Alternative Energy Workshop: Day 1

Olin College Engineering Discovery

This curriculum is designed for a three-hour workshop with approximately 30 middle school students.

Contents

Energy Introduction

Objectives

After completing this lesson, students will

- Understand different forms of energy
- Know several examples of kinetic and potential energy
- Have thought about the importance of energy in their daily lives

Preparation

Location:

A typical classroom with space for a speaker and demonstration table.

Safety:

- One of the demonstrations involves lighting a match so have a small bucket of water on hand.
- Make sure you have enough clear space for launching the film canister rocket, to avoid anyone being hit.

Student Knowledge

To get the most from this lesson, a student should know:

- Electricity is not the only form of energy
- Electrons are much smaller than protons

Instructor Knowledge

An instructor should be able to converse scientifically about these topics:

- Different forms of energy including thermal, sound, electrical, motion, gravitational, chemical, and stored mechanical energy.
- Molecules, atoms, and bonds
- Sound waves

These resources might be helpful for preparation:

- Energy Information Administration: Energy Kid's Page - www.eia.doe.gov/kids/index.html

Materials

Item	Description	Qty	Where?	Est. Cost
match		1		
windup toy		1		
Cymbal or musical instrument	To demonstrate sound, any instrument on hand is appropriate	1		
snakes in a can		1		
Film canister		1		
Antacid tablet		1		
Light bulb and socket		1		
Voltmeter		1		
Wire		Small length		
Printed out pictures of various types of energy	Pictures should illustrate all of the types of energy that will be covered	at least 1 per student		

Lesson

Introduction:

Ask students "Where have you seen/heard/used energy? What things use energy? How have you used energy so far today?"

Looking for:

Car, calculator, flashlight, light bulb, fire, sailboats, windmills, us, boats, batteries, power plants, etc.

Forms of Energy:

1.) Energy Presentation

One person talks and the other person demonstrates forms of energy behind them. Person who is talking tries not to react.

Pass out pictures to students. Explain to them that the pictures represent different forms of energy, and they should hold up their picture when they think it is demonstrating that type of energy. They should then explain what is going on in the picture and why it is that type of energy. Some pictures may involve more than one type of energy.

Energy is more than just electricity.

For example:

Kinetic Energy: This is energy found in motion. When things move, they use energy.

Thermal Energy: Thermal energy is the movement of **molecules** in an object or substance. As thermal energy increases, the molecules start moving faster. One feels an increase in thermal energy has how warm something gets.

- demo: light a match
- examples: heating your house, baking a cake, roasting a marshmallow over a campfire

Motion Energy: The movement of visible objects and substances. This is the energy used to get things from one place to another.

- demo: Wind-up toy
- examples: running, wind

Sound Energy: Energy that travels through objects and substances in **waves.** It is energy you can hear.

- demo: cymbal
- examples: talking

Electrical Energy: The movement of **electrons**. This is that is supplied to your house and you get from your electrical outlets.

- demo: light bulb
- examples: powering lights, computers, TVs

Potential Energy: This is stored energy. When one needs to use energy to make motion, it must come from somewhere.

Gravitational Energy: Energy stored in an object because of its position. In other words, objects storing Gravitational Energy have the ability to fall and have kinetic motion energy, but haven't done so yet.

- demo: drop something
- examples: a car perched on the top of a hill of a rollercoaster, water held back by a dam

Chemical: Energy stored in the **bonds of atoms and molecules**. Everything is made up of molecules which are connected. It takes energy to connect these molecules. When you break these connections energy is released.

- film canister rocket (instructions: http://www.sciencebob.com/experiments/filmrocket.php) Explain that putting the vinegar and baking soda together is like pushing the two magnets together and the explosion is like the magnets flying apart.
    - examples: baking bread, activation of an air bag, glow stick, or hand warmers, stored chemical energy in batteries, stored chemical energy in gasoline, food

Stored mechanical energy: Energy stored in objects by the application of force. This type of energy is stored when things are compressed.

- demo: snakes in a can, or other spring toy
- examples: a compressed spring, stretched bow ready to fire an arrow, a stretched rubber band

Conclusion:

Why is energy important?
Looking for:
Cause light (like a light bulb)
Cause heat (like a fire)
Cause sound (like cymbals)
Cause motion (like the motor in a car)

Energy has the ability to create light, heat, sound, motion, and all other sorts of changes in our world. The tools and machines we have convert energy into other forms of energy (like light or heat); power plants convert stored energy into electrical energy to be used in these machines; the original energy is created by plants, or other natural phenomena.

Fruit Batteries

Objectives

After completing this lesson, students will understand that

- Potential energy is stored energy.
- Chemical potential energy is stored in chemicals like lemon juice.
- Electrical potential energy is stored in metals like copper and zinc.
- A fruit battery's potential energy can be measured using its voltage.

Preparation

Location :

A typical classroom with group table space works well.

Safety:

Watch for sharp edges on the copper and zinc electrodes.

Student Knowledge

To get the most from this lesson, a student should know:

- How a basic electrical circuit with a voltage source and a resistor works

Instructor Knowledge

An instructor should be able to converse scientifically about these topics:

- Batteries
- Electricity

These resources might be helpful for preparation:

- Fruit Battery - http://chemistry.about.com/od/chemistryhowtoguide/a/fruitbattery.htm

Materials:

Item	Description	Qty	Where?	Est. Cost
Fruits	lemon, lime, orange, grapefruit	1 per group of 3	Dining hall	none
Copper and zinc electrodes		1 pair per group of 3		
Multimeters		1 per 2 groups of 3		
Wires		2 per group of 3		
LEDs		1 per group of 3		

Lesson

Introduction:

What things produce electricity?

Looking for:

Battery, solar cell, generator, lightning, etc.

How can we measure electricity?

Looking for:

Hook the electricity source up to a light bulb, LED, any electrical device, multimeter, etc.

Activity 1: Measuring voltage

Give each group of 2-3 a fruit, copper and zinc electrodes, and a multimeter.

Have them set up the fruit battery.

Talk about potential energy.

- Potential energy is stored energy.
- Gravitational potential energy is stored in how high up things are.
- Chemical potential energy is stored in chemicals like lemon juice.
- Electrical potential energy is stored in metals like copper and zinc.
- A fruit battery's potential energy can be measured using its voltage.

Have them measure the voltage with the multimeter.

Activity 2: Measuring current

Have them connect several fruit batteries in series using alligator clip wires and LEDs.

Talk about current.

- When you connect a fruit battery to something like an LED, current flows through the circuit.
- The current lights up the LED.

Have them measure the current with the multimeter.

Conclusion:

Fruit batteries can produce electricity, but not a lot of it. You need to put several fruit batteries together to get enough voltage to light an LED.

Fossil Fuels

Objectives

After completing this lesson, students will

- Understand the difference between renewable and non-renewable sources of energy
- Understand where fossil fuels come from and how they are made
- Recognize the dilemma of energy efficiency versus availability
- Understand that fossil fuels are limited and will eventually run out
- Realize that fossil fuels are our main source of energy today

Preparation

Location :

A typical classroom with group table space works well.

Safety:

Fossil fuel burning demos present fire hazard – complete these outside with adequate safety precautions.

Student Knowledge

To get the most from this lesson, a student should know:

- Energy can be stored
- What energy is/what it can do

Instructor Knowledge

An instructor should be able to converse scientifically about these topics:

- Fossil fuels (definition and formation)
- Energy efficiency
- Limits of fossil fuels
- Renewable resources (distinction w/non-renewable)

These resources might be helpful for preparation:

- DOE site on fossil fuels http://www.fe.doe.gov/education/energylessons/coal/gen_howformed.html
- Fossil fuel info site http://www.green-planet-solar-energy.com/fossil-fuel-formation.html

- Wikipedia on Ethanol http://en.wikipedia.org/wiki/Ethanol
- Whoosh bottle videos
  http://www.stevespanglerscience.com/content/science-video/whoosh-bottle

Materials

Item	Description	Qty	Where?	Est. Cost
Water cooler water bottle		1	TBA	$15
Peat brick		1	Harvey's	$10
Flammable liquid (i.e. gasoline, acetone)		10 mL	Chem lab	$0-1
Dried leaves		Handful	Soccer field	$0

Lesson

Introduction:

What did you just learn in the previous demonstration?
Looking for:
Energy can be stored, chemical energy in organic materials (fruit)

Does your car run on lemons?
What does it run on?
Looking for:
Gasoline, oil, maybe fossil fuel

Does anyone know what a fossil fuel is, what gasoline is made of?
Looking for:
Ancient, chemically modified organic matter

What are fossil fuels?

We begin by telling them what fossil fuels are and how they formed

- What is a fossil fuel?
  - *Looking for: fossil → something really old that used to be alive*
  - *Looking for: a way of storing energy in dead stuff*
- What are some examples of fossil fuels?
  - *Looking for: gasoline, coal, natural gas*
- Where do fossil fuels come from?
  - *Looking for: things that used to be living, like grass*
  - *Have you ever burnt dead wood or dead leaves?*

Show them the dried leaves and talk about how we could burn it to get energy.

Show them a timeline of fossil fuel creation and bring out a peat brick to show the next step in the creation of a fossil fuel (leaves get compressed and turn into peat brick)

Moving along the timeline we talk about coal, oil, and natural gas, the way they were formed through years of heat and pressure (show picture of layers of fuel)

- Which one of these fuels do you think stores the most energy?
  Looking for coal, oil, natural gas

Burn the three materials (lights out) in order of age, whoosh bottle for gasoline

- What was the brightest burn, which had the most energy?
  Looking for: gasoline
- Why does the gasoline have more energy?
  Looking for: more time to compress, more densely packed

Give ratio of how much grass-like material it takes to create gasoline

- Which of these do we use most today?
  Looking for: gasoline
- Which of these do we have the most of?
  Looking for: grass, harvestable plants

Conclusion:

Important concept is the trade-off between efficiency and availability, reinforce the limited availability of current resources, and the need for a powerful renewable energy source

Show when current resources are expected to run out using chart

- What's wrong with this picture?
  Looking for: we don't have a lot of what we need and we use it fast
- What can we do about this?
  Looking for: find new sources of energy that are efficient and available
- Can you think of anything that meets these requirements?
  Looking for: Sun

Solar Cells

Objectives

After completing this lesson, students will

- Understand how solar cells work
- Understand the concept of efficiency, understand issue of solar cell size

Preparation

Solar cell building activity comes from:
http://worldwatts.com/homemade_solar_cell/homemade_solar_cell.html

Because of the time it takes for copper to heat and cool, the heated copper plates will need to be prepared in advance for the students. Follow the instructions from the website to correctly prepare the copper.

Location :

A typical classroom with group table space works well.

Safety:

Instructors should work safely under fume hoods to prepare the copper.

Student Knowledge:

To get the most from this lesson, a student should:

- Understand the tradeoffs of various sources of energy: i.e. fossil fuels are good source of power, but not infinite. Solar energy may be infinite, but it's not very well concentrated
- Understand different forms of energy: i.e. electrical, chemical, etc
- Understand the concept of current

Instructor Knowledge:

An instructor should be able to converse scientifically about these topics:

- Photoelectric Effect
- Solar energy

These resources might be helpful for preparation:

- http://worldwatts.com/homemade_solar_cell/homemade_solar_cell.html
- http://en.wikipedia.org/wiki/Photoelectric_effect

Materials:

Item	Description	Qty	Where?	Est. Cost
1 sheet of cuprous oxide		1 pair / team	Copper flashing, heated by stove, pre-prepared	$5/square foot
1 sheet of copper flashing		1 sheet/team	Copper flashing	$5/square foot
½ plastic water bottle, top cut off		1 / team	Recycling, Olin trash rooms	No cost
Salt water, approx. 2 gallon		2 gallons/activity	Need containers	$3.00 for salt

Lesson

Introduction:

What's your favorite thing that you have that's electronic?
Looking for:
Cell phone, playstation, computer, Xbox, etc.

Where does the power come from?
Looking for:
From batteries, from outlets, etc.

If the electricity were out, and we needed power, where else could we get it?
Looking for:
From the wind, from the sun, from water

Let's talk about the sun. Can you think of anything that you see every day that gets its energy only from the sun?
Looking for:
Plants

Plants get their energy from the sun and use photosynthesis to make it into plant food. Unfortunately, plant food isn't very useful for running your iPod. We need to get energy in a form that we can use to do lots of different things. Does anyone have an idea what kind of energy that is?
Looking for:
Electricity, electrical energy, electrical power, etc

What we really want is a way to access the same source of infinite energy that plants do and make electricity from it.

There's a special class of materials called photovoltaic materials (write photovoltaic on the board) that can make electrical energy from solar energy.

(Draw a plane of material on the board. Draw the sun, and draw waves of energy coming down and striking the material.)

When solar energy, or light energy, shines on these materials, they accumulate a small amount of energy. So why can't you use these materials as batteries? The problem is that the materials can't store very much energy, so if you want to use it, you need to give it somewhere to go. What do we need to do that?

Looking for: complete a circuit, connect a wire, hook up a light, anything indicating understanding of allowing a current to flow.

Draw a wire at the end of the sheet, and draw an arrow indicating flow of energy. Label it energy.

Now you are going to build a solar cell of your own. (Start activity)

Activity:

Taken from http://worldwatts.com/homemade_solar_cell/homemade_solar_cell.html

“Take both the sheet of copper and the pre-prepared sheet of cuprous oxide. Bend both pieces gently, so they will fit into the plastic bottle or jar without touching one another. The cuprous oxide coating that was facing up on the burner is usually the best side to face outwards in the jar, because it has the smoothest, cleanest surface.

Attach the two alligator clip leads, one to the new copper plate, and one to the cuprous oxide coated plate. Connect the lead from the clean copper plate to the positive terminal of the meter. Connect the lead from the cuprous oxide plate to the negative terminal of the meter.

Now mix a couple tablespoons of salt into some hot tap water. Stir the saltwater until all the salt is dissolved. Then carefully pour the saltwater into the jar, being careful not to get the clip leads wet. The saltwater should not completely cover the plates -- you should leave about an inch of plate above the water, so you can move the solar cell around without getting the clip leads wet. “

Conclusion:

Explain how the cuprous oxide is a photovoltaic material, and reiterate how the solar cell works

Revisit the other energy concepts from earlier in the day (what is energy? What types of energy are there?) as a final wrap-up, going as in-depth as time permits