Module 3: Activity 2

Personal Choices at Home to Prevent Air Pollution

IT'S OUR AIR

SUMMARY

Students explore how personal choices related to energy usage can reduce air pollution and save money. They calculate the emissions of sulfur dioxide and nitrogen oxides due to the use of electricity and natural gas by a homeowner, then evaluate the effectiveness of different strategies to reduce those emissions, including changing behavior and increasing efficiency through home renovations and/or new energy-efficient appliances.

ESSENTIAL QUESTIONS

- What choices can I make that will prevent air pollution?
- Are personal actions necessary and/or sufficient to help solve environmental problems related to air pollution?

TIME NEEDED

This activity will take about one block period (90 minutes) for AP and Honors earth science classes (assuming they do Part A as homework the night before). For academic earth science classes, doing Parts A-D in class will take about two block periods (180 minutes).

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5.5 Explain how human activities affect air quality.
- CE.PFL.1 Analyze the concepts and factors that enable individuals to make informed financial decisions for effective resource planning.

MAKING CONNECTIONS

How do we as a society solve problems that affect everyone? In almost all cases, we rely on a combination of government action, nonprofit organizations, civic and social groups, and personal choice. Take public safety, for example: the government provides laws, police officers enforce laws, and most citizens do their part by following the rules and reporting wrongdoers. Nonprofit organizations and civic and social groups may become involved to introduce new laws or change old ones.

Environmental problems such as air and water pollution affect everyone. Each of these issues has some laws and governmental resources dedicated to them, and citizens also make a difference through personal actions (see Module 3, Activity 4 for more information about air quality regulations). The amount of choice we have may vary. Think about water for example. You may not have a choice about where the city obtains the water that comes out of your tap. If you are an apartment dweller, you may not have a choice about how much water the appliances and fixtures in the apartment use. But you do have a choice about how much water you use, and your choices do make a difference in your water bill and in the water security of your community. The same principles apply to energy use. You may not have a choice as to which fuels are available to houses in your neighborhood or which fuels are available in a house or apartment that you rent. But you do have choices about how much energy you use in your home. And your choices can have lasting impacts.

Another connection this activity makes is with economics and the idea of cost-benefit analysis. Some energy-saving strategies are free (adjusting the thermostat), but others require money (adding insulation to your house). Analyzing the costs alongside the benefits – money saved, increased comfort at home, reduced emissions of air pollutants, the satisfaction of saving energy – can help with decision-making. Students can apply cost-benefit analyses to many aspects of their lives, not just energy usage.

BACKGROUND

Air pollution causes or exacerbates many serious health problems, including cardiovascular disease, asthma, and chronic obstructive pulmonary disease (COPD). Even in people without these types of conditions, it can impair or reduce lung function. One way to reduce air pollution is to save energy, because most of the energy we use in the United States involves the combustion of fossil fuels. This results in the emission of air pollutants including sulfur dioxide, nitrogen oxides, particulate matter, and more. For more information on combustion and air pollution, see "Combustion Equations" (Module 1, Activity 2). For more information on sulfur dioxide and nitrogen oxides, see "Criteria Pollutants and a Closer Look at Ozone" (Module 1, Activity 4).

In this activity, students will look at some ways of reducing emissions of sulfur dioxide and nitrogen oxides by saving energy at home.

ENERGY AND ELECTRICITY

In physics, energy is the ability to do work. In daily usage, the word energy means the power to accomplish something: "I don't have the energy to finish my homework." or "My hot water heater died and I want to buy one that uses less energy." In *It's Our Air*, energy generally refers to resources used to power lights, appliances, air conditioners, furnaces, and vehicles. This energy can take many forms. A few examples: a hot water heater that runs on natural gas, a wood stove that burns wood, a furnace that uses oil, an air conditioner that's powered by electricity, a car that runs on gas. Thinking back a generation or two, mills were powered by the energy of rivers, and wagons were powered by horses or oxen.

Electricity is a type of energy that consists of electrons flowing from one atom to another. Electric power plants use generators to push electrons to homes, businesses, and industries through power lines. Electricity can be generated in many ways: by burning fossil fuels such as coal or natural gas, through nuclear fission, or by harnessing the power of the sun, wind, or water.

For more information about energy, electricity, units, and emissions, see the handout entitled "Energy, Electricity, Emissions, and Units."

In this activity, Parts A and B include information about both electricity and natural gas used in the home, while Parts C and D relate only to electricity. An interesting aspect of electricity is that it can be generated from a wide variety of fuels, including coal, natural gas, wind, solar, hydroelectricity, and nuclear. The type and amount of air pollution emitted by electricity generation varies greatly, depending on the mix of fuels used in a particular region. Burning fossil fuels emits sulfur dioxide and nitrogen oxides, while generating electricity from wind, solar, hydroelectricity, or nuclear emits none of these pollutants.

As stated above, electricity is typically generated at a central power plant. (There are exceptions, such as photovoltaic panels, wind generators and emergency gernerators that generate electricity where it is to be used.) The advantage of central generation is that emissions can be controlled and captured at that central location. Contrast this to trying to reduce air pollution from millions of individual residential furnaces. A disadvantage is that the transmission of electricity from the power plant to homes and businesses is not completely efficient: about 6% of the electricity is lost en route, which is called line loss.

ENERGY CHOICES **AT HOME**

Every house is different in terms of the type of energy used, the efficiency of the appliances, and the quality of the construction in terms of insulation and air leakage. However, there are opportunities to use less energy in any home, and doing so will save money and improve air quality.

Some houses are all-electric, while others use two or more types of energy. Space heating can be accomplished by electric heat pumps, electric baseboard heaters, natural gas furnaces, woodstoves, oil furnaces, passive solar design, geothermal heat pumps, just to name a few of the possibilities. Some appliances are almost always powered by electricity, including air conditioners, lights, electronics, refrigerators, washing machines, and dishwashers. Other appliances can be powered by either electricity or natural gas – such as hot water heaters, clothes dryers, and stoves. (All three can be powered by solar as well – think clothes lines and solar camping ovens.)

Homeowners have some choice as to the fuels they use, but not complete freedom. For example, if there are no natural gas lines in your neighborhood, you can't have a gas stove. Renters may have even less choice.

However, no matter what type of energy is used at home, people can make choices that result in reduced emission of air pollutants. Individuals can choose to use less energy (turn off lights in unoccupied rooms), purchase more efficient equipment (a more efficient refrigerator), make energy-efficient renovations (adding insulation or weather-stripping) or use alternative energy sources (using a solar clothes dryer – a clothes line).

STRATEGIES TO REDUCE ENERGY **USE AND AIR POLLUTION**

It's often hard to know which actions will make the biggest difference, or which actions affect which pollutants. Folks might know what their average monthly electric or gas bill is in dollars, but they may not have a good idea of how many kilowatt-hours of electricity or therms of natural gas they use... or the amount of air pollution emissions that results from that use. Furthermore, many people don't have a good idea of what percentage of an energy bill is due to a particular appliance. Lacking that knowledge, it's hard to know what would be the best ways to save energy (and money) and to prevent the emission of air pollutants.

A good place to start is to look at the biggest energy users in the home. In most homes, space conditioning (heating and cooling) is the largest energy expenditure, followed by hot water heating. Heating and cooling accounts for as much as half of the energy usage of a home according to the EPA at www.energystar.gov. Good strategies for reducing overall home energy usage include keeping the thermostat at a reasonable level, replacing outdated furnaces or air conditioners with new energy-efficient models, and adding insulation or replacing old, leaky windows.

SAVING ENERGY = **SAVING MONEY**

An added benefit of saving energy is saving money. Some ways of saving energy, such as turning off lights or running the air conditioner less often, don't cost anything to implement. Other strategies, such as replacing an old water heater with a new energy-efficient one, cost money up front, but save on energy bills each month. In fact, the amount saved each month can gradually add up to the purchase price of the new appliance. It's a rare example of how spending money can save you money. The length of time it takes for the monthly savings to equal the purchase price is called the "payback period." While some people like to have a payback period of 10 years or less, other people enjoy the feeling of saving energy and preventing pollution and are not bothered by a longer payback period.

OTHER WAYS OF REDUCING AIR POLLUTION THROUGH PERSONAL CHOICES

This activity is about energy use and choices at home, but of course personal choice can impact air pollution with regard to other activities. Driving cars and using gasoline-powered lawn mowers emit air pollution, so driving less or purchasing a more efficient car or mower can reduce air pollution (see Module 3, Activity 3). We can also reduce particle pollution by limiting the use of fireplaces, woodstoves, and cooking grills, and refraining from burning yard waste or trash (burning trash is illegal), as well as reducing our use of energy that comes from burning fossil fuels.

ENERGY UNITS

On bills, electricity is typically measured in kilowatt-hours (kWh) and natural gas use is typically measured in therms. In order to compare electric usage to natural gas usage, both of these units can be converted to an energy unit called a British thermal unit (Btu). One Btu is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. For a more thorough summary of energy units, see the handout titled "Energy, Electricity, Emissions, and Units."

Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

MATERIALS

- Sample electric bill (provided)
- Sample natural gas bill (provided)
- Home energy use data (provided)
- Calculators
- Optional: data about energy use from student's home

INTRODUCTION TO SOLUTIONS/ ENERGY CHOICES VIDEO

- Introduces the three major strategies for finding solutions to air pollution: societal and personal choices, regulation, and technology.
- Reviews the history on energy in North Carolina, how our energy is produced.
- Introduces the personal choices we have in choosing how we use energy and the impact that can have on air pollution, focusing on improving energy efficiency and using less energy.

Video Length: 11:00 minutes
Key Elements: animation, interviews, video footage

WARMUP

Show the video, "Introduction to Solutions/Energy Choices Video." If practical, you could have the students watch the video at home the day before you do the activity in class.

Ask students what types of energy they use in their own homes, and if they don't know, suggest that they ask their families. This activity focuses on electricity and natural gas because they are two common sources of energy used in North Carolina. In all likelihood, the families of the students in the class use a wide variety of energy types in their homes. For example, in many parts of the state, propane and heating oil are used for heating.

If necessary, review the units of electricity (kilowatt-hours) and natural gas (therms) with your students. See the handout titled "Energy, Electricity, Energy and Units" for more information.

In a class discussion, challenge your students to come up with ways they can personally reduce air pollution. Perhaps talk through a typical daily routine, from wake-up to bedtime, and develop a list of ways we contribute to air pollution every day. Notice that most of these are related to energy use. Make the point that most of the ways we use energy involve combustion, and that combustion produces emissions of air pollutants. Discuss ways of reducing the air pollution we cause. Which ways do students think would be most significant?

Teacher Tips

This activity will be more meaningful to students who are already familiar with sulfur dioxide and nitrogen oxides.

Students can research energy and electricity, and how electricity is generated, before beginning this activity.

For AP and Honors earth science classes, give Part A as homework, then do Parts B-D in class. For academic earth science classes, do parts A-B one day and parts C-D the next. To keep students on track, stop after each part and go over the results together. If the part C calculations are too challenging, do them as a class. I put students in groups of four, and have each student become a "data expert" for one of the four parts. When students are working on Part B, but need data from Part A, the "data expert" on A can supply it.

– Mark Townley

THE ACTIVITY

PART A: Energy Bills

Imagine that you live in a house in Raleigh. You use electricity for:

- air conditioning
- refrigerator/freezer
- stove/oven
- clothes washer/dryer
- lights
- computers
- audiovisual equipment (TVs, sound systems, gaming systems, etc.)
- kitchen appliances
- other electric appliances (hair dryer, vacuum cleaner, etc.)

You use natural gas for

- space heating
- hot water

Look at the provided electricity bill and answer these questions:

1. What dates of electricity usage does this bill cover? In other words, what is the billing period?
   [**Answer**: March 10, 2015 – April 10, 2015]
2. How much electricity was used during the time period? Give units. [**Answer**: 528 kilowatt-hours or kWh]
3. Look at the graph on the bill. Did you use more or less electricity this month than in the same month last year?
   [**Answer**: more]

Look at the provided natural gas bill and answer these questions:

1. What dates of natural gas usage does this bill cover? In other words, what is the billing period?
   [**Answer**: March 10, 2015 – April 9, 2015]
2. How much natural gas was used during this time period. Give units. [**Answer**: 42 therms]
3. Look at the graph on the bill. Did you use more or less this month than in the same month last year?
   [**Answer**: less]

Energy Units

1. What units are used to measure electricity?
   [**Answer**: kilowatt-hours or kWh]
2. What units are used to measure natural gas?
   [**Answer**: therms]
3. A British Thermal Unit (Btu) is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. Looking at the table below, how many Btu is 1 kWh? [**Answer**: approximately 3,412]
4. How many Btu is 1 therm? [**Answer**: 100,000]

TABLE 1: Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

Table 2 shows data from one year's worth of energy bills for your house. Use the information in Table 1 to convert kWh and therms into Btu so you can compare how much of your energy use is due to electricity and how much is due to natural gas.

TABLE 2: Data from One Year of Energy Bills [ANSWER KEY]

Month of bill	Electricity Use In kWh	Electricity Use In Btu	Natural Gas In therms	Natural Gas In Btu
Jan	1,130	[3,855,560]	74	[7,400,000]
Feb	940	[3,207,280]	99	[9,900,000]
Mar	935	[3,190,220]	68	[6,800,000]
Apr	790	[2,695,480]	42	[4,200,000]
May	935	[3,190,220]	16	[1,600,000]
June	1,385	[4,725,620]	11	[1,100,000]
Jul	1,395	[4,759,740]	8	[800,000]
Aug	1,340	[4,572,080]	8	[800,000]
Sept	775	[2,644,300]	7	[700,000]
Oct	690	[2,354,280]	9	[900,000]
Nov	935	[3,190,220]	33	[3,300,000]
Dec	1,050	[3,582,600]	69	[6,900,000]
TOTAL	[12,300]	[41,967,600]	[444]	[44,400,000]

Using the data from one year's worth of energy bills, answer the following questions:

1. In which month did you use the most electricity? Why do you think that is? Do you think you would use the most electricity in that month every year? [**Answer**: July, because it's really hot so the air conditioning runs a lot. This may not be the same every year – it would depend on the weather, if we were at home or on vacation, and where we set the thermostat]
2. In which month did you use the most natural gas? Why do you think that is? [**Answer**: February, it's really cold so the heat runs a lot]
3. Approximately how many therms of natural gas do you think you use for hot water heating each month? How did you figure this out? [**Answer**: between 7 and 9 because that's how much is used in the summer when natural gas is not needed for space heating]
4. What is the total amount of energy, in Btu, used per year? [**Answer**: 86,367,600 Btu]
5. What percentage of the total energy used in the house is for heating and water heating (in other words, what percent does natural gas account for)? [**Answer**: 44,400,000/86,367,600 X 100 or 51%]
6. What percentage of the total energy used in the house is for air conditioning, appliances, electronics, and lighting (in other words, what percent does electricity account for)? [**Answer**: 41,967,600/86,367,600 X 100 or 49%]
7. Look at Table 3 showing percentages of energy consumption by end use for various regions. How does this house compare to the averages shown in the table? **Note**: You will need to add the percentages for heating and water heating in order to compare it to the data from your house. [**Answer**: It uses a slightly higher percentage for heating and water heating than the average in Georgia, and a correspondingly lower percentage on air conditioning, appliances, electronics, and lighting. On the other hand, it uses a lower percentage on heating and water heating than the U.S. as a whole, because the climate in Raleigh, North Carolina is warmer than many parts of the U.S.]

TABLE 3: Energy Consumption by End Use (Averages from Georgia, the South Atlantic region, and the U.S.)

	Georgia	South Atlantic Region	United States
Heating	30%	29%	41%
Water Heating	19%	17%	18%
Air conditioning	11%	13%	6%
Appliances, electronics, Lighting	40%	41%	35%
TOTAL	100%	100%	100%

Source: www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ga.pdf

PART B: Reducing Air Pollution

You want to help prevent air pollution by using less energy. What would be the best ways to do so? In order to decide, first you need to know something about the types and amounts of emissions of pollutants that result from using electricity and natural gas.

Emissions from Electricity

The emissions from electric generation depend on what fuels are used to generate the electricity. The mix of fuels used varies in different parts of the country. Table 4 shows the fuels used in generating electricity in North Carolina, using data from 2012. It's important to note that the mix of fuels used changes over time. You can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. (**Note**: If everyone in the class tries to use the website at the same time, it may crash. It's best to have the teacher or one student in the class go to the site, see whether the data has been updated, and if so, share the information with the rest of the class.)

TABLE 4: Mix of Fuels Used to Generate Electricity in North Carolina

Source	2012 % of total:
Nuclear	41.2%
Coal	34.8%
Natural Gas	20.2%
Renewables (not incl. hydro)	2.5%
Hydroelectric	0.9%
Oil	0.2%

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions change with the fuel types. For example, burning coal to generate electricity produces more than three times more nitrogen oxide and 99 times more sulfur dioxide emissions as burning natural gas to produce the same amount of electricity. Generating electricity from nuclear power does not produce any emissions of sulfur dioxide or nitrogen oxides. Table 5 shows the emission factors of sulfur dioxide and nitrogen oxides from the mix of fuels used in 2012. Again, you can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. **Note**: Emission factors means the amount of emissions per unit of energy use – kWh for electricity, and therms for natural gas.

TABLE 5: Emissions of Natural Gas

Emissions of...	2012
...sulfur dioxide (SO_2)	0.0011 lbs/kWh
...nitrogen oxides (NO_X)	0.0007 lbs/kWh

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions from Natural Gas

The emissions generated from burning natural gas, whether for a furnace, hot water heater, or stove, are as follows:

TABLE 6: Emission Factors for Natural Gas

Sulfur dioxide (SO_2)	0.00006 lbs/therm
Nitrogen oxides (NO_X)	0.0092 lbs/therm

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration), Chapter 2, page 58. **Note**: 1 billion Btu = 10,000 therms. www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

TABLE 7: SO_2 and NO_x Emissions per Year [ANSWER KEY]

	Usage Info per year	Usage in Btu per year	% of home energy use	SO_2 emissions in pounds/year	NO_x emissions in pounds/year
Electricity	[12,300] kWh	[41,967,600]	[49%]	[13.5]	[8.61]
Natural Gas	[444] therms	[44,400,000]	[51%]	[0.0266]	[4.08]

Fill in the first two columns of Table 7 using information from Table 2: Data from One Year of Energy Bills. In the third column, calculate what percentage of your total energy use is due to natural gas use (heating and hot water heating) and what percentage is due to electricity use (air conditioning, refrigerator, cooking, etc.) Using the information about emissions (shown in Tables 5 and 6), fill in the chart with the emissions of sulfur dioxide (SO_2)and nitrogen oxides (NO_x) your energy use creates each year.

Comparing Strategies to Prevent Air Polllution

Which of the strategies below do you think will prevent the most air pollution and why? Answer this question before doing the calculations.

Strategy 1: Reduce your electricity use by 10% by changing your behavior: turning off lights and appliances when not in use, occasionally using a clothesline instead of clothes dryer, and keeping your home a bit warmer in the summer (remember, your house does not use electricity for heating).

Strategy 2: Reduce your electricity use by 20% by some combination of the following: replacing your old air conditioner with a new energy-efficient air conditioner, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, buying a new energy-efficient refrigerator, replacing incandescent light bulbs with compact fluorescent or LED bulbs, regularly using a clothesline instead of a dryer.

Strategy 3: Reduce your natural gas use by 10% by changing behaviors: taking shorter showers, washing your clothes in cold water, and keeping your house a bit cooler in the winter.

Strategy 4: Reduce your natural gas use by 20% by some combination of the following: replacing your old furnace with a new energy-efficient one, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, insulating your hot water heater, buying a new energy-efficient hot water heater.

Now calculate the reduction in emissions for sulfur dioxide and nitrogen oxides for each strategy. Write your answers in Table 8.

Table 8: Reduction in Emissions per Year [ANSWER KEY]

	Strategy 1: Reduce Electricity Use by 10%	Strategy 2: Reduce Electricity Use by 20%	Strategy 3: Reduce Natural Gas by 10%	Strategy 4: Reduce Natural Gas by 20%
Reduction in sulfur dioxide (SO_2) emissions	[13.5 x 0.10 = 1.35 lbs/year]	[13.5 x 0.20 = 2.7 lbs/year]	[0.0266 x 0.10 = 0.00266 lbs/year]	[0.0266 x 0.20 = 0.00532 lbs/year]
Reduction in nitrogen oxides (NO_x) emissions	[8.61 x 0.10 = 0.861 lbs/year]	[8.61 x 0.20 = 1.722 lbs/year]	[4.08 x 0.10 = 0.408 lbs/year]	[4.08 x 0.20 = 0.816 lbs/year]

Answer the following questions:

1. Which strategy would prevent the most sulfur dioxide emissions? [**Answer**: Strategy 2: cutting electricity use by 20%]
2. Which strategy would prevent the most NO_x emissions? [**Answer**: Strategy 2: cutting electricity use by 20%]
3. Which strategies would cost the homeowner money to implement? [**Answer**: Strategies 2 and 4: cutting electricity use and/or natural gas use by buying new furnaces or air conditioners, repairing ducts, or adding insulation]
4. Which strategies would not cost the homeowner anything to implement? [**Answer**: Strategies 1 and 3: changing behavior at home]
5. Which strategies would reduce your monthly bills? [**Answer**: all of them.]
6. Why is it important to know how your electricity is generated in order to devise strategies for reducing the emission of air pollutants due to home energy use? [**Answer**: Certain fuels used in electric generation produce more emissions than others.]

PART C: Which appliances use the most electricity?

Work with a partner to rank these 18 appliances in order of how much electricity you estimate they use in one year. Use the first blank column of Table 9 to record your estimated order, putting the appliance you think uses the most kWh per year as number 1 and putting the appliance you think uses the least kWh per year as number 18.

The 18 appliances in alphabetical order:

clothes dryer
clothes washer
coffee maker
dishwasher
hair dryer
iPhone 6
lamp with a 60-watt incandescent bulb
lamp with a 13-watt compact fluorescent bulb
laptop computer
microwave
refrigerator with side-mounted freezer, and through-the-door ice
refrigerator with top-mounted freezer
television, 32-inch LED
television, 65-inch plasma
vacuum cleaner
video game on desktop computer
video game system with LCD television
water heater

TABLE 9: Yearly Electricity Use of Some Common Appliances [ANSWER KEY]

Electricity Use Rank	Estimated Order	Calculated Order: List item with its kWh/yr in parentheses
1		[water heater (4,773)]
2		[clothes dryer (684)]
3		[refrigerator with side-mounted freezer, through-the-door ice (630)]
4		[refrigerator with top-mounted freezer (383)]
5		[television, 65-inch plasma (346)]
6		[dishwasher (270)]
7		[clothes washer (196)]
8		[video game system with television (153)]
9		[video game on desktop computer (137)]
10		[hair dryer (98)]
11		[television, 32-inch LED (89)]
12		[vacuum cleaner (75)]
13		[laptop computer (71)]
14		[lamp with a 60-watt incandescent bulb (66)]
15		[microwave (49)]
16		[coffee maker (2-cup) (43)]
17		[lamp with a 13-watt compact fluorescent bulb (14)]
18		[iPhone 6 (4)]

Your teacher will distribute a card for each appliance, one to each pair of students. One person from each pair should take the card to the front of the room, and form a line with the other students, arranging yourselves in order of electricity use. Discuss with your classmates until everyone agrees on an order. The teacher will write this order on the board.

Next, check your estimated ranking by calculating the electricity use for each appliance. The data you need to do this are shown in Table 10. Large appliances, such as dishwashers or refrigerators, come with a yellow Energy Guide card that shows the estimated kWh per year, so you will not need to do calculations for the large appliances. For smaller appliances, calculate it yourself: A label on the appliance will show watts (W) used. Convert this to kilowatts (kW) by dividing by 1,000. Multiply the kilowatts by the number of hours used in a year to get kilowatt-hours (kWh) per year. Round off to the nearest whole kWh.

Example: A toaster oven uses 1,200 Watts and you use it for 3 minutes every day: 1,200 W/1000 = 1.2 kW
(3 minutes/day x 365 days/year)/60 minutes/hour = 18.25 hours/year
1.2 kW x 18.25 hours = 22 kWh per year

After you have calculated the kWh per year for the smaller appliances, fill in the last column of Table 9 with the appliances in the correct order.

TABLE 10: Data for Calculating Electricity Use [ANSWER KEY]

Appliance	Wattage	Time used per year	Electricity use per year, rounded off to nearest kWh
Clothes dryer	–	–	Energy Guide: **684 kWh per year**
Clothes washer	–	–	Energy Guide: **196 kWh per year** (based on 8 loads a week)
Coffee maker (2-cup)	700	10 minutes, 365 days a year	[0.7 kW x 60.8 hours = **43 kWh per year**]
Dishwasher	–	–	Energy Guide: **270 kWh per year** (based on 4 loads a week)
Hair dryer	1875	1 hour a week, 52 weeks a year	[1.875 kW x 1 hour x 52 weeks = **98 kWh per year**]
iPhone 6	10.5 Wh (watt-hour) per charge	365 charges per year	[10.5 Wh x 365 = **4 kWh per year**]
Lamp with a 60-watt incandescent bulb	60	3 hours a day, 365 days a year	[0.06 kW x 1,095 hours = **66 kWh per year**]
Lamp with a 13-watt compact fluorescent bulb	13	3 hours a day, 365 days a year	[0.013 kW x 1,095 hours = **14 kWh per year**]
Laptop computer	60	3.25 hours a day, 365 days a year	[0.06 kW x 1,186 hours = **71 kWh per year**]
Microwave	800	10 minutes, 365 days a year	[0.8 kW x 60.8 hours = **49 kWh per year**]
Refrigerator with side-mounted freezer, and through-the-door ice	–	–	Energy Guide: **630 kWh per year**
Refrigerator with top-mounted freezer	–	–	Energy Guide: **383 kWh per year**
Television, 65-inch plasma	–	–	Energy Guide: **346 kWh per year** (based on 5 hours of use a day)
Television, 32-inch LED	–	–	Energy Guide: **89 kWh per year** (based on 5 hours of use a day)
Vacuum cleaner	1,440	1 hour a week, 52 weeks a year	[1.440 kW x 1 hour x 52 weeks = **75 kWh per year**]
Video game system with television	Video game: 20 W LCD television: 150 W	3 hours a day, 300 days a year	[(0.020 kW + 0.150 kW) x 3 hours x 300 hours = **153 kWh per year**]
Video game on desktop computer	Computer CPU: 68 W Monitor: 84 W	3 hours a day, 300 days a year	[(0.068 kW + 0.084 kW) x 3 hours x 300 days = **137 kWh per year**]
Water heater (40 gallon)	–	–	Energy Guide: **4,773 kWh per year**

Then have representatives from each pair return to the front of the room and stand in the correct order based on the new information and calculations. As a class, discuss what you learned and whether there were any surprises.

The 18 appliances in order of electricity use:

1. water heater
2. clothes dryer
3. refrigerator with side-mounted freezer and through-the-door ice
4. refrigerator with top-mounted freezer
5. television, 65-inch plasma
6. dishwasher
7. clothes washer
8. video game system with television
9. video game on desktop computer
10. hair dryer
11. television, 32-inch LED
12. vacuum cleaner
13. laptop computer
14. lamp with 60-watt incandescent bulb
15. microwave
16. coffee maker (2-cup)
17. lamp with 13-watt compact fluorescent
18. iPhone 6

Answer the following questions:

1. Which three appliances use the most electricity? [**Answer**: water heater, clothes dryer, refrigerator/freezer]
2. Which would prevent more air pollution, drying your clothes on a clothes line about half the time or giving up video games and your coffee maker? [**Answer**: drying your clothes outside about half the time.]
3. Which would prevent more air pollution, replacing an old refrigerator with a new energy efficient one that uses about half of the electricity or installing a solar water heater with an electric back-up? [**Answer**: installing a solar water heater]

PART D: Benefits and Costs of Replacing Old Refrigerator

Imagine that your refrigerator is more than 20 years old and you want to replace it.

TABLE 11: Refrigerator Energy Use and Cost Per Year Comparison

	Features	Cost	Average energy use per year According to Energy Guide label	Average cost Per Year According to Energy Guide label
Old Refrigerator From 1990-1992	Top freezer, 19-21 cubic feet	N/A	1,285 kWh	$142.64
Refrigerator B Frigidaire FFTR1814QB (2015 model)	Top freezer, 18 cubic feet	$521	404 kWh	$48

Source: www.energystar.gov/index.cfm?fuseaction=refrig.calculator and Home Depot website.

1. How much money would you save each year on your electric bill with the new refrigerator? [**Answer**: $94.64]
2. How many years until your savings paid for the cost of the new refrigerator? This time period is called the "payback period," because at the end of it, you'll have been "paid back" for the money you spent on the new refrigerator. [**Answer**: 5.5 years]
3. What would the yearly reduction in emissions of sulfur dioxide be, assuming an emission factor of 0.0011 lbs of sulfur dioxide per kWh? [**Answer**: (1,285 – 404 kWh) x 0.0011 lbs/kWh = 0.97 lbs]
4. What would the reduction in emissions of nitrogen oxides be, assuming an emission factor of 0.0007 lbs of nitrogen oxide per kWh? [**Answer**: (1,285 – 404 kWh) x 0.0007 lbs/kWh = 0.62 lbs]
5. Imagine you have decided to keep the old fridge in the garage to hold drinks and snacks. How much would it cost each year to run both the old fridge and the new one? [**Answer**: $190.64]
6. How much sulfur dioxide emissions would result from generating the electricity need to run both refrigerators each year? [**Answer**: (1,285 + 404 kWh) x 0.0011 lbs/kWh = 1.86 lbs]
7. How much nitrogen oxide emissions would result from generating the electricity need to run both refrigerators each year? [**Answer**: (1,285 + 404 kWh) x 0.0007 lbs/kWh = 1.18 lbs]
8. After purchasing your new refrigerator, would you keep the old refrigerator in the garage for drinks and snacks or get rid of it? Explain your reasoning. [**Answer**: varies]

WRAP UP AND ACTION

Review the results of the activity together and share thoughts on which energy-saving strategies students would be most likely to use. Generate a list of effective ways students can prevent air pollution, based on the knowledge gained during this activity.

Discuss the issue of a payback period. In the example in Part D, the new refrigerator saves enough money each month compared to the old refrigerator to cover its cost in 5.5 years. In many cases, payback periods will be longer because most people are not still using 20-year old refrigerators. Is payback period the only criterion to use when choosing an appliance? Would students be willing to pay more for an energy efficient appliance with a payback period of 10 years? 15 years? 20 years? Does it make sense to replace an appliance that is not very old or worn out with an energy efficient one? Or is it better to wait until appliances need to be replaced anyway?

This is a good time to discuss the idea of cost-benefit analysis. Remember that the "cost" and the "benefit" can refer to more than just money: consider convenience, personal effort, time, improved performance, feeling of satisfaction, among others. Ask students to summarize how they applied cost-benefit analyses to the various energy choices evaluated in this activity. Can students name examples of how they apply it in other areas of their life? If their cell phone has a cracked screen, yet still works, it is worth it to pay to have the screen repaired? To pay for a new phone? What factors would go into this decision?

Discuss whether personal actions are necessary to help solve environmental problems related to air pollution. Are personal actions alone sufficient to help solve environmental problems related to air pollution? Do citizens have a responsibility to take actions to prevent pollution?

ASSESSMENT

HAVE STUDENTS:

Write an editorial for the newspaper or a blog post covering the following points:

- the connection between energy use and air pollution.
- effective ways that personal choice can be used to reduce emissions of sulfur dioxide and NO_x.

EXTENSIONS

This activity will have more meaning for students if they use data from their own lives, rather than the hypothetical data given. They can calculate emissions that result from their energy use at home and then develop specific strategies to reduce those emissions. Students can do this activity themselves if they have access to the following information:

- Electricity usage in kWh in their home over the past 12 months
- Natural gas usage in therms in their home over the past 12 months

RESOURCES

Energy units calculator

If you need to convert cubic feet of natural gas into therms, or Btu into kWh, check out this energy calculator from the Energy Information Administration:

http://tonto.eia.doe.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

Online calculators for emissions from electricity use

Go to the Power Profiler at www.epa.gov/cleanenergy/energy-and-you/how-clean.html to find the mix of fuels used at your electric utility, and also to figure out what emissions are generated due to the electricity you use at home.

Online calculator for total home energy use

At this Energy Star website you can figure out how much energy your house uses, compare that to other homes, and get recommendations for ways of saving energy:

www.energystar.gov/index.cfm?fuseaction=HOME_ENERGY_YARDSTICK.showGetStarted

Learn how to read your home energy report and save money and energy

www.duke-energy.com/home/products/my-home-energy-report

How to estimate the amount of electricity an appliance uses per year

http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use

An activity for students to calculate their carbon footprint:

http://erp.unc.edu/files/2013/07/Calculating_Your_Carbon_Footprint.pdf

Energy, Electricity, Emissions, and Units

What is Energy?

In physics, energy is the ability to do work. In daily usage, the word energy means the power to accomplish something: "I don't have the energy to finish my homework." or "My hot water heater died and I want to buy one that uses less energy." In It's Our Air, energy generally refers to resources used to power lights, appliances, air conditioners, furnaces, and vehicles. This energy can take many forms. A few examples: a hot water heater that runs on natural gas, a wood stove that burns wood, a furnace that uses oil, an air conditioner that's powered by electricity, a car that runs on gasoline. Thinking back a generation or two, mills were powered by the energy of rivers, and wagons were powered by horses or oxen.

What is Electricity?

Electricity is a type of energy that consists of electrons flowing from one atom to another. Electric power plants use generators to push electrons to homes, businesses, and industry through power lines. Electricity can be produced in many ways: by burning fossil fuels such as coal or natural gas, through nuclear fission, or by harnessing the power of the sun, wind, or water.

Review of Units

Joule (J): A unit of energy. It equals the force required to accelerate one kilogram at the rate of one meter per second squared through one meter of space.
$J = (kg \times m^2)/s^2$

British thermal unit (BTU or Btu): A unit of thermal (heat) energy. It is the heat required to raise the temperature of one pound of water by one degree Fahrenheit. It equals approximately 1,055 joules.

Watt (W): A unit of power. Power refers to the rate at which energy is produced or consumed. A watt is equal to 1 joule of energy per second.
$W = J/s$

Kilowatt (kW): A unit of power. It equals 1,000 watts or 1,000 joules of energy per second.

Watt-hours (Wh): A unit of energy. It is the multiplication of power in watts (joules/second) by an hour. It equals 3,600 joules.

Kilowatt-hour (kWh): A unit of energy equal to 1,000 watt-hours. It is the multiplication of power in kilowatts by an hour. A kilowatt-hour equals 3.6 megajoules (3.6 million joules). A kilowatt-hour also equals approximately 3,412 Btu.

Megawatt-hour (MWh): A unit of energy equal to 1,000 kilowatt-hours. It is the multiplication of power in megawatts by an hour.

Therm: A unit of heat. On a bill from the natural gas company, energy use is measured in "therms." One therm equals 100,000 Btu.

Energy, Electricity, Emissions, and Units (continued)

Emissions from Burning Natural Gas, Oil, Coal

Pounds of Pollutant per Billion Btu of Energy Input
Note: 1 billion Btu of natural gas = 10,000 therms.

Pollutant	Natural Gas	Oil	Coal
Carbon dioxide	117,000	164,000	208,000
Carbon monoxide	40	33	208
Nitrogen oxides	92	448	457
Sulfur dioxide	0.6	1,122	2,591
Particulates	7	84	2744
Mercury	0.000	0.007	0.016

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration) Chapter 2, page 58.
www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

Emissions from Generating Electricity

Different utilities use different fuels to generate electricity, depending on the resources available in that part of the country: coal and other fossil fuels, hydropower, nuclear, solar, wind, biomass, etc. For this reason, the emissions that result from generating a kilowatt-hour of electricity vary as well. The EPA Clean Energy website has a page called "Power Profiler" where you can enter your zip code and find out the mix of fuels used by your electric utility and the emissions that result: http://oaspub.epa.gov/powpro/ept_pack.charts

Energy Conversion Calculator

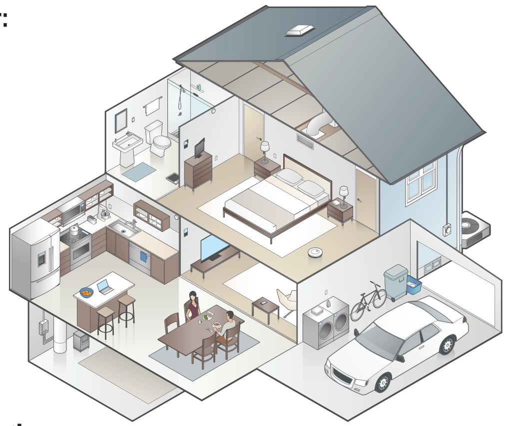
You can convert energy from one unit to another using this information on this handout. Another option is to use an online energy conversion calculator, such as this one:
www.eia.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

PART A: Energy Bills

Imagine that you live in a house in Raleigh.

You use electricity for:
air conditioning
refrigerator/freezer
stove/oven
clothes washer/dryer
lights
computers
audiovisual equipment
(TVs, sound systems, gaming systems, etc.)
kitchen appliances
other electric appliances
(hair dryer, vacuum cleaner, etc.)

You use gas for:
space heating
hot water



Look at the provided electricity bill and answer these questions:
What dates of electricity usage does this bill cover? In other words, what is the billing period?

How much electricity was used during the time period? Give units.

Look at the graph on the bill. Did you use more or less this month than in the same month last year?

Look at the provided natural gas bill and answer these questions:
What dates of natural gas usage does this bill cover? In other words, what is the billing period?

How much natural gas was used during this time period. Give units.

Look at the graph on the bill. Did you use more or less this month than in the same month last year?

Energy Units

What units are used to measure electricity?

What units are used to measure natural gas?

A British Thermal Unit (Btu) is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. Looking at the table below, how many Btu is 1 kWh?

How many Btu is 1 therm?

TABLE 1: Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

Part A: Energy Bills (continued)

MY ELECTRIC COMPANY

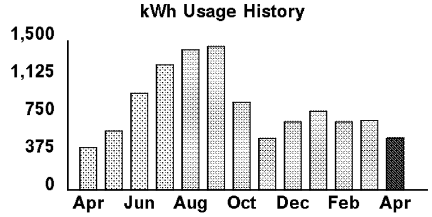
MY NAME
123 MAIN ST.
RALEIGH NC 27603-2149

Customer Bill

page 1 of 1

Account number		123 456 7890
Total due		**67.23**
Thank you for your payment	Apr 6	$100.00
Usage period		Mar 10 - Apr 10
This bill was mailed on		April 13, 2015

kWh Usage History



Usage

Meter number	EK3897
Readings: Apr 10	83617
Mar 10	- 83089
kWh usage	**528**

Days in period 31 Average kWh per day 17

Billing
Residential Service rate

	31 Days
Electric service	62.00
REPS Adjustment	0.83
7% North Carolina sales tax	4.40
Current bill amount	67.23
Balance before current bill	0.00
Amount Due on May 7,2015	67.23

MY Natural Gas COMPANY

SERVICE FOR
MY NAME
123 MAIN ST.
RALEIGH NC 27603-2149

ACCOUNT NUMBER
123 456 7890

Page 1 of 2

DATE DUE
May 10, 2015

Amount Due
48.50

CUSTOMER SERVICE - 24 HOURS A DAY
1-877-776-2427, toll-free

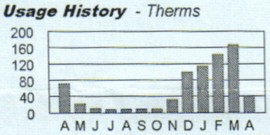
EMERGENCY SERVICE - 24 HOURS A DAY
To report gas leaks
1-877-776-2427, toll-free

STATEMENT DATE
Apr 13 2015

ACCOUNT SUMMARY

Previous Bill Amount		100.00
Payment Received	04/07/15 THANK YOU	$ -100.00
Current Charges		48.50
	Amount Due	48.50

Gas Usage History *- Therms*



	Apr 14	Apr 15
Therms used	73	42
Avg regional temp	52	57
Days in billing period	29	30
Cost	$83.69	$45.33

For a complete set of tools to analyze your usage, log on to psncenergy.com.

CURRENT CHARGES

Gas Charges

RATE PLAN
101 - Gas- Residential

METER READING
Gas Meter read on 04/09/15 at 07:19 am
(Next scheduled read date 5/7/15)

METER NO.	BILLING PERIOD	DAYS	CURRENT	PREVIOUS	CONSTANT	USAGE (CCF)	BTU FACTOR	THERMS
000296501	03/10/15 - 04/09/15	30	1348	1307	1	41	1.0310 =	42

Basic Facilities Charge	10.00
42 Therms X $ 0.841190	35.33
State Sales Tax at 7.00 %	3.17
Total Gas Charges	**$48.50**

Part A: Energy Bills (continued)

Table 2 shows data from one year's worth of energy bills for your house. Use the information in Table 1 to convert kWh and therms into Btu so you can compare how much of your energy use is due to electricity and how much is due to natural gas.

TABLE 2: Data from One Year of Energy Bills

Month of bill	Electricity Use In kWh	Electricity Use In Btu	Natural Gas In therms	Natural Gas In Btu
Jan	1,130		74	
Feb	940		99	
Mar	935		68	
Apr	790		42	
May	935		16	
June	1,385		11	
Jul	1,395		8	
Aug	1,340		8	
Sept	775		7	
Oct	690		9	
Nov	935		33	
Dec	1,050		69	
TOTAL				

Using the data from one year's worth of energy bills, answer the following questions:

1. In which month did you use the most electricity? Why do you think that is? Do you think you would use the most electricity in that month every year?

2. In which month did you use the most natural gas? Why do you think that is?

3. Approximately how many therms of natural gas do you think you use for hot water heating each month? How did you figure this out?

4. What is the total amount of energy, in Btu, used per year?

5. What percentage of the total energy used in the house is for heating and water heating (in other words, what percent does natural gas account for)?

6. What percentage of the total energy used in the house is for air conditioning, appliances, electronics, and lighting (in other words, what percent does electricity account for)?

7. Look at Table 3 showing percentages of energy consumption by end use for various regions. How does this house compare to the averages shown in the table? **Note**: You will need to add the percentages for heating and water heating in order to compare it to the data from your house.

TABLE 3: Energy Consumption by End Use (Averages from Georgia, the South Atlantic region, and the U.S.)

	Georgia	South Atlantic Region	United States
Heating	30%	29%	41%
Water Heating	19%	17%	18%
Air conditioning	11%	13%	6%
Appliances, electronics, Lighting	40%	41%	35%
TOTAL	100%	100%	100%

Source: www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ga.pdf

PART B: Reducing Air Pollution

You want to help prevent air pollution by using less energy. What would be the best ways to do so? In order to decide, first you need to know something about the types and amounts of emissions of pollutants that result from using electricity and natural gas.

Emissions from Electricity

The emissions from electric generation depend on what fuels are used to generate the electricity. The mix of fuels used varies in different parts of the country. Table 4 shows the fuels used in generating electricity in North Carolina, using data from 2012. It's important to note that the mix of fuels used changes over time. You can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. (**Note**: If everyone in the class tries to use the website at the same time, it may crash. It's best to have the teacher or one student in the class go to the site, see whether the data has been updated, and if so, share the information with the rest of the class.)

TABLE 4: Mix of Fuels Used to Generate Electricity in North Carolina

Source	2012 % of total:
Nuclear	41.2%
Coal	34.8%
Natural Gas	20.2%
Renewables (not incl. hydro)	2.5%
Hydroelectric	0.9%
Oil	0.2%

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions change with the fuel types. For example, burning coal to generate electricity produces more than three times more nitrogen oxide and 99 times more sulfur dioxide emissions as burning natural gas to produce the same amount of electricity. Generating electricity from nuclear power does not produce any emissions of sulfur dioxide or nitrogen oxides. Table 5 shows the emission factors of sulfur dioxide and nitrogen oxides from the mix of fuels used in 2012. Again, you can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. **Note**: Emission factors means the amount of emissions per unit of energy use – kWh for electricity, and therms for natural gas.

TABLE 5: Emission Factors for Electricity Generation in North Carolina

Emissions of...	2012
...sulfur dioxide (SO_2)	0.0011 lbs/kWh
...nitrogen oxides (NO_x)	0.0007 lbs/kWh

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions from Natural Gas

The emissions generated from burning natural gas, whether for a furnace, hot water heater, or stove, are as follows:

TABLE 6: Emission Factors for Natural Gas

Sulfur dioxide (SO_2)	0.00006 lbs/therm
Nitrogen oxides (NO_x)	0.0092 lbs/therm

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration), Chapter 2, page 58. **Note**: 1 billion Btu = 10,000 therms.
www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

Part B: Reducing Air Pollution (continued)

Fill in the first two columns of Table 7 using information from Table 2: Data from One Year of Energy Bills. In the third column, calculate what percentage of your total energy use is due to natural gas use (heating and hot water heating) and what percentage is due to electricity use (air conditioning, refrigerator, cooking, etc.) Using the information about emissions (shown in Tables 5 and 6), fill in the chart with the emissions of sulfur dioxide (SO_2)and nitrogen oxides (NO_X) your energy use creates each year.

TABLE 7: SO_2 and NO_X Emissions per Year

	Usage Info per year	Usage in Btu per year	% of home energy use	SO_2 emissions in pounds/year	NO_X emissions in pounds/year
Electricity	kWh				
Natural Gas	therms				

Comparing Strategies to Prevent Air Polllution

Which of the strategies below do you think will prevent the most air pollution and why? Answer this question before doing the calculations.

Strategy 1

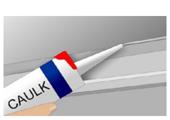
Reduce your electricity use by 10% by changing your behavior: turning off lights and appliances when not in use, occasionally using a clothesline instead of clothes dryer, and keeping your home a bit warmer in the summer (remember, your house does not use electricity for heating).

Strategy 2

Reduce your electricity use by 20% by some combination of the following: replacing your old air conditioner with a new energy-efficient air conditioner, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, buying a new energy-efficient refrigerator, replacing incandescent light bulbs with compact fluorescent or LED bulbs, regularly using a clothesline instead of a dryer.

Strategy 3

Reduce your natural gas use by 10% by changing behaviors: taking shorter showers, washing your clothes in cold water, and keeping your house a bit cooler in the winter.



Strategy 4

Reduce your natural gas use by 20% by some combination of the following: replacing your old furnace with a new energy-efficient one, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, insulating your hot water heater, buying a new energy-efficient hot water heater.

Part B: Reducing Air Pollution (continued)

Now calculate the reduction in emissions for sulfur dioxide and nitrogen oxides for each strategy. Write your answers in Table 8.

Table 8: Reduction in Emissions per Year

	Strategy 1: Reduce Electricity Use by 10%	Strategy 2: Reduce Electricity Use by 20%	Strategy 3: Reduce Natural Gas by 10%	Strategy 4: Reduce Natural Gas by 20%
Reduction in sulfur dioxide (SO_2) emissions				
Reduction in nitrogen oxides (NO_x) emissions				

Answer the following questions:

1. Which strategy would prevent the most sulfur dioxide emissions?
2. Which strategy would prevent the most NO_x emissions?
3. Which strategies would cost the homeowner money to implement?
4. Which strategies would not cost the homeowner anything to implement?
5. Which strategies would reduce your monthly bills?
6. Why is it important to know how your electricity is generated in order to devise strategies for reducing the emission of air pollutants due to home energy use?

PART C: Which appliances use the most electricity?

Work with a partner to rank these 18 appliances in order of how much electricity you estimate they use in one year. Use the second column of Table 9 to record your estimated order, putting the appliance you think uses the most kWh per year as number 1 and putting the appliance you think uses the least kWh per year as number 18.

The 18 appliances in alphabetical order:

clothes dryer
clothes washer
coffee maker
dishwasher
hair dryer
iPhone 6
lamp with a 60-watt incandescent bulb
lamp with a 13-watt compact fluorescent bulb
laptop computer
microwave
refrigerator with side-mounted freezer, and through-the-door ice
refrigerator with top-mounted freezer
television, 32-inch LED
television, 65-inch plasma
vacuum cleaner
video game on desktop computer
video game system with LCD television
water heater

TABLE 9: Yearly Electricity Use of Some Common Appliances

Electricity Use Rank	Estimated Order	Calculated Order: List item with its kWh/yr in parentheses
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

Your teacher will distribute a card for each appliance, one to each pair of students. One person from each pair should take the card to the front of the room, and form a line with the other students, arranging yourselves in order of electricity use. Discuss with your classmates until everyone agrees on an order. The teacher will write this order on the board.

Part C: Which appliances use the most electricity? (continued)

Next, check your estimated ranking by calculating the electricity use for each appliance. The data you need to do this are shown in Table 10. Large appliances, such as dishwashers or refrigerators, come with a yellow Energy Guide card that shows the estimated kWh per year, so you will not need to do calculations for the large appliances. For smaller appliances, calculate it yourself: A label on the appliance will show watts (W) used. Convert this to kilowatts (kW) by dividing by 1,000. Multiply the kilowatts by the number of hours used in a year to get kilowatt-hours (kWh) per year. Round off to the nearest whole kWh.

Example: A toaster oven uses 1,200 Watts and you use it for 3 minutes every day:

1,200 W/1000 = 1.2 kW

(3 minutes/day x 365 days/year)/60 minutes/hour = 18.25 hours/year

1.2 kW x 18.25 hours = 22 kWh per year

After you have calculated the kWh per year for the smaller appliances, fill in the last column of Table 9 with the appliances in the correct order.

TABLE 10: Data for Calculating Electricity Use

Appliance	**Wattage**	**Time used per year**	**Electricity use per year, rounded off to nearest kWh**
Clothes dryer			Energy Guide: **684 kWh per year**
Clothes washer	–	–	Energy Guide: **196 kWh per year** (based on 8 loads a week)
Coffee maker (2-cup)	700	10 minutes, 365 days a year	
Dishwasher	–	–	Energy Guide: **270 kWh per year** (based on 4 loads a week)
Hair dryer	1875	1 hour a week, 52 weeks a year	
iPhone 6	10.5 Wh (watt-hour) per charge	365 charges per year	
Lamp with a 60-watt incandescent bulb	60	3 hours a day, 365 days a year	
Lamp with a 13-watt compact fluorescent bulb	13	3 hours a day, 365 days a year	
Laptop computer	60	3.25 hours a day, 365 days a year	
Microwave	800	10 minutes, 365 days a year	
Refrigerator with side-mounted freezer, and through-the-door ice	–	–	Energy Guide: **630 kWh per year**
Refrigerator with top-mounted freezer	–	–	Energy Guide: **383 kWh per year**
Television, 65-inch plasma	–	–	Energy Guide: **346 kWh per year** (based on 5 hours of use a day)
Television, 32-inch LED	–	–	Energy Guide: **89 kWh per year** (based on 5 hours of use a day)
Vacuum cleaner	1,440	1 hour a week, 52 weeks a year	
Video game system with television	video game: 20 W LCD television: 150 W	3 hours a day, 300 days a year	
Video game on desktop computer	computer CPU: 68 W Monitor: 84 W	3 hours a day, 300 days a year	
Water heater (40 gallon)	–	–	Energy Guide: **4,773 kWh per year**

PART D: Benefits and Costs of Replacing Old Refrigerator

Imagine that your refrigerator is more than 20 years old and you want to replace it.

TABLE 11: Refrigerator Energy Use and Cost Per Year Comparison

		Features	Cost	Average energy use per year according to Energy Guide label	Average cost per year according to Energy Guide label
	Old Refrigerator From 1990-1992	Top freezer, 19-21 cubic feet	N/A	1,285 kWh	$142.64
	Refrigerator B Frigidaire FFTR1814QB (2015 model)	Top freezer, 18 cubic feet	$521	404 kWh	$48

Source: www.energystar.gov/index.cfm?fuseaction=refrig.calculator and Home Depot website.

1. How much money would you save each year on your electric bill with the new refrigerator?
2. How many years until your savings paid for the cost of the new refrigerator? This time period is called the "payback period," because at the end of it, you'll have been "paid back" for the money you spent on the new refrigerator.
3. What would the yearly reduction in emissions of sulfur dioxide be, assuming 0.002 lbs of sulfur dioxide per kWh?
4. What would the reduction in emissions of nitrogen oxides be, assuming 0.0008 lbs per kWh?
5. Imagine you have decided to keep the old fridge in the garage to hold drinks and snacks. How much would it cost each year to run both the old fridge and the new one?
6. How much sulfur dioxide emissions would result from generating the electricity need to run both refrigerators each year?
7. How much nitrogen oxide emissions would result from generating the electricity need to run both refrigerators each year?
8. After purchasing your new refrigerator, would you keep the old refrigerator in the garage for drinks and snacks or get rid of it? Explain your reasoning.