Reducing Personal CO_2 Emissions

How can we individually reduce global warming? If, as most scientists agree, man's production of greenhouse gases is contributing to the rise in worldwide temperatures, then surely there must be ways to slow this trend. Consider these possibilities:

Walking instead of driving to work or school every day can reduce carbon dioxide (CO_2) emissions by approximately 300 kg (660 lb) per year for a round trip that is 5 km (3.1 miles) long.

A household that recycles aluminum cans, glass bottles, plastics, cardboard, and newspapers can reduce CO_2 emissions by 386 kg (850 lb) annually.

Replacing the six most frequently used incandescent light bulbs in the home with compact fluorescent bulbs (CFLs) can reduce CO_2 emissions by 247 kg (566 lb) per year at the plant where the electricity is generated.

These examples are based on average energy use and waste production in the United States. Individual situations are likely to be different from the average; so your personal reduction in carbon dioxide emissions would probably vary from these values.

The average single-family household in the U.S. produces about 12,000 kg (26,000 lb) of carbon dioxide emissions each year. If personal transportation is included, the amount is approximately doubled. Keep in mind, however, that these figures do not include a household's share of all the emissions produced by others to support our way of life. When CO_2 emissions from all sectors – agriculture, commerce, industry, government, etc. – are added, the average single-family home is responsible for more than 52,000 kg (115,000 lb) of CO_2 emissions per year.

Still, this total presents an incomplete picture of household emissions, because it omits all other greenhouse gases. When methane, nitrous oxide, and other gases are included, the average household generates more than 73,000 kg (160,000 lb) of carbon dioxide equivalents annually.

Because the numbers are so large, and the sources of emissions so numerous, there are many opportunities for individuals and families to reduce greenhouse gas emissions. These opportunities might be grouped according to three general questions:

1. What things can I eliminate altogether?
2. What things can I not eliminate, but can reasonably reduce?
3. What actions can I take to offset the effects of those things I can't eliminate or reduce?

Walking instead of driving is an example that falls into the first category. Recycling and light bulb replacements could be put into the second category. Planting trees to store, or "sequester," carbon from the atmosphere is an example from the third category (more on this option shortly).

Here are several other CO_2 reduction opportunities for the typical household:

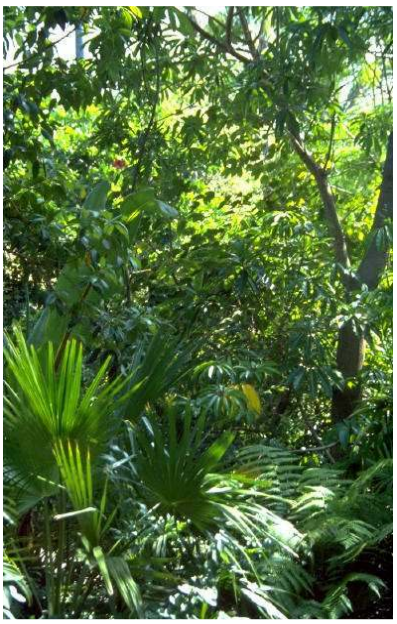
- Turning down the thermostat in winter by 1 degree Celsius (1.8 degrees Fahrenheit) could reduce carbon dioxide emissions by about 130 kg (286 lb) per year.
- Air-drying clothes instead of using a dryer for six months of the year could cut annual CO_2 emissions by 354 kg (779 lb).
- Turning off unneeded lights could remove 171 kg (376 lb) of CO_2 emissions per year.
- Trading in that "gas guzzler" for a car that has 4.3 km/liter (10 mpg) better fuel efficiency would reduce CO_2 emissions by approximately 2,000 kg (4,400 lb) for every 16,000 km (10,000 miles) driven annually.

Using average or typical values can be useful for comparing energy saving measures and for obtaining "ballpark" estimates of potential CO_2 emission reductions. However, a word of caution is in order. Applying average values to individual situations may lead to sizeable errors in estimated emission reductions because of the many variables encountered in the way people obtain and use energy in their homes.

Discussion point: Think of all the different ways in which energy is generated, delivered, and used to meet household heating and electrical needs. What factors would account for big differences in CO_2 emissions between two homes on the same street? Between two homes in separate states?

Now, about those trees...

Tree planting and reducing CO_2 emissions are very different approaches to the global warming problem. Reducing emissions tackles the problem at its source by curtailing *anthropogenic* (manmade) additions of CO_2 to the atmosphere. Tree planting, on the other hand, is designed to remove CO_2 that has already been added to the atmosphere. This two-pronged approach may be effective in slowing global warming.



Trees absorb carbon dioxide during photosynthesis and "fix" the carbon as new plant growth. Plants also respire (give off) CO_2, but there is an assumption of net gain with respect to the amount of CO_2 taken in by the trees and removed from the surrounding atmosphere. The rate at which a tree fixes carbon depends on a range of factors, including local climate, soil moisture, nutrient availability, competition from other plants, age and health of the tree, and type of tree. Accordingly, estimates for annual CO_2 uptake by trees vary widely. A value of 9 kg (20 lb) per year is a reasonable estimate to use for an "average" tree throughout its life cycle.

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The following table presents typical values for personal CO_2 emissions and reductions. Use these values to solve the problems below.

Emission Source or Mitigating Action	Approximate Carbon Dioxide Emission (***Reduction***) Rate
Automobile for personal transportation	2.4 kg/liter (20 lb/gallon)
Electricity to run lights and appliances	0.75 kg (1.64 lb) per kWh
Replacing standard bulb with CFL (average use)	*18 kg (40 lb) per year*
Recycling household solid waste	*386 kg (850 lb) per year*
Air drying clothes 6 months of the year	*354 kg (779 lb) per year*
Planting one tree	*9 kg (20 lb) per year*

1. What are the annual carbon dioxide emissions from your family's primary vehicle? Estimate annual mileage and convert to gallons of fuel used, based on the vehicle's fuel efficiency. Then calculate CO_2 emissions in kilograms. Use 12,000 miles (about 19,000 km) if you are unsure of the annual mileage. Find the average vehicle fuel efficiency of your automobile at http://www.fueleconomy.gov/feg/findacar.htm, or use these approximate values:

Hybrid	50 mpg
Subcompact or Compact	30 mpg
Mid-Size	24 mpg
Full-Size	20 mpg
Small SUV, Van, or Pickup	18 mpg
Large SUV, Van, or Pickup	15 mpg

Annual Mileage

_____ miles

Average Fuel Efficiency

_____ mpg

2. How many trees would have to be planted to absorb all of the CO_2 emissions from your car?

3. If you saved 10 percent of your household electricity usage – a very achievable goal – what would be the reduction in annual CO_2 emissions? Obtain your family's electricity usage from monthly utility bills, or use the national average of approximately 1,000 kWh per month.

4. A typical home has about 30 light bulbs. What reduction in CO_2 emissions would result from replacing 30 standard incandescent bulbs with the same number of CFLs?

5. If every household in a community of 30,000 population practiced recycling, what would be the total reduction in CO_2 emissions? Assume an average household size of 2.6 people.

6. Air-drying clothes for 6 months of the year is roughly equivalent to planting how many trees?

7. Ponder this story about a man, a wife, their automobile, and their good intentions:

   Archie and Edna decided to acquire a sporty vehicle as a second car. Archie, a retired accountant whose driving habits earned him the nickname "Lead Foot," had his eye on a red Ferrari with a fuel economy rating of 15 mpg. Edna, a retired botanist known affectionately to her friends as "Mother Earth," was particularly concerned about greenhouse gas emissions. She imagined herself fashionably zipping around town in a yellow Mini Cooper that gets 30 mpg. Archie argued that, because they would drive the vehicle no more than 5,000 miles per year, the emissions wouldn't make a great deal of difference. After much discussion, Edna agreed to the Ferrari under the condition that Archie would purchase and supervise the planting of 50 American Liberty Elm trees on the town common. The new trees would replace elms that stood proudly for many decades before succumbing to Dutch elm disease in the 1960s. Edna was not pleased about the greater CO_2 emissions that would come from their new car. However, she took comfort in Archie's civic-mindedness and in knowing that the plantings would more than offset the difference in emissions between the two vehicles.

   Was Edna correct on this last point? Show all calculations to support your reasoning.

Reducing Personal CO_2 Emissions

Teachers' Notes

Objectives: Students will consider ways in which individuals can reduce or offset carbon dioxide emissions. They will perform calculations to quantify the effectiveness of particular actions toward that end.

Grade Level: Middle/High

NSES: A3, A4, A5, A6, B6, B11, E4, E5, E6, E7, F7, F10, F13, F14, F15, F16

NHSCF: 1a, 2c, 2e, 2f, 4b, 4c, 5c, 6a, 6b, 6c

Key Concepts

The United States produces more carbon dioxide than any other nation, accounting for approximately one-third of the world's emissions. The U.S. also ranks near the top in per capita CO_2 emissions, exceeded only by a few oil-producing Middle Eastern countries. Our large population, geographical area, relatively cool climate, and high standard of living contribute to this situation. Also contributing is our inefficiency in energy consumption as measured against other industrialized nations having comparable living standards. Germany and the United Kingdom, for example, produce about half the per capita CO_2 emissions of the U.S.

At first it might seem as though there is little that individuals can do to counter this problem. One reason for this attitude might be our nearly complete dependence on fossil fuels to support our way of life. Another reason might be the difficulty our nation has had in reaching agreement on emission levels under the international Kyoto Protocol. However, as we begin to think about all the ways that we use energy as individuals, the relationships between personal actions and environmental consequences become clearer.

Making such connections requires a heightened awareness built on knowledge of the facts. Consider electricity. Many students will have only a vague idea as to where their electricity comes from. Once they know that a large part of our electric supply comes from generating stations fueled by coal, gas, and oil, students will be more likely to see the act of flipping a light switch as causing CO_2 emissions.

Students and families have many opportunities to reduce personal carbon dioxide emissions by making simple adjustments in their habits and lifestyles (sometimes, but not always, at the cost of convenience). Some of these changes come at no monetary cost and can actually save dollars by virtue of the energy savings realized. Examples of things students can do to reduce CO_2 emissions include turning off unused lights; replacing inefficient standard bulbs with compact fluorescent bulbs; walking or biking instead of taking a car for short trips; air-drying the laundry; recycling household waste; and turning down the thermostat, especially at bedtime or during the day when family members are not at home.

Planting trees is perhaps the only practicable option for individuals looking for ways to offset existing carbon dioxide emissions. Students are asked to perform a few calculations related to carbon fixation ("sequestration") by trees. It will be clear from these simple analyses that it takes many trees to offset personal carbon dioxide emissions. Energy conservation is a much more effective tool for reducing emissions.

Discussion point: Think of all the different ways in which energy is generated, delivered, and used to meet household heating and electrical needs. What factors would account for big differences in CO_2 emissions between two homes on the same street? Between two homes in separate states?

It would be instructive to begin answering these questions by discussing the various methods of energy supply – fossil fuels, nuclear, hydropower, and other renewables. Two homes on the same street are likely to have similar, if not identical, electricity sources. Therefore, any differences in CO_2 emissions would most likely come from internal differences between the households. The potential list is lengthy; here is a sampling:

- One home has six family members; the other has three.
- One home uses natural gas for space heating; the other uses heating oil.
- One home uses natural gas for hot water heating; the other uses electricity.
- One family drives two SUVs; the other drives a midsize sedan and a subcompact.
- One home has an extra refrigerator/freezer; the other has one refrigerator.
- One household recycles; the other does not.
- One home has central air conditioning; the other uses window fans in summer.

Two households in separate states could produce different amounts of carbon dioxide emissions for any of the reasons given above. However, regional factors would also be important. For example, there could be differences in the following categories that effect energy consumption and CO_2 emissions:

- Available energy sources for home heating
- Sources of electricity
- Climate
- Forms of transportation and distances traveled
- Lifestyles and recreational pursuits

Numerical data were obtained or derived from information presented at:

The Rocky Mountain Institute
http://www.rmi.org/sitepages/pid173.php

U.S. Environmental Protection Agency
http://www.epa.gov/, http://www.epa.gov/oar/

U.S. Department of Energy
http://www.fueleconomy.gov/feg/FEG2004_GasolineVehicles.pdf

Personal emissions calculators are available at these websites:

http://www.epa.gov/climatechange/emissions/ind_calculator.html
http://www.americanforests.org/resources/ccc/index.php

Other useful websites:

http://des.nh.gov/index.htm
http://www.time.com/time/2001/globalwarming/e.html

ANSWER KEY

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1. What are the annual carbon dioxide emissions from your family's primary vehicle? Estimate annual mileage and convert to gallons of fuel used, based on the vehicle's fuel efficiency. Then calculate CO_2 emissions in kilograms. Use 12,000 miles (about 19,000 km) if you are unsure of the annual mileage. Find the average vehicle fuel efficiency of your automobile at http://www.fueleconomy.gov/feg/findacar.htm, or use these approximate values:

Hybrid	50 mpg
Subcompact or Compact	30 mpg
Mid-Size	24 mpg
Full-Size	20 mpg
Small SUV, Van, or Pickup	18 mpg
Large SUV, Van, or Pickup	15 mpg

Annual Mileage

12,000 miles

Average Fuel Efficiency

24 mpg

Sample Response:

gasoline used 12,000 mi/yr / 24 mpg = 500 gal/yr (1,900 liters/yr)

emissions 500 gal/yr x 20 lb CO_2/gal = 10,000 lb CO_2/yr (4,500 kg CO_2/yr)

2. How many trees would have to be planted to absorb all of the CO_2 emissions from your car?

Sample Response: 4,500 kg CO_2/yr / 9 kg CO_2/yr/tree = 500 trees

3. If you saved 10 percent of your household electricity usage – a very achievable goal – what would be the reduction in annual CO_2 emissions? Obtain your family's electricity usage from monthly utility bills, or use the national average of approximately 1,000 kWh per month.

Sample Response:

energy savings *1,000 kWh/mo x 12 mo/yr x 0.10 = 1,200 kWh/yr*

emissions reduction 1,200 kWh/yr x 0.75 kg CO_2/kWh = 900 kg CO_2/yr (2,000 lb CO_2/yr)

4. A typical home has about 30 light bulbs. What reduction in CO_2 emissions would result from replacing 30 standard incandescent bulbs with the same number of CFLs?

   30 bulbs x 18 kg CO_2/bulb/yr = 540 kg CO_2/yr (1,200 lb CO_2/yr)

5. If every household in a community of 30,000 population practiced recycling, what would be the total reduction in CO_2 emissions? Assume an average household size of 2.6 people.

   (30,000 people / 2.6 people/household) x 386 kg CO_2/yr ≈ 4,450,000 kg CO_2/yr (9,800,000 lb CO_2/yr)

6. Air-drying clothes for 6 months of the year is roughly equivalent to planting how many trees?

   354 kg CO_2/yr / 9 kg CO_2/yr/tree ≈ 39 trees

7. Ponder this story about a man, a wife, their automobile, and their good intentions:

   Archie and Edna decided to acquire a sporty vehicle as a second car. Archie, a retired accountant whose driving habits earned him the nickname "Lead Foot," had his eye on a red Ferrari with a fuel economy rating of 15 mpg. Edna, a retired botanist known affectionately to her friends as "Mother Earth," was particularly concerned about greenhouse gas emissions. She imagined herself fashionably zipping around town in a yellow Mini Cooper that gets 30 mpg. Archie argued that, because they would drive the vehicle no more than 5,000 miles per year, the emissions wouldn't make a great deal of difference. After much discussion, Edna agreed to the Ferrari under the condition that Archie would purchase and supervise the planting of 50 American Liberty Elm trees on the town common. The new trees would replace elms that stood proudly for many decades before succumbing to Dutch elm disease in the 1960s. Edna was not pleased about the greater CO_2 emissions that would come from their new car. However, she took comfort in Archie's civic-mindedness and in knowing that the plantings would more than offset the difference in emissions between the two vehicles.

   Was Edna correct on this last point? Show all calculations to support your reasoning.

   Difference in fuel consumption

Ferrari	5,000 mi/yr / 15 mpg	≈ 333 gal/yr (1,260 liters/yr)
Mini Cooper	5,000 mi/yr / 30 mpg	≈ 167 gal/yr (630 liters/yr)
	difference	≈ 167 gal/yr (630 liters/yr)

   Difference in emissions 167 gal/yr x 20 lb CO_2/gal ≈ 3,300 CO_2/yr (1,500 kg CO_2/yr)

   Absorption by trees 50 trees x 20 lb CO_2/yr = 1,000 kg CO_2/yr (450 kg CO_2/yr)

   Conclusion: The extra CO_2 emissions from the Ferrari would be about three times the amount of CO_2 taken up by the trees. Despite her good intentions, Edna's plan shortchanges the environment.