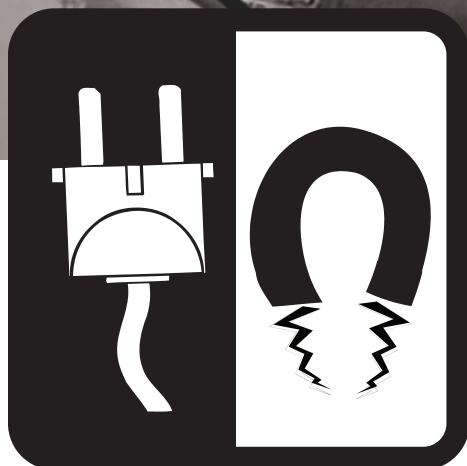


Smart Meters

Students explore smart meter technology, investigate electricity consumption of electrical devices, and determine ways to reduce energy consumption at home.



Grade Level:



Intermediate

Subject Areas:



Science



Social Studies



Language Arts



Math



Technology



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NEED Mission Statement

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

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Teacher Advisory Board

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

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.



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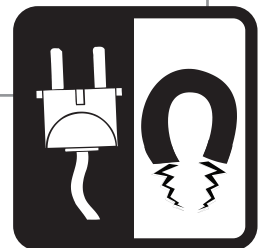


NEED gratefully acknowledges the Pacific Gas and Electric Company (PG&E) and the Commonwealth Edison Company (ComEd) for their support in the development and continued enhancement of this curriculum unit.

Smart Meters

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Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.


Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.





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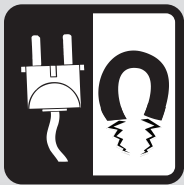
Curriculum Correlations

NEED has correlated their materials to the Disciplinary Core Ideas of the Next Generation Science Standards. NEED has also correlated all of their materials to The Common Core State Standards for English/Language Arts and Mathematics. All materials are also correlated to each state's individual science standards. Most files are in Excel format. NEED recommends downloading the file to your computer for use. Save resources, don't print!

- [Navigating the NGSS? We have What You NEED!](#)
- [NEED alignment to the Next Generation Science Standards](#)
- [Common Core State Standards for English and Language Arts](#)
- [Common Core Standards for Mathematics](#)
- [Alabama](#)
- [Alaska](#)
- [Arizona](#)
- [Arkansas](#)
- [California](#)



NEED is adding new energy workshops all the time. Want to



Teacher Guide

Overview

Smart Meters introduces students to the concepts of energy, energy consumption, economics, conservation and efficiency, electricity generation, the smart grid, and smart meter technology using nonfiction text and a series of activities that involve hands-on learning, monitoring energy use, teaching others, and changing behaviors. This unit uses students' homes and the local school as real-world laboratories. This unit was originally designed for use in the PG&E service area and showcases the customer utility account management site. However, the activities translate well for any customer whose utility provider utilizes smart meters. Simply familiarize yourself with your utility's online customer account management site before selecting and assigning activities.

Time

The sequence of lessons was designed for a 50 minute class period. In this setting, the unit will take 2-3 weeks.

Science Notebooks

Throughout this module, it is recommended that students record their observations, data, and notes in science notebooks. Student worksheets have been included in this guide. You may choose to use these instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

Lesson 1: Analyzing Home Energy Usage

Background

Students will observe and analyze their family's home energy usage over 24 hours. This lesson introduces students to smart meter technology and helps students recognize how much energy their family uses every day. Students will utilize their local utility's customer account management site.

Objectives

- Students will be able to describe how a smart meter works.
- Students will be able to quantitatively describe their home energy use.

Time

- Introductory discussion and brainstorming, 30 minutes
- Students' home observations, 24 hours
- *Using Smart Meter Technology*, 30 minutes
- *Analyzing My Energy Usage*, 60 minutes

Preparation

- Familiarize yourself with your utility's customer account management site. Online tutorials can often be found to provide assistance. Compare the graphing activities and data provided to adjust directions as needed.
- Copy the *Home Energy Usage* and *Analyzing My Energy Usage* worksheets for each student, if necessary (pages 11-12). Also prepare copies of the student informational text for each student (pages 20-30).
- If necessary, work with students to generate a letter to their parents or to create a presentation that explains why the class is studying home energy use, smart meter technology, and the benefit of saving money by using less energy.

CONTINUED ON THE NEXT PAGE

Grade Level

- Intermediate, grades 6-8

Web Resources

PG&E

www.pge.com

ComEd

www.comed.com

BGE

www.bge.com

The NEED Project

www.NEED.org

NEED Online Resources

NEED has many curriculum pieces available to support and extend your *Smart Meters* unit. The following guides (and many more) can be downloaded for free from www.NEED.org:

Energy Conservation Contract

Energy Enigma

Energy Games and Icebreakers

Energy on Stage

Great Energy Debate

Intermediate Science of Energy

Learning and Conserving

Monitoring and Mentoring

Plug Loads

Saving Energy Expo

School Energy Survey

Understanding Climate Change

▪Secure computer access for students.

▪In order for students to analyze their family's energy usage, they will need permission to access their family's utility management customer account. Students should write down their family's log in information (username and password) to log in to the site. Families without an account can sign up with their utility provider.

▪To demonstrate the account management site to the class, set up a computer with internet access projected onto a screen. You will need your personal account username and password to log in.

✓ Procedure

PART ONE—INTRODUCTORY DISCUSSION

1. Take a quick class survey. Do you believe your family uses an appropriate amount of energy, an excessive amount, or much less than other families? Let students share examples to support their beliefs.
2. Ask students if they believe it is important for people to use less energy. What difference will it make in your home, community, or to the world?
3. Discuss quantitative ways to measure how much energy a home is consuming (an electricity bill shows how many kilowatt-hours used, a utility bill has a dollar amount on it, a natural gas bill shows number of therms used, counting the number of hours an appliance is running, etc.).
4. Discuss ways a home consumes energy (appliances use electricity, furnaces burn natural gas, fireplaces burn wood, barbecue grills burn propane, etc.).
5. Assign students to read the student informational text.
6. On a blank sheet of paper, ask students to brainstorm a list of energy consuming actions or energy consuming devices used daily at home. Suggestions include:

air conditioner	microwave	flood light	printer
electrical heating system	stove/oven	desk lamp	video game console
water heater	toaster oven	humidifier	TV
pool heat pump	coffee maker	fan	satellite/cable box
dishwasher	incandescent light bulb	shower/bath taken	DVR
washing machine	compact fluorescent light bulb	bathroom appliance	DVD player
clothes dryer	bulb	hair dryer	stereo
refrigerator	LED bulb	curling iron/flat iron	telephone
freezer	porch light	computer/tablet	answering machine
kitchen appliance	night light	monitor	cell phone charger

PART TWO—HOME OBSERVATIONS

1. For homework, students will log everything going on in their home for a 24 hour period using the *Home Energy Usage* log. Students should note times appliances are used, number of showers, hours watching TV/computer or playing video games, sleeping, etc. Encourage students to get their families involved, too. Students should leave the log in a central location so family members can write down energy consuming devices they use when the student is not available.

NOTE: Students should complete the log 2-3 calendar days prior to starting the analysis activities. This will allow time for the utility to upload hourly data to the account management website. For example, students can complete the log on a Friday to begin analysis on Monday.

PART THREE—USING SMART METER TECHNOLOGY

1. Ask students to complete a timed quick-writing activity prompting them with the following: "What do you think a digital smart meter is? How might you use one at home?"
2. Have students review information about the electricity grid and smart meters by reading pages 23-25 and 30.
3. Watch the short video on smart meters produced by Baltimore Gas and Electric at www.bge.com/SmartEnergy/SmartMeter/SmartGrid/Pages/SmartMeters.aspx.

CONTINUED ON THE NEXT PAGE

4. Have students review their brainstorming activity from part one and discuss the following using a turn-and-talk, parking lot, or class discussion format.
 - What is a digital smart meter?
 - What does it do?
 - Where is it located in your home? Have you looked at it?
 - What is the advantage for the utility company in putting smart meters in homes?
 - How can your family benefit from a smart meter?
 - How can your family use the information the smart meter provides about your home energy use?

PART FOUR —ANALYZING MY ENERGY USAGE

1. Demonstrate how to access the local utility website. Log into your own account, and display your personal home energy usage for the same 24 hours students observed in their own homes. Demonstrate how to interpret the online graphs, display data by day or year, and discuss the information on the graphs displayed by clicking the 'usage' and 'costs' buttons, if applicable.
2. Display your energy usage by day. Ask students to see if they can determine the amount of kilowatt-hours consumed each hour. Scroll over each point on the line graph and show students how this represents the amount of kilowatt-hours of electricity consumed each hour.
3. If student computer access is limited, assign *Analyzing My Energy Usage* (page 12) to be completed at home, otherwise complete it in class.
4. Finally, have students answer the conclusion questions and discuss the following as a class:
 - According to your log, when did your family use the most energy consuming devices? What activities were occurring during those times? According to the data collected by your home's smart meter, when did your family consume the most kilowatt-hours of electricity?
 - Identify and make correlations about what was occurring in low energy use times (maybe sleeping) and during a spike in the afternoon (doing loads of laundry, cooking dinner in the oven, running the dishwasher, etc.).
 - Compare the energy use of the whole class. What time span or hour of the day had the most and least energy usage? Why? What was happening in your homes during those hours? If every home in our city or town is using this much energy at a peak time, will there be enough electricity for everyone? How does a utility company handle this?

Lesson 2: The Cost of Using Electricity

Background

This activity uses generic, pre-prepared, computerized graphs of energy consumption. For a more appropriate and relevant local discussion, print your own graphs using your own account and ask students to analyze local information graphically.

Objectives

- Students will list the factors that affect the cost of a kilowatt-hour of electricity.
- Students will determine how much energy appliances consume and the cost of running the appliances.

Time

- Analyzing the Cost of Using Electricity and Understanding Baseline and the Electric Tier System*, 45 minutes
- Electric Nameplates and the Cost of Using Machines*, 60 minutes

Preparation

- Copy *Analyzing the Cost of Using Electricity*, *Understanding Baseline and the Electric Tier System*, *Electric Nameplates Investigation*, *Cost of Using Machines Investigation*, and *Cost of Using Machines at Home* activities for each student, if necessary (pages 13-17).
- Secure computer access for students.

CONTINUED ON THE NEXT PAGE

✓ Procedure

PART ONE — ANALYZING THE COST OF USING ELECTRICITY

1. Work through the *Analyzing the Cost of Using Electricity* worksheet with the class. **NOTE:** While the dates may be older on the graphics, they still work to show students important data. Feel free to substitute screen shots from your own metering system, if available.

Answer Key

- Month: **August**
- 724** kWh
- Utility bill amount **\$114**
- Give two probable reasons why this family used more energy during this month. *For example, since it is summer, the weather may be hot and humid. The family might be using an air conditioning system. More family members could be home on summer vacation, using more appliances and more energy. The family could have a pool and are running a heat pump or filter.*
- Day of the week: **Sunday** Date: **November 6, 2011**
- 23** kWh
- How much did they pay for electricity on this day? **\$2.80**

PART TWO—UNDERSTANDING BASELINE AND THE ELECTRIC TIER SYSTEM

1. Work through the *Understanding Baseline and the Electric Tier System* worksheet with the class.
2. If your state's utilities use baseline quantities and a tiered system to determine the rate of a kWh of electricity on your utility bill, you will want to review and discuss how the system works with your students. Check your utility's website to see if they have examples and explanations. For example, PG&E explains their tiered system here: <http://www.pge.com/myhome/myaccount/charges/>. You may use this as an example of electricity rate payer systems, but be sure to point out your own utilities differences.
3. Help students understand that when their home uses an excess amount of energy (above their baseline amount), their electricity costs more per kWh. Using less energy will save more money for their families.

Answer Key

What are some immediate actions the family could take to use less energy and save more money at the end of this billing cycle? *Turn off the air conditioner in summer or turn up the temperature on the thermostat. Turn down the temperature on electric heaters in winter. Do not run the dishwasher, washing machine, or electric clothes dryer during peak hours. Turn off extra lights and appliances. Keep showers short.*

How could monitoring their energy usage using a smart meter benefit this family? *The family would recognize they are using too much energy earlier in the month, and can make energy conserving choices sooner, saving more money.*

4. Encourage students to log into their smart meter account and review their family's energy use over the past year. Discuss:
 - How much did your family pay for electricity in the past 12 months?
 - What is your family's baseline amount this season?
 - Has your family paid for electricity above your baseline?
 - Why do you think that happened?
 - How will you be aware so it doesn't happen again?
 - What action can you take to keep your family's use within your baseline this month?

PART THREE—ELECTRIC NAMEPLATES AND THE COST OF USING MACHINES

1. Guide students through the instructions for the *Electric Nameplates Investigation* (page 15) and the *Cost of Using Machines Investigation* (page 16). Let students work in small groups to complete.
2. For homework, have students complete *Cost of Using Machines at Home* (page 17). Brainstorm a list of possible machines, appliances, and electronic gadgets for students to investigate. Encourage students to investigate their most used, favorite, electronic devices. Some suggestions: cell phone charger, video game console, laptop power supply, hair dryer, set-top cable box or DVR, microwave, refrigerator. Remind students that some electronics, like a clothes dryer, may not be safely accessible, and therefore, not a good choice.
3. Discuss the conclusion questions with students.

Extension

- Go beyond the *Cost of Using Machines Investigation* to teach students about carbon dioxide emissions and environmental impacts. *Understanding Climate Change*, available at shop.need.org, encourages students to think about the impacts of energy use. Students create action plans to make changes in their lives that will reduce their carbon footprints.

Lesson 3: Saving Energy Saves Money

★ Objectives

- Students will be able to develop a saving energy action plan for their homes.
- Students will be able to educate their families about smart meter technology and ways to save energy and money on the family electric bill.

🕒 Time

- Student research and discussion, 45 minutes
- Saving Energy Actions* and *Saving Energy Action Plan*, 60 minutes
- Creating a *Saving Energy Action Plan* presentation, several days depending on complexity of presentations
- Wrap it up discussion, 45 minutes

📋 Preparation

- Copy *Saving Energy Actions* and *Saving Energy Action Plan* (pages 18-19) for each student, if needed.
- Secure computer access for students.

✓ Procedure

1. Give students time to research energy saving tips and suggestions either in class or as homework. Suggested websites for student research include:
 - www.energy.gov/energysaver/energy-saver
 - www.energystar.gov
 - www.pge.com/en_US/residential/save-energy-money/resources/everyday-tips/everyday-tips.page?
 - www.comed.com/WaysToSave/ForYourHome/Pages/Default.aspx
 - Your utility's website may have a section on energy saving ideas.
2. Students should record their research and ideas on the *Saving Energy Actions* worksheet. Remind students to write down tips and suggestions that they can actually accomplish with the cooperation of their family members. For example, if a home does not have an air conditioning system in it, writing down "We will set our air conditioner to 78 degrees during the summer" is not an action that will change the family's energy usage.
3. Let students share their energy saving tips with each other, and discuss those that will have the greatest impact for most families. Are there challenges or obstacles to implementing any of the energy saving action ideas? For example, purchasing a new ENERGY STAR® rated appliance would save a lot of energy, but may be out of the family's immediate budget.
4. Have students choose a favorite saving energy action and expand upon it in the *Saving Energy Action Plan*.
5. Brainstorm with students ways to share their knowledge about electricity usage, smart meter technology, energy saving tips, and their *Saving Energy Action Plan* with their families. Students could create a podcast, video, website, PowerPoint presentation, design a brochure, or write a letter. Give students time to prepare their presentations and practice with each other.
6. Have students present their *Saving Energy Action Plans* to their families and work together to save energy at home. Encourage students to tackle as many saving energy measures as possible, perhaps focusing on a new saving energy idea each month until actions become automatic habits.
7. After several months, have students log into their smart meter accounts and review their home energy usage. Compare monthly data to the same month of the previous years. Look at total kilowatt-hour usage and the costs per month.
8. Discuss as a class:
 - How successful was your saving energy action plan? If your utility bill decreased compared to last year, explain your success. If your home's energy use stayed the same or increased, why do you think this happened? Is your family using smart meter technology to manage your home's energy use? Why or why not?

CONTINUED ON THE NEXT PAGE

 **Extensions**

- Encourage students to make a contract with their parents. If energy savings goals are met, suggest that parents “share” the profits of their savings with their child.
- NEED’s *Saving Energy Expo*, available in the *Energy Expo* guide at shop.need.org, is a week-long project that will challenge students to research, prepare a presentation, and teach each other about topics such as: Energy Consumption in the U.S., Why Saving Energy is Important, Heating, Cooling, Lighting, Water Heating, Electrical Devices and Appliances, and Taking Care of Trash.
- Using NEED’s *Energy Conservation Contract*, students work with their family members to rate their energy usage behaviors, and commit to making positive changes that will save energy.



Home Energy Usage

? Question

How much energy does your family use on an average day? In order to analyze how much energy your family uses, you need to be aware of all the energy consuming activities going on in your home. Each hour, record the energy consuming devices in use in your home. Encourage family members to write down their activities on the log, too. Use additional paper as needed. Don't forget to include devices that run automatically, such as a refrigerator or air conditioner.

24 Hour Log Sheet

Home Energy Usage Date:	
12:00am	12:00pm
1:00am	1:00pm
2:00am	2:00pm
3:00am	3:00pm
4:00am	4:00pm
5:00am	5:00pm
6:00am	6:00pm
7:00am	7:00pm
8:00am	8:00pm
9:00am	9:00pm
10:00am	10:00pm
11:00am	11:00pm



How does your family use energy?

1. Log into your family's smart meter account, and review the different graphs of your family's energy use.
2. Display energy usage by day. Calculate and record the number of kWh used each hour next to the corresponding time on the *Home Energy Usage* log.
3. Draw the energy usage by day line graph in the space below. Remember to label your graph and insert the date.
4. On your graph, identify and label any areas of high energy use, extremely high energy use, or very low energy use.
5. Refer to your notes on the 24 hour log to identify what was happening in your home during these times. Which appliances were running? What activities were taking place? On the graph, write in brief notes about what was happening during these time periods.

[illegible]

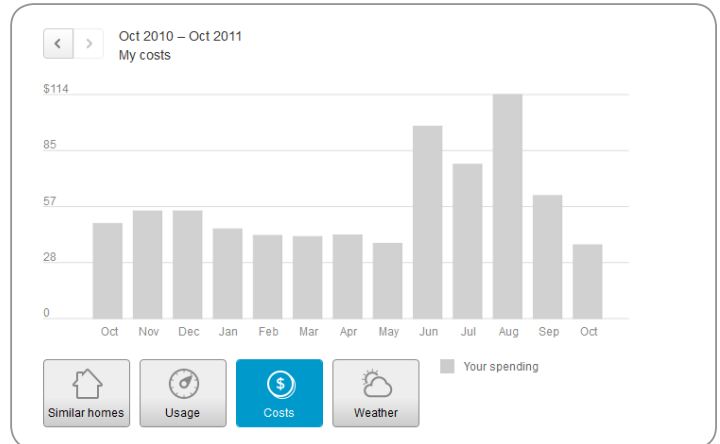
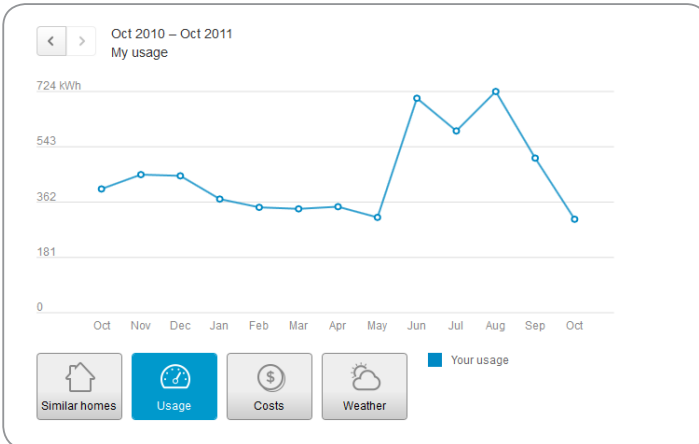
1. Explain how the smart meter data and the information on your log correlate to create a picture of your family's home energy usage.
2. Did the weather have any effect on the amount of energy your family used during the 24 hours? How?
3. What did you learn about your family's energy use habits during your observation and evaluation?



Analyzing the Cost of Using Electricity

Graph Data

Use the graphs below to answer the questions that follow.



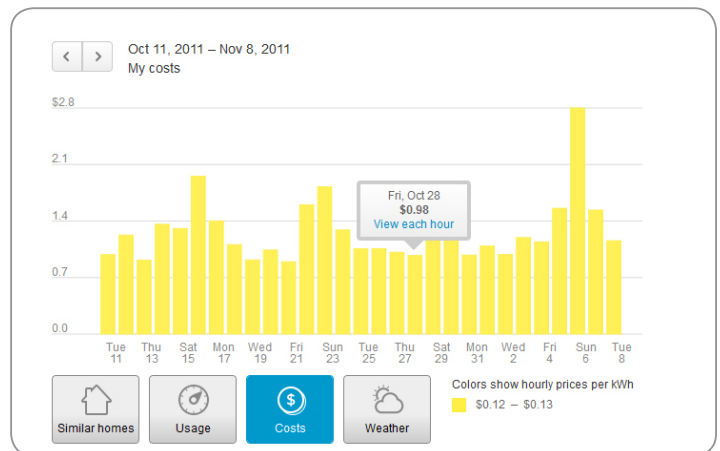
Questions

Look at the graphs for the past 12 months. In which month did this family use the most kWhs of electricity?

Month: _____ kWh Utility bill amount \$ _____

Give two probable reasons why this family used more energy during this month.

- 1.
- 2.

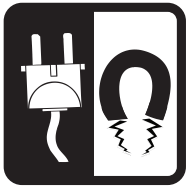


Questions

During this billing cycle, on which day did the family consume the most kWhs of electricity?

Day of the week: _____ Date: _____ kWh

How much did they pay for electricity on this day? \$ _____

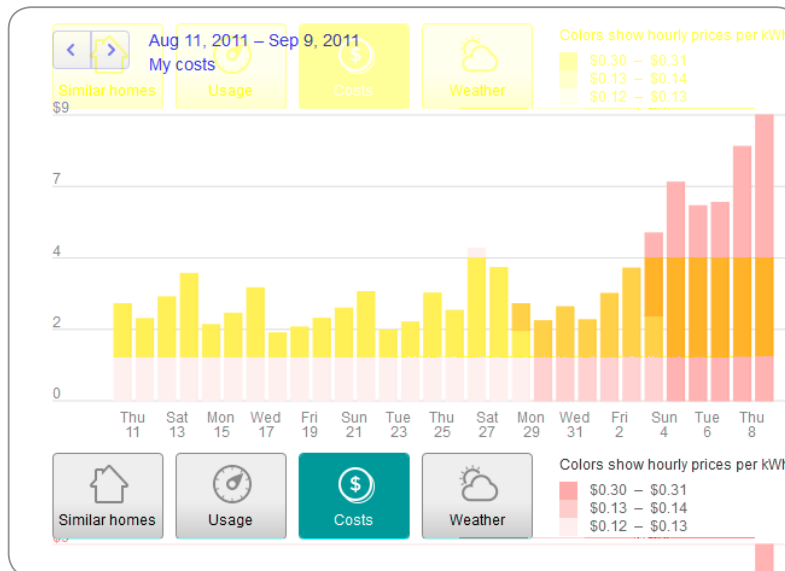


Understanding Baseline and the Electric Tier System

Background

As your family uses more energy each billing cycle, the cost of a kWh of electricity increases. Electric tiers work like many mobile phone plans—you get a low rate when your use stays within certain limits. If you go over your allotted kWh, you will be charged a higher rate, just as if you went over the allotted minutes or data in your mobile phone plan. Many utilities across the country use a tier rate structure where each additional increment, or tier, of use beyond the baseline level is charged at a higher price.

In this graph, Tier 1, Tier 2, and Tier 3 are different shades. As the family used more energy during the billing cycle, they used more than their baseline allotment, and moved into Tier 2 and then Tier 3. This family could have received a text message from their utility company alerting them they were moving into a more expensive tier.



Questions

- What are some immediate actions the family could take to use less energy and save more money at the end of this billing cycle?
 -
 -
 -
- How could monitoring their energy usage using a smart meter benefit this family?
- Log into your account and review your family's energy use over the past year. What is your family's baseline amount this season? Has your family paid for electricity above your baseline? Why do you think that happened? How will you be aware so it doesn't happen again?

** Conclusion

- What action can you take to keep your family's use within your baseline this month?



Electric Nameplate Investigation

Some appliances use more energy than others to accomplish the same task. Appliances that are very energy efficient are approved by the government's ENERGY STAR® program and have the ENERGY STAR® label on them. This means they have met high standards set by the government for energy efficiency.

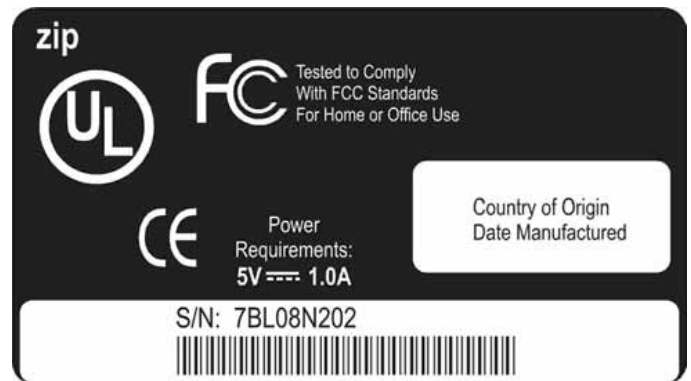
Every machine that runs on electricity has an electric nameplate on it. The nameplate is usually a silver sticker that looks like the picture below. The nameplate has information about the amount of electricity the machine uses. Sometimes, the current is listed. The current is measured in amperes (A). Sometimes, the voltage the machine needs is listed. The voltage is listed in volts (V). Sometimes, the wattage is listed. The wattage is measured in watts (W). If the wattage isn't listed, then the current and voltage are both listed.

If the wattage is not listed, you can calculate the wattage using the following formula:

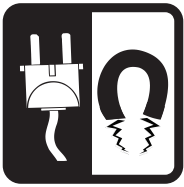
$$\begin{array}{rclcl} \text{wattage} & = & \text{current} & \times & \text{voltage} \\ W & = & A & \times & V \\ W & = & 1.0A & \times & 5V \\ W & = & 5W \end{array}$$

Often, the letters UL are on the nameplate. UL stands for Underwriters Laboratories, Inc., which conducts tests on thousands of machines and appliances. The UL mark means that samples of the machines and appliances have been tested to make sure they are safe.

You can find out how much it costs to operate any appliance or machine if you know the wattage. Let's take a look at some of the machines in your school. The nameplate is usually located on the bottom or back. See if you can find the nameplates on the computers, printers, monitors, televisions, and other machines in your classroom. Put the information in the chart below and figure out the wattage for each one.



MACHINE	CURRENT	VOLTAGE	WATTAGE	UL TESTED
Copier	11A	115V	1,265W	yes



Cost of Using Machines Investigation

Calculate how much it costs to operate the machines in your classroom that you looked at before. You need to know the wattage, the cost of electricity, and the number of hours a week each machine is used.

You can estimate the number of hours the machine is used each week, then multiply by 40 to get the yearly use. We are using 40 weeks for schools, because school buildings aren't used every week of the year. Using the copier as an example, if it is used for ten hours each week, we can find the yearly use like this:

$$\text{Yearly use} = 10 \text{ hours/week} \times 40 \text{ weeks/year} = 400 \text{ hours/year}$$

Remember that electricity is measured in kilowatt-hours. You will need to change the watts to kilowatts. One kilowatt is equal to 1,000 watts. To get kilowatts, you must divide the watts by 1,000. Using the copier as an example, divide like this:

$$\text{kW} = \text{W}/1,000$$

$$\text{kW} = 1,265/1,000 = 1.265$$

The average cost of electricity for schools in the U.S. is about eleven cents (\$0.11) a kilowatt-hour. You can use this rate or find out the actual rate from your school's electric bill. Using the average cost of electricity, we can figure out how much it costs to run the copier for a year by using this formula:

$$\begin{aligned} \text{Yearly cost} &= \text{Hours used} \times \text{Kilowatts} \times \text{Cost of electricity (kWh)} \\ \text{Yearly cost} &= 400 \text{ hours/year} \times 1.265 \text{ kW} \times \$0.11/\text{kWh} \\ \text{Yearly cost} &= 400 \times 1.265 \times 0.11 = \$55.66 \end{aligned}$$

MACHINE OR APPLIANCE	HOURS PER WEEK	HOURS PER YEAR	WATTS (W)	KILOWATTS (kW)	RATE (\$/kWh)	ANNUAL COST
Copier	10	400 hours	1,265 W	1.265 kW	\$0.11	\$55.66



Cost of Using Machines at Home

Calculate the cost of using your favorite electronic chargers, gadgets, and appliances. Use the electric nameplate of each device to complete the calculations in the first table. Then, calculate the annual cost of each device in the second table. The formulas below can help in your calculations.

Table 1: Power Consumption

$$\begin{aligned} \text{wattage} &= \text{current} \times \text{voltage} \\ \text{W} &= \text{A} \times \text{V} \\ \text{kW} &= \text{W}/1,000 \end{aligned}$$

MACHINE OR APPLIANCE	CURRENT	VOLTAGE	WATTAGE	UL TESTED

Table 2: Annual Cost

The average cost of electricity in the U.S. for homes is about thirteen cents (\$0.127) a kilowatt-hour. You can use this rate or find out the actual rate for your home from your family's electric bill, or from your smart meter account.

$$\text{Yearly cost} = \text{Hours used} \times \text{Kilowatts} \times \text{Rate}$$

MACHINE OR APPLIANCE	WATTS	KILOWATTS	HOURS PER WEEK	HOURS PER YEAR	RATE (\$/KWH)	ANNUAL COST

** Conclusions

1. Name some electrical devices or appliances in your home that use a lot more energy than others. Why do these items use more energy to operate?
2. Were you surprised by the annual cost of any electrical device or appliance?
3. What actions can your family take so that these electrical devices and appliances consume less energy and cost less money to operate?



Saving Energy Actions

Some energy saving actions have no, or very little, cost and are relatively easy to implement. These actions often involve changing how you use energy. Some actions require moderate costs, while others are more expensive and might be actions to take in the future. Brainstorm as many different saving energy actions as you can for each of these categories.

NO/LOW COST ENERGY SAVINGS IDEAS

These ideas can be implemented right away.

MODERATE COST ENERGY SAVINGS IDEAS

These ideas may need some planning to implement.

EXPENSIVE ENERGY SAVINGS IDEAS

These ideas require planning ahead and may take place further in the future.



Saving Energy Action Plan

Choose one saving energy action from page 18 that offers an opportunity for your family to reduce the amount of electricity used in your home. Use this guide to create a *Saving Energy Action Plan*. Use a separate piece of paper as needed.

What is your saving energy goal? _____

What saving energy action will you take to meet your goal? _____

How will this action help you meet your goal? _____

Who can help you make this action successful? _____

Steps to implement this action in your home: _____

Are there challenges or obstacles to implementing this in your home? _____

What will determine "success" for your action and when will success be met? _____

How can your smart meter help you monitor your progress toward meeting your goal? _____

How will you teach your family the benefits of smart meter technology and monitoring? _____

Develop a timeline for each step you plan to take. _____

Take notes and document your progress in your science notebook.



Student Informational Text

INTRODUCTION TO ENERGY

Introduction to Energy

The United States uses a lot of energy. With about 4.4 percent of the world's population, we consume about 18 percent of the world's energy resources. All of us use energy every day—for getting from one place to another, cooking, heating and cooling rooms, making products, lighting, heating water, using and charging electronics, and entertainment. We use a lot of energy to make our lives comfortable, productive, and enjoyable. Most of that energy is from nonrenewable energy sources. It is important that we use our energy resources wisely.

Forms of Energy

Energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.

POTENTIAL ENERGY

Potential energy is stored energy and the energy of position, or gravitational potential energy. There are several forms of potential energy.

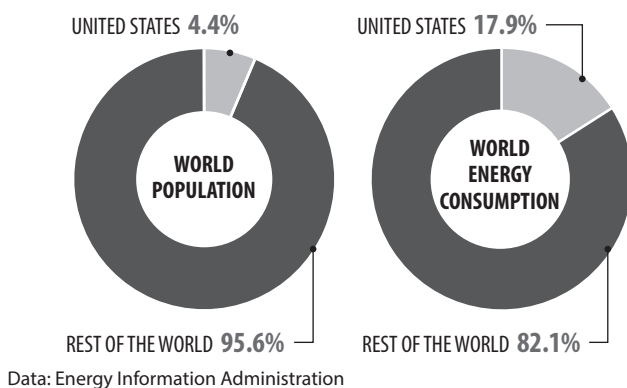
- **Chemical Energy** is energy stored in the bonds of molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.
- **Elastic Energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of elastic energy.
- **Nuclear Energy** is energy stored in the nucleus of an atom; it is the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of small atoms, mostly hydrogen, in a process called fusion.
- **Gravitational Potential Energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

KINETIC ENERGY

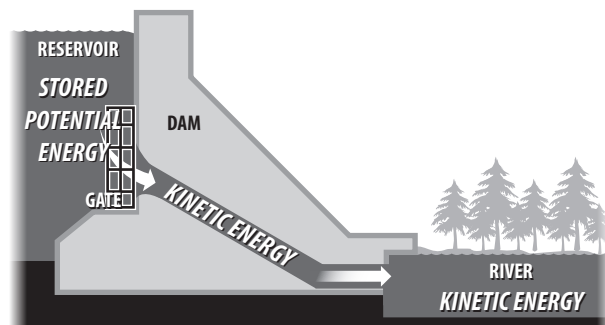
Kinetic energy is the energy of motion; it is the motion of waves, electrons, atoms, molecules, substances, and objects.

- **Electrical Energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Electrons are always moving. Applying a force can make some of the electrons move faster or in a desired direction. Electrons moving through a wire are called electricity. Lightning is another example of electrical energy.

Population Versus Energy Consumption, 2015



Hydropower Plant



- **Radiant Energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.
- **Thermal Energy**, or heat, is the internal energy in substances; it is the vibration and movement of the atoms and molecules within substances. The more thermal energy in a substance, the faster the atoms and molecules vibrate and move. Geothermal energy is an example of thermal energy.
- **Motion Energy** is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to Newton's Laws of Motion. Wind is an example of motion energy.
- **Sound Energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate; the energy is transferred through the substance in a longitudinal wave.

Sources of Energy

We use many different sources to meet our energy needs, all of which have advantages and disadvantages. Some are cheap; others are expensive. Some contribute to global warming; others are pollution-free. Some are limited in their supplies; others are abundant. Some are always available; others are only available part of the time.

Energy sources are classified into two groups—renewable and nonrenewable. In the United States, most of our energy comes from nonrenewable energy sources. Coal, petroleum, natural gas, propane, and uranium are nonrenewable energy sources. They are used to make electricity, heat our homes, move our cars, and manufacture all kinds of products.

They are called nonrenewable because the reserves of the fuels are limited. Petroleum, for example, was formed hundreds of millions of years ago from the remains of ancient sea plants and animals. We cannot make more petroleum in a short time.

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable because they are replenished by nature in a short time. Day after day, the sun shines, the wind blows, the rivers flow, and plants grow. Heat from inside the Earth—geothermal energy—is continuously made by the radioactive decay of elements in the Earth's core.

We can harness this renewable energy to do work for us. We use renewable energy sources mainly to make electricity.

Is electricity a renewable or nonrenewable source of energy? The answer is neither. Electricity is different from the other sources because it is a secondary source of energy. That means we have to use another source of energy to make it. In the United States, coal is the number one fuel for generating electricity.

Energy Efficiency and Conservation

The choices we make about using energy have environmental and economic impacts. There are many things we can do to use less energy and use it wisely. These actions include both energy conservation and energy efficiency.

Energy conservation is any action that results in using less energy. Energy efficiency focuses on technologies that use less energy to perform the same tasks. Buying a dryer that uses less energy is an example of energy efficiency. Drying clothes outside on sunny days is an example of energy conservation.

■ Law of Conservation of Energy

The Law of Conservation of Energy is not about saving energy. The law states that energy is neither created nor destroyed. When we use energy, it does not disappear; we change it from one form into another. A car engine, for example, burns gasoline, converting the chemical energy in the gasoline into useful motion; some of the energy is also converted into light, sound, and heat. Solar cells convert radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe remains the same.

U.S. Energy Consumption by Source, 2015

NONRENEWABLE, 90.2%



Petroleum 36.6%

Uses: transportation, manufacturing - Includes Propane



Natural Gas 29.0%

Uses: electricity, heating, manufacturing - Includes Propane



Coal 16.0%

Uses: electricity, manufacturing



Uranium 8.6%

Uses: electricity



Propane

Uses: heating, manufacturing

*Propane consumption is included in petroleum and natural gas figures.

RENEWABLE, 9.7%



Biomass 4.9%

Uses: electricity, heating, transportation



Hydropower 2.4%

Uses: electricity



Wind 1.8%

Uses: electricity



Solar 0.4%

Uses: electricity, heating



Geothermal 0.2%

Uses: electricity, heating

Data: Energy Information Administration

**Total does not equal 100% due to independent rounding.

Energy Transformations



Chemical



Motion



Chemical



Motion



Radiant



Growth



Electrical



Heat

■ Energy Efficiency

Energy efficiency is the amount of useful energy produced by a system compared to the energy input. A perfect energy-efficient machine would convert all of the input energy into useful work, which currently does not exist. Converting one form of energy into another form always involves a loss of usable energy. This is called a conversion loss and is usually in the form of heat. This 'waste heat' spreads out quickly into the surroundings and is very difficult to recapture.

A typical coal-fired plant converts about 35 percent of the energy in the coal into electricity. The rest of the energy is lost as heat. A hydropower plant, on the other hand, converts about 95 percent of the energy in the water flowing through the system into electricity.

Most energy transformations are not very efficient. The human body is a good example. Your body is like a machine, and the fuel for your machine is food. The typical body is less than five percent efficient at converting food into useful work such as moving, thinking, and controlling body processes. The rest is converted to heat. The efficiency of a typical gasoline powered car is about 15 percent.

■ Energy Sustainability

Efficiency and conservation are key components of energy sustainability—the concept that every generation should meet its energy needs without compromising the needs of future generations. Sustainability focuses on long-term actions that make sure there is enough energy to meet today's needs as well as tomorrow's.

Sustainability also includes the development of new clean technologies for using fossil fuels, promoting the use of renewable energy sources, and encouraging policies that protect the environment.

Sectors of the Economy

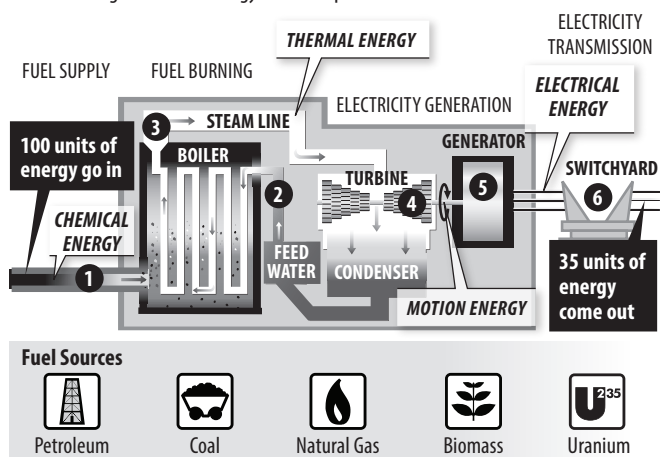
The U.S. Department of Energy classifies energy users into categories: residential, commercial, industrial, electric power generation, and transportation. These categories are called the sectors of the economy.

Residences are people's homes. Commercial buildings include office buildings, hospitals, stores, restaurants, and schools. Residential and commercial energy use are often lumped together because homes and businesses use energy in the same ways—for heating, air conditioning, water heating, lighting, and operating appliances.

The graphic to the right shows that the electric power generation sector consumed the most primary energy in 2015. However, all of the other sectors, especially the residential, commercial, and industrial sectors, use electricity after it is generated. The other sectors are the end users of electric power. When the residential and commercial sectors of the economy are combined together and electricity consumption is included, the residential and commercial sectors consume more energy than any of the other sectors, with 38.4 total quads of energy. These two sectors actually account for nearly 40 percent of the total energy consumed by the U.S., when electricity is included. The residential portion of the sector consumed 20.6 quads of energy, with nearly 69 percent of this energy coming from electricity. The commercial portion of the sector consumed 17.8 quads of energy, of which 77% is electricity.

Efficiency of a Thermal Power Plant

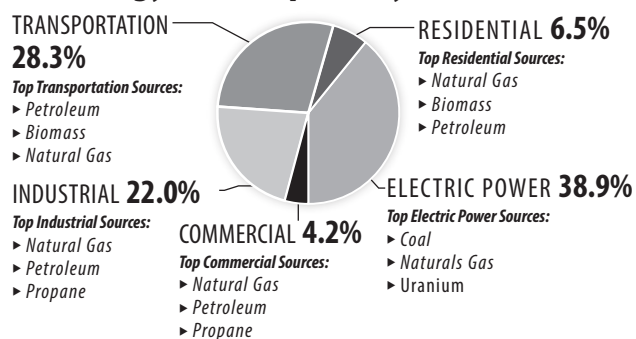
Most thermal power plants are about 35 percent efficient. Of the 100 units of energy that go into a plant, 65 units are lost as one form of energy is converted to other forms. The remaining 35 units of energy leave the plant to do usable work.



How a Thermal Power Plant Works

1. Fuel is fed into a boiler, where it is burned (except for uranium which is fissioned) to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins a ring of magnets inside coils of copper wire. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

U.S. Energy Consumption by Sector, 2015



The residential, commercial, and industrial sectors use electricity. This graph depicts their energy source consumption outside of electricity.

Data: Energy Information Administration

*Total does not equal 100% due to independent rounding.



Electricity

Electricity

Electricity is the flow of electric power or charge. Electricity is naturally occurring in nature, but we also generate a lot of electricity to meet our everyday needs.

Power plants use huge turbine generators to generate the electricity that we use in our homes and businesses. Power plants use many fuels to spin the turbines. They can burn coal, oil, or natural gas to make steam to spin turbines. They can split atoms of uranium to heat water into steam. They can also use the power of rushing water from a dam or the wind to spin the turbine.

Fuels Used to Generate Electricity

Three basic types of power plants generate most of the electricity in the United States—fossil fuel, nuclear, and hydropower. There are also wind, geothermal, waste-to-energy, and solar power plants, but they generate less than ten percent of the electricity produced in the United States.

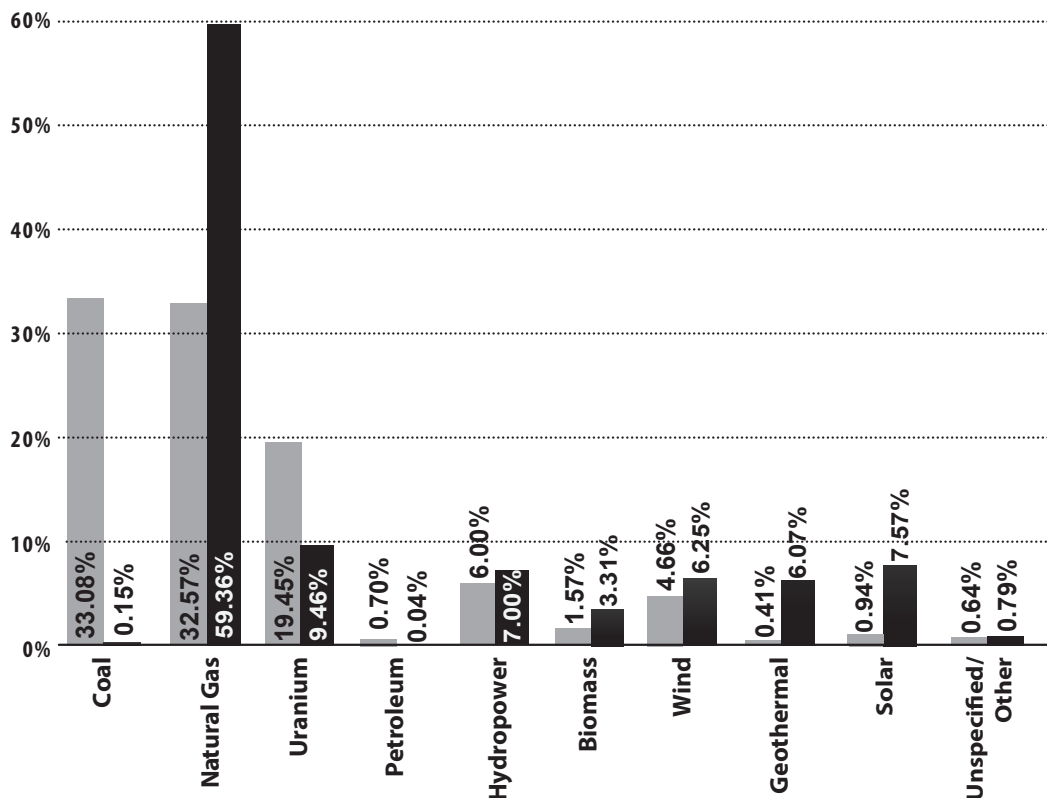
Fossil Fuel Power Plants: Fossil fuel plants burn coal, natural gas, or oil. These plants use the chemical energy in fossil fuels to superheat water into steam, which drives a turbine generator. Fossil fuel plants

are sometimes called thermal power plants because they use heat to generate electricity. Coal is the fossil fuel of choice for most electric companies, producing 33.1 percent of total U.S. electricity. Natural gas plants produce 32.6 percent. Petroleum produces less than one percent of the electricity in the U.S.

Nuclear Power Plants: Nuclear plants generate electricity much as fossil fuel plants do except that the furnace is called a reactor and the fuel is uranium. In a nuclear plant, a reactor splits uranium atoms into smaller elements, producing heat in the process. The heat is used to superheat water into high-pressure steam, which drives a turbine generator. Nuclear power plants are called thermal plants because they use heat to generate electricity. Nuclear energy produces 19.4 percent of the electricity in the U.S.

Hydropower Plants: Hydropower plants use the gravitational force of falling water to generate electricity. Hydropower is the least expensive way to produce electricity in this country, but there are few places where new dams can be built. There are some existing dams that could be retrofitted with turbines and generators. Hydropower is called a renewable energy source because it is renewed continuously during the natural water cycle. Hydropower produces five to ten percent of the electricity in the U.S., depending upon the amount of precipitation.

Comparing U.S. and California In-State Electricity Portfolios, 2015



In 2013 California emitted more carbon dioxide into the atmosphere than any other state except Texas. In an effort to reduce their greenhouse gas (GHG) emissions, California has implemented policies that will help them reduce emissions to their 1990 levels. California's electricity generation mix reflects their air quality standards, and their goal to generate 33 percent of their electricity from renewable energy sources by 2020, and 50 percent by 2030.

U.S.

CA

Data: U.S. Energy Information Administration, California Energy Almanac, California Energy Commission

Power to the People

Most electricity is generated by large utility companies; it is their responsibility to make sure electricity is available when we need it. They must consider reliability, capacity, baseload, power pools, and peak demand.

Reliability is the capability of a utility company to provide electricity to its customers 100 percent of the time. A reliable electric service is without blackouts or brownouts. To ensure uninterrupted service, laws require most utility companies to have 15 to 20 percent more capacity than they need to meet peak demand.

This means a utility company whose peak load is 12,000 MW (megawatt) must have 14,000 MW of installed electrical capacity. This ensures that there will be enough electricity to meet demand even if equipment were to break down on a hot summer afternoon.

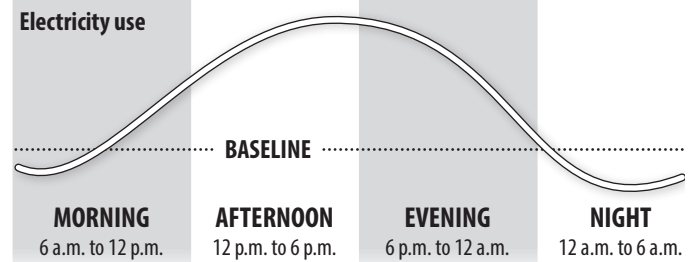
Capacity is the total quantity of electricity a utility company has on-line and ready to deliver when people need it. A large utility company may operate several power plants to generate electricity for its customers. A utility company that has seven 1,000-MW plants, eight 500-MW plants, and 30 100-MW plants has a total capacity of 14,000 MW.

Baseload power is the electricity generated by utility companies around the clock, using the most inexpensive energy sources—usually coal, nuclear, and hydropower. Baseload power stations usually run at full or near capacity.

When many people want electricity at the same time, there is a peak demand. Power companies must plan for times of peak demand so there is enough power for everyone. During the day's peak, between 12:00 noon and 6:00 p.m., additional generators must be used to meet a higher demand for energy use. These peak load generators run on natural gas, diesel, or hydro and can be put into operation in minutes. The more this equipment is used, the higher our utility bills. By managing the use of electricity during peak hours, we can help keep costs down.

The use of power pools is another way that electric power companies make their systems more reliable. Power pools link electric utilities together so they can share power as it is needed. A power failure in one system can be covered by a neighboring power company until the problem is corrected. There are nine regional power pool networks in North America. The key is to share power rather than lose it.

Peak Demand



Peak load is the maximum load during a specified period of time.

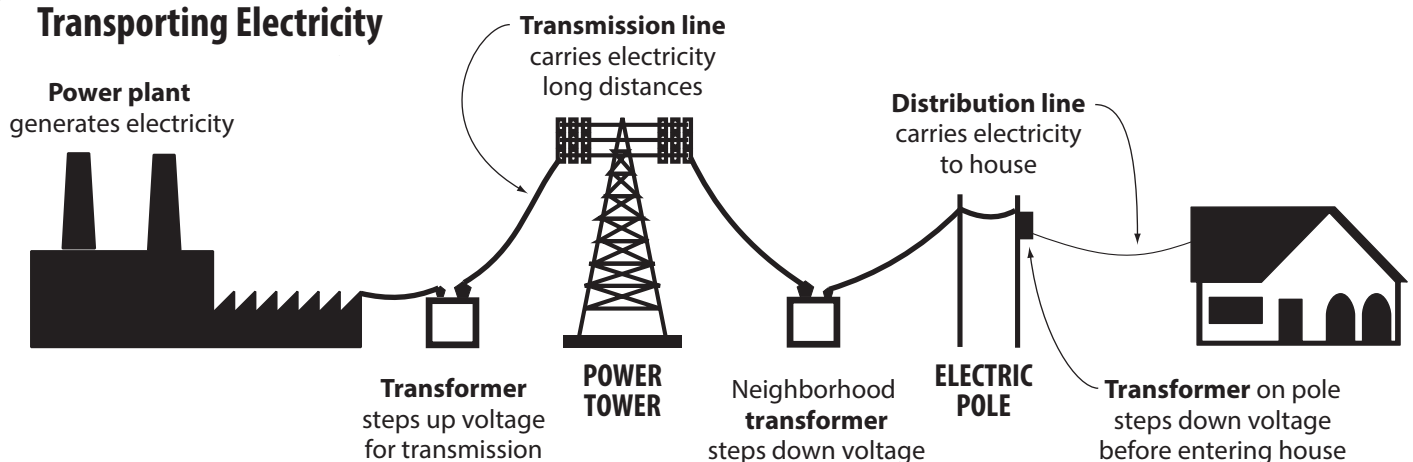
The Electric Grid

To deliver electricity to consumers, there are more than 160,000 miles of high-voltage electric transmission lines across the U.S. These lines move the electricity produced at power plants to transformers that step up the voltage to reduce energy loss while the electricity travels along the grid to where it is going to be used. Before coming into your home, another transformer steps down the power to 120 volts so it can operate your lights, appliances, and other electrical needs. And most remarkably of all, this entire process—from generation at the power plant to the trip along the lines to its availability for use in your home—takes just a fraction of a second!

These transmission lines—whether they are located on poles above ground or buried underground—make up the most visible part of what is called the “electric grid.” The grid consists of the power generators, the power lines that transmit electricity to your home, the needed components that make it all work, and the other homes and businesses in your community that use electricity.

The process starts at the power plant that serves your community, and ends with wires running from the lines into your home. Outside your home is a meter with a digital read-out or a series of dials that measure the flow of energy to determine how much electricity you’re using. Of course, there are many more parts to this process, ranging from substations and wires for different phases of current to safety devices and redundant lines along the grid to ensure that power is available at all times. You can see why the U.S. National Academy of Engineering has called America’s electric grid “the greatest engineering achievement of the 20th century.”

Transporting Electricity



The Smart Grid

The current electric grid is aging and plans are underway to update it and create a “smart grid.” The existing electric grid has worked well for many years, but developing a new, more efficient grid will help meet growing electricity demand. Updating the current grid and transmission lines would not only improve current operations, but would also open new markets for electricity generated by renewable energy sources.

The smart grid system will include two-way interaction between the utility company and consumers. During peak demand when power generation is reaching its limit, the utility company can contact consumers to alert them of the need to reduce energy until the demand decreases. The smart grid would alert the power provider to an outage or power interruption long before the homeowner has to call the provider to let them know the power is out.

Developing the smart grid would offer a variety of technologies that will help consumers lower their power usage during peak periods, allow power producers to expand their use of photovoltaics (solar), wind, and other renewable energy technologies, provide system back-up to eliminate power outages during peak times, and save money while reducing carbon dioxide emissions.

The nation’s evolution toward a smart grid is already paving the way for new technologies and products that will help Americans use energy more wisely. California’s statewide effort to upgrade to a smart grid will lead to more efficient and reliable power, a reduced carbon footprint, and the creation of green jobs and clean-energy development. Around the world, and across the United States, new wireless digital meters are being installed that enable two-way communication between energy providers and the meters. The many benefits of smart metering technology include the consumer’s ability

SMART METER INSTALLATION



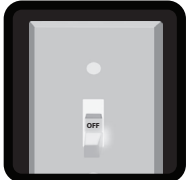
to see how and when they are using energy and the provider’s ability to quickly identify outages and restore power. In the future, consumers will be able to purchase in-home energy management devices and smart appliances that communicate with smart meters to help reduce energy use.

The typical family can spend about \$2,200 a year on utility bills. If your home is wasting energy—through leaky windows and ducts, old appliances, inefficient heating and cooling systems, or simply wasteful bad habits—you are throwing away money your family could spend in other ways. Learning and practicing smart ways to use and conserve energy in your home, will save money for your family.

The Continental U.S. Electric Grid



Data: U.S. Energy Information Administration



Home Energy Efficiency and Conservation

There are many areas in our homes that use energy and many different steps that can be taken to save energy.

■ Heating and Cooling Systems

Heating and cooling systems use more energy than any other systems in our homes. Natural gas and electricity are used to heat most homes, electricity to cool almost all. Typically, almost half of the average family's utility bills is for keeping homes at comfortable temperatures.

With all heating and air conditioning systems, you can save energy and money too, by having proper insulation, sealing air leaks, maintaining the equipment, and practicing energy-saving behaviors. For example, when using a programmable thermostat, adjusting it by seven to ten degrees Fahrenheit for eight hours per day can lower your family's heating and cooling bill by 10 percent.

■ Programmable Thermostats

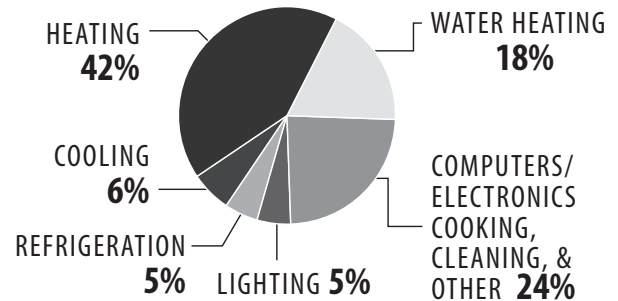
Programmable thermostats automatically control the temperature of buildings for time of day and can save energy and money. During heating seasons, for example, they can lower the temperature during the day when no one is home and at night. In the morning and evening, when people are awake at home, they can automatically raise the temperature. Most consumers set the temperature higher than recommended during heating seasons and lower than recommended during cooling seasons. A temperature setting of 68°F (20°C) during the day and 60-62°F (13-14°C) at night during heating seasons is comfortable if people dress warmly and use warm blankets. During cooling seasons, a temperature setting of 78°F (25°C) is comfortable if people dress appropriately and use fans to circulate air.

■ Insulation and Weatherization

Warm air leaking into your home in cooling seasons and out of your home in heating seasons wastes energy. You can reduce heating and cooling costs by up to 20 percent by investing a few hundred dollars in proper insulation and weatherization products. Insulation is rated using an R-value that indicates the resistance of the material to heat flow. The R-value needed varies, depending on the climate, ceilings, walls, attics, and floors. In very cold climates, a higher R-value is recommended.

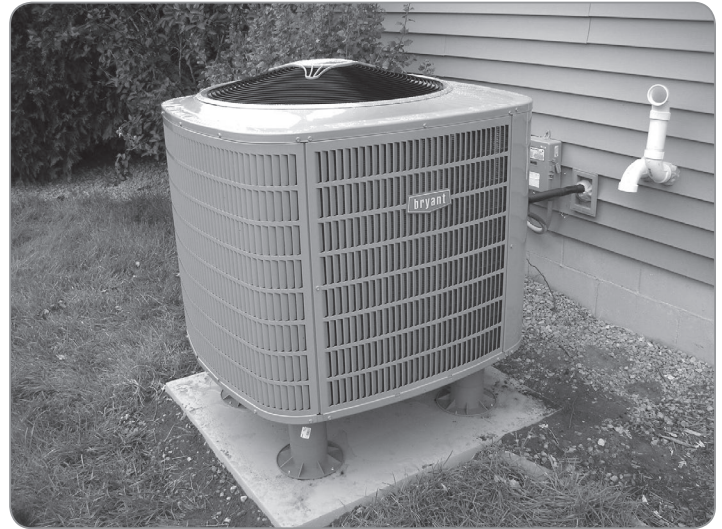
Insulation wraps your house in a blanket, but air can still leak in or out through small cracks. Often the effect of many small leaks equals a wide open door. One of the easiest energy-saving measures is to caulk, seal, and weather-strip cracks and openings to the outside. Home performance professionals can seal air leaks in attics and basements. You can save 10 percent or more on your energy bill by sealing the air leaks in your home.

Home Energy Usage, 2015



Data: U.S. Department of Energy

AIR CONDITIONING



PROGRAMMABLE THERMOSTAT



INSULATION



WINDOWS AND DOORS



APPLIANCES AND MACHINES



■ Doors and Windows

Some of a home's air leaks occur around and through the doors and windows. Doors should seal tightly and have door sweeps at the bottom to prevent air leaks. Insulated storm doors provide added barriers to leaking air.

Most homes have more windows than doors. The best windows shut tightly and are constructed of two or more pieces of glass. Caulk any cracks around the windows and make sure they seal tightly. With older windows, install storm windows or sheets of clear plastic to create added air barriers. Insulated blinds also help prevent air flow—during heating seasons, open them on sunny days and close them at night. During cooling seasons, close them during the day to keep out the sun.

■ Landscaping

Although you cannot control the weather, you can plant trees to block the wind and provide shade. Properly placed trees and bushes can reduce the energy needed to keep your home comfortable. Deciduous trees, for example, are good to plant on the south side of a building in the Northern Hemisphere, since their leaves provide shade in summer and their bare branches allow sunlight through in the winter.

■ Appliances and Machines

Appliances and machines use about 24 percent of a typical household's energy, with refrigerators, freezers, clothes washers and dryers at the top of the list. Any appliance that is designed to change temperature uses a lot of energy. You can save energy by:

- turning off appliances and machines when you aren't using them;
- using the energy-saver setting on dishwashers and refrigerators;
- keeping the doors closed as much as possible on refrigerators and freezers—know what you want before you open the doors;
- being aware that many machines use energy even when turned off—save energy by unplugging them; and
- using machines and appliances during the morning and evening, not during peak demand time.

■ ENERGY STAR®

When you shop for a new appliance, look for the ENERGY STAR® label—your guarantee that the product saves energy. ENERGY STAR® appliances have been identified as the most energy efficient. Purchasing and using energy efficient products in your home helps to reduce high energy bills, improves your family's comfort, and helps protect the environment. A list of energy efficient appliances can be found on the ENERGY STAR® website at www.energystar.gov.

■ EnergyGuide Labels

Another way to determine which appliance is more energy efficient is to compare energy usage using EnergyGuide labels. The government requires most appliances to display bright yellow and black EnergyGuide labels. Although these labels do not tell you which appliance is the most efficient, they will tell you the annual energy consumption and operating cost of each appliance so you can compare them.

Refrigerators, for example, use about five percent of household energy. Replacing an older refrigerator with a new energy efficient model can save on energy bills. With older models, a large amount of electricity can be saved by setting the refrigerator temperature at 37–40°F (3–5°C), the freezer temperature at 5°F (-15°C), and making sure that the energy-saver switch is in use.

Refrigerators should also be airtight. Make sure the gaskets around the doors are clean and seal tightly. Close the door on a piece of paper—if you can easily pull out the paper when the door is closed, you need to replace the gaskets.

■ Lighting

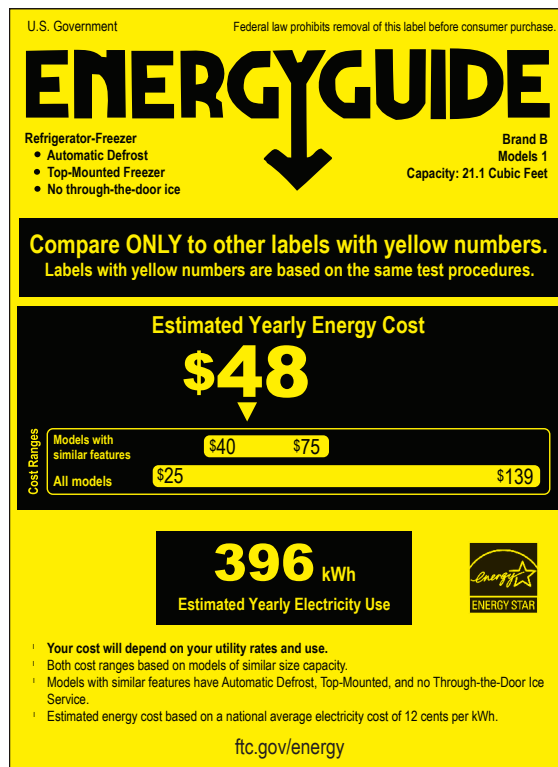
Legislation under the Energy Independence and Security Act put restrictions on how much energy light bulbs use. Most traditional bulbs, called incandescent bulbs, have been replaced by more efficient bulbs like halogens, compact fluorescents (CFLs), and light emitting diodes (LEDs) on store shelves.

About 13 percent of the electricity consumed in homes is used for lighting. This accounts for five percent of a home's total energy. Much of this is the result of using inefficient lighting. Many homes still use incandescent lighting in many rooms and fixtures. Only 10 percent of the energy consumed by an incandescent bulb actually produces light; the rest is given off as heat. There are other more efficient lighting choices on the market, including halogens, fluorescents, and LEDs. Halogens are sometimes called energy-saving incandescent bulbs because they last slightly longer, and use less energy than traditional incandescent bulbs, however they can burn hotter than incandescent lights do. Fluorescent lights produce very little heat and are even more efficient. Most schools use fluorescent tube lighting throughout the building, but may use incandescent bulbs in other spaces around the school.

Fluorescent lights use 75 percent less energy than incandescents and reduce environmental impacts. Converting to CFLs in your home is one of the quickest and easiest ways to decrease your energy bill. You can save about \$6.00 in energy costs each year for every 100-watt incandescent bulb you replace. Compact fluorescent light bulbs provide the same amount of light and save energy.

A fluorescent lamp is a glass tube lined inside with a phosphor coating. The tube is filled with argon gas and a small amount of mercury. At the ends of the tube are electrodes that generate an electric field when electricity flows through them. The energized electrons cause the mercury gas to emit UV (ultra violet) light. The invisible UV light strikes the phosphor coating, which emits visible light.

ENERGY GUIDE LABEL



INCANDESCENT BULB



HALOGEN BULB



CFL BULB



LED BULB



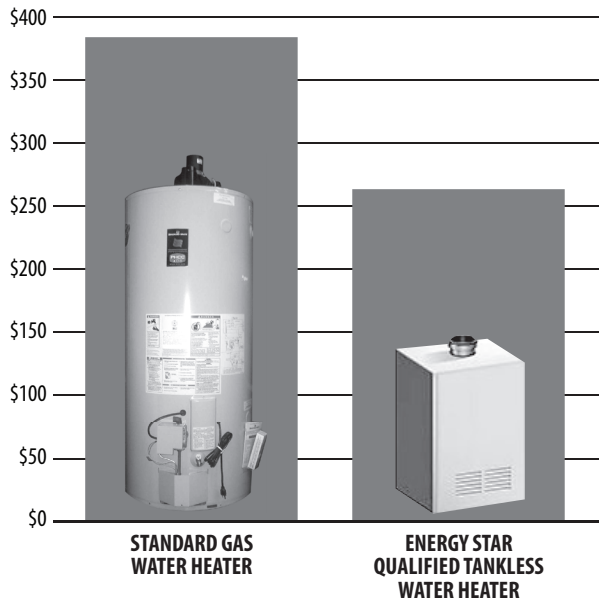
LEDs offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. LEDs now have a wide array of uses because technology has improved and costs have decreased. It is possible to see CFL use decrease as LED costs continue to improve.

Fluorescent lights have ballasts that help move the electricity through the gas inside the bulb. There are two types of ballasts, magnetic and electronic. Electronic ballasts are more efficient than magnetic ballasts and can eliminate flickering and noise.

LEDs are commonly found in electronic devices and exit signs and are now an affordable option in home lighting. ENERGY STAR® qualified LEDs use 75–80 percent less energy than incandescent bulbs and last 25 times longer. LED bulbs cost more than incandescent bulbs and CFLs, but prices are going down as more LEDs become available and technologies advance. LEDs are better suited for some locations than CFLs, such as in outdoor or dimmable fixtures.

Water Heater Comparison

ANNUAL ENERGY COSTS PER YEAR



Data: ENERGY STAR®

Water Heating

Water heating is a significant energy expense in homes. It typically accounts for about 18 percent of the average utility bill. Heated water is used for showers, baths, laundry, dish washing, and cleaning. The greatest cost of washing dishes, bathing, and washing clothes comes from the energy required to heat the water. There are four main ways you can lower your water heating bills:

- use less hot water;
- turn down the thermostat on your water heater;
- insulate your water heater and water pipes; and
- buy an ENERGY STAR® or energy efficient water heater, dishwasher, and washing machine.

The easiest way to cut the cost of heating water is to reduce the amount of hot water you use. This can be done with little cost and minor changes in lifestyle. For example, a five minute shower uses 10-25 gallons of water. You can cut that amount in half by using a low-flow shower head.

Other ways to conserve hot water include taking showers instead of baths, taking shorter showers, fixing leaks in faucets and pipes, and using the lowest temperature wash and rinse settings on clothes washers.

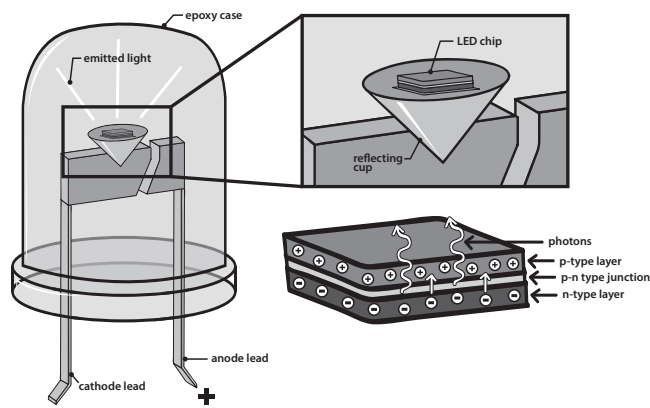
Most water heater thermostats are set much higher than necessary. Lowering the temperature setting on your water heater to 120°F (49°C) saves energy. Lowering the temperature 10 degrees Fahrenheit (6°C) can result in energy savings of \$12-\$30 annually. Buying a high efficiency water heater can save \$40-\$140 a year.

Cooking

Cooking food is another task that uses energy—usually natural gas, electricity, or propane. Most homes have several appliances for cooking food—stoves, ovens, microwaves, and toaster ovens. To save energy when you are cooking:

- Use a toaster oven or microwave instead of the oven whenever you can. These smaller appliances use less energy.
- Preheat the oven for only five minutes.
- Leave the oven door closed so hot air does not escape. Use a timer instead of checking on the food every few minutes.

Inside an LED



An LED light bulb is actually made of several light emitting diodes connected to produce a specific amount of light. Inside each LED, there are two areas; the n-type and the p-type. The material in the n-type contains substances that have free electrons. The materials in the p-type contain substances that can accept electrons. Electrons from the n-type naturally move to the p-type. When electricity is applied, electrons move from the p-type back into the n-type, and are energized. When the electrons release the extra energy, they move once again back into the p-type material and release light. The color of the light depends on which materials are used to make the n-type and p-type parts of the LED. Different materials make different colors of light.

Analog and Digital Meters

Homes and apartment buildings are equipped with meters so that utilities can determine how much electricity and natural gas each residence consumes. Some homes, apartment buildings, and commercial buildings in the U.S. may still have analog electric meters. These meters contain an aluminum disk. As electricity enters the house it passes through a pair of loops that creates a magnetic field. This creates an eddy current in the disk and causes the disk to rotate. The speed the disk rotates is proportional to the amount of power being consumed. As the disk spins, hands on dials move to record how much electricity has been consumed.

In the 1980s, digital meters began to appear on homes, apartment buildings, and commercial buildings. These meters measure current and voltage digitally to calculate usage. Traditionally, both analog and digital meters are read by a meter reader once a month by the utility company and the customer is charged for their electricity usage.

Smart Meters

With once a month meter readings, it is difficult for consumers to monitor their electricity usage. Consumers can adjust their electricity usage after they receive their bills, but it's too late to change their behaviors to affect their current bill. Monitoring electricity usage once a month doesn't help the utilities either. Once electricity is generated, it has to be used, otherwise it is lost. In order to better gauge how much electricity is needed at a given time, engineers have designed new communication devices that enable energy usage information to be sent to utilities more frequently. This technology will allow utilities to generate enough electricity to meet their customers' needs. In the future it will also allow utilities to more effectively employ renewable energy resources. These meters are called smart meters.

Smart meters are digital meters similar to those that have been in use for some time. What makes these meters "smart" is the addition of a communication system between the meter and the utility. Most smart meters in the U.S. have wireless two-way communication. However, some utilities are using wired communication. This is more common in Europe than in the U.S. Whether using wired, or wireless communication, smart meters work the same way. Rather than sending a meter reader to read meters once a month, the smart meter sends data to the utility on a more frequent basis, at least once a day, throughout the month.

Consumers can log on to secure websites to monitor their energy usage on an hourly basis (up to the previous day) as well. Seeing near real-time data allows the consumers to make changes to their energy usage, which will have a direct impact on their energy bill. Many utilities implementing smart meters offer services that will email, call, or text consumers when their electricity usage is nearing a higher price bracket, allowing consumers to adjust their electricity usage accordingly and avoid higher bills.

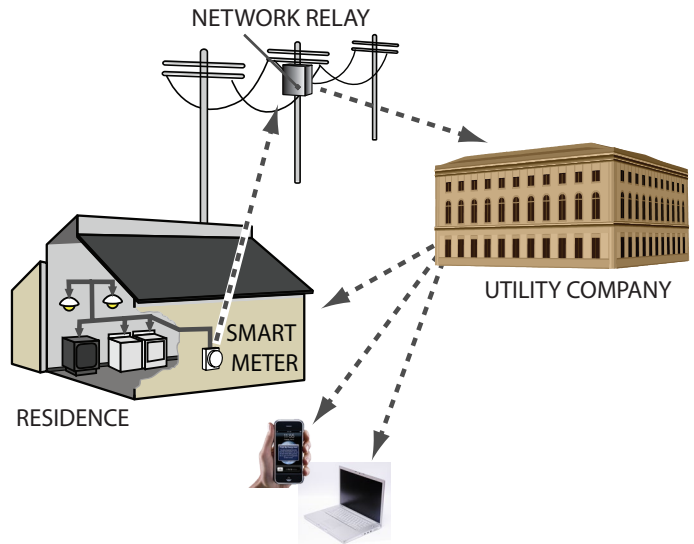
Smart meters allow customers to more closely monitor their energy usage and, if they choose, make changes in their behaviors to conserve energy.

▪ Wireless Communication

The world around us is filled with tools, devices, and gadgets that many people use as part of modern daily life. Many of these products, such as cell phones, garage doors openers, wireless laptops, radios, televisions, microwave ovens, and baby monitors, use radiofrequency or "RF" energy to communicate wirelessly.

In the United States, the Federal Communications Commission (FCC), with input from the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and other Federal Government agencies, has set limits for the amount of RF energy that products can safely use. The RF communications from smart meters fall well below those limits.

Smart Meter Communication



How Smart Meters Work

1. Smart meters transmit data to a network relay, often mounted on an electric pole.
2. The relay sends the data to the utility.
3. The utility monitors your electricity consumption.
4. The utility communicates your electric consumption back to you. Special alerts can be sent to emails and mobile phones when electricity usage is pushing you into a higher-priced electric tier.
5. Customers can go online at any time to view their energy usage and costs. Customers can compare their daily consumption to previous days, weeks, months, even years.
6. Customers can make energy saving changes to their behavior to lower their electricity consumption, and their electric bills.

SMART METER



Smart meters communicate to the electric company daily so electricity usage can be monitored by consumers more closely.

Image courtesy of PG&E



Smart Meters Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

- | | | |
|--|------------------------------|-----------------------------|
| 1. Did you conduct the entire unit? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 2. Were the instructions clear and easy to follow? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 3. Did the activities meet your academic objectives? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 4. Were the activities age appropriate? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 5. Were the allotted times sufficient to conduct the activities? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 6. Were the activities easy to use? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 7. Was the preparation required acceptable for the activities? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 8. Were the students interested and motivated? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 9. Was the energy knowledge content age appropriate? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 10. Would you teach this unit again? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
- Please explain any 'no' statement below*
- _____

How would you rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

How would your students rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**

8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820



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