Energy Basics

What Is Energy?

Energy is the ability to do work. The sun is the energy that powers the wind, the water cycle and photosynthesis. Food provides the energy that powers our bodies. Energy comes from natural resources, which exist without the actions of humankind and come from the earth or sun. Renewable energy sources like sun, water, wind and biomass can be naturally replaced. Energy resources like natural gas, coal, oil and uranium are replaced very slowly or are not replaced at all.

Uses of Energy

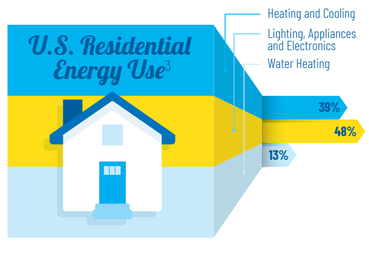
Imagine a great-great-grandparent washing clothes by hand. Modern energy use in the U.S. makes our lives productive, convenient and enjoyable. Energy transports people and products, powers industries that are important to our economy and runs schools, businesses and homes. It even takes energy to create the products we use and the buildings we live in.

Understanding how we use energy can help us use it wisely. Electricity and natural gas are the most consumed energy sources in U.S. homes.[1] Electricity is man-made. It is generated with natural gas, coal, uranium (nuclear), oil or renewable energy sources. A home in the United States uses about half of its energy for lighting, appliances and electronics, over one-third to heat and cool its air, and about one-seventh of its energy to heat water.

Energy Savings

The United States represents 4.4 percent of the world's population yet consumes 18 percent of the world's total energy.[2] Using less energy extends the life of our natural resources and reduces our impact on the environment. We can also save money!

Both energy efficiency and wise energy behaviors are needed to save energy. Energy efficiency is managing the consumption of energy through the use of efficient technologies like low flow water devices, LED bulbs or a smart thermostat. Efficient technologies make saving energy easy! Wise energy behaviors, like taking a short shower or turning off the lights, are important ways for people of all ages to save energy.



Categorize Your Energy Use

Brainstorm items or processes that use energy for three minutes. They could be found inside or outside, at school or at home. Put each object in the column under the energy source that it uses. Think of another energy source that is not listed. Which items could use less energy through energy efficiency (efficient technologies)? Which items could use less energy through wise energy behaviors? Which of your energy sources are renewable?

Electricity	Natural Gas	Petroleum	Other_____

[1] United States Energy Information Administration, *eia.gov/energyexplained/index.cfm/data/index.cfm?page=us_energy_homes*, accessed April 2018
[2] United States Energy Information Administration, *eia.gov/consumption/residential/index.php*, accessed April 2018
[3] United States Census Bureau, *census.gov/popclock/* and United States Energy Information Administration *eia.gov/tools/faqs/faq.php?id=87&t=1*, United States Energy Information Administration, *eia.gov/consumption/residential/index.php*, accessed April 2018

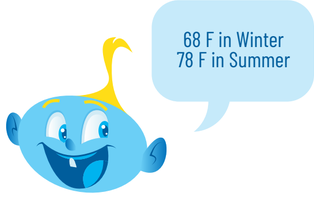
Heating and Cooling

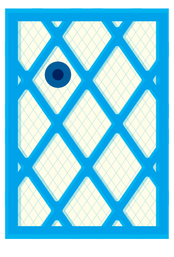
Thermostat

Adjusting your thermostat up in the summer and down in the winter will save energy used to heat and cool your home. A national setting of 68 F in the winter (lower when asleep or away from home) and 78 F in the summer (when you are at home and need cooling) is recommended.[1] A programmable or smart Wi-Fi thermostat makes this easy and also allows you to preset different schedules for times when less heating or cooling is needed. For example, less summer cooling when family members are away at school and work, sleeping or on vacation.

Heating and Cooling Systems

Changing filters on furnaces, central air and heating systems is very important. A unit will work much harder, and use more energy, to push air through a dirty filter. A clean filter also prevents dirt from building up inside the system, which can cause breakdowns. Furnace filters should be changed every 1 to 3 months, depending on the type of filter and how much the system is in use.[2] Using a furnace filter alarm that makes noise when the filter is dirty can help remind you to change a filter. A newer model smart thermostat will also alert you when a filter needs to be changed.





Routine checks of heating and cooling systems by a qualified technician will help them run efficiently and extend the life of the equipment. When old equipment needs to be replaced, consider ENERGY STAR® certified heating and cooling equipment. It can help save up to 15 percent more energy and money on utility bills.[3]

Trick Question

Survey four people to ask the question "Do fans cool the air?" Record their names next to their answer below and check the box in the last column after you teach those who did not know the correct answer.

Name	Yes	No	Don't Know	I taught this person.

On a hot day, we perspire to lose heat through evaporation. A fan helps move the hot, humid air surrounding a sweating person with cooler, drier air. This allows for more evaporation.

Even without sweat, heat will transfer by convection from a body with a higher temperature to the surrounding, cooler air. A breeze from a fan carries the hot air away from your body.

The answer to the survey question is NO! In either of these processes, the fan cools a person, not the air. Fans can save a lot of energy. If you use air conditioning, a ceiling fan will allow you to raise the thermostat setting about 4 F while still feeling just as cool.[4]

[1] United States Department of Energy, *energy.gov/energysaver/thermostats*, accessed March 2018
[2] United States Environmental Protection Agency, *energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf?fe9-b026*, accessed March 2018
[3] United States Environmental Protection Agency, *energystar.gov/products/heating_cooling/furnaces*, accessed March 2018
[4] United States Department of Energy, *energy.gov/energysaver/home-cooling-systems/fans-cooling*, accessed March 2018

Weatherization

What Is Weatherization?

Think of the exterior of a building as a giant barrier that protects the inside from outside heat or cold. Things we do to weatherize keep this barrier strong and intact. As a result, the temperature is comfortable with less energy use.

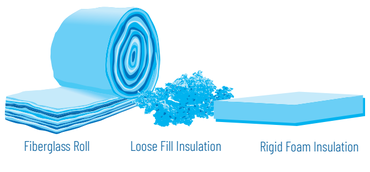
Sealing Building Openings

Anytime a door, window, pipe or wire penetrates the exterior of a building, air may be able to leak in or out. Leaks around window and door frames or pipe and electrical wire openings can be sealed with caulk, weather stripping or expanding foam insulation. Insulation can also be added behind electrical outlets and light switch plates to block leaks.

A home inspection by a certified energy professional is the best way to find an air leak. However, you can find leaks on your own by holding a thin strip of tissue paper next to doors, windows, pipes (where they meet an exterior wall) or light switches. If the tissue moves horizontally, there is probably a leak.

Insulation

A building is more comfortable and uses less energy to heat and cool with insulation in its attic, exterior walls and basement. Materials with a higher R-value, or insulation level, are needed in colder climates and areas with more transfer of heat. Insulation can also help specific items in a building to operate efficiently. For example, an insulating blanket can be put around a water heater or pipe wrap added to its hot water pipe.



Doors, Windows and Skylights

ENERGY STAR® certified doors, windows and skylights save energy and improve the comfort of a building by reducing heat transfer. Windows and doors should be closed when the furnace or air conditioner are operating. Blinds, drapes, tints or films can cover windows to insulate against heat transfer. If your home is not being heated or cooled, windows can be left open to let a cool breeze into a warmer home.

Sealing Ductwork

You may have seen metal ductwork in a room with unfinished walls. It directs heated or cooled air to where it is needed. Unsealed ductwork openings can keep up to 30 percent of this air from reaching the living areas of a home.[1] Duct leaks cause rooms to feel warmer, cooler or more humid than they should. They can also draw dust or mold into occupied areas.

Design Your Energy Dream Home

Materials

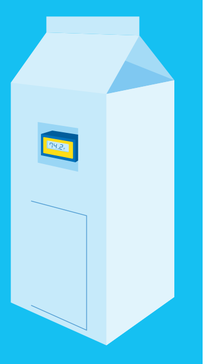
- Paper milk carton or shoe box
- Four weatherization materials – cardstock, aluminum foil, plastic wrap, bubble wrap, cotton, gauze or tape
- Thermometer

Rules

- You must be able to see through the window.
- No weatherization material can be more than 1 centimeter thick.
- The door and window must be regulation size.

The Challenge

- Draw a window (2" by 2") and a door (3" by 4") on your house. Carefully cut out the window and the door, leaving one side of the door attached.
- Your goal is to "weatherize" your home with materials that represent caulk, insulation, window coverings and weather stripping so that it maintains its cool temperature.
- When your weatherization efforts are complete, tape the thermometer to the window where you can see it. Close the door and record the temperature of the inside of the house.
- Put your house in a sunny window or under a strong lamp. Wait 20 minutes and record the temperature again.



Did your house get warmer? If so, how would you change your design?

[1] Energy Star, *energystar.gov/index.cfm?c=home_improvement.hm_improvement_ducts*, accessed March 2018

Lighting and Appliances

Lighting

Light emitting diodes (LEDs) use at least 80 percent less energy than incandescent bulbs. Because they last up to 25 times longer, they can be replaced much less frequently. LED bulbs can be used in dimmable switches, recessed lighting, ceiling fixtures, porch and holiday lights. By 2027, widespread use of LEDs could save more than 30 billion dollars of electricity in the United States at today's electricity prices.[1]

LEDs are available in a wide range of colors and light levels. A lighting facts label gives valuable information when purchasing lighting.

Lighting Facts per LED bulb

Brightness	**800 lumens**
Estimated Yearly Energy Cost $1.08 Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use	
Life Based on 3 hrs/day	23 years
Light Appearance Warm 2700 K Cool	
Energy Used	**9 Watts**

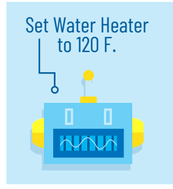
Lumens are a measure of the brightness of a light bulb. To save energy, find bulbs with the lumens you need, then choose the one with the lowest wattage.

The lighting facts label helps find the shade of light customers prefer, from "warm" or yellowish light to "cool" bluer light.

A Watt is a unit of measurement of electrical power.

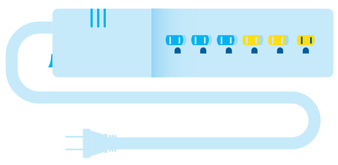
Appliances

When shopping for appliances, look for the yellow and black EnergyGuide label. It will give you an estimate of a product's energy consumption. Here are some tips to save energy with appliances:



- Set water heater to 120 F, use a timer to turn heater off during the day.
- Wash laundry with cold water, do full loads, use a clothesline and clean the dryer filter with every load.
- Set refrigerator temperature between 37 and 40 F, set freezer to 0 F.
- Wash only full loads in the dishwasher, use air dry and energy saver settings.
- Use a microwave oven when cooking, if possible, keep the oven door closed, use lids when cooking on the stove top and match the heating element to the pot size.

Phantom Loads



Phantom loads, devices that use power even when they are turned off, are often responsible for adding 10 percent or more to your monthly utility bill [2]. Chargers, items with remote controls and electronics with clocks or indicator lights are often phantom loads. There are several types of advanced power strips. They all have the same job of shutting off power supply to items that are not in use. For instance, one type will automatically cut off power to your computer monitor, printer and speakers when the main computer is shut down.

Demonstration - Controlling Consumption

Controlling our consumption of energy, water and other natural resources helps them last longer.

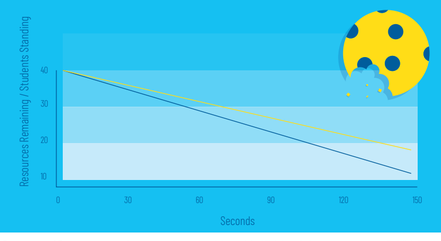
Give students a cookie or cracker and have them stand. Explain that when you give the signal, they are to begin eating. When they have swallowed the last bit, they should sit down. Every 30 seconds, count the number of students who are still standing. You may wish to stipulate that they may take more than one bite to get a clearer result.

Create a line graph for the data: resources remaining (students standing) versus time.

Distribute a second cookie or cracker. This time students can only take a bite when you say "take a bite" (every 30 seconds).

Put the results of the second experiment on the same line graph with a different line and compare the two results.

Discuss how the rate of consumption was controlled with the second cookie? How can humans control how rapidly we use resources?



[1] United States Department of Energy, *energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money/led-lighting*, accessed March 2018
[2] United States Department of Energy, *energy.gov/articles/4-ways-slay-energy-vampires-halloween*, accessed May 2018

The Smart Grid

The Grid - Past, Present and Future

The grid is the complex system of power plants, transformers and transmission lines that deliver electricity to your home. We are beginning to use technology to provide better and increased communication between providers and consumers of electricity in the grid. Our electrical devices, solar panels or plug-in electric vehicles can even be a part of this enhanced communication by using, supplying or storing energy when it is most beneficial to the overall system. When parts of the grid communicate, disruptions, like a downed power line, can be identified and responded to more quickly. Our increasingly "smarter" grid will use electricity with more flexibility, reliability, affordability and efficiency.

Smart Meters

For a century, utility companies have sent workers to homes to read meters and gather data on electricity use. Today, about half of all U.S. electricity customers have smart meters.[1] These meters often come with a web portal that shows information on near hourly electricity consumption. This data can help consumers understand their energy use patterns. Consumers might use what they learn to take actions like shifting energy use away from peak demand times when the need for electricity is high. Smart meters can also be used with home energy management systems (EMS) to track overall energy use or use by an individual appliance.

Smart Appliances

Families can now purchase smart thermostats, refrigerators, dish and clothes washers, air conditioners and even electric outlets and switches. Smart appliances can be networked together and operated through an EMS. Consumers can even control them remotely! Smart appliances can reduce demand on the grid by responding to signals that help them avoid power use during peak demand times.

Visit *smartgrid.gov* to watch fun and informative videos on the smart grid.

The Electricity Roller Coaster

Electricity providers have the tricky job of matching electricity supply to demand in real time! We tend to need more electricity in the summer and winter months when homes need to be heated and cooled. Did you know that our demand for electricity also changes throughout the day?

Draw a where demand is low and it would be a good time for an electric vehicle to charge on the smart grid.

Draw a where demand is high and energy from a nearby wind farm could be used.

Draw a at the top of the "morning ramp" where more electricity is needed to start the day.

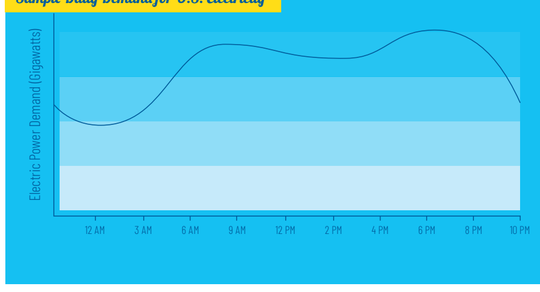
Draw a at peak demand time when the most electricity is needed and generating it might be more expensive. What do you think people are doing at this time of day to cause that demand?

Draw a where demand is low and it would be a good time to program a dish or clothes washer to start.

Draw where lights could be turned off by a home energy management system.

*Note to teachers – This activity may be adapted for a whole class activity by drawing the graph on a white or SMART board.

Sample Daily Demand for U.S. Electricity[2]



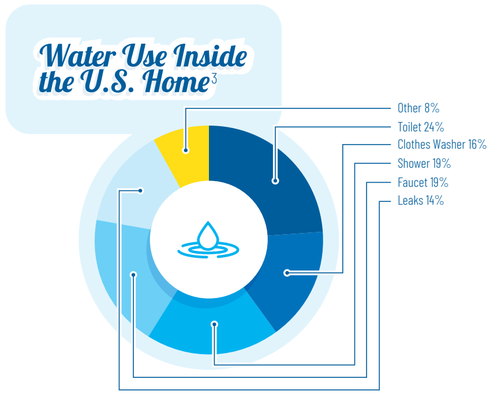
1 United States Energy Information Administration, *eia.gov/todayinenergy/detail.php?id=34012*, accessed April 2018
2 United States Energy Information Administration, *eia.gov/todayinenergy/detail.php?id=4190*, accessed April 2018

Water and Transportation

Water

Purifying, transporting and heating water all use energy. So, when you save water, you also save energy! Letting hot water run for just 5 minutes uses as much energy as a 60 Watt light bulb uses in 18 hours.[1]

- Look for the WaterSense® label to purchase high-efficiency shower heads, faucet aerators and toilets.
- Fix leaks to save water and money.
- Choose plants with low water needs and use drip irrigation to water them.
- Do not overwater! The average lawn needs only about 1 inch (2.5 cm) of water per week.[2]
- Water in the early morning or evening to reduce evaporation.



[1] United States Environmental Protection Agency, *epa.gov/watersense/statistics-and-facts*, accessed March 2018
[2] United States Environmental Protection Agency, *epa.gov/watersense/watering-tips*, accessed March 20183 United States
[3] Alliance for Water Efficiency, *allianceforwaterefficiency.org/residential-end-uses-of-water-study-1999.aspx*, accessed March 2018
[4] Alternative Fuels Data Center, *afdc.energy.gov/uploads/publication/which_is_greener.pdf*, accessed March 2018

Transportation

Not all modes of transportation are created equal. Walking, biking and mass transit are the most energy-efficient modes of transportation. Items that we use are also transported with energy. Use these tips to save energy and reduce harmful emissions.

- Carpool and ride share
- Combine trips
- Buy local products — Locally produced items use less fuel to get to their end user.
- Idling — Idling a car for 10 seconds uses more fuel than turning the car off and on.[4]
- Maintain vehicles — Dirty air filters and engine oil, low tire pressure and using incorrect types of tires waste fuel.
- Driving habits — Obey speed limits, avoid sudden starts and aggressive driving and eliminate extra weight in the vehicle to increase mileage.

Water Tickets

Make 20 simple tickets like the one below. Each time you use water to drink, eat, clean, use the restroom or for any other purpose, put one ticket aside.

How long do you predict it will take you to run out of tickets?

Did you consider the water it took to produce your books, pencil and other things that you use?

Save or Waste?

Print and cut out the strips of paper below and give one to each student. Challenge those with energy saving actions to find the person with the corresponding energy wasting action and vice versa. Have each pair report to the class the benefits of their energy saving action while they point it out on the front of this poster. Have pairs mention whether the energy saving action is energy efficiency (managing the consumption of energy through the use of efficient technologies) or a wise energy behavior.

It saves energy when you...	It wastes energy when you...
Close windows and doors when air conditioning or the furnace/boiler are running.	Leave windows and doors open when air conditioning or the furnace/boiler are running.
Use an advanced power strip to cut off power to devices that are turned off.	Have phantom loads that are plugged into a power source but are not in use.
Find and fix water leaks.	Let a water leak keep dripping.
Turn off lights and electronics when you are not in the room.	Leave lights and electronics on when you leave the room.
Use LED light bulbs.	Use inefficient lighting.
If you have one, take advantage of information from a smart meter to save energy.	Ignore information available through a smart meter.
Seal building openings with caulk, weather stripping or foam insulation.	Let the air outside flow into your home through openings.
Use both sides of a piece of paper.	Use one side of a piece of paper and throw it away.
Purchase WaterSense® high-efficiency shower heads, faucets, aerators and toilets.	Use inefficient shower heads, faucets, aerators and toilets.
Change filters on furnaces, central air and heating systems and the clothes dryer. Use a filter alarm for a reminder.	Let furnace, central air and clothes dryer filters get dirty.
Set the water heater to 120 F.	Set the water heater higher than 120 F.
Combine car trips and carpool.	Drive alone and make multiple trips to the same area.
Use a smart thermostat to adjust air conditioning or heating when you are away.	Keep heat or air conditioning running to maintain the same temperature all of the time.
When you are at home, use thermostat settings of 68 F in the winter and 78 F in the summer.	Do not change thermostat settings for the seasons.
Insulate the attic, exterior walls and basement.	Do not use insulation to stop heat transfer in your home.

Recycling/Credits

Three Rs and a T

You have heard of the three Rs - reduce, reuse and recycle. To practice energy efficiency, add a T for Think! Energy. That means to Think! about our choices, Talk! to others about energy efficiency and Take Action! to improve the efficiency of our homes, schools and businesses.

Reduce — to use less of something.

- Use efficient lighting, shower heads, faucet aerators and appliances.
- Turn off electronics and appliances when not in use. Unplug them when they are not used on a regular basis.
- Avoid disposable items, such as shopping bags, paper plates, napkins and plastic utensils.
- Buy in bulk and look for items with the least amount of packaging.

Reuse — to use something over again.

- Donate used items to thrift stores and shop at thrift stores for items you need.
- Use both sides of the paper when doing work or making copies.

Recycle — to use old materials to make a new object.

- Check with your local municipality or *earth911.com* to see what recycling programs are available in your area. Most programs recycle cardboard boxes, paper, plastics, glass and metals. Recycle ink/toner cartridges and small electronics.
- Buy new products that are made from recycled materials.
- Compost lawn clippings and food waste for lawn mulch and fertilizer.

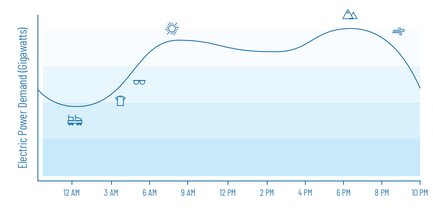
About the National Energy Foundation

The National Energy Foundation (NEF) is a unique 501 (c)(3) nonprofit organization dedicated to increasing energy literacy through the development, distribution and implementation of educational programs and materials. These resources relate primarily to energy, natural resources, energy efficiency and energy safety. Concepts are taught through science, math, art, technology and writing.

Sample Answers to Categorize Your Energy Use

Electricity	Natural gas	Petroleum	Other __Sun__
Air conditioner	Furnace/boiler	Vehicle	Electrical generation
Refrigerator	Water heater	Airplane	Calculator
Water heater	Barbecue/grill	Boat	Road sign
Hairdryer	Oven	Making plastic	Drying clothes
Led bulb	Stove	Lawnmower	Space heating
Toaster	Making fertilizer	Making asphalt	Growing plants
Computer	Making plastic	Making wax	Heating a reptile's body
Cell phone	Vehicles	Making cosmetics	Solar oven
Furnace/boiler	Clothes dryer	Bus	Solar powered vehicle

Sample Answers to the Electricity Roller Coaster



Acknowledgments

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