# The Carbon Cycle – Students Help to Control Their Carbon Footprint

### Category

**Science, Mathematics, Reading**

### Materials

**Data Tables and Template for Personal Data (Included)**

### Real World Connection

**Research, Future Planning, Commerce, Climate, Transportation**

## Problem Questions

**How much energy is used by appliances on stand-by mode?**

**How can a student help to control greenhouse gas emissions?**

### Prior Knowledge
### What I Know

*Based on your prior knowledge, answer the problem question to the best of your ability.*

1.

2.

### Conclusion
### What I Learned

*Answer the problem question after completing the activity.*

1.

2.

## Background - Introduction

Every time you turn on a light, get in a car to run an errand, or take a plane on vacation, do you think about how much carbon you are adding to the atmosphere?

Probably not.

Yet, whenever you use a fossil fuel, you leave a carbon dioxide "footprint" upsetting the natural rhythm of the carbon cycle.

**Carbon Footprint** **is** *The amount of $CO_2$ released into the atmosphere by burning fossil fuels*

Fossil fuels - coal, natural gas, and oil - provide the energy that we depend upon for our comfortable standard of living. For example, most electricity is produced by burning coal; and, both gasoline for our cars and jet fuel are made from oil. Whenever you use a fossil fuel, you leave a carbon dioxide "footprint" upsetting the natural rhythm of the carbon cycle.

## Background – Student Activities

Between 1961 and 2007, in about a half century, the average amount (concentration) of carbon dioxide ($CO_2$) in the Earth's atmosphere has increased from 317 parts per million (ppm) to 384 ppm.

What percent increase is this?

Let's do the math!

First, subtract to find the difference.

$$384$$
$$\underline{-317}$$
$$67 \text{ ppm}$$

Now, divide this difference by the beginning $CO_2$ concentration.

**67 divided by 317 (67/317) = 0.21**

Last, move the decimal two places to the right for a percent (the same as multiplying by 100).

**<u>21% increase in carbon dioxide in the Earth's atmosphere from 1961 to 2007</u>**

In the space that follows, calculate the percent $CO_2$ concentration increase between 1914 and 1960.

**1914 $CO_2$ concentration = 301 ppm**
**1960 $CO_2$ concentration = 316 ppm**

Compare and contrast: Which half century has the highest percent increase of $CO_2$?

How many times greater is the percent of $CO_2$ increase?

**<u>FYI</u>**
**384 parts per million (ppm) means that, for every one million (1,000,000) molecules of dry air in our atmosphere (oxygen, nitrogen, argon, and many minor gases), 384 of those molecules are carbon dioxide. Parts per million is a standard method to measure concentration of a particular element in a mixture of elements.**

## Background – Student Activities (Continued)

Fossil fuels not only provide energy, but serve as the raw material for thousands of consumer products. Listed in the following table are examples of these products.

1.  Study the list, then add at least one example from your experience.

2.  Check-off (✓) those that you might give-up to reduce your carbon footprint.

| Category | Example | Student Examples | Check-Off |
|---|---|---|---|
| Fuels | Gasoline, Electricity, Jet Fuel | | |
| Plastics | Furniture, Computer Parts, Toothbrushes, Plexiglass, Contact Lenses, Sunglasses | | |
| Fabric | Nylon, Synthetic Fabrics | | |
| Floors | Tile | | |
| Medications | Pepto-Bismol, Vaseline | | |
| Household | Detergents, Paints, Waxes, Solvents, Weed Killer | | |
| Make-Up | Lip Gloss, Hair Spray, Hair Coloring | | |
| Toys | Stuffed Animals | | |
| Source: Illinois Department of Natural Resources (http://www.ioga.com/Special/PetroProducts.htm) | | | |

**Reduce Your Carbon Footprint!**

**Students, joining together to reduce carbon emissions, can make a difference!**

# Background - Student Activities (Continued)

## Reduce Your Personal Carbon Footprint

How can one person, especially a student like you, reduce your carbon footprint to help control greenhouse gas emissions? Do you know how much carbon dioxide you contribute to our atmosphere? Probably more than you might guess.

For example, many people think of electricity as a clean source of energy, but most electrical power in the U.S. is produced by burning coal, a fossil fuel.

Suppose you keep a 100 watt light bulb on as a night light for eight hours a day, 365 days a year, and each kilowatt hour (kWh) of electricity requires burning 1.37 pounds of coal, you contribute 500 pounds of $CO_2$ per year.

One light bulb does not sound like much, but if every person in the U.S. joined the effort, that would be 100 million households x 500 pounds of $CO_2$ = 50,000,000,000 pounds (fifty trillion). Now that is impressive!
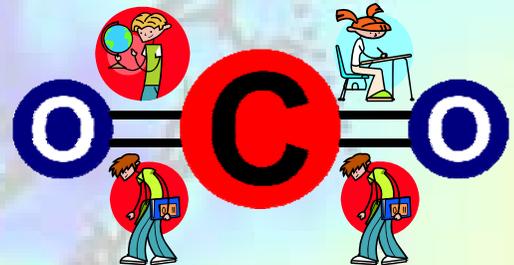
## What Can Each of Us Do to Reduce Our Own $CO_2$ Footprint?

The answer should be obvious...

Reduce the amount of energy that we use.

How?

1.  At home **use less** electric **power, heating** and **air conditioning.**

2.  For **transportation, ride** a bike, **walk**, **carpool, or use** public transportation!

3.  **Reduce** air travel.

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You will notice that some uses of fossil fuels, like heating and cooling your home and air travel, are not included in this activity. We want you, as a student, to concentrate on what you can do to reduce your carbon footprint in one area of energy use that you have direct control over...

### Electricity!

Each and every student in the United States controls an amazingly large amount of carbon. Therefore, you have the power to make a big difference!

### No need to wait...

# Take Action!

## For Example

A microwave oven has a 1500 Watt rating, that is used for one half hour each day.

If ...  $\mathbf{kWh = \dfrac{W \times h}{1000}}$

Then ... $\dfrac{1500 \times 0.5}{1000}$ = **0.75 kWh**

Now ... **Cost = kWh x cost per kWh**

Note ... The local power company charges $0.10 (10 cents) per kilowatt-hour.

So ... 0.75 kWh x $0.10 = **$0.075 per day**
        **(round off to $0.08 per day)**

Thus ... $0.08 x 7 days per week = **$0.56 per week**

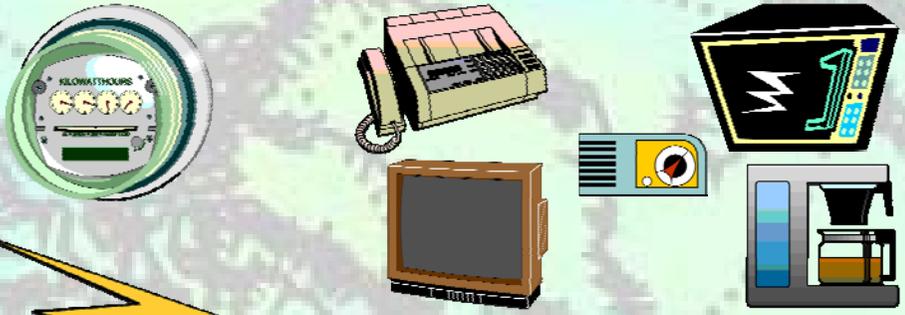And ... $0.56 x 52 weeks per year = **$29.12 per year**

# Procedure – Part 1

Have you ever suspected that some appliances "leak" electricity?

## Some do!

Appliances that have a remote control need electric power and function with a "stand-by" option.

Compare and contrast the rate of using electricity for both the "on" and "stand-by" operations. Use the directions in the steps that follow. Use the data in the table at the bottom of this page to draw a **bar graph** on Page 14-6 (Figure 14-1) of this activity.

1. On the x-axis of the grid, for each appliance, draw two bars side-by- side, one for "on" and one for "stand-by". For numbers greater than 100, write the actual number on the top of its bar.

2. On the y-axis, number the amount of energy used in Watts.

3. Label both axes and write a title for your graph.

4. Make a color key for the bars: one color for "on" and  different color for "stand-by".

Although the data are approximate, there is enough information to compare the energy needed to operate appliances both while "on" and on "stand-by". Assume that the "stand-by" mode is off when the appliance is "on".

**From UPPCO and Directgov - UK**

## Typical Electricity Use Per Appliance

**(The typical rate of energy use, in watts, by appliances on "stand-by" compared to "on", for one day.)**

| Appliance | Standby | On |
|---|---|---|
| Answering Machine | 3 | 3 |
| Clock Radio | 2 | 10 |
| Computer | 50 | 270 |
| Microwave | 3 | 1500 |
| Mobile Phone Charger | 1 | 5 |
| VCR | 5 | 19 |
| Stereo | 12 | 22 |
| Broadband Modem | 14 | 14 |
| DVD Player | 7 | 12 |
| Television | 10 | 100 |
| **Total** | | |
| **(Students – Find the Totals)** | | |

**Title:** _____

**Color Key**

**Greater Than 100**

**100**
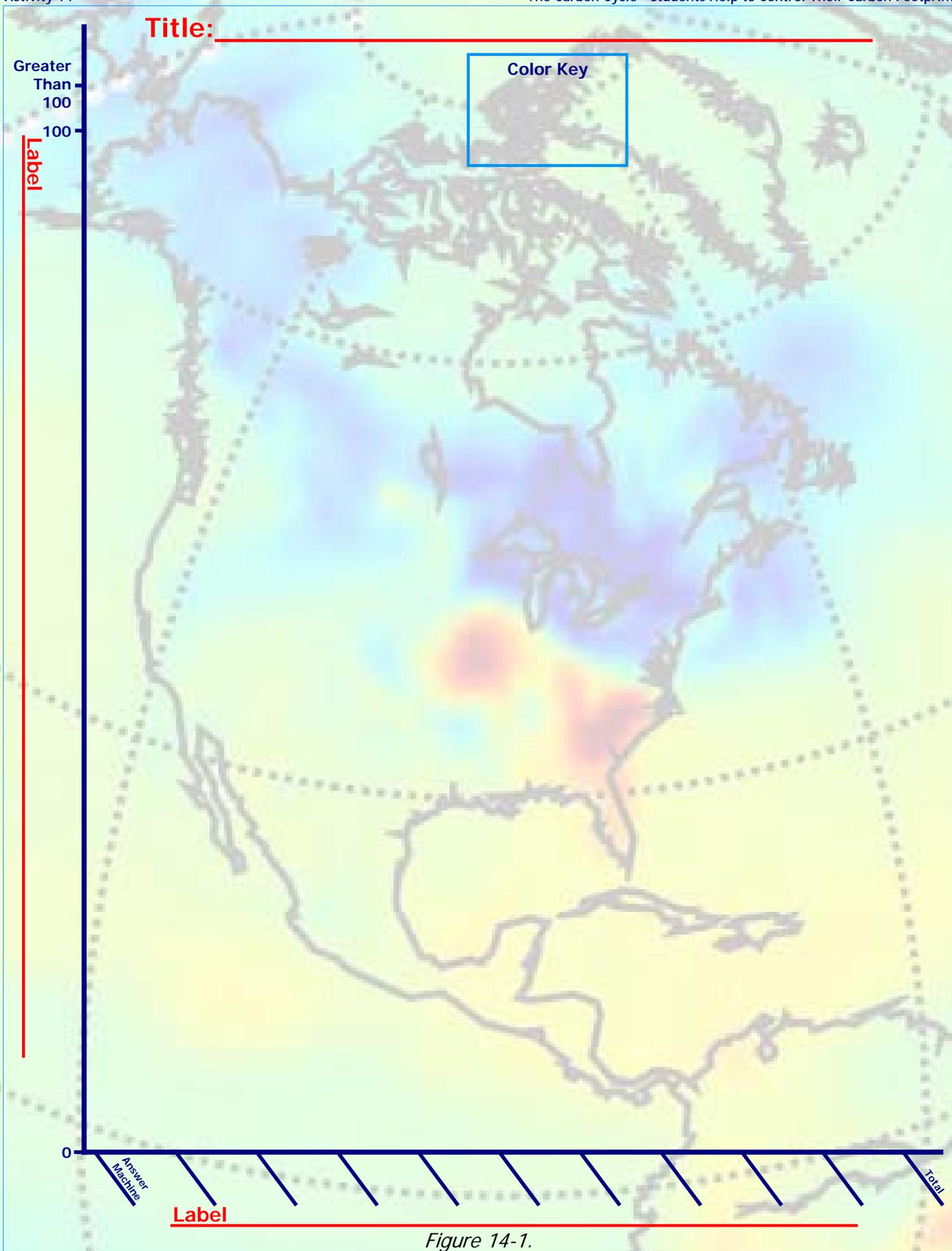
**Label**

**0**

Answer Machine

**Label**

Total

*Figure 14-1.*

## Questions – Part 1

1.  What appliance uses the most power while fully operating? What appliance uses the most power while on "stand-by? Does this make sense? Explain.

2.  If all of the appliances were used in one day for the typical amount of time, find the total number of Watts for "stand-by", then find the total for "on".

3.  Find the number of kilowatt hours of electricity used to continuously operate the appliances for one day. (Refer to the table on page 14-5.) (Hint: When "on", appliances do no use "stand-by" energy.)

4.  What percent of the total amount of electricity used in one day is the "stand-by" total?

5.  If your local power company charges ten cents per kilowatt hour, calculate the cost for using only the "stand-by" function for one day. For one week. For one year. (Note that Cost = kWh x 0.10.)

6.  Which appliance surprised you by its power use?  Why?

# Procedure – Part 2

By keeping track of the amount of time that you use each electrical appliance, you can calculate approximately how much $CO_2$ that you add to Earth's atmosphere as a result of using these appliances.

In other words...

**you can calculate part of your carbon footprint.**

## Planning to Collect Data Based on your Personal Electric Appliance Use

Begin by collecting baseline data for future comparison. Without changing your life style, keep a record of the amount of electricity that you use for **two days**.

For the **next two days** do your best to contribute as little $CO_2$ as possible.

Leave blank the row for appliances that you do not use. Add appliances on the blank lines that you use, but are not on the list.

Then, create a plan for the future, based on your personal data.

1. Set a goal to reduce your use of electricity.
2. List the actions that you will take.

## How to Fill-In the Data Tables to Calculate Part of your Personal Carbon Footprint

*As you read these instructions, refer to the steps in the sample table at the bottom of this page.*

Under the heading "h" (Hrs), enter the number of hours that each appliance is used. For a fraction of an hour, let each minute equal **0.02 hrs**.

On a separate sheet of paper, calculate the number of kilowatt hours that you use each appliance per day, and enter the results. Then, find the number of kilowatt hours for a week and for a year. Enter your results.

On a separate sheet of paper, calculate the approximate amount of carbon that is contributed to Earth's atmosphere by operating each appliance. Enter that number under pounds $CO_2$.
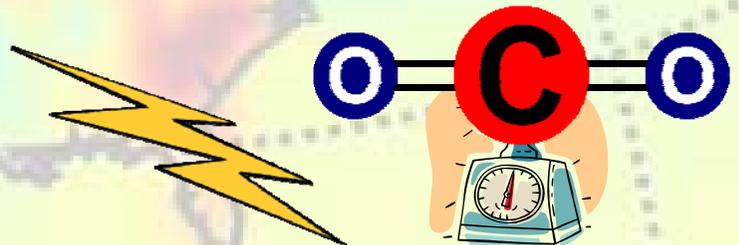
## Sample Data

**Follow the directions, using Steps 1 – 6 in this table, to calculate the approximate amount of $CO_2$ that you contribute to our atmosphere in two days and one year. Fill in the tables on Pages 14-9 and 14-10 with your answers. Use the back of these pages to write out your calculations. Use extra paper if you need it.**

| Appliance | Step 1 Number of Watts the Appliance Uses While "On" - (W) | Step 2 Number of Hours While "On" - (h) | Step 3 Number of Kilowatt Hours (kWh) of Power Used per Day $\frac{W \times h}{1000} = kWh$ | Step 4 Number of Kilowatt Hours of Power Used per 2 Days of the Activity $\frac{kWh}{Day} \times 2 = \frac{kWh}{2\ Days}$ | Step 5 The Average Amount of $CO_2$ Produced for 1 kWh of Power is 1.37 pounds (lbs) $\frac{kWh}{2\ days} \times \frac{1.37\ lbs}{kWh}$ | Step 6 Pounds (lbs) $CO_2$ Produced per Year $\frac{lbs}{2\ Days} \times \frac{365\ Days}{Year}$ |
|---|---|---|---|---|---|---|
| Example: A 100 Watt Light Bulb | Example: 100 Watts | Example: 8 Hours | Example: $\frac{100 \times 8}{1000} = 0.8$ | Example: $0.8 \times 2 = 1.6$ kWh per 2 days | Example: $1.6 \times 1.37 = 2.2$ lbs $CO_2$ per 2 Days | Example: $\frac{2.2 \times 365}{2}$ = 401.5 lbs $CO_2$ per Year |

# Procedure – Part 2 (Continued)

| Current Use | | Day 1 | | | Day 2 | | | Two-Day Total | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Appliance | Watts | Hrs | kWh | lbs. $CO_2$ | Hrs | kWh | lbs. $CO_2$ | Hrs | kWh | lbs. $CO_2$ |
| Answering Machine On | 3 | | | | | | | | | |
| Answering Machine Standby | 3 | | | | | | | | | |
| Broadband Modem On | 14 | | | | | | | | | |
| Broadband Modem Standby | 14 | | | | | | | | | |
| Clock Radio On | 10 | | | | | | | | | |
| Clock Radio Standby | 2 | | | | | | | | | |
| Computer On | 270 | | | | | | | | | |
| Computer Standby | 50 | | | | | | | | | |
| DVD Player On | 12 | | | | | | | | | |
| DVD Player Standby | 7 | | | | | | | | | |
| Hair Dryer | 1500 | | | | | | | | | |
| Lightbulb 100 Watts | 100 | | | | | | | | | |
| Lightbulb 60 Watts | 60 | | | | | | | | | |
| Lightbulb 40 Watts | 40 | | | | | | | | | |
| Microwave On | 1500 | | | | | | | | | |
| Microwave Standby | 3 | | | | | | | | | |
| Cordless Phone Charger On | 5 | | | | | | | | | |
| Cordless Phone Charger Standby | 1 | | | | | | | | | |
| Stereo On | 22 | | | | | | | | | |
| Stereo Standby | 12 | | | | | | | | | |
| Toaster | 1100 | | | | | | | | | |
| TV On | 100 | | | | | | | | | |
| TV Standby | 10 | | | | | | | | | |
| VCR On | 19 | | | | | | | | | |
| VCR Standby | 5 | | | | | | | | | |
| Video Game | 79 | | | | | | | | | |
| Total Amount of $CO_2$ in lbs | | | | | | | | | | |
| Total Amount of $CO_2$ in kg | | | | | | | | | | |

Use this side for your calculations for Page 14-9.

# Procedure – Part 2 (Continued)

| Reducing Your Footprint | | Day 3 | | | Day 4 | | | Two-Day Total | | |
| Appliance | Watts | Hrs | kWh | lbs. $CO_2$ | Hrs | kWh | lbs. $CO_2$ | Hrs | kWh | lbs. $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Answering Machine On | 3 | | | | | | | | | |
| Answering Machine Standby | 3 | | | | | | | | | |
| Broadband Modem On | 14 | | | | | | | | | |
| Broadband Modem Standby | 14 | | | | | | | | | |
| Clock Radio On | 10 | | | | | | | | | |
| Clock Radio Standby | 2 | | | | | | | | | |
| Computer On | 270 | | | | | | | | | |
| Computer Standby | 50 | | | | | | | | | |
| DVD Player On | 12 | | | | | | | | | |
| DVD Player Standby | 7 | | | | | | | | | |
| Hair Dryer | 1500 | | | | | | | | | |
| Lightbulb 100 Watts | 100 | | | | | | | | | |
| Lightbulb 60 Watts | 60 | | | | | | | | | |
| Lightbulb 40 Watts | 40 | | | | | | | | | |
| Microwave On | 1500 | | | | | | | | | |
| Microwave Standby | 3 | | | | | | | | | |
| Cordless Phone Charger On | 5 | | | | | | | | | |
| Cordless Phone Charger Standby | 1 | | | | | | | | | |
| Stereo On | 22 | | | | | | | | | |
| Stereo Standby | 12 | | | | | | | | | |
| Toaster | 1100 | | | | | | | | | |
| TV On | 100 | | | | | | | | | |
| TV Standby | 10 | | | | | | | | | |
| VCR On | 19 | | | | | | | | | |
| VCR Standby | 5 | | | | | | | | | |
| Video Game | 79 | | | | | | | | | |
| Total Amount of $CO_2$ in lbs | | | | | | | | | | |
| Total Amount of $CO_2$ in kg | | | | | | | | | | |

Use this side for your calculations for Page 14-10.

## Questions – Part 2

1.  Which appliance(s) uses the most electricity?

2.  For the appliance(s) that used the most electricity in one day, how many pounds of $CO_2$ would be produced per year?

3.  Calculate the total amount of $CO_2$ that you produced per year by using all of the appliances in your data tables.

4.  Combine appliance use and stand-by use to calculate your personal electric energy cost.

5.  List strategies to reduce your carbon foot print.

6.  Using SI units ( Meter, Liter, Gram), calculate the mass (weight ) of $CO_2$ that you contributed in one week. In one year. (Note: One pound [lb] = 0.45 kilograms [kg])

# Questions – Part 2 (Continued)

7. To estimate your total footprint, fill in the following table.

| Energy Source | Average $CO_2$ Emission | Personal Number of Units | Estimate of Personal $CO_2$ Footprint (lbs) | Estimate of Personal $CO_2$ Footprint (kg) |
|---|---|---|---|---|
| Electricity | 1.37 lbs $CO_2$ per Hour | _____ Hours | | |
| Natural Gas | 11 lbs per Cubic Foot | _____ Cubic Feet | | |
| Waste | 2.2 lbs per day (Based on 0.4 lbs per day for two people) | _____ per Person | | |
| Auto Transportation | 20 lbs per Gallon | _____ per Gallon | | |
| Air Travel | 0.424 lbs per Mile Flown | _____ per Air Mile | | |

### Use this space and extra paper if need for your calculations.