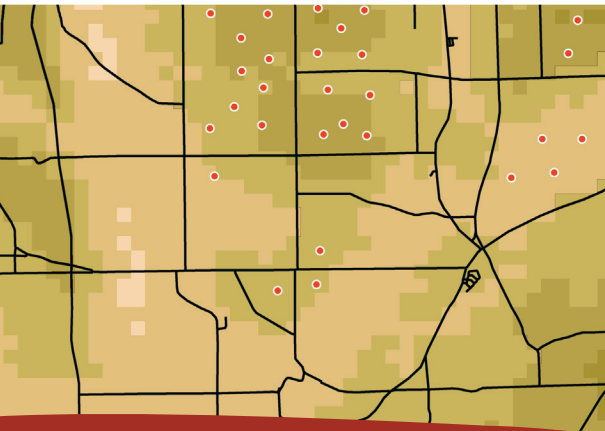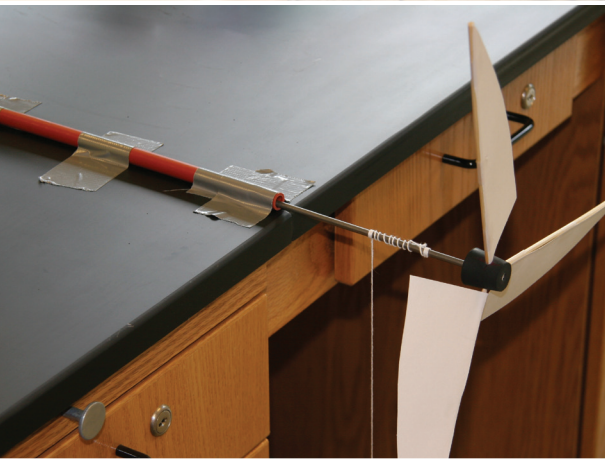# WindWise Education

Transforming the Energy of Wind into Powerful Minds

A Curriculum for Grades 6–12

2nd edition

windwise
education

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V2.0

WHAT IS THE COST OF INEFFICIENCY?

LESSON 3

KEY CONCEPT

Students learn about work, energy and power and that using electrical appliances and devices has economic and environmental costs.

TIME REQUIRED:

2 class periods

GRADE LEVEL:

6–8
9–12

SUBJECTS:

Environmental Science
Physical Science
Technology

BACKGROUND

The US Department of Energy projects that the demand for electricity will increase 30 percent by 2040. Improving the efficiency of homes, businesses, schools, governments, and industries is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, environmental concerns, and global climate change in the near term. Mining this efficiency could help us meet up to 50 percent of the expected growth in US consumption of electricity in the coming decades. This would yield billions of dollars in saved energy bills and avoid significant emissions of greenhouse gases and other air pollutants.

Energy efficiency and energy conservation are necessary first steps toward a sustainable energy future. All energy users need to understand the value of energy efficiency.

OBJECTIVES

At the end of the lesson, students will:
- define the concepts of work, power, and energy, and provide examples of each
- describe the relationship between work, power, and energy
- know how to calculate the economic and CO_2 savings from using energy-efficient appliances
- understand the concepts of energy efficiency and energy conservation and provide examples of each

METHOD

Students apply the concepts of power and energy in order to test three different types of light bulbs with a Kill A Watt Meter.
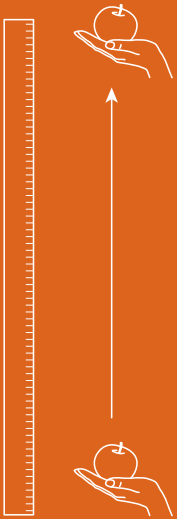
MATERIALS

- ☐ 2 lamps
- ☐ 2 light bulbs of equal brightness (measured in lumens); incandescent and compact florescent are included in the activity kit. For additional comparison you can also look for new LED bulbs but they are expensive.
- ☐ Kill A Watt Meters*
- ☐ Calculator
- ☐ Student sheets*
  *included with this activity

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POWER

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

A simple demonstration of work and power can be done using an apple with a mass of 100 grams.

GETTING READY

Make copies of all student sheets. Read over the lesson information and become comfortable with the concepts. Practice using the Kill A Watt Meter and doing the calculations in Part II: Measuring Power and Energy. Set up three stations with a lamp, light bulbs, and Kill A Watt Meter.

ACTIVITY PART I: WORK, POWER AND ENERGY

Step 1: Introduction
Ask students some questions to get them thinking about using electricity, such as:
- What electrical appliances and devices do you use at home?
- Which appliances do you think uses the most electricity in your house? Why?
- What electrical appliances and devices do we use in our classroom?
- Which appliances use the most electricity in our classroom? Why?
- Why is it important to conserve electricity?
- Is there a way to measure how much electricity appliances and devices use? If so, what is it?

Step 2: Discuss the concept of work
Tell students that the scientific definition of work is a force causing a displacement. Write this definition on the board.

Demonstrate this concept to students by lifting an apple one meter. We are using an apple as it represents a mass of 100 grams. The concept of work can be shown by displacing the apple one meter. This can be done quickly or slowly—the amount of work does not change. Power is equal to work/time. 1 watt of power would be equal to lifting this 100 gram apple, 1 meter in 1 second.

Using the definition of work on the board, ask students to tell you why work was done during this demonstration. Answer: You have applied a force to the apple, and displacing it (moved it up one meter).

Ask students to provide other examples of work that can be observed in everyday life such as a tractor pulling a plow through a field, a father pushing a grocery cart down the aisle of a grocery store, a student lifting a backpack full of books upon her shoulder, a weightlifter lifting a barbell above his head, an Olympian launching the shot-put, etc. In each of these examples, a force is exerted on an object that results in the object being displaced.

The amount of time it takes to do work has nothing to do with the amount of work being done. Whether it took you two seconds or four seconds to lift the apple, the same amount of work was done. Whether it took the father one minute or three minutes to move the shopping cart down the aisle does not change the amount of work that was done.

Step 3: Discuss the concept of power
Tell students that the definition of power, on the other hand, is a measure of how quickly a certain amount of work can be done, or the rate at which work is done.

Let's return to the example of lifting the apple. Power depends on the time it takes to raise the apple one meter. Whether the apple is lifted rapidly or slowly, it's the same amount of work. If it is lifted rapidly, the same amount of work is being done in a shorter period of time, and more power needs to be applied.

In order to sell his newly improved steam engines, James Watt was forced to combine the idea of time with the definition of work.

The equation for power is force times distance divided by time: $P = \dfrac{F \times D}{t}$

But F×D=Work, so power is equal to work divided by time or: $P = \dfrac{W}{t}$

The basic unit of work in the metric system is the joule and a joule per second is known as a watt (W).

A watt is roughly the amount of power needed to lift 100 grams (the mass of a average sized apple) one vertical meter of height in one second. Demonstrate one watt by lifting the apple one meter in one second (the amount of time it takes to slowly say one-one thousand).

Ask students if you need to be "powerful" to lift one apple one meter in one second. Explain to the students that because a watt is a small unit of measurement, kilowatts (kW) and megawatts (MW) are sometimes used. A kilowatt is 1,000 watts, or the power needed to raise 1,000 apples one meter in one second. A megawatt is a million watts. Do you have to be "powerful" to lift one thousand or one million apples one meter in one second?

Note: Horsepower is occasionally used to describe the power delivered by an engine. One horsepower is equivalent to 746 watts, or lifting 550 pounds, one foot in one second.

Step 4: Discuss the concept of energy
Tell the students that the amount of energy an appliance or device uses depends on how much power (watts) is needed to operate it and, more importantly, how much time it is consuming that power. A powerful car does not use any energy (gas) if it is parked in the garage all day. The same car consumes a lot of energy during an eight-hour drive to Grandma's house, however.

Energy is the capacity for doing work. It is a quantity, not a rate. Since the joule is a very small quantity of work or energy, explain that electrical energy is measured in larger units known as the watt-hour (3600 J), kilowatt-hour (1000 Wh), or a megawatt-hour (1,000,000 Wh). To determine how much energy an appliance uses in joules, you have to multiply the number of watts needed to operate it by the length of time that it is "on" in seconds. Watts × seconds = wattseconds (Ws), also known as a joules (J).

EXAMPLE POWER LABEL

INPUT : 100-250 Vac, 50/60Hz, 0.5A
DC OUTPUT: 48V, 0.35A   F013435G
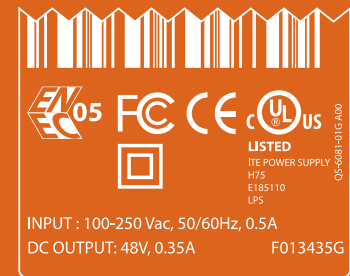
Almost all electronic devices have a label describing how much power they consume when turned on. These labels vary greatly. To determine how many watts the device will use, multiply the output voltage and the current. Does this match the Kill A Watt meter reading? Why might these be different?

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USING KILL A WATT METERS

Kill A Watt Meters are great tools to see power and energy being used by appliances. In a classroom it can be challenging to measure energy due to short lab times. To get around this set up a few meters to measure energy use at the beginning of the day or week.

Another cool thing you can do is let students sign them out for a week and collect data at home. As a class you can aggregate this data for analysis.

During class it is a good idea to have many appliances that students can plug into the Kill A Watt so students can experiment.

PART 2: MEASURING POWER AND ENERGY

Step 1: Demonstrate how to use a Kill A Watt Meter

Distribute the Kill A Watt Meter Student Sheet and the Economic and Environmental Cost of Using Appliances Activity Sheet. Show students the Kill A Watt Meter and explain that it is an instrument that measures the power it takes to run a device and the amount of energy the device consumes.

Demonstrate how to use a Kill A Watt Meter with a device in your classroom or an appliance from home. Go over the directions with the class, plug in your example appliance or device, and demonstrate how the meter can record both power (kilowatts) and energy (kilowatt-hours). See data collection sheet on page 81.

Step 2: Determine the power the appliance uses

The power is measured by pushing the Watt/VA key. With the meter plugged into a wall socket or extension cord and the appliance plugged into the meter, press the Watt/VA key.

Note: The Watt/VA Key is a toggle function key. Press the Watt/VA key once to display watts. Press the key again to display the VA meter. Tell students to record the power of the appliance/device you are demonstrating using the Watt function. The power drawn by an LCD television, for example, is 120 W.

Appliances draw different amounts of power, depending on their use. Make sure students use the appliance to see how it affects power consumption. For example turn the fan on low, medium, and high. Let the computer go into sleep mode. Students may have to choose an average number for this column.

Step 3: Estimate the amount of time the appliance is on in one day

Determine about how long the appliance is using power during the day. If you round this number off to the nearest hour, the next calculation will be easier, but using 15 minute segments will provide more accuracy.

In the LCD television example, the estimated time is 4 hours.

Step 4: Determine the amount of electrical energy the appliance uses in one day

Energy is measured by pushing the KWH/Hour toggle function key. Press the KWH/Hour key once to show the cumulative energy consumption since power was applied to the unit. Then press the key to display the cumulative time since power was applied to the unit.

Energy consumption will be displayed in kilowatt-hours (from 0.01 KWH to 9999 KWH). Time will initially be displayed as hours:minutes (from 00:00) and then will switch to hours (to 9999). To reset, remove the power from the unit momentarily.

It is very challenging to collect enough energy data in one class period to get measurable data that is accurate. If you have time, you can set up a Kill A Watt

Meter early in the morning and leave it on during the day to see how much energy the appliance you are testing has consumed.

We recommend collecting power consumption data with the Kill A Watt and then estimating how much energy your device would consume in a day.

Energy Consumed (Day) = Watts × Hours Device is Used

480 Watt-hours (Wh) = 120 Watts × 4 hours

To make things simple for later calculations, convert watt-hours (Wh) to kilowatt hours (kWh).

$$kWh = \frac{Wh}{1000}$$

$$.48kWh = \frac{480Wh}{1000}$$

Step 5: Calculate how many kilowatt-hours the appliance uses in one year
To calculate the amount of energy an appliance or device consumes in one year, multiply the amount it uses in one day times 365. Tell students to do this calculation for the demonstration appliance or device and record the amount on their worksheet.

In the television example, 0.48 kWh per day times 365 days equals 175.2 kWh. The television consumes 175.2 kilowatt-hours in one year.

**Step 6: Calculate the yearly cost of running the appliance**
Once you have determined the number of kilowatt-hours the appliance uses in one year, you multiply this number by the amount your power company charges you for each kWh of electricity. In 2010, the national average cost of electricity was $0.10 per kilowatt-hour. Use the map on page 76 to explore energy costs and sources in your state.

The television consumes 175.2 kWh per year; 175.2 times $0.10 equals $17.52. It costs $17.52 to watch four hours of television each day for one year.

Step 7: Determine the amount of carbon dioxide (CO_2) generated in one year by the appliance
Different sources of energy are used to produce electricity. Each source produces a different amount of CO_2 emissions. Coal produces more CO_2 than any other method of generating electricity. A majority of the electricity generated in the United States comes from coal-fired power plants. The national average for all methods of generating electricity is .62 kilograms of CO_2 per kWh. To calculate the yearly amount of carbon dioxide produced by running an appliance, you multiply the number of kWh of electricity it consumes in one year by .62. Ask students to do this calculation and record the result in the seventh column of the second row. Students can use the map
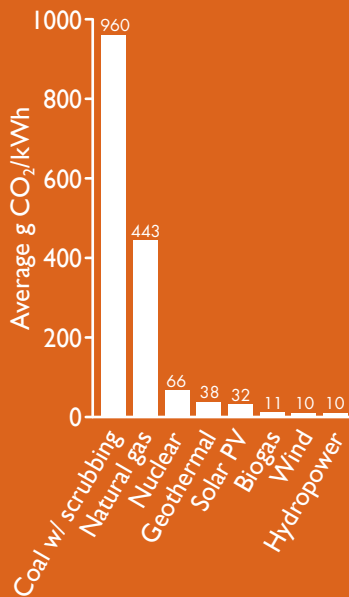
ESTIMATED COST OF ELECTRICITY, 2016
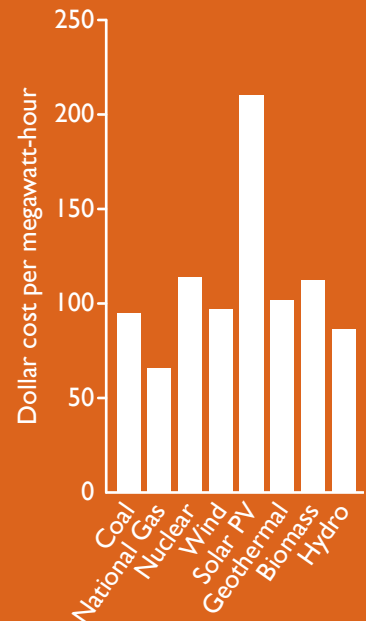
Data: US EIA, "Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011"

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CO$_2$ EMISSIONS BY SOURCE

Data: Sovacool, Benjamin K. "Valuing the greenhouse gas emissions from nuclear power: a critical survey." *Energy Policy*, Vol. 36, 2008, p. 2950.

on page 76 to determine the amount of CO2 that each kWh produces in their state.

The television consumes 175.2 kWh per year: 175.2 times .62 equals 108.6 kilograms of carbon dioxide.

Step 8: Calculating the cost and environmental impact of light bulbs
Divide students up into three groups and ask each group to record the type of light bulb they are measuring (incandescent, compact florescent, or LED if you used these bulbs) in the first column of the third row. Tell them to complete the calculations for their bulb. If students are not confident about doing this on their own, you can do this as a classroom demo.

Step 9: Discussion of their findings
Wrap up by discussing what the students discovered. Discuss the economic and environmental costs of each bulb.
- Which type of light bulb consumed the most power? The least power?
- Which type of light bulb used the most energy in a year? The least energy?
- Which type of light bulb costs the most to operate for a year? The least?
- Which type of light bulb produced the most carbon dioxide in a year? The least carbon dioxide in a year?
- Were there any surprises?

Compare your calculations to the data on the box of light bulbs. This is a very good consumer math activity.

PART 3: ENERGY EFFICIENCY

Step 1: Introduction
- What do you think energy efficiency means? What are some examples?
- What do you think energy conservation means? What are some examples?

Step 2: Energy efficiency reading passage
Ask students to read the passage (page 78).

Step 3: Discussion
Ask students which type of light bulb is the most efficient. Ask them to explain their answer.

Remind students that all energy transformations result in waste heat; the amount of "lost" heat is not the same in each transformation. (This concept was covered in Lesson 1.) Energy efficiency is a measure of how well a device transforms or converts one form of energy to another. The less energy that is "lost," the more efficient the transformation and the more efficient the device. In the case of light bulbs, the energy transformation we're looking for is electrical energy into radiant energy (light). The incandescent bulb transforms only 10 percent of the electrical energy into radiant energy. Consequently, we say that it is only 10 percent efficient because 90 percent of the electrical energy is transformed into thermal energy (waste heat). An incandescent light bulb is not a very efficient device.

On the other hand, 65 percent of the electrical energy powering a compact florescent light bulb is transformed into radiant energy, so we say that it is 65 percent efficient because 35 percent is lost to thermal energy (waste heat). This is why many people are switching from incandescent bulbs to compact fluorescents. Compact fluorescents not only save energy; they also save us money because we need to pay a power company for the electricity we use.

LED light bulbs are approximately 80 percent efficient; only 20 percent of the energy is lost to thermal energy.

EXTENSIONS

Measuring other appliances or devices

Ask students to measure the economic and environmental costs of other appliances or devices. On the Economic and Environmental Cost of Using Appliances Activity Sheet, there are additional rows for students to record their findings. You can have some students take a Kill A Watt Meter home to measure electrical devices in their homes.

Energy vampires (phantom loads)

Energy vampires are those electronic devices that we leave in the standby mode. In order to be ready to operate at all times, the electronic device, gadget, or appliance maintains a slow, reduced draw of electricity. The device still sucks energy when turned "off", hence the vampire reference. Even though the draw of the device is reduced, you are still paying for energy you aren't using. The bills can add up, particularly now with the rising cost of energy.

This undesired loss of electricity also is known as phantom load and some of the biggest culprits are electronics chargers. iPods, cell phones, and digital chargers have a steady current of energy flowing at all times—even when they say they are fully charged. Additionally, your television and DVD player, computers, auto-coffee maker and cordless phones all consume energy even when they are not in use. Computers can draw 7 watts (W) and microwaves can draw 1.2 W while in standby mode. The reason for standby is convenience, but now this convenience is coming at the cost of higher energy bills!

Consider this scenario: A young, four-person family with two cell phone chargers (1.2 W), two computers plugged in (7 W each), a microwave (1.2 W), a stereo (2.5 W), a DVD player (3 W), and two televisions (3.5 W each): has a total phantom energy load of 30.1 watts. This equates to .7224 kWh of energy per day or 264 kWh a year. In dollars this adds up to approximately $60 annually at the average rate of .10/kWh. And just remember, this is a conservative estimate. Often there are more phantom energy points than just the ones mentioned here.

Even though this is a relatively small portion of your total energy bill (approximately 5 percent of your total home energy consumption), the environmental and financial savings can accumulate, especially if everyone takes action. For the entire United States, this could add up to 65 billion kWh/year,

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which equals $5.8 billion in savings as well as eliminating 87 billion pounds of carbon dioxide from entering the atmosphere. That's some powerful change.

More Extensions

■ Learn about where some of your energy comes from by visiting a local power plant.

■ Arrange for students to conduct a classroom or home energy audit. Download from http://kwind.me/g2c

■ Complete a carbon footprint calculator such as http://kwind.me/f2h or http://kwind.me/a1p

VOCABULARY

carbon dioxide (CO_2) – A colorless, odorless, non-combustible greenhouse-gas that contributes to climate change.

compact florescent (CFL) – A fluorescent light bulb the size of a standard incandescent light bulb. In a CFL, electricity vaporizes mercury gas, causing it to emit radiant energy which reacts with a coating inside the bulb, transforming UV waves to visible light.

energy – The ability to do work or to cause a change.

energy conservation – Reducing the overall amount of energy used through behavioral changes eg. turning lights off or dialing down the heat.

energy efficiency – Reducing the amount of energy used through improved technology. Examples include changing incandescent light bulbs to CFLs or LEDs and swapping out older applicances with Energy Star appliances.

incandescent – A bulb that makes light by heating a metal filament wire to a high temperature until it glows.

kilowatt (kW) – 1 kW = 1000W.

kilowatt-hour (kWh) – 1 kWh = 1000Wh.

LED (Light Emitting Diode) – A semiconductor device that emits visible light when an electric current passes through it.

megawatt (MW) – 1MW = 1,000kW = 1,000,000W

megawatt-hour (MWh) – 1MWh = 1000kWh

phantom load – The electric current consumed by a device when plugged in but switched to its labeled "off" position.

power – The amount of work done in a given amount of time.

watt – The measure of power consumed by an electrical appliance or device.

watt-hour – A unit of energy equal to 1 watt of power expended for 1 hour.

work – A measure of force times the distance through which it acts.

RELATED ACTIVITIES

■ Previous Lesson 5: Can Wind Power Your Classroom?

ADDITONAL RESOURCES

TRUSTWORTHY CYBER INFRASTRUCTURE FOR THE POWER GRID—http://kwind.me/g2c—Students explore some of the economic and environmental costs of generating and using electricity. Downloadable applet, lesson plans, and student sheets.

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What is the Cost of Inefficiency?

EMISSION INTENSITY AND RETAIL PRICE OF ELECTRICITY (PER KWH)

CO$_2$ emitted in electricity production

- 0–0.13 kg/kWh
- 0.13–0.37 kg/kWh
- 0.37–0.58 kg/kWh
- 0.58–0.84 kg/kWh
- 0.84–1.13 kg/kWh

0   200 400   km
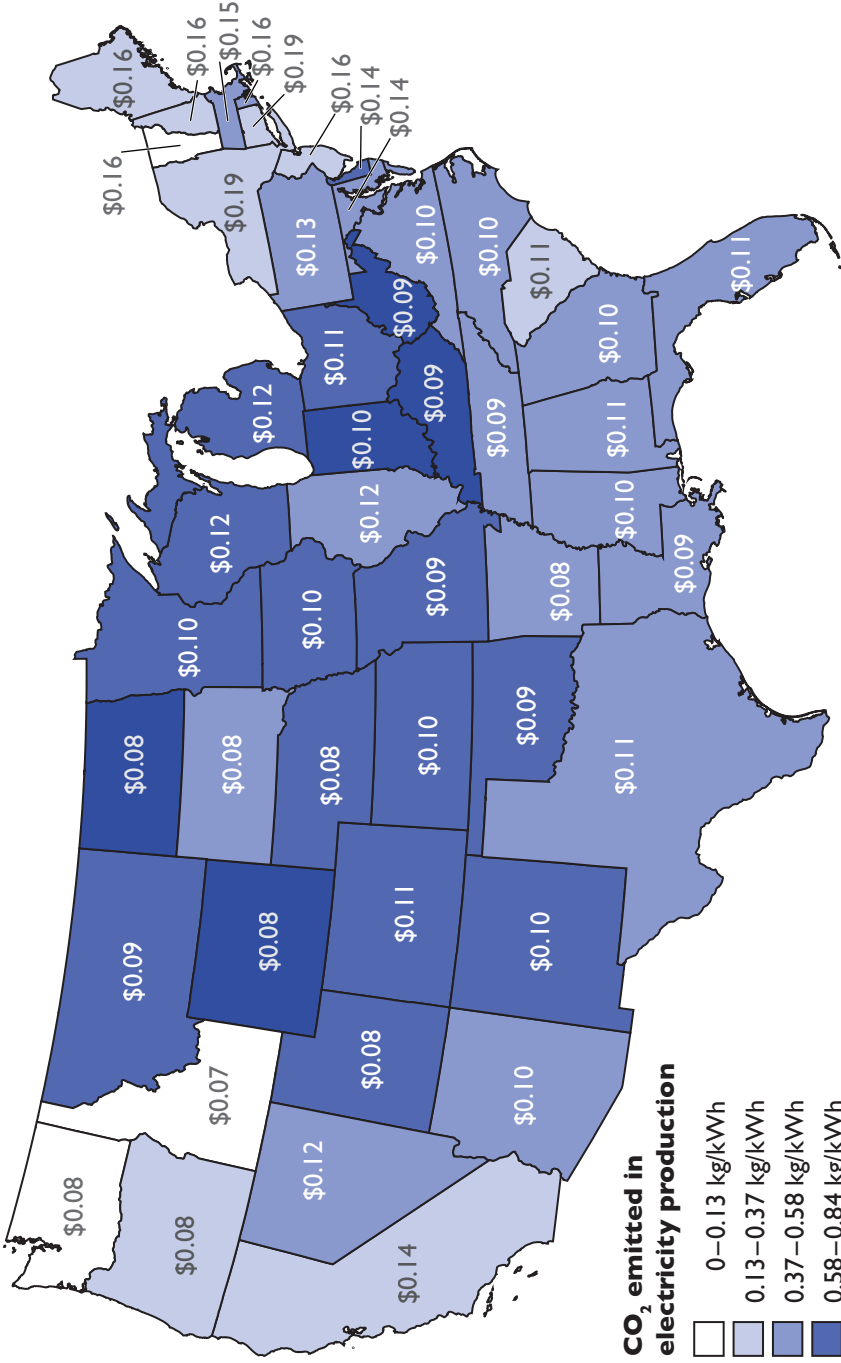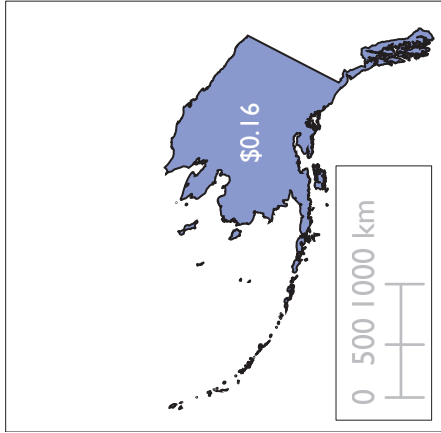
Map projection: Albers Equal Area
Data: Energy intensity: US EPA eGRID2012, 2011
Price: US Energy Information Administration, 2011

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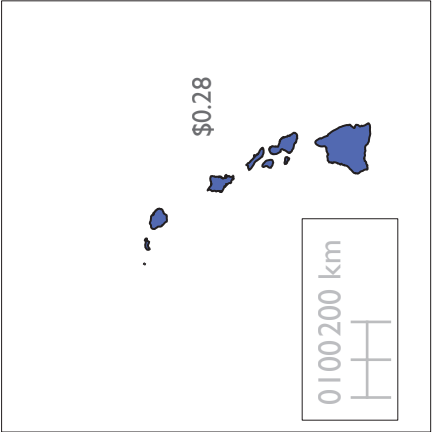
KILL A WATT METER

The Kill A Watt Meter is a device that lets you "see" how much power and/or energy an appliance in your house is using instantaneously or over a period of time. This page will help you understand some of the basic tools on this energy meter.
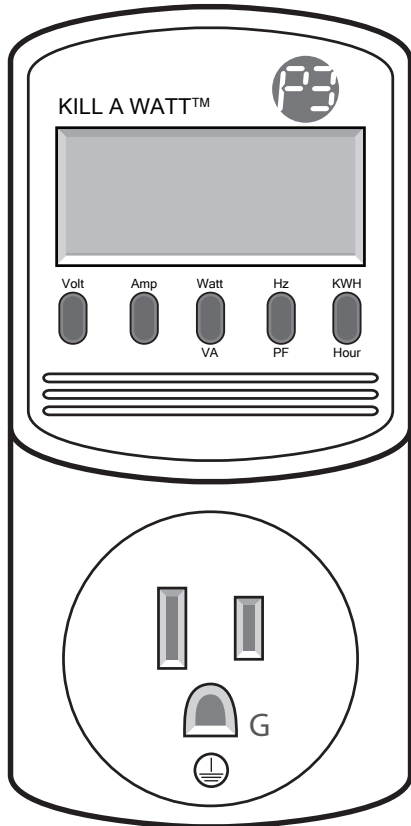
Directions: Plug the Kill A Watt Meter into a wall socket. Plug the device into the socket on the meter. The Watt button and KWH button are toggle switches. Make sure you have toggled each switch to make sure the readout is for watts (Watt/VA button) and kilowatt-hours (KWH/Hour button).

Volt button
When the Kill A Watt is plugged into the wall, the volt button will probably read somewhere around 120V. When you plug an appliance into the meter, it indicates the output voltage required to run your appliance.

Amp button
The AMP button will measure the flow of electric charge required to run your appliance. This value can vary greatly depending on the appliance you have plugged into the meter. When nothing is plugged in, this should read zero since no charge is flowing.

Watt button
The Watt button measures the power required to run your appliance. This is a measure of the movement of electrical energy required to make your device (blender, TV, etc.) function.

KWH
The KWH button measures the amount of energy used by your appliance.

In a water analogy, this would be equivalent to a bucket of water. It is a quantity of energy that can do a certain amount of work. If we had a lot of pressure (voltage) and a lot of water (current) moving through a hose, we could fill up the bucket very fast.

What is current?
Current (amperage) is the flow of electric charge in a conductor.

Using water as an analogy, we can think of this as the amount of water flowing through a tube. The higher the current, the more water that is moving in the tube. Low current would be similar to less water flowing in the same size tube.

What is voltage?
A negative charge will attract a positive charge, and invisible fields of voltage exist between the charges, kind of like magnetic fields. Voltage causes the attraction between opposite charges; we can quantify this attraction with a simple multimeter.

Using water as an analogy, we can also think of voltage like water pressure. Low voltage would resemble water under low pressure. High voltage would resemble water under high pressure. The amount of water is not so important; it is the pressure of the water that matters.

KILL A WATT™

| Volt | Amp | Watt | Hz | KWH |
| | | VA | PF | Hour |

G

Less Current

More Current
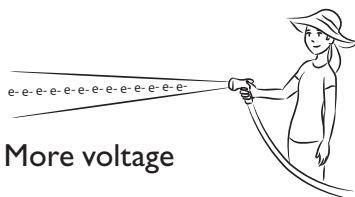
More voltage

Less voltage

READING PASSAGE: ENERGY EFFICIENCY

Energy efficiency is a very broad term referring to the many different ways we can get the same amount of work (light, heat, motion, etc.) done with less energy. It covers efficient cars, energy saving lighting, improved industrial practices, better building insulation and a host of other technologies. Since saving energy and saving money often amount to the same thing, energy efficiency is highly profitable.

Efficient energy use, sometimes simply called energy efficiency, is the goal of efforts to reduce the amount of energy required to provide products and services. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Installing compact fluorescent or LED lights reduces the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. Compact fluorescent light bulbs use two-thirds less energy and may last 6 to 10 times longer than incandescent lights.

There are various motivations for improving energy efficiency. Reducing energy use reduces energy costs. Reducing energy use is also seen as a key solution to the problem of reducing harmful emissions generated by coal-burning power plants. According to the International Energy Agency, improved energy efficiency in buildings, industrial processes, and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases.

Since we currently generate about half of our electricity in the United States from coal-fired power plants, the choices we make about electricity consumption have a significant impact on the amount of carbon dioxide (CO_2) released into the atmosphere. CO_2 is one of the major gases that traps heat in our atmosphere. Every kilowatt-hour (kWh) of electricity that we consume in the US—approximately $0.10 worth of electricity—generates .62 kilograms of CO_2. The amount of CO_2 per kWh changes in different parts of the country, due to the major sources of electrical energy.

STATE	KILOGRAMS CO_2 PER KWH	DOMINANT FUEL SOURCES
Alabama	0.47	coal, nuclear, gas
Alaska	0.47	gas, oil, hydro
Arizona	0.49	coal, gas, nuclear
Arkansas	0.5	coal, nuclear, gas
California	0.25	gas
Colorado	0.79	coal, gas
Conneticut	0.26	nuclear, gas
Delaware	0.81	coal, gas
Washington, DC	1.13	oil
Florida	0.54	gas, coal
Georgia	0.58	coal, nuclear
Hawaii	0.69	oil
Idaho	0.05	hydro
Illinois	0.48	nuclear, coal
Indiana	0.92	coal
Iowa	0.74	coal
Kansas	0.76	coal

Kentucky	0.93	coal
Louisiana	0.51	gas, coal
Maine	0.23	gas, hydro
Maryland	0.56	coal, nuclear
Massachusetts	0.51	gas, coal
Michigan	0.69	coal, nuclear
Minnesota	0.63	coal, nuclear
Mississippi	0.5	gas, coal, nuclear
Missouri	0.82	coal
Montana	0.65	coal, hydro
Nebraska	0.72	coal
Nevada	0.48	gas
New Hampshire	0.27	nuclear, gas
New Jersey	0.25	nuclear, gas
New Mexico	0.83	coal
New York	0.26	nuclear, gas
North Carolina	0.52	coal, nuclear
North Dakota	0.93	coal
Ohio	0.81	coal
Oklahoma	0.68	coal, gas
Oregon	0.16	hydro, gas
Pennsylvania	0.52	coal, nuclear
Rhode Island	0.41	gas
South Carolina	0.37	nuclear, coal
South Dakota	0.41	hydro, coal
Tennesse	0.49	coal, nuclear
Texas	0.56	gas, coal
Utah	0.84	coal
Vermont	0.001	nuclear, hydro
Virginia	0.45	nuclear, coal
Washington	0.13	hydro
West Virginia	0.91	coal
Wisconsin	0.69	coal, nuclear
Wyoming	0.96	coal

Energy efficiency and renewable energy, such as wind power, are said to be the twin pillars of a sustainable energy future. In many countries, energy efficiency is also seen to have a national security benefit because it can reduce the need for energy imports (i.e. petroleum and coal) from foreign countries and may slow down the rate at which domestic energy resources are depleted.

Modern energy-efficient appliances, such as refrigerators, dishwashers, and clothes washers, use significantly less energy than older appliances. Current energy-efficient refrigerators, for example, use 40 percent less energy than conventional models did in 2001.

Energy conservation is broader than energy efficiency and includes active efforts to decrease energy consumption, for example through behavioral change. Examples of conservation without efficiency include lowering the temperature on the thermometer during the winter, turning off the light(s) when leaving a room, and riding a bike or walking instead of driving a car.

CAREER PROFILE: JIM BROWN, ENERGY AUDITOR

I help people save money and protect the environment by showing them ways to save energy in their home or work. As an energy auditor, I examine how energy is being used in a building and then make energy efficiency and conservation recommendations to the people who live or work in the building. I might suggest that they buy new, more energy-efficient appliances and equipment to replace older, less efficient models. There are also lots of different conservation strategies that I tell people about.

One of the most common things that I will do in any building is to switch all of the inefficient, incandescent light bulbs to compact fluorescents or other highly efficient lighting technologies. Another lighting technology that I really like is the passive solar technology that allows the use of daylight, which means letting sunlight into the building instead of turning on electric lights. When a building is designed properly, there often is little need for lights during the daytime.

When I perform an energy audit, I use specialized tools, such as Kill A Watt Meters, blower doors, air flow meters, and infrared cameras to evaluate how much energy a building is using. Kill A Watt meters measure how much electricity an appliance uses when it is on. They are also very helpful in finding energy vampires and phantom loads—appliances that use energy even when they are turned off. My favorite tool is a blower door, which is used to depressurize a building. By forcing air out of the building with the blower door, I can then find where air is leaking into or out of a building. Air leaks can account for a large percentage of the energy used for heating and cooling a building. Infrared cameras can help me pinpoint exactly where the leaks are so that I can come up with a plan to fix them.

Energy auditing is a fun job that involves science, technology, and a good deal of problem solving. The most rewarding parts of the job is knowing that I'm doing something good for the environment and helping people save money. Growing concerns about climate change, energy security, and fuel prices mean that there's more and more work for energy auditors. It's a good career to consider.

What is the Cost of Inefficiency?

Name_____   Date_____   Class_____

THE ECONOMIC AND ENVIRONMENTAL COST OF USING APPLIANCES ACTIVITY SHEET

State _____ Electricity cost ($/kWh) _____ State's major sources of energy _____ Emmission intensity (kg of CO_2/kWh) _____

US average cost: kWh: 0.1   US average intensity: 0.62 kg of CO_2/kWh

Appliance/Device	Measured power use (W)	Time Appliance on per day (hours)	Energy used in one day (kWh)	Energy Use in a Year (kWh)	Yearly Cost (use your state energy cost)	CO_2 produced to in one year (use your state data)
Example: (20" LCD Television)	120	4 hours	480Wh = .48 kWh	.48 kWh × 365 = 175.2 kWh	175.2 kWh × $0.10 = $17.52	175.2 kWh × 0.62 kg/ kWh = 240.02 kWh

81   WindWiseEducation.org   Lesson 3

Name_____   Date_____   Class_____

WINDWISE ENERGY EFFICIENCY ACTIVITY WORKSHEET

1. Define power (use examples):

2. Define energy (use examples):

3. Unit Conversions (Remember, 1 kW=1,000W and 1 MW=1,000,000 W)
    a. 1500 W   = _____ kW
    b. 500 kW   = _____W
    c. 1000 kW = _____ MW

Using data from the worksheet:

4. Which light bulb uses the most power?

5. Which light bulb uses the most energy?

6. Name one appliance that would be called an energy vampire. Why is it using energy even when it seems to be turned off?

7. How much energy would the following devices use?
    a. 15-watt compact fluorescent that is on for 10 hours: _____Wh
    b. 60-watt incandescent bulb that is on 5 hours: _____Wh
    c. 1200-watt oven that is used for 1.5 hours: _____Wh

8. Which uses more energy in one month (30 days)?
    a. Energy vampire that uses 5 watts for 24 hours a day
    b. 100-watt stereo that is used for 1 hour each day
    c. 1000-watt toaster that is used for 0.1 hour each day

9. What is one way you can save energy at home through conservation?

10. What is one way you can save energy at home through efficiency?

11. Answer the following questions based on the graph at the end of the worksheet.
    a. People in what country use the most electricity per year?

    b. People in what country use the least electricity per year?

   c. Why might there be such great differences in electricity use among different countries?

d. Do you think that people in Europe (such as France, Germany, and the United Kingdom) have a lower standard of living than people in the United States and Canada? Why?

e. How many people in India could live their daily lives using the electricity consumed by one person in the United States?

PER CAPITA ANNUAL ELECTRICITY USE, AROUND THE WORLD
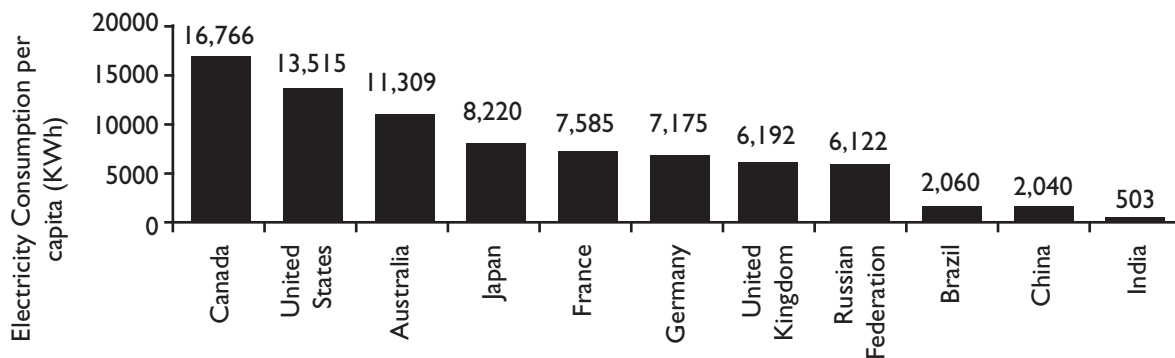
(Data Source: IEA, Key World Energy Statistics 2008)

1. Define power (use examples)
    The amount of work done in a given amount of time. Students may have many examples.

2. Define energy (use examples)
    The ability to do work or to cause a change. Students will have many examples.

3. Unit Conversions (Remember, 1 kW=1,000 W and 1 MW=1,000,000 W)
    a. 1500 W   = 1.5 kW
    b. 500 kW   = 500,000 W
    c. 1000 kW   = 1 MW

Using data from the worksheet:
4. Which light bulb uses the most power?
    Incandescent

5. Which light bulb uses the most energy?
    Incandescent

6. Name one appliance that would be called an energy vampire. Why is it using energy even when it seems to be turned off?
    Student observations. Any device that is consuming power when it is turned "off" can be called an energy vampire. It may be using energy to stay warm so that it can turn on quickly or may not be designed to use electricity efficiently. A few examples include: cell phone chargers, VCRs and DVD players, and TVs.

7. How much energy would the following devices use?
    a. 15-watt compact fluorescent that is on for 10 hours   150 Wh
    b. 60-watt incandescent bulb that is on for 5 hours   300 Wh
    c. 1200-watt oven that is used for 1.5 hours   1800 Wh

8. Which uses more energy in one month (30 days)?
    a. Energy Vampire that uses 5 watts for 24 hours a day   3600 Wh
    b. 100-watt stereo that is used for 1 hour each day   3000 Wh
    c. 1000-watt toaster that is used for 0.1 hour each day   3000 Wh

9. What is one way you can save energy at home through conservation?
    Possible answers include:
    Turning off lights when you are going out of the room
    Take shorter showers
    Energy conservation is changing your behavior in order to save energy.

10. What is one way you can save energy at home through efficiency?
    Possible answers include:
    Using CFL bulbs
    Installing a programable thermostat
    Installing a low-flush toilet
    Using Energy Star appliances

11. Answer the following questions based on the graph at the end of the worksheet.
    a. People in what country use the most energy per year?
    Canada

    b. People in what country use the least energy per year?
    India

c. Why might there be such great differences in energy use among different countries?
    People in affluent countries generally have larger houses, more electronic devices, and they tend to waste more energy. Also people from colder climates tend to use more energy for heating and lighting during winter months.

d. Do you think that people in Europe (such as France, Germany, and the United Kingdom) have a lower standard of living than people in the United States and Canada? Why?
    Student observations will vary, but generally people in Europe have lights, heat, and all the electricity they need to lead very modern lives. It is all about doing the same with less and improving efficiency. One place to read more about how much energy we could save and still lead very modern lives is at the Rocky Mountain Institute (www.rmi.org/rmi) or American Council for an Energy Efficient Economy (www.aceee. org).

e. How many people in India could live their daily lives using the energy consumed by one person from the United States?
    Approximately 26 people. In the US, the average person consumes 13515 kWh of energy each year. In India, the average person consumes 503 kWh of energy per year.

$$\frac{US\ 13515\ kWh}{India\ 503\ kWh} = 26.87$$