5TH GRADE CURRICULUM

5^{TH} GRADE CURRICULUM
Ending project: Energy Use Investigation of the School Computers

Lesson I: 5^{th} Grade
What is Energy?
- Brainstorming activities to begin discussion

Lesson 2: 5^{th} Grade
What is Energy?: Investigations
- Experiments exploring energy conversion (ex. running in place–mechanical energy into thermal energy)
- Create Energy Matrix Conversion Charts
- Candle burning experiment–discuss potential energy

Lesson 3: 5^{th} Grade
Reading EnergyGuide Labels
- Introduces the EnergyGuide labeling system for home appliances created by the U. S. Department of Energy (DOE)
- Teach students why this system is important
- Discuss how it could affect their families, and
- Teach students how to read the Energy Star Labels.

Lesson 4: 5^{th} Grade
Reading a Utility Bill
Understanding Electricity: Watts and Kilowatt Hours (kwh)
- Provide students with the basic framework of our relationship with the utility company–how to de-code energy use and how to read the electricity portion of an utility bill.

Lesson 5: 5^{th} Grade
Understanding Watts: Voltage, Current, & Resistance
- Discussion of current, voltage & resistance
- Exploration of what a watt represents

Lesson 6: 5^{th} Grade
Lighting Comparison Study
CFLs and Incandescent Lighting
- Experiment with measuring temperatures of different kinds of light bulbs
- Discuss energy efficiency
- Life cycle analysis exercises

Lesson 7: 5^{th} Grade
Energy Use Investigation: How to Use a Watt Meter
- Basic lesson on watt meters–what / how they measure
- Measuring the energy use of everyday appliances

Lesson 8: 5th Grade

Computer Energy Use Investigation

- Create hypotheses for project discoveries
- Create action plans for project execution

Lesson 9: 5th Grade

Continue the Computer Energy Use Investigation: Measuring

- Measure with computer energy use with watt meters
- Compile and graph data

Lesson 10: 5th Grade

Report Findings of Computer Energy Use Investigation: Chart & Graph Findings

- Compile Computer Energy Use findings–create visual and textual

Lesson I: 5th grade
What is Energy?

Lesson Overview: All life and action in the world involves some form of energy.
Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Materials:
- Large white paper for note-taking

Standards:
- English:
  - IX.11.LE.1 (Inquiry & Research: Generate questions about important issues that affect them or topics about which they are curious, and use discussion to narrow questions for research).
- Mathematics:
  - III.1.LE.4 (Data Analysis & Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
- Science:
  - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: 1 class period (40 – 50 minutes)

Class Structure: whole class experiments and discussion

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1

Lesson I: 5th grade
What is Energy?

This lesson is an introduction and exploration of what is energy. This lesson focuses on physical movement–student's moving their bodies and moving objects with their bodies–as one way of beginning to think about energy.

This Lesson is review material of lessons learned in K - 4th grades.

Lesson Overview: All life and action in the world involves some form of energy.
Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Supplies Needed:
- Large white paper for note-taking

Background Information:
The primary focus is on mechanical energy / our bodies in motion. Often, physical movement is a good starting point for introducing larger–more complex–issues. During this lesson, the focus is for students to realize that 'energy' is an integral part of their life–they cannot live and move without 'energy'.

Mechanical energy can be understood as the moving of any mass through space (air). This basically includes any physical actions that take place in the world. Therefore, using our bodies as examples to demonstrate mechanical energy is a good starting place. But, please do not stress that our bodies are machines. Mechanical does not mean mechanistic. We are much more that machines, even in the world of physics.

At this point (if this is not the first year teaching the E.E.K! for Sustainable Development curriculum), the students hopefully have a deep understanding of energy conversion, potential energy, and renewable and non-renewable forms of energy. Therefore, Lesson 1 and Lesson 2 should be a quick review of previously learned lessons.

CLASS EXERCISES: Review Material

I. Brainstorming 'What is Energy?' with the class
   - Ask the class the question: what do you think energy is?

Write down all the responses. Write down the responses on a large piece of paper that you can keep posted somewhere in the classroom for the entire module or bring out throughout the module for reference (we suggest 18 x 24 heavy duty construction paper or poster board).
Prompts:
- Does your body use energy? When?
- Where does your energy come from?
- How do plants grow? What do they need in order to grow and be healthy?
- How do animals (other than humans) grow? What do they need in order to grow and be healthy?
- How does your body grow? What do you need in order to grow and be healthy?

II. Brainstorming 'How Do We Use Energy Everyday?' with the class:

- As a class discussion or in small group discussions, ask the class, "What are some ways in which we use energy every day?" They may respond with object-related answers, i.e. take the bus to school, use a toaster, the refrigerator keeps my food cold, etc. Discuss the energy source of each of their ideas. Then, shift the focus by asking the following lead questions–leading the discussion to how energy affects their bodies and the motion of their bodies.

- Write down all of these responses also as you did above on a large piece of paper that can be posted in the classroom.

Lead Questions:

- What happens if you rub your hands together very quickly?
- What happens if you run around the track as fast as you can 5 times?

Both answers include: you produce heat. Heat is a form of energy called thermal energy. You move your body (mechanical energy) and heat is produced. The mechanical energy is transformed into thermal energy.

Lead Questions:

- How does your body get energy? (from food)
- Does food have energy? (yes, embodied energy)
- Does all food provide you with the same amount of energy? (No, different types of food have different amounts of embodied energy.)
    - What might you eat if you wanted a long and sustaining amount of energy?
    - What might you eat if you wanted a short burst of energy?

III. Forms of Energy

Write the following 4 different forms of energy on 18x24 pieces of construction paper or poster board (use different colors for each form of energy) and place on the board or wall where the class can see them.

4 Forms of Energy:
Mechanical energy
Thermal energy
Chemical energy
Electrical energy

Have the students brainstorm, either in small groups or as a whole class, different examples of each form of energy. After they have compiled at least three examples for each form of energy, compile all the answers in a visible place in the room (on the wall, board, etc.). Encourage the students to openly discuss all possibilities for different examples of the 4 forms of energy being discussed.

Teacher's Note: If the students are already fluent in understanding different forms of energy, have them create examples of energy conversions where the outcome of the end energy conversion is an example of each form of energy. For example, running in place is an example of creating thermal energy.

Lesson 2: 5th grade
What is Energy?: Investigations

Lesson Overview: All life and action in the world involves some form of energy.
Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Materials:
- Large white paper for note-taking
- 4 different colors of construction paper or poster board
- Black marker
- Dynamo flashlight
- Hotplate
- Tea Kettle with functioning whistle
- Crackers
- Vortex blender
- Frozen fruit & juice (smoothie ingredients)
- Pillar candle
- Matches

Standards:
- English:
  - IX.11.LE.1 (Inquiry & Research: Generate questions about important issues that affect them or topics about which they are curious, and use discussion to narrow questions for further exploration).
- Science:
  - I.1.LE.1 (Construct New Scientific and Personal Knowledge: Generate reasonable questions about the world based on observation).
  - II.1.LE.4 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
  - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).
  - V.1.LE.4 (Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts: Describe uses of materials taken from the earth).
- Social Studies:
  - II.2.LE.2 (Geographic Perspective: Describe the location, use, and importance of different kinds of resources and explain how they are created and the consequences of their use).
  - II.2.LE.4 Geographic Perspective: Explain how various people and cultures have adapted to and modified the environment).

Timeline: 2 class periods (40 – 50 minutes each)

Class Structure: whole class & small group experiments and discussion

Assessment Strategy: EEK! Daily Assessment, General Assessment Strategy #1

Lesson 2: 5th Grade
What is Energy?: Investigations

This lesson picks up directly where Lesson 1 ended. Students will lead self-directed experiments and discuss energy conversions.

This Lesson is review material from lessons learned in K – 4th grades.

Lesson Overview: All life and action in the world involves some form of energy.
Lesson Concept: Any physical process that takes place in the world involves mechanical energy.

Supplies Needed:
- Large white paper for note-taking
- 4 different colors of construction paper or poster board
- Black marker
- Dynamo flashlight
- Hotplate
- Tea Kettle with functioning whistle
- Crackers
- Vortex blender
- Frozen fruit & juice (smoothie ingredients)
- Pillar candle
- Matches

Background Information:
Even though there are other forms of energy, this lesson will continue to focus on the four discussed in Lesson 1.
4 Forms of Energy:
Mechanical energy
Thermal energy
Chemical energy
Electrical energy

CLASS EXERCISES: Review Material
I. Energy Conversions
- Have the students create the following experiments:

1. Rubbing Hands Together–mechanical into thermal
   Rubbing your hands together creates friction. Whenever two 'things' create friction, heat is created.
2. Running in Place–mechanical into thermal
   You run (mechanical) and your body begins to increase in temperature (thermal) and create body heat

3. Eating crackers–mechanical into chemical

   You chew the crackers (mechanical) and then after swallowing the crackers, your body begins the process of digesting the crackers (chemical) and extracting the embodied energy stored in the crackers to fuel your body.

4. Dynamo Flashlight–mechanical into electrical

   Pumping your hand on the handle (mechanical) moves gears inside the flashlight (mechanical to mechanical) the gears spark an electrical current (mechanical into electric) and the light turns on as long as you continue to pump the handle.

5. Heating Water on a Hot Plate–electrical into thermal

   The hot plate uses electricity (electrical energy). As the water molecules are excited (mechanical energy) the water becomes hot (thermal energy).

6. Boiling Water in a Kettle–thermal into mechanical

   The boiling water (thermal energy) forces steam (chemical energy) through the whistle on the kettle and produces a sound (mechanical energy).

7. Vortex Blender–mechanical into mechanical

   Turning the crank by hand (mechanical energy) moves the gears (mechanical energy) inside the blender.

III. Stating results:

After completing the experiments use large sheets of paper to create a class Energy Conversion Matrix Chart. Below is an example of what one could look like to explain the energy conversions in the above experiments.

Energy Conversion Chart

From → To ↓	**Mechanical energy**	**Thermal energy**	**Chemical energy**	**Electrical energy**
Mechanical energy	Vortex Blender	Tea kettle whistling		
Thermal energy	Friction: rubbing hands together Running in place			Heating water
Chemical energy	Eating crackers	Boil water		
Electrical energy	Dynamo flashlight			

- Ask students to try and explain energy conversion in their own words. One way to explore this is to ask the students to explain what happened in Class Exercise #1–rubbing your hands together. (We begin with our hands at rest, then put them in motion, and then create heat.)
- One way to explain energy conversion is: "We begin with an action. But, during that action a change takes place and our end result is that we now have something different–something that we didn't begin with."
- Another way to think of the overall concept for yourself is: There is a **potential to create energy and a result of creating energy** (potential energy is discussed later in the Lesson for the students).

IV. Potential Energy: Candle Burning Exercise

- This exercise is also taught in 2nd, 3rd, and 4th grades.
  - If the students have already had this lesson and understand embodied energy then skip the Candle Burning Exercise.
  - Lessons 1 and 2 have been a quick review of the previous grades' lessons.
  - Lesson 3 begins completely new information and learning not previously taught in K - 4th grades.

Background Information:

Everything in the world has potential energy that can be converted into useable forms of energy. Your body, for example, has potential energy. It can move objects, squeeze flashlight handles, jump in the air. Here is another way to think about potential energy: food has potential energy stored inside of it. We eat the food and are able to run, jump, and think. The sun has potential energy and it can heat objects that absorb its energy.

REVIEW:

I. Dynamo Flashlights

Remember the Dynamo Flashlights? (Demonstrate the Dynamo and pass around the class).

- Discuss how the Dynamo flashlight works and the energy conversions involved in order to create the light. Ask the following questions:
  - What action causes the light to turn on? (Squeezing the handle with your hand causes the light to come on).
  - Do you remember the energy conversion that takes place? (At this point, you could hang up the colored pieces of paper from Lesson 2 that illustrated the sequence of the energy conversion.)
  - Energy conversion sequence: the motion of your hand squeezing the handle back and forth (mechanical energy to mechanical energy) turned gears inside the flashlight (mechanical energy to mechanical energy) that sparked wires (mechanical energy to electrical energy) and caused the light to come on (electrical energy to electrical energy). The mechanical energy was ultimately transformed into electrical energy.
  - Question: In the Dynamo flashlight experiment, what 2 things have potential energy? (your body and the Dynamo flashlight)

CLASS EXERCISE:

After discussing the above ideas about potential energy lead the Candle Burning Experiment. Refer to the Energy Conversion Matrix the class created earlier.

I. Candle Burning Experiment: this is a teacher-only led experiment

Have the students gather around a table and place the candle on the table.

Supplies: 1 large pillar candle
Matches
Large glass jar (mayonnaise size)

The Main Concept of this experiment is to demonstrate a potential energy source

- Place the candle on the table
- Play a version of "Simon Says" with the students. Ask the students to take turns around the circle and direct you through the process of lighting the candle. If they miss a step, you will stop, make some sort of funny sound, and the next person has a turn.

Candle Lighting Steps: students take turns directing you (example of possible answer scenario below):

- Pick up the box of matches
- Open the box of matches
- Take a match out of the box
- Strike the match on the box
- Move the match over next to the wick
- Light the wick
- Blow out the match
- Put the extinguished match down in a safe place
- Close the box of matches

Now, the candle is lit. Have the students go through the same process out loud to figure out how the candle is staying lit.

Possible prompt questions for the students below: questions in green and responses in blue

- What happens to the candle as it burns?

The wax melts and forms a puddle at the base of the wick.

- What is the wick doing?

The wick is fueling the flame. The wick wicks up the wax from the melted puddle. The wick, through wicking up the wax, keeps the combustion reaction happening.

- How does the wick stay lit?

The wick stays lit because it is coated in wax.

- What happens if we cover the candle with glass jar?

The flame will die out. It needs the oxygen from the air to keep lit (keep burning, continue the combustion process).

- Why doesn't the entire candle melt instantaneously?

When something burns a combustion reaction occurs. The candle burning is a combustion reaction. Combustion reaction occurs depending on the amount of the fuel source and the amount of available oxygen in the air. The fuel source is the melted wax puddle created at the base of the wick. When we place the glass jar over the flame, we limit how much oxygen is available to "feed the flame". ****TEACHER NOTE: Rate limiting effect of combustion is how much oxygen is available to continue the combustion effect. ****

- What is the potential energy?

The candle is the potential energy.

- What is the fuel source?

The melted wax is the fuel source. And, the wick keeps the fuel source available for use.

- Have the students describe the change in energy (the energy conversion) that takes place during the Candle Burning Experiment. If they seem stumped, refer to the Energy Matrix Chart that has been created during Lessons 1 & Lesson 2.

Energy Conversion for Candle Burning Experiment
Chemical Energy to Thermal Energy:
The motion of your hand striking the match: mechanical energy
The match lighting: chemical energy
The candle burning: chemical energy
The candle creates heat: thermal energy

II. After finishing the Candle Burning Experiment, have the students re-cap 'what is potential energy' through the following actions. Also, have them map the energy conversions first and then ask what is the energy potential source.

- Jump in the air

Mechanical energy to mechanical energy: legs bend (mechanical energy) and jump into the air, your body pushes through the air around itself (mechanical energy) and then lands on the floor and makes a sound (mechanical energy). Potential energy: your body

- Run in place for 1 minute

Mechanical energy to thermal energy: legs move back and forth (mechanical energy), as your body is moving it begins to heat (thermal energy). Potential energy: your body

Lesson 3: 5th grade
Reading EnergyGuide Labels

Lesson Overview: Not all appliances use the same amount of energy.
Lesson Concept: Energy Star Labels contain important consumer information to help families purchase energy efficient appliances.

Materials:

- EnergyGuide student hand-outs (or use as overhead)
  - What is an EnergyGuide
  - EnergyGuide Game Cards
- Pencils
- Paper

Standards:

- English:
  - VIII.10.LE.3 (Ideas in Action: Use oral, written, and visual texts to research how individuals have had an impact on people in their community and their nation).
- Mathematics:
  - III.1.LE.1 (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
  - III.1.LE.4 (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
- Science:
  - II.1.LE.4 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
  - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: 1 class period (40 – 50 minutes each)

Class Structure: small group lesson and discussion

Assessment Strategy: EEK! Daily Assessment
Pre-Module Assessment Questions #1, #2, #3

Lesson 3: 5^{th} Grade
Reading EnergyGuide Labels

This lesson

- introduces the EnergyGuide labeling system for home appliances created by the U. S. Department of Energy (DOE);
- teaches students why this system is important;
- discusses how it could affect their families; and,
- teaches students how to read the Energy Star Labels.

Lesson Overview: Not all appliances use the same amount of energy.
Lesson Concept: Energy Star Labels contain important consumer information to help families purchase energy efficient appliances.

Supplies Needed:

- EnergyGuide student hand-outs (or use as overhead)
  - What is an EnergyGuide
  - EnergyGuide Game Cards
- Pencils
- Paper

Background Information:

Verify the students have the basic understanding of the following:

- What is energy?
- What are the different forms of energy?
- Energy changes from one form to another. Energy cannot be created or destroyed. (No net energy is lost in energy conversion).
- In order to make anything happen in the world, energy converts from one form to another.

In this lesson, we begin discussing how energy use affects our daily lives–whether we realize it or not.

> The following information for this lesson has been compiled from the *Consumer Guide to Home Energy Savings* by Alex Wilson and John Morrill. This book is the definitive resource for information on the most energy efficient appliances on the consumer market. This book is published by the American Council for an Energy-Efficient Economy (ACEEE) in Washington , D.C. and updated editions are published usually every 2 years. They also publish a a separate book on energy efficient automobiles.

I. What is an EnergyGuide Label?

Federal law requires that EnergyGuide labels be placed on all new appliances including:

- refrigerators
- freezers
- water heaters
- dishwashers
- clothes washers
- room air conditioners
- central air conditioners
- heat pumps
- furnaces
- boilers

These labels are bright yellow with black lettering.

The EnergyGuide labels provide the consumer with the amount of energy per year the unit (appliance) will consume. It will also indicate the range of annual energy consumption for models similar in size and type. The label also estimates how much money it will cost to operate the appliance for a year.

II. Why are EnergyGuide labels important?

It is important for consumers to know how much energy an appliance will consume every year. Energy consumption affects multiple quality of life issues by affecting the world we live in (pollution issues) and our family's pocketbook.

*Teachers Note: Add information from the Teacher's Notes here to discuss CO_2 emissions, greenhouse effect and global warming, U.S. energy consumption, world-wide energy consumption, and how purchasing more energy efficient appliances *CAN MAKE A DIFFERENCE*.

CLASS EXERCISES:

I. Reading EnergyGuide Labels

- Hand out the EnergyGuide Labels to discuss what each line of information represents and how to read the labels.

II. Energy Label Game

- Divide the class into small groups of 3-5 students.
- Hand out the EnergyGuide Label Packs and have students determine which appliance is the best purchase and why.

Teacher's Note: There are two appliances represented in the Packs–dishwashers and laundry machines. Have the students consider multiple variables in determining the total energy used by each appliance. Encourage / lead the following questioning:

- Do you need more information about each appliance? If yes, such as what?
- Are they the same size (capacity)?
- How much water do they each use?

- How are residents charged for water?
- How fast does the clothes washer spin? Is this important to find out? Why? (to determine how much water is wrung out of the clothing before it goes into the dryer)
- Do you need to rinse the plates before they go into the dishwasher? How much– completely clean of food or not?

Based on standard U.S. Government tests

ENERGYGUIDE

Refrigerator-Freezer
With Automatic Defrost
With Side-Mounted Freezer
Without Through-the-Door-Ice Service

XYZ Corporation
Model ABC-W
Capacity: 23 Cubic Feet

Compare the Energy Use of this Refrigerator with Others Before You Buy.

This Model Uses
776 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	**Uses Most Energy**
776	**1467**

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only models with 22.5 to 24.4 cubic feet and the above features are used in this scale.

Refrigerators using more energy cost more to operate.
This model's estimated yearly operating cost is:

$64

Based on a 1992 U.S. Government national average cost of 8.25¢ per kWh for electricity. Your actual operating cost will vary depending on your local utility rates and your use of the product.

This label indicates this refrigerator is the most efficient model on the market.

EnergyGuide Label Game: Clothes Washer (4)

Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard

Model(s) MAYTAG FAV6800 FAV9800

Compare the energy use of this clothes washer only with other models tested using the 2004 test procedure.

This Model Uses 328 kWh/year

ENERGY STAR A symbol of energy efficiency

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
177	1298

kWh/year (kilowatt-hours per year)is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$27 When used with an electric water heater

$15 When used with a natural gas water heater

Based on eight loads of clothes a week and a 2000 U.S. Government national average cost of 8.03¢ per kWh for electricity and 68.8¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 C.F.R. Part 305)

Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard

Whirlpool Corporation
Model: 1KDJKVR(4C)

Compare the Energy Use of this Clothes Washer only with other Models tested using the 2004 Test Procedure.

This Model Uses
506 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
177	1298

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$41 when used with an electric water heater

$20 when used with a natural gas water heater

Based on eight loads of clothes a week and a 2000 U.S. Government national average cost of 8.03¢ per kWh for electricity and 68.80¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 CFR Part 305).

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Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard
Top Loading

XYZ Corporation
Model(s) MR328, XL12, NAA83

Compare the Energy Use of this Clothes Washer with Others Before You Buy.

This Model Uses
873kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
267	1818

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size, top loading clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$72 when used with an electric water heater

$28 when used with a natural gas water heater

Based on eight loads of clothes a week and a 1992 U.S. Government national average cost of 8.25¢ per kWh for electricity and 58¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard

Whirlpool Corporation
Model: 17BJKV0(4C)

Compare the Energy Use of this Clothes Washer only with other Models tested using the 2004 Test Procedure.

This Model Uses
595 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
177	1298

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$48 when used with an electric water heater

$23 when used with a natural gas water heate

Based on eight loads of clothes a week and a 2000 U.S. Government national average co: of 8.03¢ per kWh for electricity and 68.80¢ per therm for natural gas. Your actual operati cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 CFR Part 305).

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EnergyGuide Label Game: Dishwasher (3)


Based on standard U.S. Government tests.

ENERGYGUIDE

Dishwasher
Capacity: Standard

Model(s)
FDR252

Compare the Energy Use of this Dishwasher with Others Before You Buy.

ENERGY STAR A symbol of energy efficiency

This Model Uses
387 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy 222

Uses Most Energy 653

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only Standard size dishwashers used in this scale.

DISHWASHERS using more energy cost more to operate. This model's estimated yearly operating cost is:

$33 When used with an electric water heater

$18 When used with a natural gas water heater

Based on five wash loads a week and a 2003 U.S. Government national average cost of 8.41 ¢ per kWh for electricity and 81.6 ¢ per therm for natural gas.

Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 C.F.R. Part 305).

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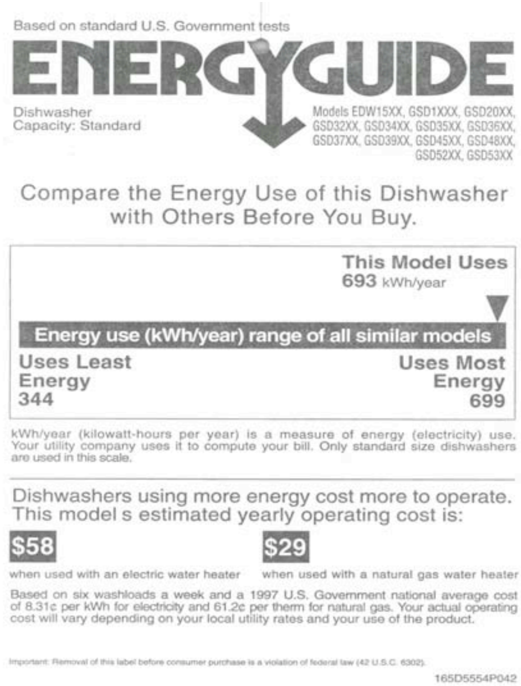

Based on standard U.S. Government tests

ENERGYGUIDE

Dishwasher
Capacity: Standard

Models EDW15XX, GSD1XXX, GSD20XX, GSD32XX, GSD34XX, GSD35XX, GSD36XX, GSD37XX, GSD39XX, GSD45XX, GSD48XX, GSD52XX, GSD53XX

Compare the Energy Use of this Dishwasher with Others Before You Buy.

This Model Uses
693 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy 344

Uses Most Energy 699

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size dishwashers are used in this scale.

Dishwashers using more energy cost more to operate. This model s estimated yearly operating cost is:

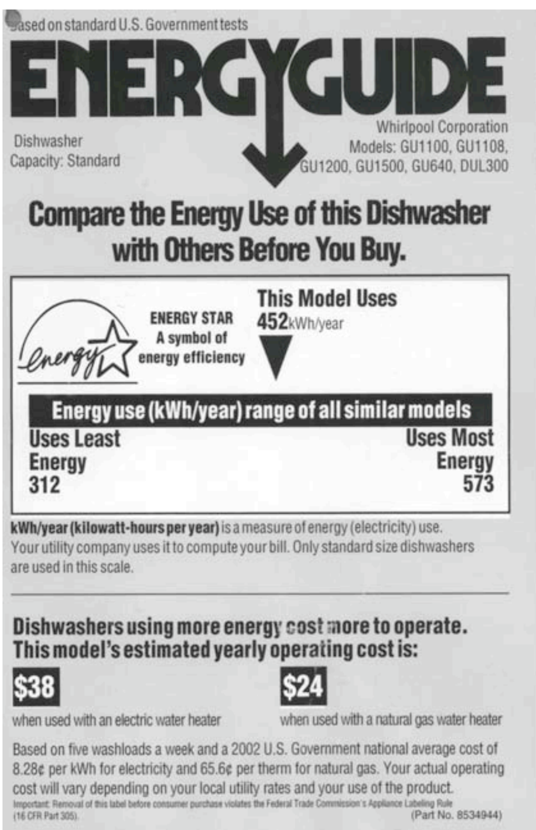
$58 when used with an electric water heater

$29 when used with a natural gas water heater

Based on six washloads a week and a 1997 U.S. Government national average cost of 8.31¢ per kWh for electricity and 61.2¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302).

165D5554P042


Based on standard U.S. Government tests

ENERGYGUIDE

Dishwasher
Capacity: Standard

Whirlpool Corporation
Models: GU1100, GU1108, GU1200, GU1500, GU640, DUL300

Compare the Energy Use of this Dishwasher with Others Before You Buy.

ENERGY STAR A symbol of energy efficiency

This Model Uses
452kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy 312

Uses Most Energy 573

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size dishwashers are used in this scale.

Dishwashers using more energy cost more to operate. This model's estimated yearly operating cost is:

$38 when used with an electric water heater

$24 when used with a natural gas water heater

Based on five washloads a week and a 2002 U.S. Government national average cost of 8.28¢ per kWh for electricity and 65.6¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 CFR Part 305).

(Part No. 8534944)

Teacher Background Material

WORLDWIDE ENERGY USE:
Worldwide, approximately 20 billion tons of CO_2 are pumped into the atmosphere each year. With currently 6 billion plus people living on earth, that equals nearly 3.5 tons per every person alive today. (*Consumer Guide to home Energy Efficiency, p.2. www.aceee.org/consumerguide*)

United States:
The United States accounts for 5% of the world's population, but consumes 25% of the world total resource use each year. That places us as the world leaders of per-capita energy use equaling 5 billion tons of CO_2 per year for the United States. On a per capita basis and divided equally, that comes to approximately18 tons for each American, though some produce more or less than others depending on their lifestyle. The typical American family spends nearly $1300 per year on home utility bills. The burning of coal, oil, and natural gas for energy accounts for 85% of carbon dioxide emissions and the largest contributor to air pollution.

World-wide:
Energy use and population are not evenly distributed throughout the world. As a result, two issues become inextricably joined: a growing number of people need access to energy sources *and* large consumers of energy need to decrease their energy consumption. There are a finite amount of fossil fuel sources available. The chart below compares the percentage of population and energy use in different regions of the world. As you will see, overall energy consumption and per capita energy use do not directly correlate to percentage of population. What effect does this uneven distribution of energy use have on societies? One main result is that impoverished, 'undeveloped', countries remain that way. Another is countries may use alternatives to fossil fuel burning for their energy sources.

World Population and World Energy Use (fn*)

Country/Region	**% World Population**	**%Energy Consumption**	**Per Capita Energy Use (kg)**
Middle East / North Africa	4.9%	4.8%	1,374
North America	5.2%	28.6%	7,823
Latin America / Caribbean	8.4%	5.7%	960
Sub-Saharan Africa	10.1%	1.7%	237
Europe / Central Asia	15.4%	33.6%	3,097
South Asia	22.0%	3.4%	222
East Asia / Pacific	33.9%	22.2%	934

The above statistics were compiled by Zero Population Growth.

Global Warming: A working definition

> Technically, the term(s) global warming or global cooling refer to the natural warming and cooling trends that the earth has experienced all through its history. However, the term "global warming" has become a popular term encompassing all aspects of the global warming problem, including the potential climate changes that will be brought about by an increase in global temperatures.
> (ww.climatechangecentral.com/default.asp)

This term has become popularized and is currently used to express an extremely different set of circumstances–than the natural warming trends throughout history–the world's population is now facing.

For the first time in history, people are the direct cause of the warming of the planet. This unprecedented event is upsetting the balance of nature causing climatic shifts that even thus far have proven to be disastrous for all life. The current rate of habitat loss, increase in storm severity, increase in pollution induced illnesses, and the increase in death, and malformation of those living in areas that are exposed to polluted foods, land, and water is intensifying at an alarming rate around the globe.

It is of the utmost importance for the youth of today to have a conscious awareness of their direct complicity in the warming of the planet and to then decide how they might or might not change their actions that directly affect the health of all life on the planet and the life of the planet itself.

Therefore, an encompassing, working definition of global warming can be thought of as:

A gradual warming of the Earth's atmosphere caused by the burning of fossil fuels and industrial pollutants.

Photograph courtesy of Greenpeace. Blomstrandbreen Glacier in Svalbard, Norway. Taken in 1918 (top) and today (bottom), this photograph illustrates the retreat of the glacier approximately 2 km in the past 80 years. Since 1960, the average retreat of that glacier has been about 35 m a year, accelerating in the last ten years.

The Greenhouse Effect

Global warming is often explained through the example of the greenhouse effect. In a greenhouse–a building made of glass or clear plastic–the sun shines through the walls and the heat is trapped inside. The same basic principle applies for regulating the temperature of the earth.

The earth's atmosphere is a complicated system of gases and energy. It allows energy from the sun to pass through to the earth and also allows energy from the earth to escape into space. By delicately balancing this exchange of energy, the atmosphere regulates our climate.

A blanket of invisible gases surrounds the earth. These gases make up the earth's atmosphere. When the sun shines through the earth's atmosphere onto the earth, certain gases such as carbon dioxide and water vapor trap the heat of the sun close to the earth. This is important, because without this blanket of gases, the earth would be very cold and uninhabitable. As the earth absorbs the sun's warmth, it reflects the heat back toward space. When the earth's atmosphere takes in more energy than it releases, this causes the earth to become warmer.

The burning of coal, oil, and natural gas has increased the concentration of certain gases in our atmosphere. Factories, electric power plants, and vehicles that burn fossil fuels to create energy are raising the level of carbon dioxide in the atmosphere.

How does this happen? Fossil fuels consist primarily of hydrocarbons. Hydrocarbons are atoms created from hydrogen and water. When hydrocarbons burn, the carbon combines with oxygen to produce carbon dioxide. When excessive amounts of carbon dioxide build up in the atmosphere, more and more of the sun's heat is trapped in the atmosphere surrounding the earth. In this scenario, rate of greenhouse gas increase exceeds the rate of absorption. The result is a human activity induced climate warming. Carbon dioxide is one of the greenhouse gases believed to cause global warming; others are methane, nitrous oxide, and chlorofluorcarbons (CFCs).

How is this a problem? A rise in temperature, even a degree, can wreck havoc on the balance of ecosystems. At this point, scientists have documented an increase of nearly one degree Fahrenheit in the past century. The rising global temperatures are the most serious threat of global warming.

The Warming Trend: Can a few degrees make a difference?

Throughout history, major shifts in temperatures have occurred at a very slow rate–usually changing only a few degrees over thousands of years. However, over the last century, scientists have documented a 1° F rise in the temperature of the planet. If temperatures continue to rise at this rate, climate scientists predict that global warming will raise the average temperature of the planet by 3 to 10 degrees Fahrenheit over the next 80 years.

How much of a difference can a few degrees make? The answer is simply: a few degrees in global temperature change can have drastic affects on the planet. The warming trend increases the intensity of both droughts and storms such as hurricanes, tornadoes, and flooding. Since 1995, more than 5,400 square miles of Arctic ice shelves have melted causing rises in sea-levels around the world. Given that 70% of the earth's surface is covered by water, low-lying parts of the world are now much more vulnerable to flooding and the devastation that follows. Variability in temperature, precipitation, soil moisture, humidity, and wind can increase susceptibility or growth of diseases and pest resistance, and change the natural occurrence of fires, droughts, and floods. Varieties of plants and animals including coral reefs and pine forests are incapable of shifting habitat and are in rapid decline. Climate shifts can also affect food supplies, and the availability of shelter, space, and water for all.

This change in climate is likely to accelerate in the next century and could continue until several decades after the greenhouse gas concentrations reach a peak. (When that peak occurs specifically depends on how we choose to live our lives).

As studies suggest, according to the EPA (Environmental Protection Agency), breathing smoggy air containing fine pollution particles can be as dangerous as breathing second hand cigarette smoke. (Photo courtesy EIA: the air over the Los Angeles, California is hazy with pollution).

Global Warming and Increased Health Problems

Infectious disease is the second major threat that global warming poses to human health. Scientists at Harvard Medical School have linked recent U.S. outbreaks of dengue fever, malaria, and hantavirus to climate change. As temperatures increase, formerly cool areas become new habitats for disease-carrying mosquitoes and rodents. These creatures are the vectors for diseases that more commonly thrived in tropical climates.

Since 1990, outbreaks of locally transmitted malaria have occurred in California, Florida, Georgia, Michigan, New Jersey, and New York. The Intergovernmental Panel on Climate Change (IPCC) predicts that as warmer temperatures spread north and south from the tropics and to higher elevations, malaria-carrying mosquitoes will spread with the shifting climates. This may put as much as 65% of the world's population at risk of infection. This is an increase of 20% within the next century.

EnergyGuide Labels and Home Appliance Use:
The EnergyGuide Program helps inform consumers about the energy use of an appliance before they purchase it. The Environmental Protection Agency (EPA) and the Department of Energy (DOE) have even taken the labeling system one step further to create the ENERGY STAR® label to help consumers identify energy-efficient appliances, computers, lighting, and home entertainment equipment. Through increasing consumer information and increasing consumer purchasing of more energy efficient models of appliances and products (and therefore encouraging industries to build more energy efficient products), the overall amount of CO_2 emissions can be decreased. One kilowatt-hour (kWh) of electricity equals over two pounds of CO_2. Reducing CO_2 emissions by a few tons per year, especially in the energy gluttonous United States, can make a tremendous difference. This is an example of how individuals can make a difference through their everyday actions and purchases.

To directly view the Energy Star Ratings labeling system visit www.energystar.gov

A few bits of general appliance information:

- The average American family of three will open their refrigerator nearly 22 times every day–that equals nearly 8000 times per year.
- According to Energy Star statistics, Americans spend over $1 billion (collectively) each year to power their TVs, VCRs, DVDs, and stereo systems when they are switched OFF.
- Each year, stereo systems and DVD products alone consume 7 billion kilowatts of electricity when turned off. That is enough energy to satisfy the needs to New York City and Westchester County for more than 2 months. (according to energy star, see website)
- Turn off your computer when not in use. This can save up to 75% of the energy otherwise consumed if you left it on.

Clothes Washers: laundry

- Most of the energy used by washing machines is for heating the water accounting for about 90% of the total energy use.
- In order to save energy, use cold water wash and rinse cycles.
- Front-loading (horizontal-axis) washers use approximately1/3 the total water than top loading (vertical-axis) washers.
- The speed of the spin cycle also plays an important role in reducing the total amount of energy used when washing clothes. The faster the spin cycle, the less water will be retained in the clothing. Therefore, less drying time will be necessary (this is especially important if using a clothes dryer).

Dishwasher

- Most of the energy used by a dishwasher goes toward heating the water accounting for approximately 80% of the total energy use. Models that use less water therefore use less energy. Dishwashers built since the mid-1990's (1994 onward) use on average 7 – 10 gallons of water per cycle. But, older dishwashers, pre-1994, use, on average, between 8 – 14 gallons of water per complete wash cycle.

The above information is from the United States Department of Energy EnergyStar website. Please visit the website for further information concerning appliance energy use and the EnergyStar program: www.energystar.gov.

Lesson 4: 5th grade
Reading a Utility Bill
Understanding Electricity: Watts and Kilowatt Hours (kWh)

Lesson Overview: Learning how to read an electric bill.
Lesson Concept: Empowering students to become more informed citizens.

Materials:
- *The Magic School Bus and the Electric Field Trip* by Joanna Cole & Bruce Degan is an excellent resource to explain how electricity is generated. The book is available from Scholastic at www.scholastic.com/magicschoolbus
- Student hand-out (or use as overhead)
    - Copy of utility bill (electric bill portion only)

Standards:
- Mathematics:
    - II.3.LE.6 (Geometry and Measurement: Apply measurement to describe the real world and solve problems).
- Science:
    - II.1.LE.4 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
    - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: 2 class periods (40 – 50 minutes each)

Class Structure: whole class lesson and discussion

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #3

Lesson 4: 5th Grade
Reading a Utility Bill
Understanding Electricity: Watts and Kilowatt Hours (kWh)

This lesson's intent is to provide students with a basic understanding of our relationship with the utility company–what we are charged for and how to read the bill.

Lesson Overview: Learning how to read an electric bill.
Lesson Concept: Empowering students to become more informed citizens.

Supplies Needed:

- *The Magic School Bus and the Electric Field Trip* by Joanna Cole & Bruce Degan is an excellent resource to explain how electricity is generated. The book is available from Scholastic at www.scholastic.com/magicschoolbus
- Student hand-out (or use as overhead)
    - Copy of utility bill (electric bill portion only)

Teacher's Note: Resource material on renewable and non-renewable energy and pollution issues are included at the end of this lesson.

Background Information:
Please fold the following information into an inquiry-based, student-led discussion about purchasing energy from utility companies. We suggest beginning the class with reading the *Magic Schoolbus*.

I. Purchasing Energy from Utility Companies

- Utility companies sell us energy. With this energy, we run our lights, refrigerator, freezer, television, computer–anything we plug into an outlet in order to 'turn it on'–in the buildings where we live and work (our homes, school, workplace, etc.).
- But, in order for this to happen, we must pay the utility company for the energy *we* use that *they* are providing.
- This lesson is devoted to understanding how the utility company charges for the energy we use.

- How is energy measured?

Energy can be measured in many different forms: a joule, a BTU, or a calorie to name three. But, for our purposes here, we are not focusing on these measurements and their conversions. However, it is important to realize two significant points:

  - Energy can and is measured in different units–in joules, BTUs, calories–and;
  - There are *units* of energy and *units* of power. ***These units are measured differently and are not interchangeable.*** Just as distance and speed are different *units* measured in different ways–distance can be measured in inches, feet, miles, meters, kilometers, etc. and speed can be measured in miles per hour, kilometers per hour, etc. We do not confuse distance and speed to be the same thing–the same holds true with energy and power. Therefore, the question is not "how are energy and power different" but, they are different things–apples and oranges. A watt is a unit of power and a joule or a BTU or a calorie is a unit of energy.

- Why is electricity so special?

Electricity is a form of energy that can do many different kinds of work. With electricity we can heat buildings *and* run appliances.

- How is electricity generated?

The utility company uses a variety of sources to make electricity.

Teacher's Note: Oftentimes, 60% - 70% of the net energy created is lost as heat. This heat loss is called 'waste heat' and is created when a generator makes the electricity. This waste heat heats the atmosphere. Out of 100 units of electricity generated, barely 30 units of useable electricity are available in a typical electricity generating situation.

Electricity Generation in the United States: Review Statistics

Please review the following statistical break-downs with the students of how electricity is generated in the U.S. (information from: eia.doe.gov, country analysis briefs)

Coal-fired power plants	53%
Nuclear power plants	21%
Natural gas power plants	15%
Hydro power	7%
Oil	3%
Geothermal, wind, solar	1%

Making electricity is a mechanical process. A fuel (coal, natural gas, nuclear power, oil, wood) is used to heat a boiler that makes high-pressure steam. The steam that is made spins a turbine. The turbine spins a generator. The generator makes the electricity.

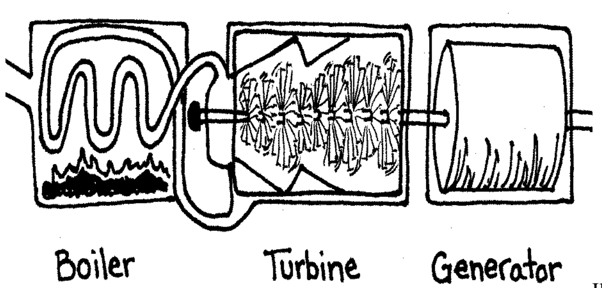


Illustration by Jessica Western

Teacher's Note: Please see the 3rd grade curriculum, Lesson 3 for a detailed review of how to generate electricity from different sources. Please see the 4th grade curriculum, Lesson 3 for a lesson review of Michigan State University's power plant.

The following are a few examples of how that process can play out:

- What are we purchasing?
  Electricity is purchased in 'bundles of energy'. Think of a bundle as any fixed amount similar to a cord of wood or a car's gas tank. For example, we go to the gas station to purchase a tank of gas. One way to think of the utility company is being continually connected to the gas station so you never have to return to buy a tank of gas. As soon as the tank is empty, it automatically fills up again. But, when we are discussing electricity, each 'tank' of gasoline is equal of a 'bundle' of energy.

  The bundle of electricity is called a kilowatt hour–kWh. (1000 watts used continuously for one hour)

- What can we do with a kilowatt hour–kWh?

A kWh is 1000 watts used continuously for 1 hour. With this amount of energy you could:

  - Run a hair dryer (continuously) on medium setting for 1 hour
  - Run 20 50watt light bulbs for 1 hour
  - Run 40 25watt light bulbs for 1 hour
  - Run 10 100watt light bulbs for 1 hour
  - Run 1 20watt compact fluorescent light bulb (CFL) for 50 hours

- Do we use the same amount of electricity for everything?

No. As we learned in Lesson 3 from studying the EnergyGuide labels, different appliances (and different styles of the same appliance) use different 'amounts' of electricity. But, this amount is actually how fast of slowly we use the electricity. The amount of energy (electricity) we use in a fixed period of time determines how *efficient* the appliance. More energy used in a fixed period of time equals a *less efficient* appliance. Less energy used in a fixed period of time equals a *more efficient* appliance. (Refer to the EnergyStar labels and information from Lesson 3).

Example:
When you make a fire by burning wood, the wood is the 'bundle of energy' used to create heat. Consider the following example to demonstrate how much energy is being used over time (energy consumption).

Burning wood: you have two stacks of wood that are the same–the same size, the same density, the same type of wood, the same dryness, etc.

A. You decide to burn one stack of wood quickly. This creates a lot of heat, but you burn your entire woodpile rather quickly and then the heat is gone.

B. You decide to burn the other stack of wood slowly. This creates less heat, but the fire lasts for a longer period of time. The woodpile, your energy source, lasts longer.

Question:
Do you have a different result from burning the wood at different rates? Imagine another example of how you could burn wood at a different rate and have another outcome. *(Burning wood in an efficient wood stove for heating a house.)*

- Does efficiency matter?

Yes. If we use less electricity to perform a given task, then we will reduce our impact on the environment. We will produce less carbon dioxide (CO_2), mercury (and other particulates) for any given task–whether heating water on a stove, popping popcorn in a microwave, cooling food in a refrigerator, or lighting rooms in a home.

Teacher's Note: Please see teacher support materials at the end of this section for more detailed discussion on national and international energy use.

II. Decoding the Energy Bill

To return to our utility bill, essentially the utility company charges for the energy we use. If they are charging for electricity, they charge for how many bundles of energy you use each month. But how is this 'bundle' measured? The bundle of energy is measured in kWh.

A kWh Example:

You and a friend decide to take a walk outside. It is a beautiful day and you want to relax and take a leisurely walk while your friend decides that she wants to run instead of walk. You both agree to meet in 1 hour. Your friend runs away and you continue walking. You both continue walking or running until you meet again in 1 hour.

Question:
Do you think that you and your friend traveled the same distance during that one hour?
Do you think that you and your friend used the same amount of energy during that one hour?
No. Unless your friend is a very slow runner and you are a very fast walker. Most likely, she traveled further and used much more energy than you did while she was running. But, the point of this example is that both of you were moving your bodies for the entire hour–neither of you stopped.

When you are using electricity, there is a continuous flow of energy in bundles measured in kWh–1000 watt of continuous energy flow per hour. Depending on how quickly or slowly you use the kWh results in how much money you will be charged on your utility bill.

- How is the utility company measuring how many kWh are used each month?

The utility company charges for the *rate of energy consumption* that is used each month. We've already established a kWh is a fixed amount of energy–1000 watts of continuous use. *(Remember the tank of gasoline example, there is only one tank–and it is a specific size–for each car).*

Another way to think of this is: the utility company charges for the amount of power used. Power is a tricky word because it is often used inappropriately–when power isn't really being discussed. For example, "Power is used when we turn on our lights." Or , "I want to power this CD player, so I will plug it into the wall." We use electricity to make the lights and the CD player work–not power.

- What is power then?

Power is a measurement of energy used over a given period of time. Another way to think of power is the *rate* at which work is done.

Officially, Power = Energy Per Unit Time $\text{Power} = \frac{\text{energy}}{\text{time}}$

Therefore, the utility company charges for how much electricity is used. The electricity is a *bundle of energy* measured in *kWh.* How *many* bundles of energy we use is determined by the *rate* at which we use the *kWh.* We can determine how *efficient* an appliance is by determining how many *kWh* it will use *over a specific period of time*. That figure will be its *power use.*

III. Reading the Utility Bill:

Now, we have enough basic information to read an Energy Bill with insight and new- found awareness. Answer the following questions based on the fictitious Consumer's Energy Bill provided–(these questions are also at the end of the lesson formatted as a student hand-out / overhead):

- Is the same amount of money charged for all of the electricity used?

No, there is a tier structure based on 300 kWh use. Remember, we are purchasing bundles of energy. On this particular utility bill the bundles are in 300 kWh bundles.

- Describe the different amounts charged.

The 2nd tier is .14¢ less expensive than the 1st tier. But, the 3rd tier is the same amount as the 1st tier.

- Why might the Utility Company charge less for the 2nd tier of energy use but for the 3rd tier?

To discourage using more energy–that would be a positive incentive.
To make more money–hopefully that is not the sole reason.

- Why might less electricity have been used during the same time period this year compared to last year?
    - Perhaps there were guests or more people living in the house last year.
    - Perhaps it was colder last year than this year.
    - Perhaps the residents did not leave as many lights on.
    - Perhaps a more efficient appliance was purchased–or appliances were purchased.
- What can you tell from the Energy Use History provided on the bill? Create a possible one-year biography for the household based on the energy use.

Sample Energy Bill*

***there is a charge for using electricity and gas, but the example below only includes the electric portion of the bill**

NAME	THE CAT IN THE HAT	ACCOUNT NO.	0987654321
SERVICE ADDRESS	2485 SUNNY DRIVE		
	KALAMAZOO MI 49006		

RATE: 1201W ELECTRIC RESIDENTIAL WATER HEATER SERVICE

METER NUMBER	**LOCATION**	**BEGIN READ**	**END READ**	**ENERGY USE**
01234567	2485 SUNNY DRIVE	426	1120	694 KWH

TOTAL METERD ENERGY USE 694 KWH

<u>ACCOUNT STATUS</u>

LAST MONT'S ACCOUNT BALANCE	$72.58	
PAYMENT APPLIED FEB 06 - THANK YOU	$72.58-	
ACCOUNT BALANCE BEFORE CURRENT CHARGES		$0.00

ANY PAYMENTS APPLIED AFTER THE BILLING DATE OF FEB 25, 2005 ARE NOT INCLUDED

<u>CURRENT BILL</u>

ELECTRIC

FIRST	300 KWH @	0.078740		$23.62	
NEXT	300 KWH @	0.064740		$19.42	
NEXT	94 KWH @	0.078740		$7.40	
SECURIZATION CHARGE		694 KWH @	0.001299	$0.90	
SECURIZATION TAX CHARGE		694 KWH @	0.000419	$0.29	
					$51.63
SALES TAX					$2.24
TOTAL CURRENT BILL	DUE ON OR BEFORE 03/15/04				$53.87
TOTAL AMOUNT DUE					$53.87

AFTER THE DUE DATE, A 2% LATE PAYMENT CHARGE WILL BE APPLIED TO THE UNPAID BALANCE

ELEC USE/DAY - THIS MONTH 23.1 KWH LAST YEAR 29.6 KWH

<u>YOUR ENERGY USE HISTORY: DATES ARE WHEN YOUR METER WAS READ /ESTIMATED</u>

	Jan 26-04	Dec23-03	Nov24-03	Oct16-03	Sep16-03	Aug14-03
ELEC-KWH	960	752	813	602	780	591

	Jul17-03	Jun17-03	May16-03	Apr16-03	Mar18-03	Feb18-03
ELEC-KWH	624	445	573	602	621	919

TOTAL HISTORY

ELEC-KWH 8282 KWH

Teacher Resource Section

Electricity

In 2003, the United States generated 3,848 billion kilowatt hours (kWh) of electricity, including 3,691 billion kWh from the electric power sector plus an additional 157 billion kWh coming from combined heat and power (CHP) facilities in the commercial and industrial sectors. For the electric power sector, coal-fired plants accounted for 53% of generation, nuclear 21%, natural gas 15%, hydroelectricity 7%, oil 3%, geothermal and "other" 1%. During the first eight months of 2004, electric power generation rose about 2.2% year-over-year.

World-wide Energy Needs

More than 2 billion (approximately 1/3 of the world population) people world-wide depend primarily on wood for their energy needs. This has led to resource depletion (combined with other significant factors) and contributes up to 40 percent of global greenhouse gas emissions. It's also firmly linked to acute respiratory infection, which is the leading health hazard to women and children in developing countries as well as lung and eye disease. In countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. In cultures that depend on fuel wood as their primary energy source for cooking, three hours per day is typically spent gathering wood.

2005 Energy Policy Act

On August 8, 2005 the energy policy bill was signed. One provision within the bill is to provide additional funding to the expansion of existing and creation of new nuclear reactor plants. Proponents of nuclear energy state that this will provide a cleaner form of energy production for the United States. Although nuclear reactor plants do not create smog-emissions, nuclear plants do create dangerous radioactive wastes that are difficult to dispose of and last for 235,000 years. No permanent safe storage sites exist in the world for the waste. (Please have students research the Yucca Mountain debate for further information concerning nuclear waste disposal).

Potential Energy and Energy Conversion
Table for Teachers:

<table>
<tr><th>Potential Energy</th><th>Energy Conversion</th></tr>
<tr><td>Natural gas
Potential energy source: natural gas</td><td>Natural gas is mined from deep inside the earth, pumped out, and then shipped to the gas supply facility in your state. It is then distributed to a regional power supply company. In Michigan, one of the power companies is Consumers Energy.

Natural gas pipelines are laid deep in the ground throughout your town and neighborhood. Some houses, but not all, have pipes connecting the larger pipes in your neighborhood to the smaller natural gas lines in your house. If you have a gas stove, the stove has gas lines connecting it to the larger gas lines in your house that are connected to the even larger gas lines in your neighborhood that are connected to the even larger gas line piping network throughout your town where those pipes are connected to the main supply area.

Energy Conversion: chemical energy to thermal energy
Turn on the gas: methane is released in the air (clicking sound that many stoves make, there is a second or so after you turn on the dial to light the stove before the gas ignites–that is when the methane is released) (mechanical to chemical)
The methane reacts with the oxygen in the air and a spark happens (chemical to chemical)
The spark ignites the natural gas from the burners (chemical to chemical)
The ignited natural gas is now undergoing combustion (it is burning) and maintains a flame (chemical to chemical)
The flame produces heat (chemical to thermal)
The heat is transferred to the pan on the stove (thermal to thermal)
The heat from the pan is transferred to the food or water in the pan (thermal to thermal)</td></tr>
<tr><td>Electricity–coal burning
Potential energy source: coal</td><td>Coal is mined from deep inside the earth, chiseled out, and carried to the surface. The coal is then shipped, primarily by railroad, throughout the country to power plants.

Coal-fired power plants account for 53% of the total electricity generation in the United States. Burning coal (and oil) creates sulfur dioxide, nitrogen oxide, and carbon dioxide. These gases are the main contributors to creating acid rain, smog, and global warming. The mining technologies cause habitat destruction and loss, and pose severe health risks often leading to fatal disease (black lung disease of coal miners) for the workers.

Energy Conversion: chemical energy to electrical energy to thermal energy
As the coal burns, it produces heat (chemical to thermal)
The heat from the coal burning turns the turbine (thermal to mechanical)
The turbine creates electricity (mechanical to electrical)
The electricity in your stove coils heat when turned on (electrical to thermal)
The heat is transferred to the pan on the stove (thermal to thermal)
The heat from the pan is transferred to the food or water in the pan (thermal to thermal)</td></tr>
</table>

Electricity–high impact hydro Potential energy source: falling water	In order to build a hydro-electric plant, rivers must be dammed. Dams change a river's natural flows and endanger fish and other species habitat and livelihood. Dams often cause degraded water quality, depleted food sources, and block migratory pathways all leading to threatening species survival. High impact hydro power plants produce 7% of the total amount of electricity generated in the United States. Energy Conversion: mechanical energy to electrical energy to thermal energy • Falling water turns the turbines (mechanical to mechanical) • The turbines create electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) The heat from the pan is transferred to the food or water in the pan (thermal to thermal)
Electricity–nuclear Potential energy source: nuclear energy	Although nuclear reactor plants do not create smog-emissions, nuclear plants do create dangerous radioactive wastes that are difficult to dispose of and last for 235,000 years. No permanent safe storage sites exist in the world for the waste. As of 2003, nuclear reactor plants provided 21% of the total amount of electricity generated in the United States. Energy Conversion: chemical energy to thermal energy • The waste heat from the nuclear energy reactors are used to turn the turbines (thermal to mechanical) • The turbines create electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) • The heat from the pan is transferred to the food or water in the pan (thermal to thermal)
Electricity–geothermal Potential energy source: hot water or steam inside the earth	Geothermal electricity is generated by utilizing steam or hot water that lies below the surface of the earth in certain locations. In the United States, states located in western and southwestern parts of the country are geothermally active. Geothermal plants produce and emit little air pollution. As of 2003, geothermal, solar, biomass, and wind provide 1% of the total amount of electricity generated in the United States. Energy Conversion: thermal energy to thermal energy • The heat from the geothermal plant is used to turn the turbines (thermal to mechanical) • The turbines create electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) • • The heat from the pan is transferred to the food or water in the pan (thermal to thermal)

Electricity–biomass Potential energy source: organic wastes	Biomass facilities use the energy that is stored in organic matter to make electricity. These facilities burn wood, agricultural wastes, or methane gases from landfills in order to spin a turbine that generates electricity. Energy Conversion: chemical energy to thermal energy • Organic wastes or wood is burned (chemical to chemical) • The combustion reaction produces heat (chemical to thermal) • The heat is used to turn the turbines (thermal to mechanical) • The turbines create electricity (mechanical to electrical) • The electricity in your stove coils heat when turned on (electrical to thermal) • The heat is transferred to the pan on the stove (thermal to thermal) • The heat from the pan is transferred to the food or water (thermal to thermal)
Wood Potential energy source: wood fibers	Different types of wood have different amounts of embodied energy. Dense, dry woods have the highest embodied energy. For example, seasoned oak has more embodied energy than pine. So, the type of wood that is being burned is very important. More than 2 billion people world-wide depend primarily on wood for their energy needs. And, in countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. Deforestation leads to siltification of rivers, land erosion, and soil nutrient depletion. This then in turn affects crop yields, drinking water quality / availability, species destruction, and decline in species populations of plants and animals. The pollution from burning wood for fuel has been linked to acute respiratory infection, lung disease, and eye disease. Acute respiratory infection is one of the leading health hazards to women and children in developing countries. In countries where wood has been traditionally relied on as the primary energy source, fuel wood is becoming scarce. In these areas of wood scarcity the typical amount of time spent gathering wood is 3 hours. ***Even though wood is considered a renewable resource it is important to discuss the issues around the amount of time it takes for a tree to reach maturity.* ***This topic could be an excellent assignment for writing a persuasive essay.*** *Very few stands of old growth trees remain–many trees that were hundreds of years old have been cut down. It is important for the students to recognize that if you cut a tree down a new tree is not a direct replacement. Important issues for extrapolation / student research: habitat, forest ecosystem, soil health, soil erosion, forest management.* Energy Conversion: chemical energy to thermal energy • Organic wastes or wood is burned (chemical to chemical) • The combustion reaction produces heat (chemical to thermal) • The heat is transferred to the pan from the fire (thermal to thermal) • The heat from the pan is transferred to the food or water (thermal to thermal)

Solar Potential energy source: the sun	Solar energy is radiant energy from the sun that travels to earth in electromagnetic waves (or rays). Solar energy is produced in the sun's core when atoms of hydrogen combine under pressure to produce helium, in a process called fusion. During fusion, radiant energy is emitted. Solar energy is harnessed with solar collectors that turn the radiant energy into heat. Photovoltaic cells turn radiant energy into electricity. We also use solar energy to see. Solar energy is not available all the time–in darkness or whcn dense cloud cover is present. At this point, it is expensive to use solar energy to produce electricity, but new technologies will make solar energy a major energy source in the future. Solar energy is a very clean energy source, producing no air or water pollution. Energy Conversion: electromagnetic energy to thermal energy *A solar cell is any device that directly converts the energy in light into electrical energy through the process of photovoltaics. A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of a PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. The current (and power) output of a PV cell depends on its efficiency and size, and is proportional to the intensity of sunlight striking the surface of the cell. Because of this, a typical commercial solar cell has an efficiency of about 1/6 of the sunlight striking the cell generates electricity. The first solar cells, built in the 1950s, had efficiencies of less than 4%.* (The above information taken directly from Department of Energy website (www.doe.gov)

Reading the Energy Bill
Student Hand-out

Please answer the following questions based on the energy bill provided:

1. Is the same amount of money charged for all of the electricity used?

2. Describe the different amounts charged.

3. Why might the Utility Company charge less for the 2^{nd} tier of energy use but for the 3^{rd} tier?

4. Why might less electricity have been used during the same time period this year compared to last year?

5. What can you tell from the Energy Use History provided on the bill? Create a possible one-year biography for the household based on the energy use.

Sample Energy Bill*
*there is a charge for using electricity and gas, but the example below only includes the electric portion of the bill

---

NAME	THE CAT IN THE HAT	ACCOUNT NO.	0987654321
SERVICE ADDRESS	2485 SUNNY DRIVE		
	KALAMAZOO MI 49006		

RATE: 1201W ELECTRIC RESIDENTIAL WATER HEATER SERVICE

METER NUMBER	**LOCATION**	**BEGIN READ**	**END READ**	**ENERGY USE**
01234567	2485 SUNNY DRIVE	426	1120	694 KWH

TOTAL METERD ENERGY USE 694 KWH

ACCOUNT STATUS

LAST MONT'S ACCOUNT BALANCE	$72.58
PAYMENT APPLIED FEB 06 - THANK YOU	$72.58-

ACCOUNT BALANCE BEFORE CURRENT CHARGES $0.00

ANY PAYMENTS APPLIED AFTER THE BILLING DATE OF FEB 25, 2005 ARE NOT INCLUDED

CURRENT BILL

ELECTRIC					
FIRST	300 KWH @	0.078740		$23.62	
NEXT	300 KWH @	0.064740		$19.42	
NEXT	94 KWH @	0.078740		$7.40	
SECURIZATION CHARGE		694 KWH @	0.001299	$0.90	
SECURIZATION TAX CHARGE		694 KWH @	0.000419	$0.29	
					$51.63
SALES TAX					$2.24
TOTAL CURRENT BILL	DUE ON OR BEFORE 03/15/04				$53.87
TOTAL AMOUNT DUE					$53.87

AFTER THE DUE DATE, A 2% LATE PAYMENT CHARGE WILL BE APPLIED TO THE UNPAID BALANCE

ELEC USE/DAY - THIS MONTH 23.1 KWH LAST YEAR 29.6 KWH

YOUR ENERGY USE HISTORY: DATES ARE WHEN YOUR METER WAS READ /ESTIMATED

	Jan 26-04	Dec23-03	Nov24-03	Oct16-03	Sep16-03	Aug14-03
ELEC-KWH	960	752	813	602	780	591

	Jul17-03	Jun17-03	May16-03	Apr16-03	Mar18-03	Feb18-03
ELEC-KWH	624	445	573	602	621	919

TOTAL HISTORY
ELEC-KWH 8282 KWH

Lesson 5: 5th grade
Understanding Watts: Voltage, Current, & Resistance

Lesson Overview: Understanding wattage.
Lesson Concept: Voltage, current, and resistance together create what we refer to as electricity.

Materials:
- This lesson plan.

Standards:
- Mathematics:
  - II.3.LE.6 (Geometry and Measurement: Apply measurement to describe the real world and solve problems).
- Science:
  - II.1.LE.4 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).
  - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).

Timeline: *2 class periods (40 – 50 minutes each)
*You may want to allow additional time and review this lesson and lesson 4 together after teaching lesson 5.

Class Structure: whole class lesson and discussion

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #3

Lesson 5: 5th Grade
Understanding Watts: Voltage, Current, & Resistance

This lesson further investigates watts and begins investigating current.

Lesson Overview: Understanding wattage.
Lesson Concept: Voltage, current, and resistance together create what we refer to as electricity.

Background Information:

Hopefully, the students now have a better grasp on how electricity is measured (in kilowatts–kWh), and have applied that knowledge interpreting and analyzing the Utility Bill in the previous lesson (Lesson 4). Let's take a deeper look at electricity. Specifically, what is a watt?

I. Watts

Watts and kilowatt hours (kWh) are different entities and should not be confused as the same thing.

- The work electricity does is measured in watts (w).
- A kilowatt hour (kWh) measures how much electricity is used over a specific period of time.

We are now focusing on what is a watt. Our goal is to have the students be able to use and read a watt meter. Watt meters measure the amount of electricity an appliance uses. The students will use watt meters during the second half of the curriculum when they conduct the Energy Use Investigations.

- What is a watt?

A **watt** is equal to voltage times current.
W = E x I (voltage = E and amps = I, current is the rate at which electricity flows and is measured in amps)

> You can have voltage without current. In this scenario, there would be potential, but no electrons are flowing. But, *you cannot have current without voltage.*

- What is voltage?
  - **Voltage** is the force that pushes electricity.
  - **Voltage** is measured in volts.
  - **Voltage** is sometimes called **potential** because whenever there is voltage there is potential for electricity to move. If something has a lot of potential it has a lot of voltage and vice versa.
  - Voltage is also called **electromotive-force** and is abbreviated by the letter **E** in formulas.

> **A very important note about voltage:**
> There does not need to be any movement in order to have voltage only the *potential* for movement.

- What is current?
  - **Current** is the movement of electrons through something.
  - **Electricity** has both current and voltage at the same time.
  - **Current** is measured in amperes (amps).
  - Current is abbreviated by the letter **I** in formulas.

An Example:

Question: If 10 amps of current are flowing, and you are using a 12-volt battery to push that current, then how many watts are you are using?

Answer: 120 watts

The formula is: W = E x I (W = 12 x 10)

II. A Current and Voltage Parable

Read the parable below for another way of discussing current and voltage. Hopefully, this story will provide more clarity.

> Teacher's Note: This parable was written by Kenn Amdahl (with very minor editing) and can be found in *There Are No Electrons: Electronics For Earthlings* published by Clearwater Publishing Company, Inc. in Broomfield, CO. This is a great book to read for de-mystifying how electricity works. More detailed information in included in the Bibliography Section of the curriculum.

A Parable: Lake Dubious (current and voltage)

High on a mountain sits a vast, cold lake–Lake Dubious. Two rivers leave Lake Dubious and wander down the mountainside to the ocean far below. One of the rivers is mighty, like the Mississippi. It is deep and wide, filled with huge, silent fish. The other river is tiny, only a few inches deep and only a few feet wide. It's really just a creek. You can see the rocks you step on when you wade across it.

Lake Dubious is exactly one mile higher than sea level. Regardless of the twists and turns either river takes, they each transport water one vertical mile over the course of their journey to the sea. The one-mile difference in elevation between the lake and the sea is the reason the water flows down either river. Any drop of water in that lake has a *potential fall* of one mile in its future. *This difference in elevation is the liquid equivalent of voltage*.

Both rivers have the same voltage. They each have the same one-mile difference in elevation from beginning to end. They are not identical rivers, however. One has a lot more water in it. The big river can do more work than the small river. It can carry larger ships, move large boulders that happen to fall into it, and turn a much larger water-wheel. *Current is the muscle of electricity*.

(If you're looking for an electrical river to be your body-guard, choose one with many amperes).

Either river can move sand to the ocean. If moving sand is the job at hand, you have to know how much voltage is available, and also how much current. If you have more voltage, you'll move more sand. If you increase the current flow, you'll also move more sand. Since both of the rivers flowing out of Lake Dubious have the same voltage or potential, other variables account for their differences. Things like the size of their channels, whether they meander or plunge, or if either one is obstructed.

The power company charges you for the work their electricity does. They charge for however many watts you use each month. Their meters measure the actual work done by electricity in your home. Your bill is based on how much sand you moved, and how far you moved it.

III. Resistance

- The third main component to understanding electricity is: resistance.
  - **Resistance** is anything that makes it difficult for current to flow.
  - Materials that have a lot of resistance are called insulators. Wood is a good insulator.
  - Resistance is measured in **ohms**.
- The counterpart to resistance is conductivity (conductors).
  - **Conductors** are things that are easy to move through.
  - Conductors have very little resistance.
  - Metals are usually good conductors; they have very little resistance.

A material's resistance to current is determined by its size, shape, and what it is made of.

When we see lightning in the sky what are we seeing?

Lightning is the visible creation of a lot of heat. This heat (the lightning bolt) is in the form of electricity. The heat is created by a lot of current traveling through a lot of resistance (the air). Since air has a lot of resistance, a lot of voltage is needed to move the electrons through the air.

A Parable: The Car Theory (resistance)

Current is like traffic, but, there are many different kinds of roads. Some roads are smooth, straight, and easy to drive. They don't offer much resistance to traffic. Other roads are tricky–dirt roads filled with potholes, roads covered in snow, narrow, one-lane roads–these roads offer a lot of resistance to traffic. When driving on these roads, traffic slows down. The traffic may even come to a complete stop if there are too many cars on the road at one time.

The same is true with electricity. Remember current is the rate at which electricity flows. It is measured in amps. Depending on the pathway for the current to flow through determines how much resistance the current will encounter. Resistance changes current. Therefore, the amount of amps used depends on the amount of resistance.

CLASS EXERCISES:

Resistance Activities:

- What has more resistance?
    - A long wire or a short wire? long wire
    - A large wire or a thin wire? thin wire
    - Wood or metal wood
    - Water or air air
    - Copper or iron iron

- Have the students create their own list of questions and answers. (What has the less resistance? What are good conductors? What are good insulators?)

Electricity always produces heat when it moves through resistance. This can be very handy AND it can be a problem.

Question: What might be some items you use daily where the by-product of creating heat with electricity is helpful?

electric grill
toaster
electric water heater
electric air heater

Question: What might be some items you use daily where the by-product of creating heat with electricity is not helpful? (Cooling devices are often added to appliances so they do not malfunction.)

light bulb (especially in the summer)
computer
television
air conditioner

IV. Volts, Amps, and Resistance Review

- If voltage increases, current increases.
- If resistance increases, current decreases.

- Heat is produced as a by-product of resistance.
- Add more current = more heat.
- The more resistance = the more heat BUT when more resistance is added, current will be reduced, so the total amount of heat might not change.

- When heat is not the desired end product, the energy that is converted to heat is wasted and contributes to the inefficiency of the product.
- In many cases, enough heat is produced incidentally that equipment must be designed with a provision for cooling.

Lesson 6: 5th grade
Lighting Comparison Study
CFLs and Incandescent Lighting

Lesson Overview: Learning about the differences between compact fluorescent light bulbs and incandescent light bulbs.
Lesson Concept: Not all light bulbs have the same efficiency.

Materials:

- Paper /journals
- Pens / pencils (note-taking materials)
- CFL student hand-out / overhead
- IR Thermometer
- Power Strip
- 3 clamp lights
- 3 different light bulbs
  - 2 incandescents–75-watt & 35-watt
  - 1 CFL–23-watt

Standards:

- Mathematics:
  - III.1.LE.1 (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
  - III.1.LE.4 (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
- Social Studies:
  - IV.4.LE.2 (Economic Perspective: Describe how they (students) act as a producer and a consumer).

Timeline: 1 class period (40 – 50 minutes each)

Class Structure: whole class and small group lesson

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #2
General Assessment Strategy #4

Lesson 6: 5th Grade
Lighting Comparison Study
CFLs and Incandescent Lighting

This lesson is devoted to taking a deeper look at energy efficiency. The single most effective way to increase energy efficiency in buildings is by using efficient lighting systems. Energy use and efficiency will be discussed through measuring electricity draw of incandescent and compact fluorescent light bulbs.

Lesson Overview: Learning about the differences between compact fluorescent light bulbs and incandescent light bulbs.
Lesson Concept: Not all light bulbs have the same efficiency.

Supplies Needed:

- Paper /journals
- Pens / pencils (note-taking materials)
- CFL student hand-out / overhead
- IR Thermometer
- Power Strip
- 3 clamp lights
- 3 different light bulbs
- 2 incandescents–75 watt & 35 watt
- 1 CFL–23 watt
- Student Hand-outs (2): Energy Cost Analysis, Life Cycle Analysis Chart

BACKGROUND MATERIALS:

I. Light Bulbs

What kind of light bulbs you use may not warrant a lot of thought, but it should. Lighting accounts for 20% to 25% of all the electricity consumed in the U.S. per year. Consider the following statistics:

- If a 100-watt light bulb is on for 12 hours a day, every day, for a year, it can use enough electricity to burn nearly 400 pounds of coal.
- Remember, 1 kWh is a unit of *ENERGY*. It can be looked at as the amount of energy that could run a 1000 watt appliance for 1 hour, a 100 a watt appliance for 10 hours, or a 25 watt appliance for 40 hours.
- One kWh of electricity creates about 1.5 lbs of CO_2 (this is for a nationally weighted average of coal, oil, and gas).
- Of all the electricity that a light bulb uses, only 10% is turned into light. The remaining 90% of the energy used is converted into heat–that is why incandescent bulbs are so hot after they have been on for a while. The waste heat produced from incandescent light bulbs is not an efficient way to heat your home and creates the necessity to provide additional cooling during the summer months.
- Turning off the lights when you leave the room is important, but did you know there are light bulbs you can use that will save energy and last longer?

There are two basic types of light bulbs we will discuss:

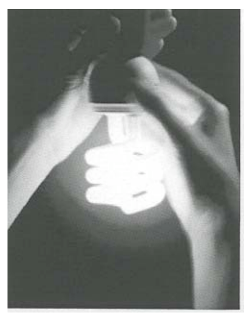
- Incandescent–the classically shaped bulb that is considered by most to be the 'typical light bulb'.
- Compact fluorescent light bulbs (CFLs)–an often, but not always, spiral shaped cylinder type light bulb.

Are incandescent and CFLs the same?

- No. CFLs use 75% less energy–1/4 of the energy–that an incandescent bulb uses.
- CFLs will last 10 times longer. High quality CFLs last for approximately 10,000 hours of light. This equals 13 incandescent bulbs used for every 1 CFL.

10,000 hours of light

or



Do they cost the same? Let's do the math:

- Depending on the cost of electricity, the CFL will equal approximately ¼ of the total cost of the incandescent bulb. Even though the upfront cost–purchasing price at the store–is more expensive.

Below is a comparison chart of the total life cycle cost for a 75 watt incandescent light bulb and a 23 watt compact fluorescent light bulb:

	Incandescent light bulbs	CFLs
Price at store	$.75 each	$5.00 each
Hours of light	750 hours each	10,000 hours each
Cost for 10,000 hours of light	$10	$5.00
Cost of electricity for 10,000 hours @ $.08/kWh	$80.00	$18.40
Total life cycle cost for 10,000 hours of light ($.08/kWh)	$90.00	$23.40
Cost of electricity for 10,000 hours @ $.10/kWh	$100.00	$23.00
Total life cycle cost for 10,000 hours of light ($.10kWh)	$110.00	$28.40

CLASS EXERCISE

Teacher's Note: You may want to divide the class into 2 groups and conduct these experiments simultaneously WITH SUPERVISION (you would then need to double the supplies: 6 clamp lights, 6 bulbs, 2 power strips)

I. Comparing Brightness: Are there differences?

By quickly looking at each light bulb (turned on), gauge the brightness of each (this is a sensory lesson, a lumen meter is not necessary).

The reasoning behind testing two different incandescent light bulbs is primarily to see the brightness difference between the 23 watt CFL and the 35 watt incandescent.

CFLs are very bright–a 23 watt CFL is commonly compared to a 75 watt incandescent bulb in lumens–and are made in a variety of color tones from bright white light (blue undertone) to soft daylight (yellow undertone). CFLs require a few minutes of 'warm-up' time to reach their full brightness output.

- Screw 1 light bulb into each clamp light
- Plug the power strip into the wall
- Plug the clamp lights into the power strip
- Shine each light onto a large piece of white paper.
- Do the lights look the same? Are they the same brightness?
- Does the CFL light change during the first 3 minutes?
- Record the data

II. Measuring Heat: Are there differences?

Measure the heat of the light bulbs with the IR Thermometer

- Begin with cold (to the touch) light bulbs
- Plug the power strip into the wall
- Screw 1 light bulb into each clamp light
- Plug all 3 clamp lights into the power strip
- Turn on all 3 clamp lights at the same time
- Measure the heat of each bulb every 2 minutes for 10 minutes total
- Record the data
- If time allows, continue measuring for 20 minutes

III. Energy Cost Analysis: 2 exercises

Exercise #1: Comparing the Life Cycle Costs of Light Bulbs

A. Bring in one package of incandescent light bulbs–60, 75, or 100 watt
B. Bring in one package of CFLs that produce the same light output (lumens) as the incandescent bulbs
C. Compute the Life Cycle of each light bulb using the charts provided.

Bulb Specifications	Incandescent	Compact Fluorescent (CFL)
Light Output (lumens)		
Life Expectancy (hours)		
Energy Used (watts)		
Cost per Bulb (dollars)		

Question #1: How many bubs are needed to produce 10,000 hours of light?

10,000 hours of light = ________________________ incandescent bulbs (life expectancy)

10,000 hours of light = ________________________ CFL bulbs (life expectancy)

Question #2: What is the cost for bulbs to produce 10,000 hours of light?

__________ incandescent bulbs needed x 10,000 hours = $__________ for incandescent bulbs

__________ CFL bulbs needed x 10,000 hours = $__________ for CFL bulbs

Question #3: What is the cost of electricity to produce 10,000 hours of light?
Incandescent Bulbs

__________ watts for incandescent bulbs x 10,000 hours = ___________ watt hours for incandescent bulbs

__________ watt hours for incandescent / 1,000 hours per kilowatt = _________ kWh (kilowatt hours) for incandescents

__________ kWh for incandescents x $0.08 per kWh = $_________ using incandescent bulbs

CFL Bulbs

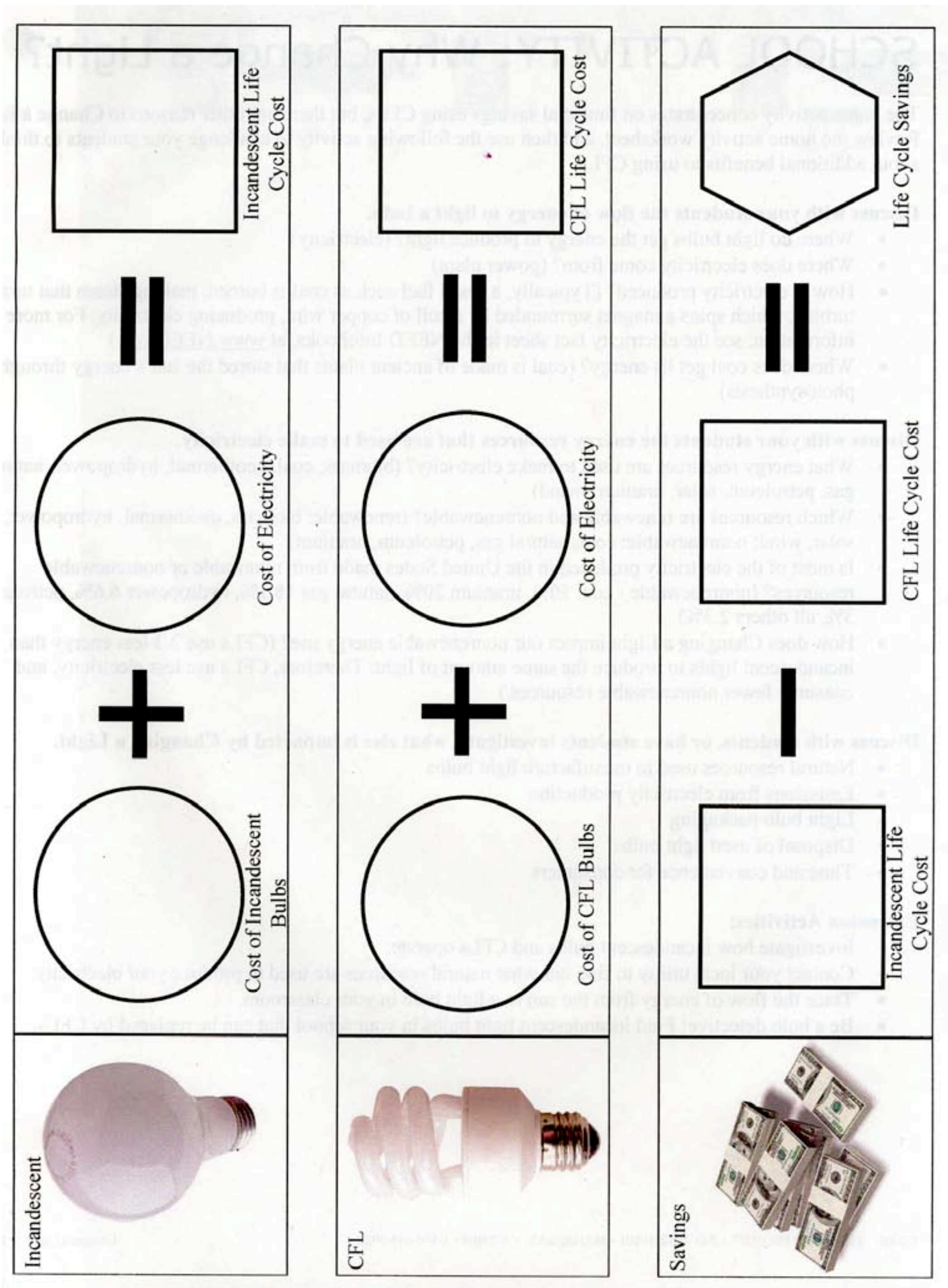
__________ watts for CFL bulbs x 10,000 hours = ___________ watt hours for CFL bulbs

__________ watt hours for CFLs / 1,000 hours per kilowatt = _________ kWh (kilowatt hours) for CFLs

__________ kWh for CFLs x $0.08 per kWh = $_________ using CFL bulbs

Final Charting of the Information

Below is a graphic from the NEED Project's *Change a Light* curriculum. After the class has determined the answers for the above questions, transfer the information to this page as a visual reference guide. Please see the student handouts at the end of this lesson. (THE NEED PROJECT, www.need.org, 1-800-875-5029, P.O. Box 10101 Manassas, VA 20108)



Exercise #2: Compare Energy Costs for a Household

After Exercise #1 has been completed, have the students, working in small groups, compare the approximate energy costs for a household using incandescent light bulbs and a household using CFLs with the following information:

- The Home:
  - 5 rooms
  - 2 light bulbs in each room
  - each light is on for 5 hrs/day

Scenario #1:
What would be the approximate total lighting cost for 1 year if the energy cost was $0.08/kWh for each home outfitted with incandescent light bulbs?

Scenario #2:
What would be the approximate total lighting cost for 1 year if the energy cost was $0.08/kWh for each home outfitted with CFL bulbs?

Scenario #3:
How much would the cost increase if the energy cost was $.10/kWh for Scenario #1?

Scenario #4:
How much would the cost increase if the energy cost was $.10/kWh for Scenario #2?

Student Handout
Energy Cost Analysis

Bulb Specifications	Incandescent	Compact Fluorescent (CFL)
Light Output (lumens)		
Life Expectancy (hours)		
Energy Used (watts)		
Cost per Bulb (dollars)		

Question #1: How many bubs are needed to produce 10,000 hours of light?

10,000 hours of light = ________________________ incandescent bulbs (life expectancy)

10,000 hours of light = ________________________ CFL bulbs (life expectancy)

Question #2: What is the cost for bulbs to produce 10,000 hours of light?

__________ incandescent bulbs needed x 10,000 hours = $__________ for incandescent bulbs

__________ CFL bulbs needed x 10,000 hours = $__________ for CFL bulbs

Question #3: What is the cost of electricity to produce 10,000 hours of light?
Incandescent Bulbs

__________ watts for incandescent bulbs x 10,000 hours = ___________ watt hours for incandescent bulbs

__________ watt hours for incandescent / 1,000 hours per kilowatt = _________ kWh (kilowatt hours) for incandescents

__________ kWh for incandescents x $0.08 per kWh = $_________ using incandescent bulbs

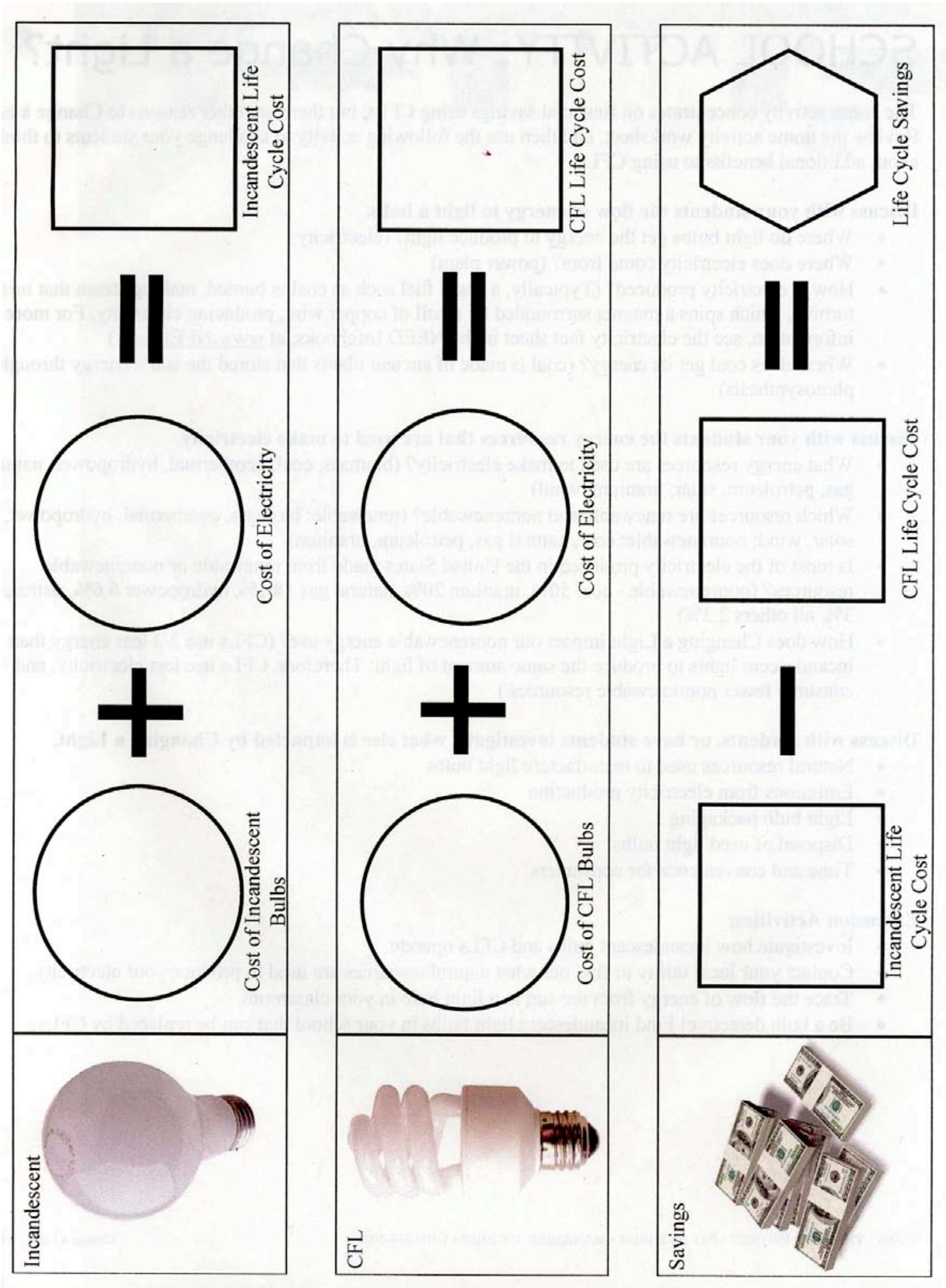
CFL Bulbs

__________ watts for CFL bulbs x 10,000 hours = ___________ watt hours for CFL bulbs

__________ watt hours for CFLs / 1,000 hours per kilowatt = _________ kWh (kilowatt hours) for CFLs

__________ kWh for CFLs x $0.08 per kWh = $_________ using CFL bulbs

Student Handout
Life Cycle Analysis



Optional Student Handout / Overhead

Life Cycle Costs

	Incandescent light bulbs	**CFLs**
Price at store	$.75 each	$5.00 each
Hours of light	750 hours each	10,000 hours each
Cost for 10,000 hours of light	$10	$5.00
Cost of electricity for 10,000 hours @ $.08/kWh	$80.00	$18.40
Total life cycle cost for 10,000 hours of light ($.08/kWh)	$90.00	$23.40
Cost of electricity for 10,000 hours @ $.10/kWh	$100.00	$23.00
Total life cycle cost for 10,000 hours of light ($.10kWh)	$110.00	$28.40

10,000 hours of light

or

Lesson 7: 5th grade
Energy Use Investigation: How to Use a Watt Meter

Lesson Overview: Measuring energy use of typical, everyday, small appliances.
Lesson Concept: Developing an understanding of daily energy use of common items in our homes and schools.

Materials:
- Watt meter
- Blow dryer
- Clock
- Radio
- Power strip
- Paper
- Note-taking supplies (journals, pens, graph paper, pencils)
- Student hand-out: Energy Use Compilation

Standards:
- Mathematics:
  - III.1.LE.1 (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
  - III.1.LE.4 (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
  - III.3.LE.2 (Data Analysis and Statistics: Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them).

Timeline: 2 - 3 class periods (40 – 50 minutes each)

Class Structure: small group experiments

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #3

Lesson 7: 5th Grade
Energy Use Investigation: How to Use a Watt Meter

In this lesson students will measure a variety of electrical appliances' energy use.

Lesson Overview: Measuring energy use of typical, everyday, small appliances.
Lesson Concept: Developing an understanding of daily energy use of common items in our homes and schools.

Supplies Needed:
- Watt meter
- Blow dryer
- Clock
- Radio
- Power strip
- Paper
- Note-taking supplies (journals, pens, graph paper, pencils)
- Student hand-out: Energy Use Compilation

Background Information:
- Watt meters can help you figure out electrical expenses by the hour, day, week, month, and even an entire year.
- A watt meter measures voltage and current and assesses appliance efficiency.
- There are different styles of watt meters available on the market, but one of the more affordable (and easy to use) are the Kill A Watt meters (approximately $30.00). Below is a brief description of the different functions of a Kill A Watt meter. *The information is from the Safe Home Products website, www.safehomeproducts.com/shp2/sm/electricity_monitor.asp

The Kill A Watt power meter

In order to begin practicing energy conservation, a first step is to understand how much energy appliances use. Watt meters are a great tool to facilitate this understanding. You can measure kWh use and "evaluate your utility company's quality of electrical power monitoring voltage (Volt), line frequency (Hz) and power factor (VA)."

*How to Use the Power Meter:
- Plug in Kill A Watt into standard USA outlet.
- Plug in 110VAC to 115VAC appliance.
- Depress Volt, Amp, Watt, Hz, or KWH buttons.
- Read LCD display. Note energy efficiency level of the appliance.
- LCD display shows energy consumption by Kilowatt-hour like a utility company energy efficiency meter. Calculate electrical expenses by the hour, day, week, month, etc. with this kWh meter (kilowatts/hour).

CLASS EXERCISES: small group exercises

I. **Measuring energy use with the watt meter**

- Measure the following electrical items with the watt meter.
- Plug the watt meter into the power strip.
- Plug the following items into a power strip (1 at a time) and turn on for one minute
- Record how many watts the appliance is using during the 60 second time period
  - Blow dryer–measure the energy use at different settings
  - Clock
  - Radio–measure the energy use when ‘off’ and ‘on’: some appliances draw energy even when in ‘off’ mode
  - Any other item you have in the classroom that runs on electricity
- Approximate how many appliances could you use with 1 kWh

Important: Remember that 1 kWh is 1000 watts used continuously for 1 hour.

II. **Continuing the Study**

- After the students have gathered the initial data for various appliances, have each group choose one appliance to collect data over a 24-hour time period.
- For each power strip, plug in one watt meter and one appliance. If possible have the students test the appliance for two 24-hour periods–one day in the “off” position and one day in the “on” position or “sleep” position
- Record the kWh usage and calculate the approximate cost of the appliance for the following amounts of time:
  - 1 day
  - 1 week
  - 1 month
  - 1 year

Student Hand-out
Appliance Energy Use Compilation Sheet

Experiment A: various appliances watt use

Appliance Description	watt use for 1 minute
1.	
2.	
3.	
4.	
5.	

Experiment B: choose 1 appliance and measure 24 hr energy use

Appliance Description	kWh use (24 hr) "on"	kWh use (24 hr) "off / sleep"

Experiment C: above appliance energy use over time

Appliance Description	Timespan	kWh use "on"	kWh use "off / sleep"
	1 day		
	1 week		
	1 month		
	1 year		

Lesson 8: 5th grade
Computer Energy Use Investigation: Beginning the Project

Lesson Overview: Measuring the energy use of computers.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Materials:
- Note-taking materials
- Journals to compile all notes for the energy use survey
- Clipboards

Standards:
- Mathematics:
  - III.1.LE.1 (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
  - III.1.LE.4 (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
  - III.3.LE.2 (Data Analysis and Statistics: Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them).

Timeline: 2 - 3 class periods (40 – 50 minutes each)

Class Structure: small group investigations

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #2

Lesson 8: 5th Grade
Computer Energy Use Investigation: Beginning the Project

In this lesson, the students will begin a Computer Energy Use Survey.

Lesson Overview: Measuring energy use of computers.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Supplies Needed:

- Note-taking materials
- Journals to compile all notes for the energy use survey
- Clipboards

Background Information:
This project is a small group project (3-5 students per group). For the survey, the students will create questions to investigate and measure the energy use of the computers around the school. Watt meters will be used to measure the energy use of each computer.

CLASS EXERCISE;

I. Introduce Project

- Measuring the energy use of the school computers
- Discuss what to measure.

Ask the students:

- o What are a few of the different functions of a computer?
- o Do you believe all functions of a computer have the same amount of energy use?
- o Are there different 'modes' of a computer?

II. Create Questions

- In small groups, create a list of questions that the students hope to answer with their energy use survey. Some questions might include:
  - o What is the energy use of different computer programs?
  - o What is the energy use of the computer start-up?
  - o What is the energy use of the computer in sleep mode (or on, off)?
  - o Do some computers have different energy use than others?
  - o What uses less energy–: turning the computer off every night OR keeping the computer in sleep mode? (Don't forget to add in the energy used for start-up).

III. Create Hypotheses of Outcomes

- In their journals, create hypotheses (and detailed support opinions) for what might be the answers for the questions they have chosen to investigate.

IV. Create An Action Plan

- Determine which computers in the school will be part of the energy use survey
- Divide who will measure what & when (if measuring computers in multi-use rooms finding out when the rooms are not being used by another class, etc.)

V. Create an Energy Use Survey Compilation Form

Lesson 9: 5th grade
Continue the Computer Energy Use Investigation: Using the Watt Meters

Lesson Overview: Measuring the energy use of computers.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Materials:
- Note-taking materials
- Journals to compile all notes for the energy use survey
- Clipboards
- Watt meters

Standards:
- Mathematics:
  - III.1.LE.1 (Data Analysis and Statistics: Collect and explore data through counting, measuring and conducting surveys and experiments).
  - III.1.LE.4 (Data Analysis and Statistics: Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data).
  - III.3.LE.2 (Data Analysis and Statistics: Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them).
- Science:
  - I.1.LE.1 (Construct New Scientific and Personal Knowledge: Generate reasonable questions about the world based on observation).
  - III.5.LE.5 (Use Scientific Knowledge from the Life Sciences in Real-World Contexts: Describe positive and negative effects of humans on the environment).
  - IV.1.LE.4 (Use Scientific Knowledge from the Physical Sciences in Real-World Contexts: Identify forms of energy associated with common phenomena).
- Social Studies:
  - IV.4.LE.2 (Economic Perspective: Describe how they (students) act as a producer and a consumer).

Timeline: 2 - 3 class periods (40 – 50 minutes each)

Class Structure: small group investigations

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #2
General Assessment Strategy #3
General Assessment Strategy #4

Lesson 9: 5th Grade
Continue the Computer Energy Use Investigation: Using the Watt Meters

Clipboards and watt meters in hand, the student groups will begin measuring the energy use of the chosen computers–from Lesson 8.

Lesson Overview: Measuring the energy use of computers.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Supplies Needed:
- Note-taking materials
- Journals to compile all notes for the energy use survey
- Clipboards
- Watt Meters

Background Information:
The computers are measured in the same way the students measured various appliances in Lesson 7–plug the watt meter into either the wall or power strip and plug the computer into the watt meter. Each computer will need to remain plugged in for a minimum of 1 hour.

Teacher's Note: Make sure the computers are turned off before un-plugging them from their outlet when you plug them into the watt meter.
STUDENTS SHOULD BE SUPERVISED AT ALL TIMES DURING THIS EXPERIMENT.

CLASS EXERCISE:
- Begin measuring the energy use of each computer
- Keep detailed notes

Lesson 10: 5th grade
Report Findings of Computer Energy Use Investigation: Chart and Graph

Lesson Overview: Creating interesting visual data to convey results.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Materials:
- 18 x 24 white paper
- Graph paper
- Journals
- Pens / Pencils / Markers

Standards:
- Science:
  - II.1.EE.2 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Show how science concepts can be interpreted through creative expression such as language arts and fine arts).
  - II.1.EE.4 (Reflect on the Nature, Adequacy, and Connections Across Scientific Knowledge: Develop an awareness of and sensitivity to the natural world).

Timeline: 2 - 3 class periods* (40- 50 minutes each) (*or up to 1 week depending on the detail of the presentations

Class Structure: small group investigations and presentations

Assessment Strategy: EEK! Daily Assessment
Post-Module Assessment Questions #1, #2, #3

Lesson 10: 5th Grade
Report Findings of Computer Energy Use Investigation: Chart and Graph

In this lesson, students will review all notes from the energy use survey and create graphs / charts / or any other visual explanation and presentation of their findings.

Lesson Overview: Creating interesting visual data to convey results.
Lesson Concept: Energy can be measured and the efficiency of the appliance can be assessed.

Supplies Needed:
- 18 x 24 white paper
- Graph paper
- Journals
- Pens / Pencils / Markers

CLASS EXERCISE:
- Create interesting, visual explanations from the data collected.
- Compare their results with their original hypotheses.
- Discuss and compare each group's findings and hypotheses (through group presentations) with the entire class.