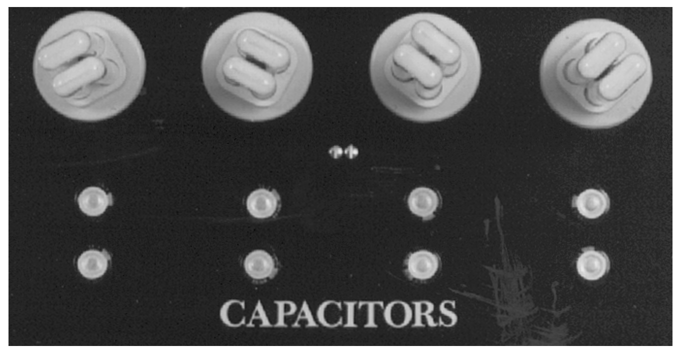
GET SET

1. Set up the Energy Bike. Insert four CFLs and four incandescent bulbs. Plug in the radio/ tape player. Test all components.
2. If any problems occur while testing the Energy Bike, refer to the Troubleshooting section.
3. Flip the amp meter switch up as indicated in the picture below. Flip up the terminal post switch.



GO

1. Review the Energy Bike Safety Contract with your students.
2. Describe the task:
   a. As a volunteer pedals the Energy Bike, energy will be stored in the capacitors.
   b. The stored energy will be used to power the radio/tape player.
3. Indicate the Energy Bike's capacitors to the students as shown in the picture below.
4. Define **capacitor:** A capacitor is a device that stores electrical charge.



HOW DOES A CAPACITOR STORE ENERGY?

A capacitor is made of two conductive plates separated by an insulating material called a dielectric. The dielectric can be made of non-conductive material such as paper, plastic, mica, glass, ceramic or air. The plates can be either aluminum foil or a thin metal film applied to opposite sides of a solid dielectric material.

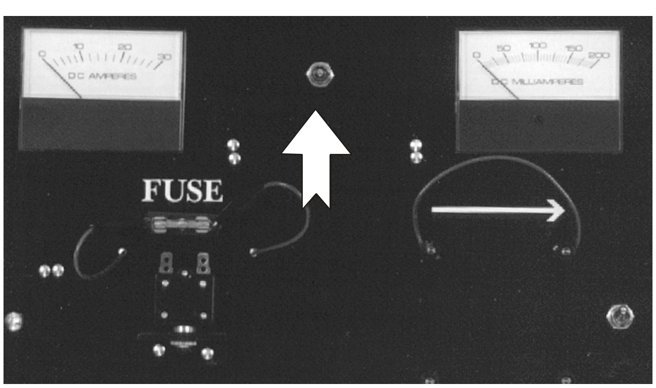
To charge the capacitor, the two plates are attached to the terminals of an electrical source: one plate to the positive terminal and the other to the negative terminal. Electrons flow from the negative terminal to one plate (making it negative) and they flow to the positive terminal from the other plate (making it positive). The charged plates cannot pass charge through the dielectric, so they store the charge until the capacitor is connected to a load, like a light bulb.

5. Discuss: What is used to make a capacitor? *Capacitors are composed of two conductors (metal plates) separated by an insulator. The insulation can be a variety of materials, such as paper, plastic, mica, glass, ceramic, or air. Note: An Oreo cookie is constructed much like a capacitor (cookies are the conductors, cream filling is the insulator).*

6. Discuss: Is a capacitor a type of battery? *No, both devices are able to release energy, but there are many differences between the two:*

	CAPACITOR	BATTERY
How is the energy stored?	The energy is stored electrostatically. An outside electrical source creates an electrostatic field between the conductors.	The energy is stored chemically. When a circuit is connected across the terminals, chemical reactions release electrons.
How long is the energy stored?	Energy can be stored for several days.	Energy can be stored for long periods.
At what rate is the energy released?	Instantaneously upon being connected. The electrons in the negative plate are free to flow.	Only as quickly as the chemical reactions can take place.
What are the typical uses?	Capacitors power items requiring quick bursts of energy, such as camera flashes. They also regulate current surges in sensitive equipment, such as TVs and computers.	Batteries power items that require energy over long periods, such as radios, clocks, watches, flashlights, and calculators.

7. Select a volunteer to ride the Energy Bike. Ask the class to imagine that the volunteer will be pedaling a bicycle up a hill.



8. Flip the top amp meter switch to the center (off) position. Have the volunteer begin to pedal, and when 12-13 volts register on the volt-meter, charge the capacitors by flipping up the capacitor switch.

9. Observe the 0-5 amp meter. The needle will gradually fall to zero. Once the needle reaches zero, instruct the volunteer to stop pedaling.

10. Ask the class to observe the volt-meter. Typically, when the Energy Bike is not being pedaled, the volt-meter registers zero. However, due to the potential energy stored in the capacitors, the volt meter will register 10-12 volts.

11. Define **potential energy**: Potential energy is stored energy or energy of position.

    Define **kinetic energy** : Kinetic energy is the energy of motion, or energy that is doing work.

12. Does a bicycle stopped at the top of a hill have potential or kinetic energy? *Potential energy.*

13. How does the Energy Bike store potential energy? *The electrons are stored in the Energy Bike's capacitors. When no light bulbs or appliances are turned on, the electrons stay in the capacitors.*

14. When a bicycle goes downhill, the potential energy is converted to kinetic energy. How can you convert potential energy to kinetic energy using the Energy Bike? *Electrons in the capacitors have a difference in potential energy (voltage). Once a bulb or appliance is turned on, the electrons will be released and the potential energy is converted to kinetic energy of moving electrons.*

15. Switch the fan on to FAST and allow the volunteer to enjoy the breeze, just as if the volunteer were coasting downhill on a bicycle. Once the fan is no longer blowing air, turn it OFF.

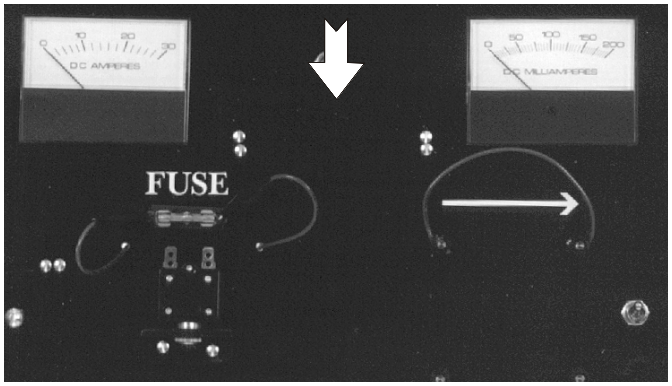
16. Select another volunteer. When the Energy Bike registers 12-13 volts on the volt-meter, recharge the capacitors as described in Steps 8-9.

17. Ask the class if they think the radio or the tape player will use the most energy. *The tape player uses more energy, so the radio will play longer.*

18. Pull out the radio's antenna and switch it on. Have the students record how long the radio plays. How many amps does the radio use? *The amp meter should register zero; however, the radio uses approximately 0.05 amps.*

CAPACITORS...The Energy Trap

19. Since the 0-5 amp meter cannot register such a small measurement, use the milliamp meter. Flip the meter switch down to the milliamp (mA) setting.



Define **amp (ampere)**: An amp is a measure of electrical current.

Define **milliamp**: 1/1000 of an amp. One amp = 1,000 milliamps.

20. Record the number of milliamps shown on the meter and calculate the number of watts the radio uses.

volts x amps = watts

21. Why does the milliamp meter's needle seem to follow the rhythm of the music? *Louder sounds require more energy. To prove this, turn the volume down and the needle will adjust accordingly. The students can save energy by turning down their music!*
22. Have the students record the length of time the radio plays. *It will play for approximately 3 minutes.* Turn the radio off.
23. Select another volunteer to recharge the capacitors. Remember to keep the top amp meter switch in the center (off) position, and flip the capacitor switch up as directed in Step 8. Ask the students to monitor how long the tape player will run.
24. Once the capacitors are charged, flip the milliamp meter switch down to display the milliamp meter and turn on the tape player. Ask the students to record the amount of time the tape player runs. *It will play for approximately 30 seconds.*
25. How many milliamps does the tape player use? *Approximately 100-150 milliamps.*
26. Calculate the number of watts the tape player requires:

volts x amps = watts

27. Ask the students why they think a tape player uses more energy than a radio. *The tape player has a motor that turns the tape; whereas the radio just receives a signal and emits sound.*
28. Trace the energy flow with the students: The electrons stored in the capacitors had potential energy. When the Energy Bike's radio/tape player begins working, the potential energy is converted to kinetic energy, in the form of sound.
29. Discuss with your students some ways in which capacitors are used:

Capacitors are included in television and computer circuits to protect them from power surges.

Camera flashes are powered by capacitors. In most cameras, a battery is used to slowly charge the capacitor, then the capacitor releases a quick burst of energy to fuel the flash.

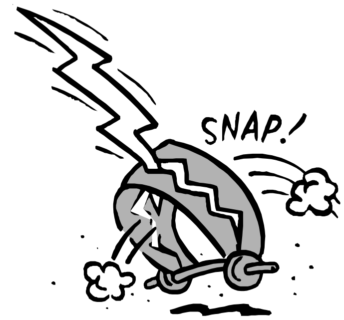
Electric companies use capacitors. If everyone in a city were to turn on their air conditioners at the same time, the electric company would have to meet the demand for electricity instantly. Starting an idle generator at a power plant takes a lot of time. Capacitors, however, are able to release electricity quickly and efficiently. The generators can then be used to recharge the capacitors.

30. After completing this activity, it is important to discharge the energy from the capacitors, as follows:

- ♦ Flip the top amp meter switch to the center (off) position.
- ♦ Flip the capacitor switch to the up position.
- ♦ Turn on an incandescent bulb until the voltmeter registers zero.
- ♦ Flip the capacitor switch down.
- ♦ Flip the lower amp meter switch to the center (off) position.
- ♦ Flip the top amp meter switch to the 0-5 (up) position.

POWER WORKSHEET

CAPACITORS...THE ENERGY TRAP



1. Define capacitor:

2. Name two objects that use capacitors:
   a.

   b.

3. Place a check mark in the correct column:

	Capacitor	Battery
Produces quick bursts of energy		
Stores energy for a short period of time		
Releases energy from a chemical reaction		

4. Define potential energy:

5. Give two examples of potential energy:

   a.

   b.

6. Define kinetic energy:

7. Give two examples of kinetic energy:

   a.

   b.

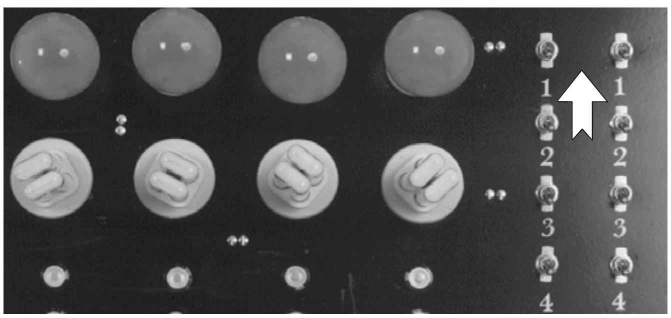
POWERFUL CALCULATIONS	Radio	Tape Player
Length of time the capacitors powered the music		
Amount of current used (amps)		
Amount of power used (watts)		

OVERVIEW

This activity compares the amount of time the stored energy in the capacitors lights a compact fluorescent bulb and an incandescent bulb.

GO

1. Have a student pedal until 12-13 volts are registered.
2. Charge the capacitors by flipping the top amp meter switch to the center (off) position. Have the volunteer begin to pedal, and when 12-13 volts register on the volt-meter, charge the capacitors by flipping up the switch.
3. When the capacitors are charged, switch on a CFL while the student pedals. After five seconds, instruct the cyclist to stop pedaling. When the rear wheel stops spinning, record the number of seconds the CFL produces light. *A CFL will light for about 8-16 seconds.*



The Energy Bike has two columns of switches that power the incandescent and fluorescent bulbs. The first column powers the incandescent bulbs, and the second column powers the CFL.

4. Select another volunteer and recharge the capacitors. Turn on one incandescent bulb and record the length of time the bulb produces light. *An incandescent bulb will light for about 1-2 seconds.*
5. Calculate the amount of power (watts) used by the CFL and incandescent bulbs as a student pedals and you turn on one of each type of bulb. Obtain the volt and amp readings from the meters.

   CFL: 12 volts x 1 amp = 12 watts

   Incandescent: 12 volts x 4 amps = 48 watts
6. Is there a connection between the amount of time each bulb stayed lit and the number of watts each bulb used? *Incandescent bulbs use four times the power as CFLs. Therefore, the CFL should have stayed lit at least four times longer than the incandescent bulb.*
7. When you have completed this activity, it is important to discharge the energy from the capacitors. To do so, perform the following steps:
   - ♦ Keep the top amp meter switch in the center (off) position.
   - ♦ Flip the capacitor switch up.
   - ♦ Turn on an incandescent bulb until the voltmeter registers zero.
   - ♦ Flip the capacitor switch to the down position.
   - ♦ Flip the top amp meter switch to the 0.5 amp (up) position.

STORING ENERGY

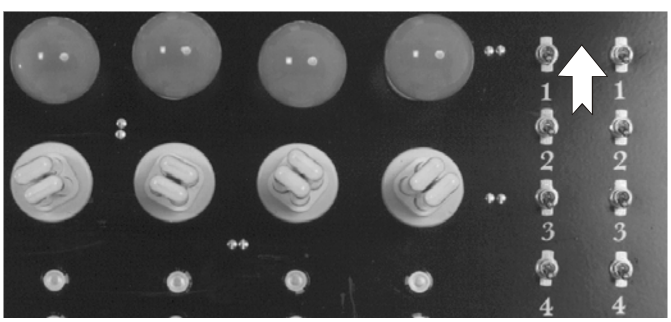
OVERVIEW

Students will discover the importance of energy storage for intermittent, renewable energy sources, such as the sun and wind. Students will pedal the Energy Bike to store energy in the capacitors. A volunteer will then pedal intermittently to simulate the energy source while trying to light a bulb. The students will learn the importance of stored energy by demonstrating that the light bulb will stay lit even when the volunteer is not pedaling.

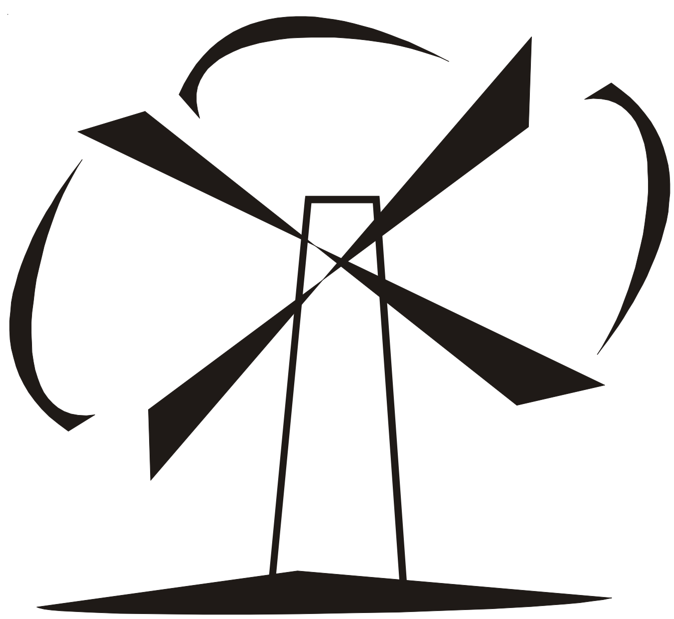
In this activity, the Energy Bike will represent a wind turbine.

GO

1. Define **intermittent renewable energy**: Renewable energy sources that do not provide a steady source of power. For example, there are times when the wind is not blowing or the sun is not shining.
2. Define **energy storage facility**: A facility used to store potential energy until it is needed. The Energy Bike uses capacitors, portable devices use batteries, and utilities use pumped water storage.
3. Flip up the amp meter switch. Select a volunteer to ride the Energy Bike. Once 12-13 volts are registered on the volt-meter, turn on one compact fluorescent bulb.



4. Instruct the volunteer to pedal, but stop and start every few seconds to simulate a lull in the wind. The CFL will flicker on and off.
5. Charge the capacitors by flipping the top amp meter switch to the center (off) position. Have the volunteer begin to pedal, and when 12-13 volts register on the volt-meter, charge the capacitors by flipping up the switch.
6. Again, have the cyclist pedal erratically. This time the bulb will stay continuously lit as long as the pedaling isn't stopped for longer than eight seconds. Adequate energy storage is necessary for the effective use of intermittent renewable energy.
7. When you have completed this activity, it is important to discharge the energy from the capacitors. To do so, perform the following steps:
   - Keep the top amp meter switch in the center (off) position.
   - Flip the capacitor switch up.
   - Turn on an incandescent bulb until the voltmeter registers zero.
   - Flip the capacitor switch to the down position.
   - Flip the top amp meter switch to the 0.5 (up) position.



DON'T BLOW A FUSE!

OVERVIEW
This series of activities explores electrical efficiency and safety. Students will learn about electrical resistance by comparing wires of different thickness and length. Using the Energy Bike, students will overload a wire, which will cause the wire to burn. They will explore open and closed circuits, and blow a fuse to demonstrate a fuse's ability to prevent electrical fire.

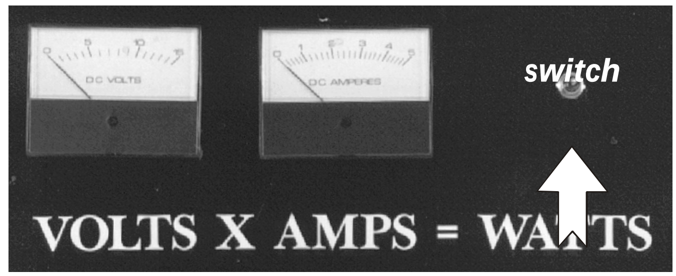
OUTCOMES
Students will:

- be able to define the terms electricity, resistance, circuit, and fuse.
- understand that materials with high resistance cause electrical energy to be converted into other forms of energy.
- recognize that not all wires can carry the same amount of current.
- observe the effects of too much current flowing through a wire.
- understand the role of fuses and circuit breakers in an electrical system.

MATERIALS
- 1 spool of 30 gauge copper wire
- 1 spool of 22 gauge copper wire
- 1 spool of 16 gauge copper wire
- 8-inch piece of 30 gauge red aluminum wire
- 4 incandescent bulbs
- 4 compact fluorescent bulbs
- 6-amp fuse
- hair dryer
- fan
- beverage warmer
- extension cord

GET READY
1. Gather the materials listed above. All of the materials are included in the Energy Bike case.
2. Make copies of the worksheet found on page 43.

GET SET
1. Set up and test the Energy Bike. Insert four incandescent bulbs and four CFLs, and plug in the fan. If any problems occur while testing the Energy Bike, refer to the troubleshooting section.
2. Cut an 8" piece of 30 gauge wire.
3. Flip the amp meter switch up as indicated in the picture.

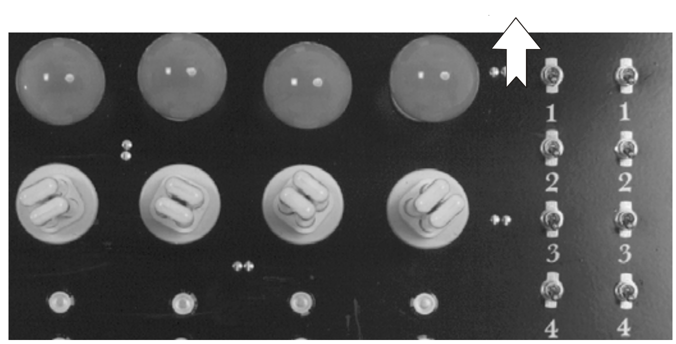


GO
1. Review the Energy Bike Safety Contract with your students.
2. Define **electricity**: Electricity is the flow or movement of electrons.

   Define **resistance**: Resistance is opposition to the flow of electricity.
3. Explain that objects with low resistance are good conductors of electricity, and objects with high resistance are poor conductors. Have the students think of examples of good and poor conductors.

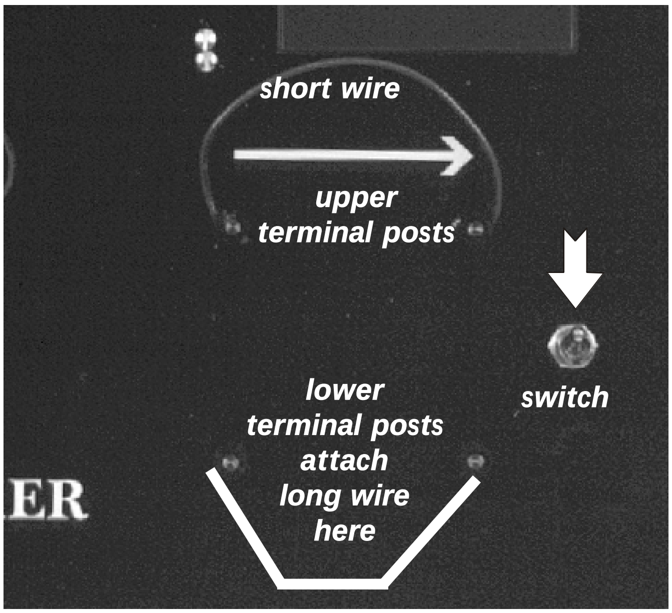
   Good Conductors: copper, aluminum, silver, gold

   Poor Conductors: tungsten, iron, carbon, nichrome
4. Ask a volunteer to ride the Energy Bike. Turn on one incandescent bulb.



The Energy Bike has two columns of switches that power the incandescent and fluorescent bulbs. The first column powers the incandescent bulbs, and the second column powers the CFL.

5. Incandescent bulbs have resistors in them that transform electricity into two different forms of energy. Ask the students to name the forms of energy: *Radiant (light) and thermal (heat) energy.*
6. Flip down the amp meter switch. Have the volunteer pedal the Energy Bike, and turn on four incandescent bulbs. The electricity is flowing through the short, thick wire on the front of the display board.



7. Have the students observe and record the number of amps shown on the amp meter.

   Short Wire: 12 volts x 16 amps = 192 watts
8. Have the volunteer stop pedaling, and ask the students to determine if the short, thick wire has high or low resistance. *It has low resistance because it is short and thick. The electrons travel a short distance and flow on a wide path.*
9. Select ten students to become utility towers. Have them form a circle around the room that begins and ends near the Energy Bike. Completely uncoil the spool of 28 gauge copper wire and have the students hold it with their fingertips.
10. Clip the ends of the uncoiled 28 gauge wire into the lower pair of terminal posts. Flip the switch to the right of the terminal posts down to send the electricity through the 28 gauge copper wire.
11. Flip up the amp meter switch. Have the rider pedal again, and turn on one incandescent bulb. The bulb will be dim, and the amp meter will register fewer amps.
12. Have the students observe and record the number of amps shown on the amp meter.

    Long Wire: 12 volts x 2 amps = 24 watts
13. Ask the students to determine whether the long, thin 28 gauge wire has resistance. *It has resistance because the electricity must travel a long distance and flow on a narrow path.*
14. Have the volunteer stop pedaling. Detach the long 28 gauge wire and recoil it on the spool.
15. Repeat Steps 9 through 14 using the 22 and 16 gauge wires. Have the students predict the effect of the different wire gauges on the light bulbs. *With thicker wires, the brightness of the bulbs will increase and the fan will spin faster. Larger diameter (smaller gauge) wires allow more efficient transmission of electricity.*

Utility Transmission

Electric utilities use thick conducting wires in power lines that decrease, but do not eliminate resistance. This increases efficient transmission of electricity between the power plant and consumers. Utility companies expect to lose 5-10% of the electricity transmitted. Technology could improve the efficiency of the power lines to reduce such losses, but it would not be cost efficient.

Resistance
Advantage or Disadvantage?

It depends upon the type of job you want electricity to do. If you want electricity to travel fast and deliver a lot of electrical energy to an appliance, then resistance is a disadvantage. Many of the wires to electrical outlets are made of copper, which has low resistance, allowing electricity to flow quickly and efficiently.

Resistance is an advantage if you want electricity to produce heat or light. When electricity flows through a substance that has resistance, the electricity is converted into other forms of energy. For example, the heating element in a toaster is made of nichrome, a resistor. The nichrome does not allow the electricity to flow quickly or efficiently, causing the electrical energy to be converted into thermal and radiant energy.

DON'T BLOW A FUSE!

Why does high resistance produce heat?

The same amount of electrical power enters both the long and the short wires; thus, the same amount of power is released. However, the power is released in different ways. The short wire has low resistance, allowing most of the power to flow to the light bulb. This allows more power to be released from the bulb as light. The longer wire has high resistance, so the energy traveling through it converts from electrical to heat energy.

Ohm's Law states that the amount of current (amps) is directly proportional to the voltage, and is inversely proportional to the amount of resistance.

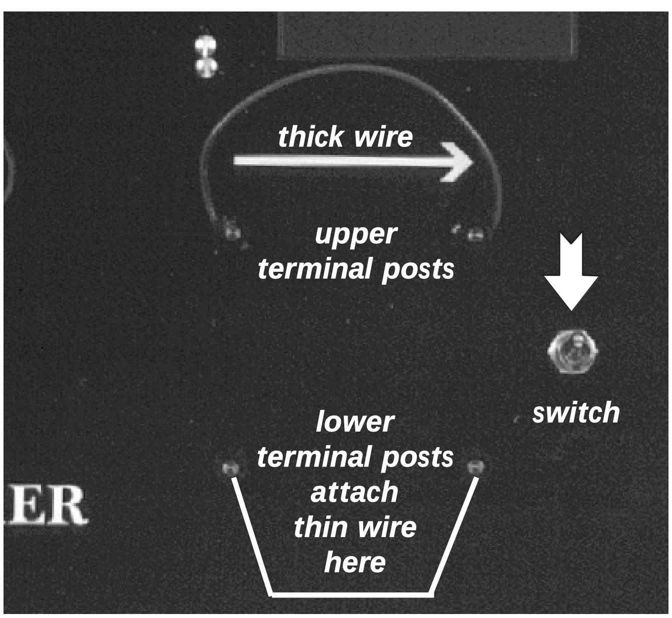
If voltage increases, current increases.

If resistance increases, current decreases.

Resistance increases if a wire is longer, thinner, or hotter. The length and small diameter of the wire cause the electrical energy to change into heat energy. As the wire becomes warmer, the resistance increases.

current = voltage ÷ resistance

16. Explain that all of the Energy Bike's wires are the same gauge as the thickest wire used in the previous experiment (16 gauge). The next experiment demonstrates what would happen if they were a higher gauge (thinner wire).
17. Place the 8" piece of 30 gauge wire into the bottom set of terminal posts on the display board as shown in the picture.



18. Ask for a volunteer. Inform the volunteer that this experiment results in the thin wire suddenly burning. The bicycle should be two feet away from the display board. Take every precaution to ensure that the rider's hair and clothing will not come into contact with the wire.
19. Have the volunteer begin to pedal. Turn on four incandescent bulbs. *After a few minutes, the wire should begin to smoke and burn.*
20. Ask your students why the short 30 gauge wire burned, but the long 28 gauge wire did not? *During the first experiment, about 200 watts traveled across the long 28 gauge copper wire. Those 200 watts were spread along its length, resulting in a heating intensity of about 0.27 watts per inch.*

    During the second experiment, about 200 watts traveled over the short 30 gauge wire. The heat intensity is about 25 watts per inch, which is almost 100 times greater than in the long wire. The wire's diameter makes it incapable of carrying a lot of electricity. The electricity is converted into thermal energy very fast. The resistance increases as the temperature rises. Eventually the wire gets too hot and burns.

    The National Electric Code specifies the amount of current that can be carried by different types of wires. This code prevents electrical hazards from occurring. What device prevents electrical hazards in our homes? A fuse box or a circuit breaker.
21. Flip the terminal post switch up. When the thin wire has cooled, release it from the connection and pass it around for the class to observe.

OPEN, CLOSED & SHORT CIRCUITS

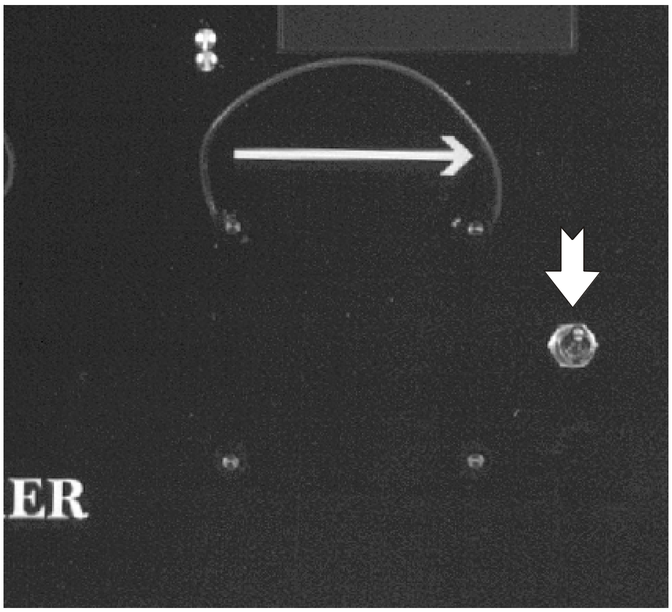
Have the students imagine a network of roads in a city, with one of the roads having a drawbridge. When the drawbridge is down, cars can drive over it. This is like a closed circuit. When electrons have a closed path to travel on, they can flow.

If the drawbridge is up, what happens to the cars? They cannot get from one side of the bridge to the other. This is like an open circuit. When there is an opening in the path of electricity, the electrons cannot flow.

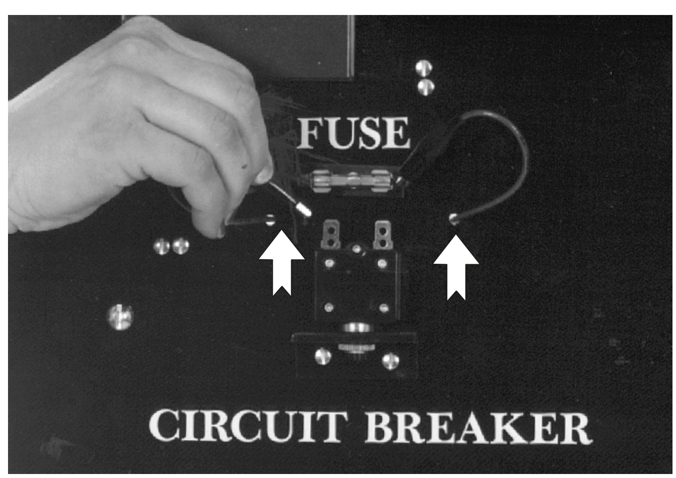
A short circuit occurs when something is wrong with the electrons' path, such as damaged insulation. When this happens, the electrons take a "shortcut" within the electrical system. Instead of traveling on the path of wires, they jump from one wire to another.

DON'T BLOW A FUSE!

22. Define **circuit**: A circuit is a path through which electricity flows.
23. Ask for a volunteer to ride the Energy Bike. While the volunteer pedals, turn on a compact fluorescent bulb. Ask the students if they are observing an open or closed circuit. *It is a closed circuit because the electricity is traveling on a complete path.*
24. Flip down the terminal post switch as shown in the picture. *Since there is no wire connecting the lower two terminals, an open circuit exists.*



25. Have the volunteer stop pedaling. Ask if he/she has ever blown a fuse or tripped a circuit breaker at home. What happens to the lights and appliances in the house? *The lights and appliances do not work because an open circuit exists.*
26. Define **fuse**: A fuse is a safely contained, intentionally thin conducting element that will melt sooner than the wire that it is protecting.
27. Define **blown fuse**: A blown fuse is a contained electrical fire. When too much current flows through the fuse, the metal in the fuse melts, creating an open circuit. This protects the other wires in the circuit by stopping the flow of electricity.
28. Define **circuit breaker**: A circuit breaker is a device that causes an open circuit when too much current is flowing through a circuit. Instead of catching fire, the circuit breaker has a switch that is activated by large current. When the current is too large, the switch opens the circuit and stops the flow of electricity.
29. Attach another 8" piece of 30 gauge wire to the terminal posts, just as was done in the last experiment. Remove the 20-amp fuse from the fuse holder, and replace it with the six-amp fuse.
30. While a volunteer pedals the Energy Bike, turn on one incandescent bulb.
31. Indicate the amp meter to the students while explaining that the fuse can handle up to six amps. The metal in the fuse is not melting because the incandescent bulb only requires four amps.
32. Flip the amp meter switch down to the 0-30 amp meter.
33. Have the students watch the fuse closely as you turn on a total of three incandescent bulbs. *The students should observe a bright light in the fuse when it blows, followed by the light bulbs suddenly turning off.*
34. After the metal in the fuse has melted, remove the fuse and pass it around the class. Replace the 20-amp fuse and discard the 6 amp fuse.
35. Demonstrate how the circuit breaker differs from the fuse. Detach the wires from the square metal terminals of the fuse holder by unclipping the red alligator clips, then attach the clips to the square metal terminals on the circuit breaker.
36. Perform steps 30-33 again, this time explaining that the circuit breaker will protect the wire. *The Energy Bike's circuit breaker breaks the circuit when the temperature increases to a certain level. If too much electricity is flowing through the breaker, heat is produced, and the breaker opens the circuit.*
37. Using the circuit breaker, repeat Step 36 several times. Note that the circuit breaker opens the cirtcuit more quickly each time, as the switch becomes hotter and has increased resistance.



POWER WORKSHEET

DON'T BLOW A FUSE!

1. What is electricity?

2. What is resistance?

3. List two good conductors of electricity:
   a.

   b.

> **FUN FACT**
> *You cause circuits to open and close every day!*
> *Turning ON a light switch = CLOSING a circuit*
> *Turning OFF a light switch = OPENING a circuit*

4. List two poor conductors of electricity:
   a.

   b.

5. Does the short, thick copper wire have high or low resistance? ______________

6. How many amps register on the amp meter when the short, thick wire is being used? How many watts are produced? Fill in the blanks:

   12 VOLTS x _______ AMPS = ________ WATTS

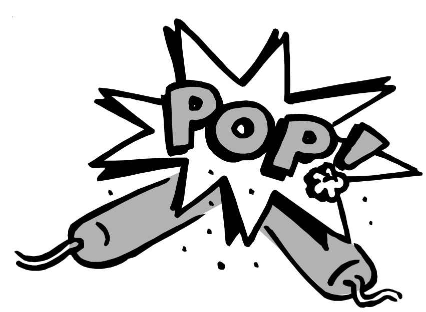
7. Does the long, thin copper wire have high or low resistance? ______________

8. How many amps register on the amp meter when the long, thin wire is being used? How many watts are produced? Fill in the blanks:

   12 VOLTS x _______ AMPS = ________ WATTS

9. What is a circuit?

10. What is a fuse?



DISCOVERY 5

IT'S ELECTRIC!

1. Investigate the fuse box or circuit breaker at home. Look for a label that tells you information about its capacity. What is the maximum amount of amps that the fuse box or circuit breaker will allow? How many volts will it allow? Record your findings:

Maximum amps: _________________

Maximum volts: _________________

Calculate the maximum watts: ________________

2. Investigate the electrical appliances in your home. Each appliance should have an amp or watt rating labeled on it. In the space below, write the name of the appliance and the amp or watt rating. *If you are given a wattage rating, divide the watts by 120 volts to determine the amps.*

APPLIANCE	VOLTS		AMPS		WATTS
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
	120	X		=	
				TOTAL	

3. Add the number of watts for all appliances. If you were using all of these appliances at once, would you blow a fuse or trip the circuit breaker?

CONNECTION PROTECTION

OVERVIEW

Students will simulate an electrical system protected by a fuse. A power source will be constructed using a lamp cord and batteries. Aluminum foil will serve as the fuse.

GET READY

Gather the following materials:

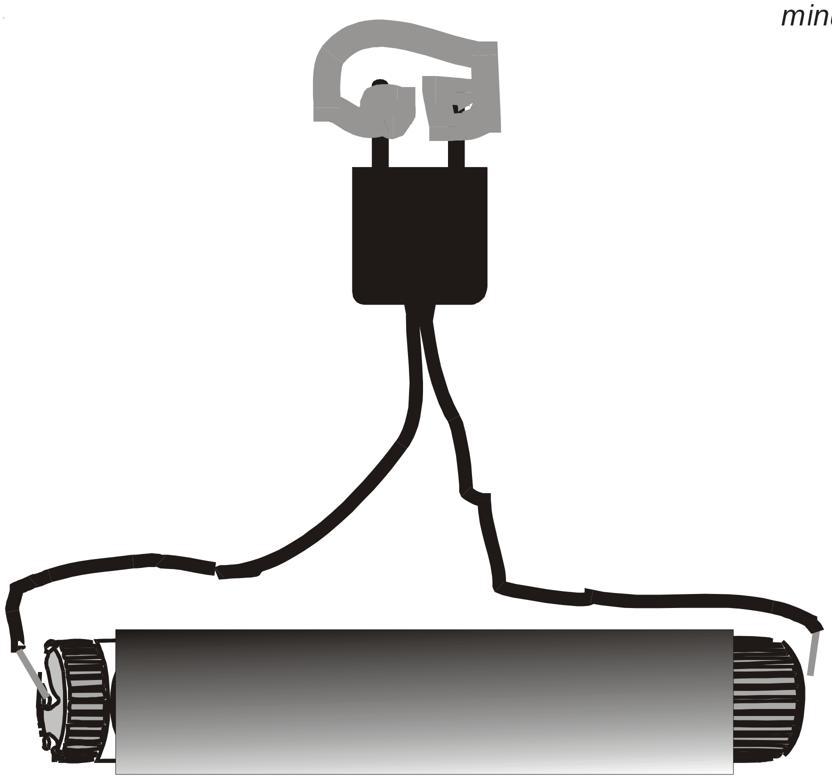
- Scissors*
- Wire stripper*
- Empty cardboard paper towel tube*
- Five D-cell batteries*
- Aluminum foil*
- Marker*
- An old 18" lamp cord with a plug on one end*

GET SET

Conduct this experiment with an adult. Find a safe open space to do the experiment, such as a desk or a sidewalk. Remove any flammable materials.

GO

1. Notice that the lamp cord consists of two cords side by side. Separate the two halves of the cord by gently pulling them apart at the cut end.



2. Using the wire stripper, carefully trim 1/4 inch of the insulation from the ends of the separated cords.
3. Slide the batteries into the cardboard tube, with all of them pointing in the same direction. This aligns them in a series, with the positive end of one battery touching the negative end of the next battery.
4. One end of the tube should have the positive end of a battery showing, and the other end should have the negative end of a battery showing. Use the marker to indicate the positive and negative ends on the tube.
5. Using the scissors, cut a piece of aluminum foil that is 4 inches long and 1/8 inch wide. The aluminum foil will be used as a fuse.
6. Wrap one end of the aluminum foil stightly around one of the prongs of the plug. Wrap the other end of the aluminum foil around the other prong.
7. Keep your fingers at least two inches away from the ends of the wire. Keep the "fuse" away from you and anything else flammable. Hold one end of the cord to the positive end of the batteries.
8. Briefly touch the other end of the cord to the negative end of the batteries.
9. If the "fuse" does not change in appearance, try the experiment again with a thinner piece of aluminum foil.
10. Describe what happened to your "fuse". *The aluminum foil should burn.*

IT'S ELECTRIC...POWER

OVERVIEW

In this activity, the class will role play as the board of directors for an electric company. One student will act as the company's "power plant" by pedaling the Energy Bike. Each incandescent bulb will represent a new town being added to the utility company's service territory. Eventually, the power plant will not be able to sustain the load. The board of directors will consider alternatives that will affect its customers and stockholders.

OUTCOMES

Students will:

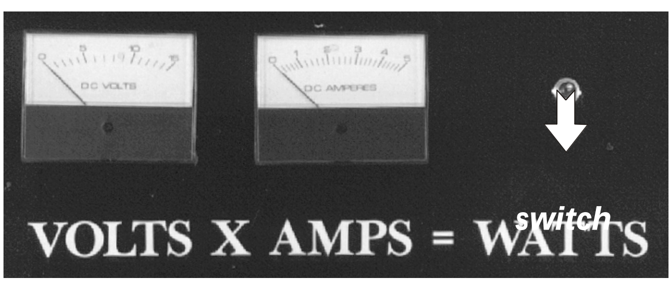
- ♦ understand supply-side alternative(s) and demand-side management.
- ♦ develop creative thinking and problem solving skills.

GET READY

1. Make copies of the Power Worksheet on page 48.
2. Have a bag of candy to simulate energy input.

GET SET

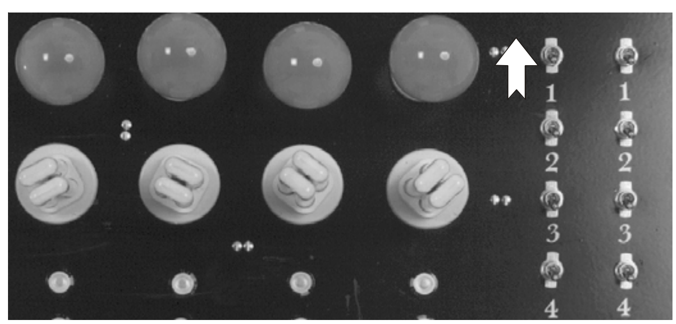
1. Set up and test the Energy Bike. Insert four incandescent and four fluorescent bulbs. If any problems occur, refer to the troubleshooting section.
2. Flip the amp meter switch down as shown in the picture.
3. Flip up the terminal post switch.



GO

1. Review the Energy Bike Safety Contract with your students.
2. Describe the task:
   - ♦ The class will become the board of directors for a new electric company. Their goal will be to expand the company's electric service into new territory.
   - ♦ One student will act as the "power plant" by pedaling the Energy Bike. Each incandescent bulb will represent the electrical demands of a new town.
3. Choose a volunteer to ride the Energy Bike.
4. Explain: that the new electric utility is fueled by biomass, which in this case is candy. As long as the board members purchase enough candy to fuel the power plant, the power plant will produce electricity, the stockholders will make money, and the customers will be happy!

   The company celebrates its grand opening and the volunteer is ready to generate power! The power plant's job is to maintain a steady, reliable voltage for the consumers. The town council is convinced that the new electric company can provide its residents with the most affordable price per kilowatt-hour.
5. Have the volunteer begin to pedal. When the volt-meter registers 12-13 volts, flip up the first incandescent switch to light one incandescent bulb.



6. A second community emerges as people move to the area. The electric company's stock prices rise and both towns are happy with their electric service. Light a second incandescent bulb by flipping the second switch.
7. Word begins to spread about what a great place this is to live! A third community is formed and the electric company is there to fill the residents' needs. Flip on the third incandescent bulb switch.

8. The power plant is starting to really heat up. The board members purchase more candy.
9. A fourth town is built; light the fourth incandescent bulb. *At this point, the incandescent lights will be dimming due to the load on the "power plant."*
10. Have the volunteer stop pedaling and discuss: What is happening? Consumers are starting to call the customer service department because their lights are dimming! The power plant has been overloaded. Ask the board members to consider options, and give the power plant a rest:

- ♦ Build a new power plant (volunteer). *Ask the power plant's age... explain to the class that consumers can't wait that long for another "power plant" to grow. Also, too much money has already been invested during this power plant's building process, maintenance, etc.*
- ♦ Make the power plant stronger. *The power plant could go on a weight training program, but that would take time and money for the health club. During the training, however, the consumers still wouldn't have electricity!*
- ♦ Get another Energy Bike. *It would take four weeks to receive the parts and then it must be assembled. Also, it would cost at least $2,650 to purchase a new Energy Bike. The company may need to borrow money and its stock prices would plummet.*

11. Point out to the students that the above answers have been supply-side alternatives.

    Define **supply-side alternatives**: Energy saving changes implemented by the electric company.

    The following are examples of supply-side alternatives implemented by real life utility companies:

    - ♦ Operate using 765,000 volt transmission lines. This helps to provide customers with the most economical and reliable power supply possible.
    - ♦ Install hyperbolic cooling towers. These tall, arching towers create a natural draft of air that cools power plant water at lower cost.
    - ♦ Use reheated steam to help power generators. Reheating steam transfers more thermal energy from the fuel and cuts fuel costs.

12. Define **demand-side management**: Utility companies promote changes that their customers can make to reduce the amount of electricity being used in their homes and businesses.
13. How can the board of directors encourage the consumers to practice demand-side management? Common student answers include:
    - ♦ *Have consumers use CFLs.*
    - ♦ *Educate consumers about CFLs.*
    - ♦ *Sell CFLs to consumers at a reduced price.*
    - ♦ *Give customers CFLs.*
    - ♦ *Offer a rebate to customers using CFLs.*
14. Demonstrate how energy conservation methods can save energy. Have the volunteer pedal until 12-13 volts register on the meter and begin turning on the four incandescent bulbs again. Then, one at a time, turn off an incandescent bulb and turn on a CFL. Continue until only CFLs are lit. The cyclist should not have any problem keeping the same number of CFLs lit that previously blacked-out the power plant.
15. Demand-side management programs implemented by utility companies include:
    - ♦ Offering home energy audits, weatherization practices and other low-cost, energy-efficient measures to residential customers.
    - ♦ Promoting energy-efficient lighting, motors and electrotechnologies by studying how customers use energy and by offering financial incentives to implement energy efficient practices.
    - ♦ Offering Load Management Rates: A discount given to households that use less electricity during designated months.
16. Discuss ways that students can manage their demand for electricity at home to save energy.
    - ♦ Use compact fluorescent bulbs.
    - ♦ Turn off lights and appliances when not in use.
    - ♦ Keep the oven and refrigerator doors closed. A peek inside the oven can reduce the temperature inside by 25^{O}F.
    - ♦ Take short showers rather than baths.
    - ♦ Hand wash dishes. It saves half the cost per dishwasher load.
    - ♦ Wash clothes in warm or cold water. It saves about $80 a year for a family of four.
    - ♦ Insulate the hot water heater.
    - ♦ Use a programmable thermostat.

POWER WORKSHEET

It's Electric...Power!

1. Define supply-side alternatives:

2. List two examples of supply-side alternatives that can be implemented when using the Energy Bike as a power plant, and by real-life utility companies:

Energy Bike	Utility Companies

3. Define demand-side management:

4. List two examples of demand-side alternatives that can be implemented when using the Energy Bike as a power plant, and by real-life utility companies:

Energy Bike	Utility Companies

5. If you were the president of the electric company, which supply-side or demand-side alternatives would you implement?

6. How can you manage your demand for electricity at home to save energy?

DISCOVERY 6

Appliance Reliance

Imagine waking up one morning to read the newspaper headlines ***"All Electric Utility Consumers Limited to 3500 Watts"***. Examine the appliances below, and list the ones you would choose to use. Remember, you are limited to 3500 watts!

Appliance	Average Wattage	Average Operating Cost
Air conditioner (window)	1150	$16.22/month
Air conditioner (central)	3800	$57.00/month
Clock	2	$0.11/month
Clothes dryer	4856	$4.48/month
Coffee maker	600	$0.01/15 minutes
Compact disc player	13	$0.01/hour
Curling iron	40	$0.02/10 minutes
Dishwasher	1200	$8. 55/month
Electric blanket	150	$0.05/8 hours
Fan (window)	200	$3.23/month
Fluorescent light bulb	18	$0.04/month
Grill (outdoor)	1500	$0.11/hour
Hair dryer	1000	$0.01/8 minutes
Hot plate	1250	$0.05/30 minutes
Incandescent light bulb	100	$0.23/month
Iron	1100	$0.04/hour
Microwave oven	1450	$0.12/hour
Personal computer	300	$0.02/hour
Monitor	114	$0.01/hour
Radio	71	$0.05/hour
Range (large surface unit)	2100	$0.08/hour
Refrigerator-freezer (manual defrost)	300	$2.00/week
Refrigerator-freezer (automatic defrost)	440	$3.00/week
Television (black & white)	100	$0.08/hour
Television (color)	240	$0.02/hour
Toaster	1100	$0.24/month
Vacuum cleaner	630	$0.05/hour
VCR	50	$0.04/hour
Washing machine	512	$0.04/hour
Water heater	2500	$9.75/week

FUN FACT

The average lifetime consumption of a person living in the United States is 170 tons of coal, 2000 barrels of oil, and 7.5 million cubic feet of natural gas.

APPLIANCE RELIANCE

1. Appliances I would use:

APPLIANCE	AVERAGE WATTAGE	AVERAGE OPERATING COST

2. How much would it cost to run all of your appliances for one week? Remember to convert all units to hours.

It would cost $_________ to operate all of the appliances for one week.

3. Are there any appliances you would like to use that are not listed on the chart?

4. Compare your choices to those of other students. How do you think the choices reflect lifestyle and values? Try this activity with your family. Are the results similar?

DISCOVERY 7

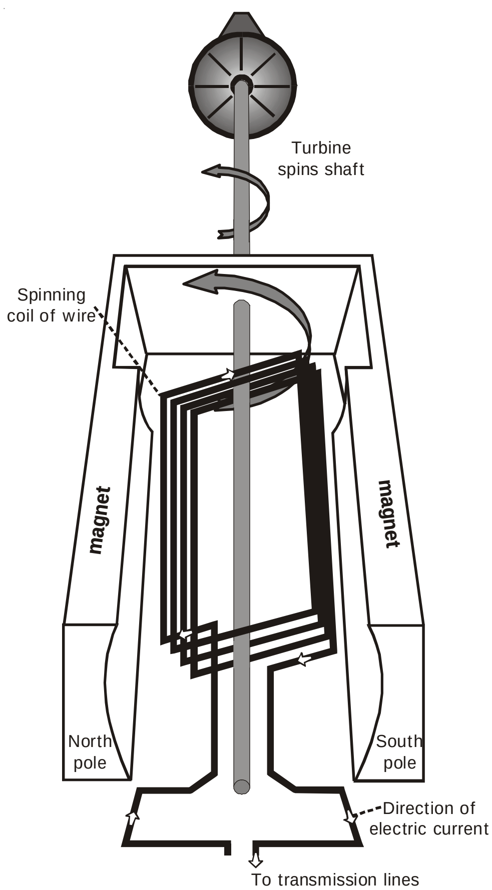
Electricity on the Move

After reading the following selection, complete the Discovery Activity on page 52.

MAKING ELECTRICITY

Most of the electricity in the United States is generated by large, centrally located power plants that use coal, nuclear fission, natural gas, or other energy sources to produce thermal energy, which super heats water into steam. The very high pressure of the steam (it's 75 to 100 times normal atmospheric pressure) turns the blades of a turbine. (At a hydropower plant, the force of falling water turns the blades.) The blades are connected to a generator with magnets and coiled copper wire. The blades spin the wire inside the magnets, producing electricity.

The steam, still very hot but at normal pressure, goes to a heat exchanger, where it is cooled into water. The heat exchanger is a system in which pipes with steam flow next to pipes with cool water from a river, lake, ocean, or cooling tower. The water then returns to the boiler to be used again. Today, power plants can capture some of the heat from the cooling steam. In old plants, the heat was simply wasted.



MOVING ELECTRICITY

We use more electricity every year. Electricity is used because it's easy to move from one place to another. Electricity can be produced at a power plant and moved long distances. Let's follow the path of electricity from a power plant to your home.

First the electricity is generated at a power plant. Next it travels by wire to a transformer that "steps up" the voltage. A step-up transformer increases the voltage of electricity. The generator produces from 2,300 to 22,000 volts and the step-up transformer increases it to as much as 765,000 volts. Power companies step up the voltage because less electricity is lost along the lines when the voltage is high.

The electricity is then transmitted on a nationwide network of transmission lines. Transmission lines are the huge tower lines you may see when you are on the highway. The lines are interconnected, so should one line fail, another will take over the load.

"Step-down" transformers located at substations along the lines reduce the voltage to 12,000 volts. Substations are small buildings or fenced-in yards containing switches, transformers, and other electrical equipment.

Electricity is then carried over distribution lines that bring electricity to your home. Distribution lines can be on overhead poles or buried underground. The overhead distribution lines are the electric wires you see along streets. Underground distribution lines go to pad-mounted transformers, which are usually green boxes found along the streets near homes.

Before the electricity enters your home, the voltage is again reduced at a transformer that looks like a large gray box. This transformer reduces the electricity to the 120 volts needed to operate appliances in your home.

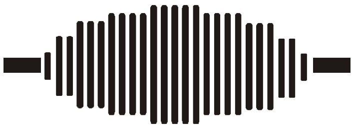
Electricity enters your home through a three-wire cable to a fuse box or circuit breaker, then to outlets and switches in different rooms. An electric meter measures how much electricity you use so that the electric company can bill you.

The time it takes for electricity to travel from the power plant to a light bulb in your home is only a fraction of a second.

DISCOVERY 7 *continued*

ELECTRICITY ON THE MOVE

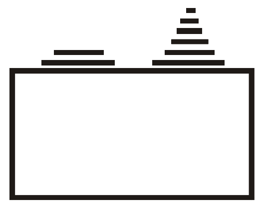
Below are nine parts of an electric power system. Your challenge is to unscramble the parts of the system so that the parts are in the correct order. Number the pictures 1 through 9 on the lines to the right of the pictures, with 1 as the first part of the system and 9 as the last part of the system.



Generator____________

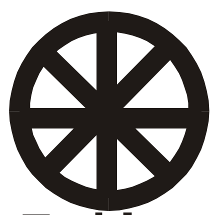
Home ____________

Step-Down Transformer____________

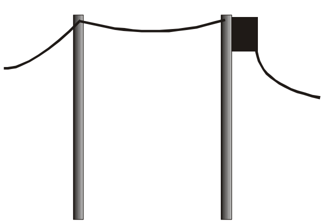


Step-Up Transformer____________

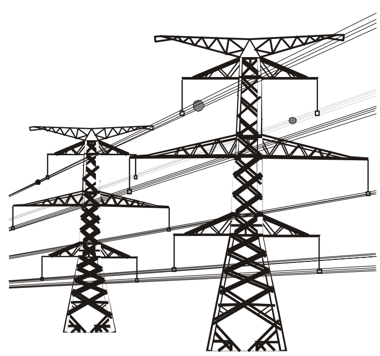
Energy Source____________



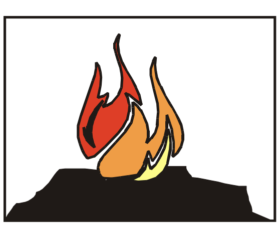
Turbine____________



Distribution Line & Transformer____________



Transmission Line____________



Boiler____________

KILO-WHAT?

OVERVIEW

Electric companies measure the amount of electricity that consumers use in kilowatt-hours (1000 watt-hours). Knowing that electricity is sold in units allows students to understand electricity in concrete terms. This activity illustrates the low cost of electricity and how to reduce the amount of electricity used during peak hours of consumption.

OUTCOMES

Students will:

- be able to define kilowatt-hour.
- know that consumers purchase energy in units of kilowatt-hours.
- understand how utility companies ensure reliable service for consumers.
- understand the concept of peak shaving.

MATERIALS

- 4 incandescent bulbs
- 4 compact fluorescent bulbs
- 1 digital timer
- 1 fan
- 1 hair dryer
- 1 tape player
- 1 clock with a second hand*

GET READY

1. Make copies of the Power Worksheet on page 56.
2. Gather the materials needed.

GET SET

1. Set up the Energy Bike so that a clock with a second hand is visible. Insert the incandescent bulbs and CFLs into the sockets. Plug in the fan, hair dryer, and radio/tape player. All materials, except for the clock, are included in the Energy Bike case.
2. Test the Energy Bike. If any problems occur while testing, refer to the troubleshooting section.
3. Set the digital timer to six minutes and clip it to the top of the display board.
4. Flip the amp meter switch down as shown in the picture on the right.

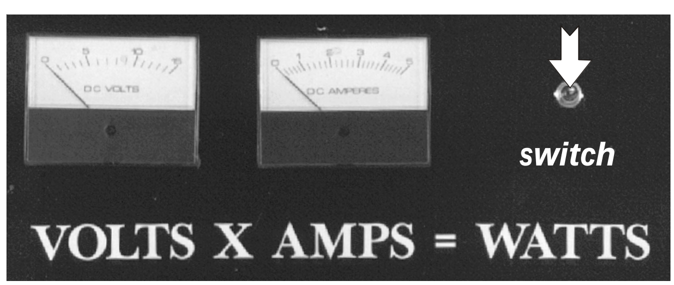
GO

1. Review the Safety Contract with your students.
2. Ask the class to give examples of ways they have used electricity today: *turning on lights, cooking, curling or blow drying hair, waking up to an alarm clock, listening to radio, etc.*
3. Ask the students if they know how long the electricity was used? Did anyone use lights or appliances for exactly one hour?
4. Electricity is measured in units called kilowatt-hours (kWh).
5. Define **kilowatt-hour**: A kilowatt-hour is a unit of measure equal to one thousand watt-hours of electricity.

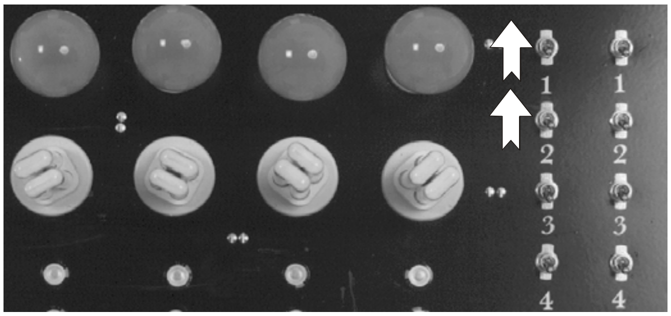
The Kilowatt-hour Made Simple

Imagine ten 100-watt bulbs burning for one hour. The bulbs would use one thousand watts of electricity during that hour, or a kilowatt-hour. Because we don't use electricity for a set amount of time, the utility company keeps track of it on an electric meter. Electric meters are cumulative recorders much like a car odometer. They track every watt of electricity we use and convert it to kilowatt-hours. Each day the average American home uses approximately 25 kilowatt-hours of electricity.

6. Describe the task:
   - Six volunteers will take turns riding the Energy Bike for six minutes or 1/10 of an hour.
   - The riders will power two incandescent bulbs equal to 100 watts and experience the amount of energy required to power 100 watts for 1/10 of an hour.
   - The class will learn that one kilowatt-hour is 100 times the amount of energy produced by the students.



7. Select the first volunteer to ride the Energy Bike. When the volt-meter registers 12-13 volts, turn on the timer and two incandescent bulbs by flipping up the switches. The volunteer is producing approximately 100 watts of electrical power.



8. When the first volunteer tires, pause the timer and turn off the bulbs until the next student registers 12-13 volts on the voltmeter. Repeat this process until the full six minutes have elapsed.
9. The riders will probably feel as if a lot of energy was used to perform the demonstration, but only one tenth of a 100 watt-hour has been generated! Ask the students to determine the number of 50 watt bulbs they would have to power to produce one kilowatt-hour. *Twenty 50 watt-bulbs.*
10. Describe this scenario to your students: They have decided to pursue a career as an Energy Bike power plant that will provide electricity for consumers. How much would they charge per kilowatt-hour? How much do they think electric companies charge per kilowatt-hour? *On average, utility companies charge residential customers 8.5¢ per kilowatt-hour.* Would 8.5¢ per hour be a fair price for the students to be paid as an Energy Bike power plant?
11. To discuss peak residential consumption, ask the students if they use the same amount of electricity at all times throughout the day. Are there times when we use more or less electricity?
12. Select a volunteer to ride the Energy Bike. This volunteer will be a power plant and produce electricity for a city on a typical day. In this activity, two minutes of real time equals one day. When the second hand of the clock points to 12, midnight is represented.
13. Have the volunteer begin to pedal. When the second hand reaches 12, turn on the fan and one CFL. This represents electricity usually used in homes at midnight for heating and/or cooling and safety lighting.
14. When the second hand reaches the 6 (6:00 a.m.), switch on another CFL to represent alarm clocks going off, people turning on lights.
15. As the second hand reaches the 8 (8:00 a.m.), switch on a third CFL to represent cooking breakfast, watching TV, and using small appliances to get ready in the morning.
16. When the second hand reaches the 10 (10:00 a.m.), switch off everything but one CFL and the fan. Many people are at work or school, but some are home. That bulb represents the energy used in residences during the day.
17. When the second hand reaches the 6 (6:00 p.m.), flip off the fan and all the CFLs. Switch on two incandescent bulbs and the tape player. This represents people coming home from work, turning on lights, stereos, televisions, and cooking dinner.
18. When the second hand reaches the 8 (8:00 p.m.), turn on the hair dryer to represent major appliances such as dishwashers and clothes washers, as well as computers. At this point, a blackout will most likely occur. The volunteer has just experienced being a power plant during peak residential consumption hours.
19. Ask students to name other peak residential demand hours: *Summer afternoons when air conditioners are required, winter mornings and evenings when lights and furnaces are used.*

HOW CAN POWER COMPANIES AVOID BLACKOUTS?

Many utility companies use backup generators and form “power pools” with other power plants to handle peak demand. Energy supply systems can be linked together by power lines, which will support one another at times of peak demand or equipment failure. In an urgent need to prevent a blackout, utility companies can also temporarily shut off power to a small portion of their customers until the situation is corrected.

The National Electric Reliability Council (NERC) was formed to improve the reliability of electrical service after a major blackout occurred in the Northeast in 1965. The NERC sponsors research and development projects that enable power companies to learn more about preventing power failures.

20. We have demonstrated peak electricity consumption for residential consumers, however businesses and industry use about two times more energy than residential consumers. Discuss with the students who pedaled the Energy Bike how they would feel about powering residential, business, and industry needs.
21. Ask the students to name ways residential energy consumers can help to reduce the amount of energy used during peak consumption hours. *The most effective action is to stagger the use of appliances.*
22. Define **peak load shaving**: Peak load shaving is shifting electricity use from a peak (or high) demand time to a low demand time.
23. Some utility companies offer lower rates to customers who use electricity at off-peak times. Discuss ways to shift electricity use, such as:

Run dishwasher late at night.

Do laundry late at night.

Use fewer lights and more candles in the evening.

Use only one or two large appliances at a time.

Summary of Activities

Clock Second Hand = Time	Energy Bike Bulbs & Appliances	Electricity Used by Consumers
12 = midnight	fan 1 CFL	heating and cooling safety lighting
6 = 6:00 a.m.	fan 2 CFLs	people waking up, turning on lights, getting ready for school and work
8 = 8:00 a.m.	fan 3 CFLs	small appliances, cooking appliances, TV
10 = 10:00 a.m.	fan 1 CFL	many people are at work, some at home using appliances
6 = 6:00 p.m.	2 incandescent bulbs tape player	people coming home from work, turning on lights, cooking dinner, watching television, listening to music
8 = 8:00 p.m.	2 incandescent bulbs tape player hair dryer	lights operating, watching television, running dishwasher, using computers, doing laundry

POWER WORKSHEET

Kilo-What?

1. Name three ways you have used electricity today:

   a.

   b.

   c.

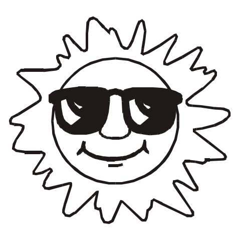
2. Define kilowatt-hour:

3. How many kilowatt-hours of electricity does the average American home use per day?

4. What is the average residential price for a kilowatt-hour of electricity?

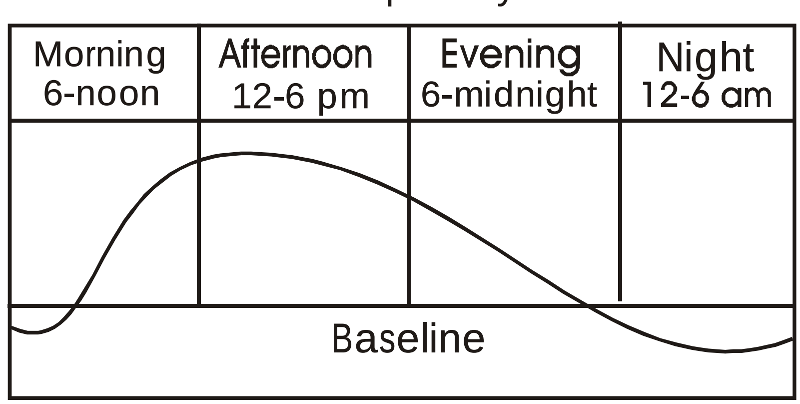
5. Using the facts above, how much does it cost to power the average American home for one day?

6. Define peak load shaving:



Peak Demand

People use more electricity between 12 noon and 6 p.m., especially in the summer.



FUN FACT
In one year, the average home uses 9,125 kilowatt-hours of electricity.

JUST A THOUGHT
Think conservation, not convenience!

DISCOVERY 8

THE COST OF CONVENIENCE

1. Monitor one electrically-powered device or appliance in your home that is used frequently.
2. For one week, record the approximate number of hours the appliance is used per day. Calculate the average hours per day it is used.

DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	AVERAGE

3. Identify and record the number of watts needed to power the device or appliance. *Most appliances have labels that indicate the required wattage. If a label provides amps, calculate the watts:* 120 volts x amps = watts.

Watts used: _________

4. Multiply the number of watts by the average time it was used. This will produce the average number of watt-hours per day.

Watt-hours per day: __________

5. Divide by 1000 to calculate the kilowatt-hours per day.

Kilowatt-hours per day: __________

6. Multiply the kilowatt-hours per day by 30 days to get the total kilowatt-hours per month.

Watt-hours per month: __________

7. Ask for permission to review your family's electric bill. How much does the electric company charge per kilowatt-hour?

Cost per kilowatt-hour: __________

8. Multiply the kilowatt-hours per month by the cost per kilowatt-hour. How much does it cost to power the appliance for one month?

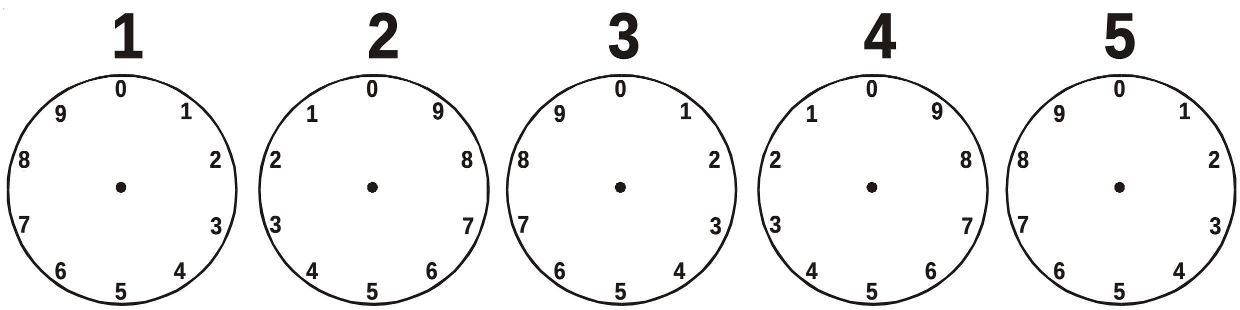
Cost per month to power device: __________

DISCOVERY 9

Meter Reader

1. Locate the electric meter for your home. Look at the meter at eye level.

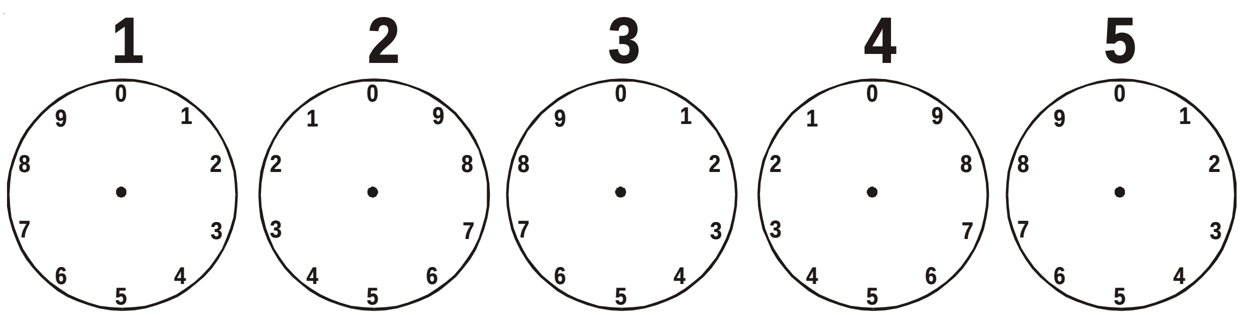
2. The meter has dials that measure the kilowatt-hours your family has used. The face of the meter has five dials, each with the numbers 0 through 9. Not all of the dials are alike, however. The numbers of the first dial increase in a clockwise direction, while the numbers on the second dial increase in a counter-clockwise direction. The dials continue to alternate until the end of the row. Draw pointers on the dials below to make them match the dials on your home's meter:



______ ______ ______ ______ ______

3. Write the number that each dial is pointing to in order from left to right on the lines above. *If a pointer is between two numbers, always write the smaller number.*

4. After one week, read your electric meter again. Draw pointers on the dials below to make them match the dials on your home's meter:



______ ______ ______ ______ ______

5. Write the numbers shown on the dials on the lines above.

6. Subtract the numbers you recorded on the first day from the last day's reading. How many kilowatt-hours did your family use in one week?

HORSEPOWER!

OVERVIEW

Horsepower is used to measure the power of engines and motors. One horsepower is equal to 746 watts. During this activity, loads (light bulbs) will be added to the Energy Bike to simulate the pedaling resistance of riding a bicycle on a flat road. The number of watts being produced will be calculated. From the number of watts, the approximate amount of mechanical horsepower the cyclist is producing will be calculated.

OUTCOMES

Students will:

- understand that the power of engines and motors is typically stated in horsepower.
- recognize that one horsepower is equal to 746 watts.
- be able to define load.
- calculate the horsepower of a person riding a bicycle.

MATERIALS

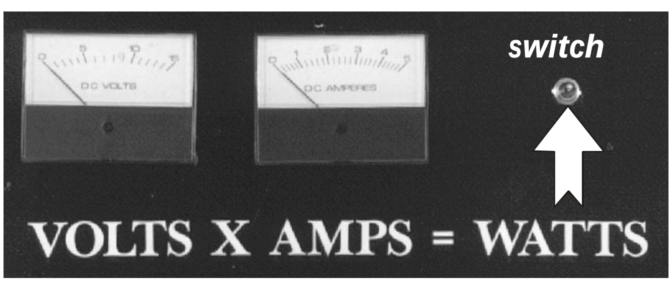
- 4 incandescent bulbs
- 4 compact fluorescent bulbs
- 1 fan

GET READY

Make copies of the Power Worksheet on page 61.

GET SET

1. Set up the Energy Bike. Plug the fan into a receptacle. Insert four incandescent and four CFLs.
2. Test the bike. If any problems occur, refer to the troubleshooting section.
3. Flip the amp meter switch up as indicated in the picture below.

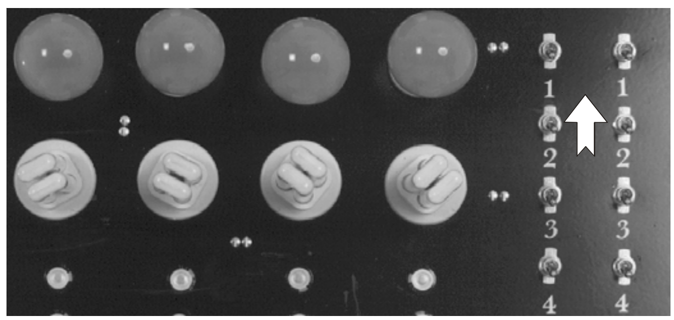


GO

1. Review the Safety Contract with your students.
2. Define **horsepower**: Horsepower is a unit of measure for the power of engines and motors. One horsepower is equal to 746 watts.

   Define **load**: A load is a device that uses electricity to do useful work such as light bulbs and appliances.
3. Describe the task:
   - One volunteer will ride the Energy Bike.
   - Loads (light bulbs) will be lit individually until the volunteer states that the pedaling resistance is similar to pedaling on a flat road.
   - From the watts produced, the horsepower of the volunteer will be calculated.
4. Select a volunteer who often rides a regular bicycle. When the volunteer begins pedaling and the volt-meter registers 12-13 volts, flip the fan on to FAST speed.

   The fan's airflow simulates the breeze felt when riding a bicycle. However, the pedaling resistance is still too easy to represent the experience of riding a bicycle on level ground.
5. Turn on one CFL by flipping up the switch. Switch on additional CFLs until the cyclist states that the pedaling resistance feels comparable to that of bicycling on flat ground.



6. Record the number of volts and amps being produced. If the load is equal to one fan and four CFLs, the meters will read as follows:

   Volts = 12 Amps = 5
7. Determine the number of watts the cyclist is producing when the load is equal to one fan and four CFLs:

   volts x amps = watts

   12 volts x 5 amps = 60 watts

HORSEPOWER!

HORSEPOWER?

When James Watt built his steam engine in the 1760s, he wanted to use a unit of power that most people would recognize. Since the horse was the most common source of power in the eighteenth century, Watt decided to express steam-engine power in terms comparable to a horse.

Watt determined that a strong horse could move a 550-pound weight one foot in one second or 33,000 pounds one foot every minute. Although horsepower is no longer measured in terms of an actual horse, it is used to measure the power of engines and motors.

8. To calculate the horsepower required to power the light bulb, divide the number of watts produced by 746 watts.

1 horsepower is equal to 746 watts

60 W ÷ 746W/1 horsepower = 0.08 horsepower

9. The bicycle is about 50% (0.50) efficient at converting the rider's mechanical energy to the rotating wheel of the bike. The generator is about 90% (0.90) efficient at converting mechanical energy to electrical energy. Therefore, the total efficiency of the Energy Bike is:

0.90 x 0.50 = 0.45

10. Now that the horsepower produced has been calculated and the efficiency of the Energy Bike is known, the actual horsepower produced by the Energy Bike can be calculated.

If the power input (P_{in}) is .45 (45% efficiency) and the power output (P_{out}) is 0.08 horsepower, then the total horsepower produced by the bike is:

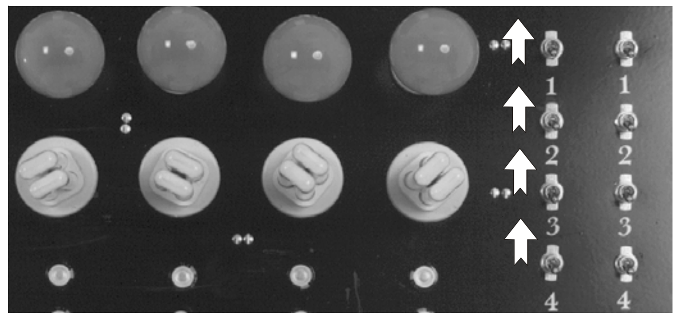
0.45(P_{in}) = 0.08(P_{out})

0.08/0.45 = 0.18 horsepower

11. How does the horsepower that the Energy Bike produced compare with other machines?

Small electric motor	**1 horsepower**
Engine of car	**200 horsepower**
Diesel train engine	**10,000 horsepower**

12. Select a new volunteer. Demonstrate the strength required to produce a quarter horsepower by having the student light four incandescent bulbs. Flip all four incandescent switches up as shown.



13. Calculate the horsepower required to light the four incandescent bulbs.

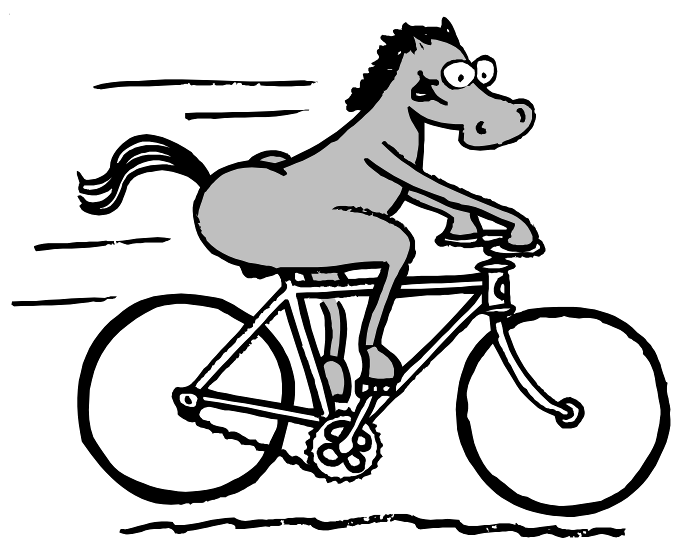
12 volts x 16 amps = 192 watts

192 W ÷ 746 W/1 horsepower = 0.26 horsepower

14. Calculate the amount of horsepower produced by the cyclist to light the four incandescent bulbs.

0.45(P_{in}) = 0.26(P_{out})

0.26/0.45 = 0.58 horsepower



WORKSHEET 9

HORSEPOWER!

1. Define horsepower.

2. One horsepower = _______ watts

3. How much voltage was produced when the Energy Bike felt like a bicycle moving on flat land?

   ______ volts

4. How much current was produced when the Energy Bike felt like a bicycle moving on flat land?

   ______ amps

5. Calculate the wattage when the Energy Bike felt like a bicycle moving on flat land: volts x amps = watts

   ______ watts

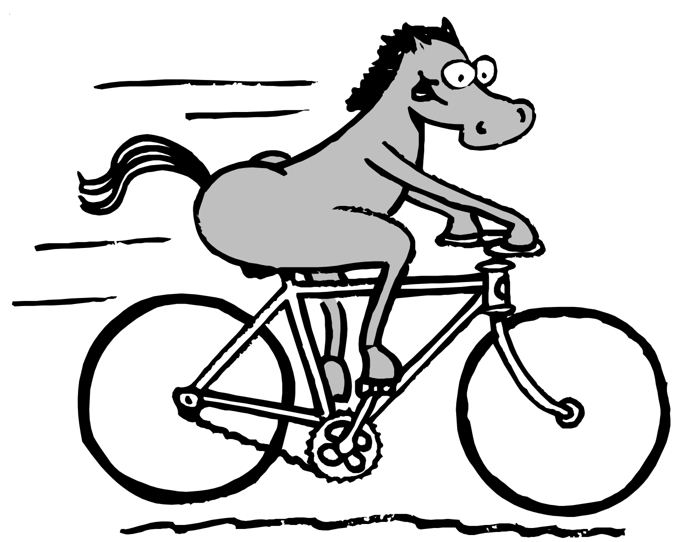
6. Calculate the horsepower based on your answer for question 5.

7. Name three things commonly measured in horsepower.

   a.

   b.

   c.

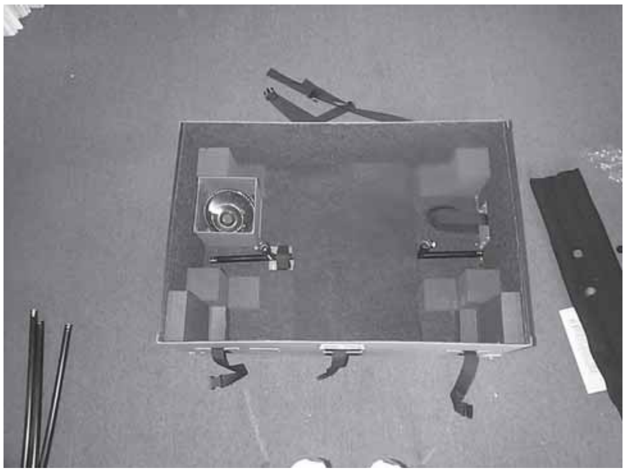


DISMANTLING THE ENERGY BIKE

Dismantling the Energy Bike takes about 20 minutes, following these steps:

1. Unscrew or unplug the bulbs and appliances attached to the display board and bike.

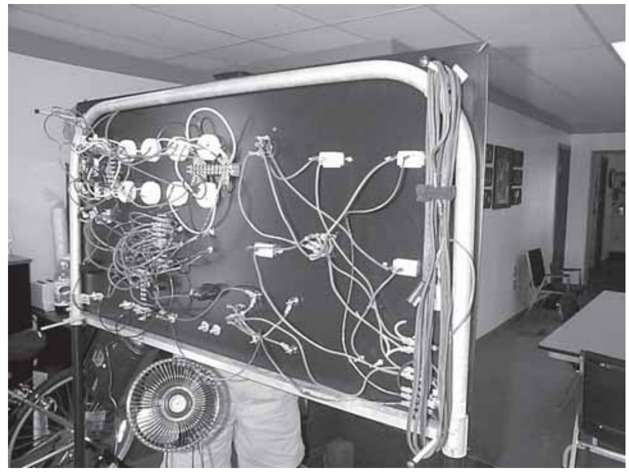
   Place the fan in the small box. Place all other devices and bulbs in the long pull-out box, then set the box aside.



2. Disconnect the long black cable from the motor by pulling the connectors apart. Do not pull on the wires.

   Coil the cord and hang it on one of the long metal bolts protruding from the back of the display board.

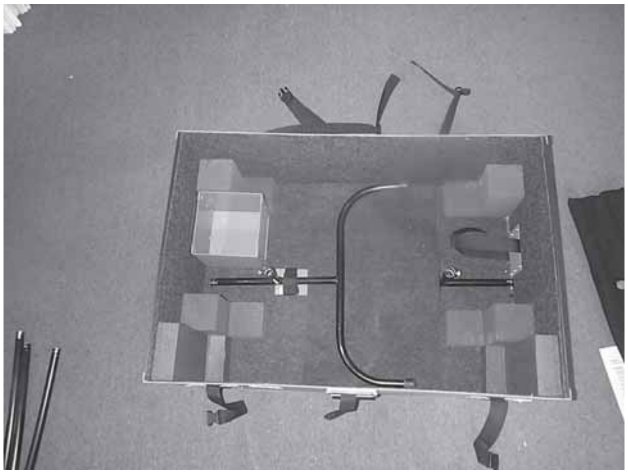
3. Loosen the silver bolts that secure the display board to the support poles. Lift the display board from the stand and set it aside. Retighten the bolts.



4. Loosen the bolts that connect the display board's support poles to the stand bases. Remove the poles and retighten the bolts.
5. Loosen the bolts that hold the display board's crossbar to its base. Remove the crossbar and retighten the bolts.
6. Put the support poles and crossbar into the black bag and set them aside.

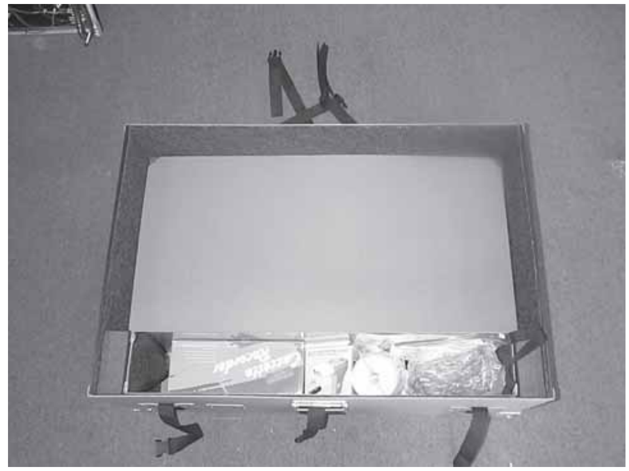
7. Attach one display board base into the bottom of the carrying case with the Velcro. Place the base so that its top is flush with the side of the case and its legs are pointing toward the center of the case.

   The Velcro secures around the center pole of the base. Cover with a piece of gray felt. Attach the other base to the bottom of the case in the opposite direction and cover with the second piece of felt.

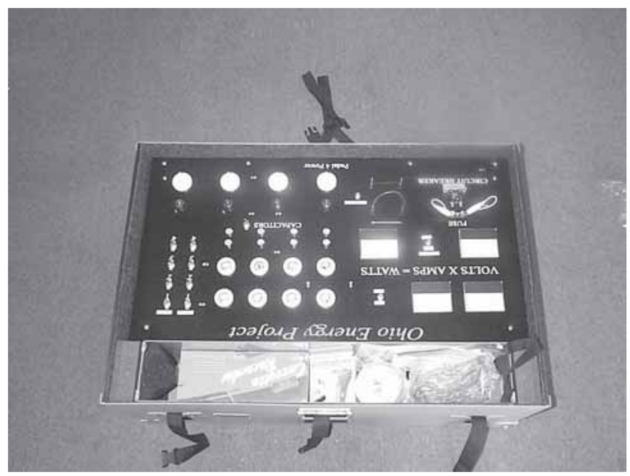


8. Using two people, remove the bike from the stand as follows:
    - ♦ Spin the inner black knobs until they are next to the outer black knobs.
    - ♦ With one person supporting the rear wheel, loosen the outer black knobs as far as possible.
    - ♦ Slide the wheel out of the silver slotted cups and lower the wheel to the ground.
    - ♦ Roll the bike away from the stand.
    - ♦ Tighten the outer black knobs until they are flush with the stand.
9. Place the bike stand onto the gray felt so that its base rests on the gray foam blocks at the bottom of the case (with the wheels). Use the velcro straps to anchor the base in place.
10. Place the long pullout box into the carrying case.
11. Place the long black bag with the poles on the opposite side of the carrying case from the box.
12. Place the poles on top of the bike stand.

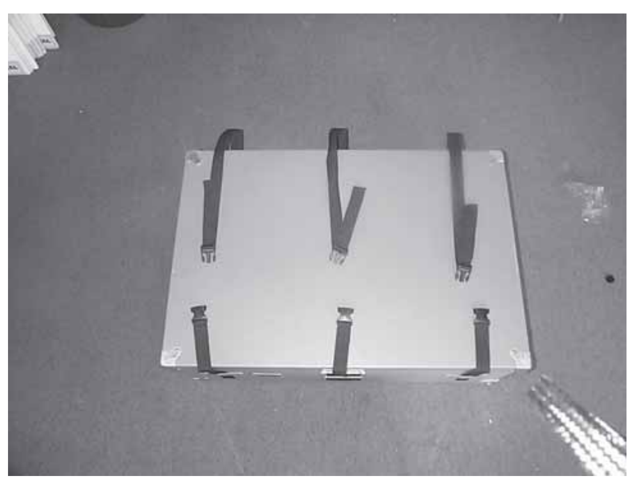
13. Place the light gray divider into the case with the soft side facing down.



14. Place the display board into the case with the wires facing down.



15. Place the top of the carrying case onto the bottom of the case and strap it into place.



TROUBLESHOOTING

MOST COMMON PROBLEMS

- ☐ The black cord should be connecting the generator and the display board.
- ☐ Are any of the screws that are holding wires in place loose? If so, reconnect any loose wires and tighten any loose screws.
- ☐ Do any of the connectors pull apart too easily? Secure any loose connections.
- ☐ Is the switch next to the volt and amp meters in the center position? It must be flipped up or down to send current to the bulbs and appliances.
- ☐ On the front of the board, is there a wire connecting the two round terminal posts? If not, an open circuit exists and the wire must be reattached. Also, the switch to the right of the terminal posts should be in the up position.
- ☐ Are the capacitors charged? Unless you are using the capacitors, they should not be charged. Check if they are charged by putting the top amp meter in the down position, then flipping the capacitor switch up. If the volt meter shows voltage, the capacitors are charged. To release the charge, turn on an incandescent bulb until the volt meter reads zero. Flip the switch next to the capacitors into the down position.

OTHER SITUATIONS

Zero Voltage

- ☐ The black cord should be connecting the generator and the display panel.

Capacitors Won't Stay Charged

- ☐ Confirm that all bulbs and appliances are turned off, and the beverage warmer is unplugged.
- ☐ Confirm that the switch to the right of the volt and amp meters is in the center, or "off" position.

Good Voltage & High Current with No Bulbs or Appliances On

- ☐ Make sure bulbs and appliances are turned off and beverage warmer is unplugged.
- ☐ The capacitor switch should always be in the center (off) position, unless a capacitor activity is being performed. To check if the capacitors are charged, put the top amp meter in the center position, and flip the capacitor switch up. If volts register on the voltmeter, the capacitors are charged. To release the charge, turn on an incandescent bulb until the voltmeter reads zero. Flip the switch next to the capacitors into the down position.
- ☐ Could a short circuit exist? Check the wiring for any exposed wire or crossed connections.

Appliance & Light Bulb Problems

- ☐ Make sure the switch located between the volt and amp meters is not in the center position. Flip it up to the 0-5 amp meter or down to the 0-30 amp meter.
- ☐ The wire between the top two terminal posts should be securely connected.
- ☐ Make sure the fuse in the fuse holder is not blown. If necessary, replace it with a 20-amp fuse.

Radio Isn't Working Properly

- ☐ Make sure the plug in the back of the radio is secure. If not, the radio will stop intermittently when lifted from the hook.
- ☐ The radio plug should be secure in the Energy Bike's receptacle.
- ☐ The AC-DC power converter that plugs into the receptacle should be adjusted so that the voltage switch is on "6".
- ☐ Check the tip of the AC-DC power converter that plugs into the radio. The "Tip" label should be closest to the "+" sign. If not, disconnect the tip, rotate and re-connect it.

Wire Connections

- ☐ Look at the back of the display board. Do any of the screws that connect the wires to the board look loose? Use a screwdriver to secure any loose connections.
- ☐ Are any of the ends of the copper wires exposed? The wire may have been pulled from a connector. Look at the board to see if a connector appears to be attached to the board, but is missing a wire.
- ☐ Reattach the wire by removing the connector from the board, then examining the end that was crimped (the blue plastic tube). Be sure to remember exactly where the connector was attached! Using a wire crimper, squeeze the connector in the opposite direction that it was originally crimped. This will return it to its original round shape. If this does not work, check the Energy Bike case for extra connectors.
- ☐ Find the wire that was pulled out. Twist the strands on the end to create a uniform wire.
- ☐ Insert the wire back into the connector. Using the crimper, squeeze the connector together to secure it back onto the wire in the original direction that it was crimped. Squeeze very hard!
- ☐ Reattach the connector to the display board by inserting it under the screw from which it was removed, and tightening the screw.

Answer Key

Light Bulb or Heat Bulb?
1. Electricity is the flow or movement of electrons.
2. Volts measure electric potential - the energy available to move electrons.
3. Amps measure electric current.
4. Watts measure electric power.
5. Incandescent
6. Energy is neither created nor destroyed; it is transformed into other forms of energy.
7. Heat and light (thermal and radiant)
8. Compact fluorescent

Powerful Calculations: Readings from activity.

Which Light Bulb Would You Use?

1.	Inc: 750,000 Wh	CFL: 200,000 Wh
2.	Inc: 750 kWh	CFL: 200 kWh
3.	Inc: $60.00	CFL: $16.00
4.	Inc: 13.33	CFL: 1
5.	Inc: $6.67	CFL: $10.00
6.	Inc: $66.67	CFL: $26.00

Mighty Motors
1. False: More energy is required to start a motor than to keep it running.
2. Inertia is the resistance of an object to any change in its direction or speed.
3. Hair dryer uses more energy because it is producing heat.
4. Generator: mechanical energy into electrical energy.
5. Motor: electrical energy into mechanical energy.
6. Refrigerator, fan, air conditioner, hair dryer, mixer, dish washer, washing machine, dryer.
7. A blackout is the loss of electricity to an area.
8. Discuss.

Powerful Calculations: Readings from activity.

BTU Is One Hot Topic
1. One British Thermal Unit (BTU) is the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit.
2. 40,000 BTU

3-7. Readings from activity.

Capacitors...The Energy Trap
1. A capacitor is a device that stores electrical charge.
2. Camera flashes, televisions, computers.
3. Capacitor: produces quick bursts of energy.
stores energy for a short period.
Battery: releases energy from chemical reaction.
4. Potential energy is stored energy or energy of position.
5. Chemical, gravitational, nuclear.
6. Kinetic energy is the energy of motion.
7. Radiant, thermal, electrical, mechanical, sound.

Powerful Calculations: Readings from activity.

Doní Blow a Fuse
1. Electricity is the flow or movement of electrons.
2. Resistance is opposition to the flow of electrons.
3. Good conductors: copper, aluminum, silver, gold.
4. Poor conductors: tungsten, iron, carbon, nichrome.
5. Low resistance.
6. Readings from activity.
7. High resistance.
8. Readings from activity.
9. A circuit is a path through which electricity flows.
10. A fuse is a conducting element designed to melt more quickly than the wire it is protecting.

Itís Electric...Power
1. Supply-side alternatives are energy-saving options implemented by a utility company.
2. See lists on page 47.
3. Demand-side management is encouraging customers to reduce energy consumption through incentives.
4. See lists on page 47.

5-6. Discussion questions.

Kilo-What?
1. Discussion.
2. Kilowatt-hour is a unit of measure of electricity equal to 1000 watt-hours.
3. 25 kWh
4. $0.085 per kWh
5. $2.13
6. Peak load shaving is shifting electricity use from a peak demand time to a low demand time.

Horsepower!
1. Horsepower is a unit of measure for engines and motors.
2. One horsepower = 746 watts.

3-6. Readings from activity.

7. Car , motorcycle, lawnmower, plane, train engines.

Discovery 1-6
Information from activities.

Discovery 7
1. Energy source
2. Boiler
3. Turbine
4. Generator
5. Step-up Transformer
6. Transmission Line
7. Step-down Transformer
8. Distribution Line and transformer
9. Home

Discovery 8-9
Information from activities.

ENERGY BIKE

Evaluation Form

State: ___________ **Grade Level:** ___________ **Number of Students:** __________

1.	Did you conduct the entire activity?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activity meet your academic objectives?	Yes	No
4.	Was the activity age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activity?	Yes	No
6.	Was the activity easy to use?	Yes	No
7.	Was the preparation required acceptable for the activity?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

Please fax or mail to:

NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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