Concept:
Carbon dioxide, or CO_2, is a greenhouse gas. Humans have been increasing the amount of carbon dioxide in the air by burning fossil fuels, by producing cement and by clearing land. We can measure the amount of CO_2 we each produce when we use energy. The United States emits a much larger amount of CO_2 each year than any other nation.

Objectives:
Students will be able to:
- Solve mathematical word problems.
- Collect data on personal transportation and energy use.
- Complete the EPA's on-line Personal Greenhouse Gas Calculator.
- Describe ways to decrease CO_2 emissions based on their actual findings.

Subjects:
Math, Family & Consumer Sciences, Science

Skills:
Data collection, solving word problems using formulas, multiplying, dividing, using ratios

Method:
Students collect data and compute word problems to calculate their family's contribution of CO_2 into the atmosphere.

Environment/Land Use

Population

Quality of Life

Global Warming Begins at Home USA

Introduction:
Energy made from the combustion of fossil fuels produces CO_2, one of the major contributors to climate change. CO_2 is released any time coal, oil, natural gas, or even a renewable resource such as wood is burned. The problem with carbon dioxide is that it acts as a greenhouse gas. Such gases naturally function to insulate the planet from harmful ultraviolet rays. In recent years, greenhouse gases have been added to the atmosphere much more rapidly than in the past, leading to an overall warming trend. Warming temperatures have far-reaching effects and have changed the weather on our planet. They make it hotter in some areas, and colder in others. Some of the effects include heat waves, periods of unusually warm weather, ocean warming, coastal flooding, the melting of glaciers, Arctic and Antarctic warming, and the bleaching of coral reefs. While climate change is a global issue, many of the causes and solutions lie in individual decisions.

Materials:
Student worksheet
Calculator
Optional: Student's home energy bills
Computer with internet access

Procedure:
Students will need the correct answers in part 1 in order to complete the remaining parts of the activity. Students may estimate answers where appropriate.

Parts 1 and 3 can be done in class. Part 2 uses data from the students' home energy use. Students can collect this data by asking family members about energy use, or optimally, by examining their recent electricity bills.

Have students use their answers from Part 2 to complete the Environmental Protection Agency's on-line Personal Greenhouse Gas Calculator and explore actions they can take to lower emissions while reducing energy and waste disposal costs: http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ResourceCenterToolsCalculators.html

Discussion Questions:
1. Did any of the answers to the questions surprise you?

   Answers will vary.

2. Based on what you know, what are your views on global climate change?

   Answers will vary.

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3. Why does there seem to be such resistance to lowering global fossil fuel emissions?

There are many reasons for the resistance, and no firm answer to this question. However, leaders in the field have identified the following as some of the possible reasons:
- *the lack of immediacy of the issue*
- *the complexity of the science of climate change, and lack of full public understanding*
- *concern that economic progress will be impeded by action on climate change*[1]

However, it should be noted that there are many individuals, groups, businesses, and governments that are not resistant and have taken action. In particular, many U.S. states and city mayors (see www.ci.seattle.wa.us/mayor/climate) have pledged to reduce emissions.

4. What can we do to slow down global warming?

Fossil fuel consumption is a large share of greenhouse gas emissions. Gains can be made in the efficiency of production of electricity, or by switching to renewable sources of energy, such as solar or wind. The transportation sector is responsible for a huge portion of emissions. Reducing miles on the road through ridesharing, using mass transit or walking or biking, and using more efficient vehicles can all help. Finally, slowing population growth will bolster these per-capita improvements. These changes can be made at an individual level, as well as through collective actions.

Follow up:

Have students calculate the class average for CO_2 production, then compare it to the answers in part 2, to national averages, or to the average use of energy in other countries. What actions can they take as a class to reduce CO_2 emissions?

Sources:

[1] Abbasi, Daniel R. (2006) *Americans and Climate Change: Closing the Gap Between Science and Action.* Yale University School of Forestry and Environmental Studies: New Haven, CT.

[2] Energy Information Administration. "Voluntary Reporting of Greenhouse Gases Program." Department of Energy: Washington, DC www.eia.doe.gov/oiaf/1605/factors.html

[3] Department of Energy and Environmental Protection Agency. (2000) *Carbon Dioxide Emissions from the Generation of Electric Power in the United States.* Washington, DC

[4] Jardine, Christian N. (2005) "Calculating the Environmental Impact of Aviation Emissions." Oxford University Centre for the Environment: Oxford, England

[5] Environmental Protection Agency: Global Warming - Emissions - Individual (2000) http://yosemite.epa.gov/oar/globalwarming.nsf/content/emissionsindividual.html

[6] Sampson, R. Neil. (1988) "ReLeaf for Global Warming." *American Forests,* Vol. 94, Number 11/12.

[7] Energy Information Administration. "World CO_2 Emissions from the Consumption and Flaring of Fossil Fuels 1980-2004." *International Energy Annual 2004.* Department of Energy: Washington, DC

[8, 9] Population Reference Bureau. *2006 World Population Data Sheet.* www.prb.org.

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Answer Key

Part 1: The Jones Family

1. 21,000 miles / 21 miles/gallon = 1,000 gallons

2. 1,000 gallons x 20 lb CO_2/1 gallon = 20,000 lb CO_2

3. 4,000 kWh x 2 lb CO_2/ 1 kWh = 8,000 lb CO_2

4. 12,000 miles x 1 lb/1mile = 12,000 lb CO_2

5. 20,000 lb CO_2 + 8,000 lb CO_2 + 12,000 lb CO_2 = 40,000 lbs CO_2

6. 40,000 lb CO_2 x 2 = 80,000 lbs CO_2

7. 80,000 lbs indirect CO_2 + 40,000 lbs direct CO_2 = 120,000 lbs CO_2

8. 120,000 lbs CO_2 / 2,000 lbs/ton = 60 tons CO_2

9. 60 tons CO_2 / 4 people = 15 tons/person

Part 2: Your Family's Production

1– 5. *Answers will vary for each student.*

6. Answers will vary, but might include: Homes that use air conditioning tend to have spikes in energy use during the hotter months of the year; those that require heat during the colder months will also see elevated energy use when the heat is turned on. After heating and cooling systems, the largest energy use in the average American home is light fixtures. These might be used less during months with longer periods of daylight.

7 – 15. Answers will vary for each student.

16. 23 billion tons CO_2/6.5 billion people = 4.2 tons/person

17. Answers will vary.

18. 7.34 billion tons/9.3 billion people = 0.8 tons/person

19. Answers will vary.

20. Answers will vary, but could include increasing energy efficiency (use compact fluorescent bulbs, better insulate homes, upgrade appliances to more efficient models); increasing use of public transit instead of driving; recycling and reducing consumption (to avoid emission of CO_2 in production of new goods).

21. Answers will vary.

Part 3: Choices

1. 10 miles/ 22 miles/gallon = 0.5 gallons

2. 0.5 gallons/5 people = 0.1 gallons/person

3. 10 miles/6.5 miles/gallon = 1.5 gallons

4. 1.5 gallons/30 people = 0.05 gallons/person

5. 0.5 gallons/day x 150 days = 75 gallons gas/year

75 gallons gas x 20 pounds CO_2/gallon gas = 1,500 lbs. CO_2

6. 0.05 gallons/person/day x 150 days = 7.5 gallons

7.5 gallons of gas x 20 lbs CO_2/gallon of gas = 150 lbs CO_2

1,500 lbs – 150 lbs = 1,350 lbs CO_2 saved

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Name _____ Date _____

Student Worksheet, Page 1

Global Warming Begins at Home USA

Part 1: The Jones Family

Clearly show how you arrived at each answer and be sure to indicate the appropriate units.

1. Last year, the Jones family drove 21,000 miles total in two cars that average 21 mpg. How many gallons of gasoline did they use? _____

2. How many pounds of carbon dioxide did the Jones family produce? (For each gallon of gas burned, approximately 20 lbs. of CO_2 is released into the atmosphere.[2]) _____

3. In their all-electric house, the Jones family used about 4,000 kilowatt-hours of electricity last year. Generating a kilowatt-hour of electricity in the US produces 2 lbs. of CO_2.[3] How many pounds of CO_2 did that add to the atmosphere? _____

4. Mr. Jones flew 12,000 miles on business. Flying one mile in an airplane generates approximately 1 pound of CO_2 per passenger.[4] How many pounds were generated by his air travel? _____

5. Add the total amounts of CO_2 from questions 2, 3, and 4 above to calculate the Jones family's direct production of CO_2. _____

6. Scientists estimate that carbon dioxide produced indirectly – in the production of many items we buy, in the heating and cooling of public buildings we use, etc. – contributes twice as much CO_2 as our personal use.[5] Double your answer to the last question to account for the CO_2 produced indirectly through the purchase of goods and services: _____

7. How many pounds of CO_2 is that altogether for the Jones family? _____

8. There are 2,000 pounds in one ton. How may tons of CO_2 is that altogether? _____

9. There are 4 people in the Jones family; how many tons of CO_2 is that per person? _____

Part 2: Your Family's Production

To answer the following questions, talk to your family to get the most accurate data for your calculations.

1. If your family has a car, how many miles did your family drive last year? _____

2. How many miles does your car(s) average per gallon of gas? _____ (If your family has more than one car, average the mpg for all the cars.)

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Name _____ Date _____

Student Worksheet, Page 2
Global Warming Begins at Home USA

3. How many pounds of carbon dioxide did your family produce by driving? (Hint: Use the figure for CO_2 production from Part 1, question 2.) _____

4. Ask someone in your family to estimate the kilowatt-hours of electricity your family uses in one year. Take a look at a recent electric bill and use it to estimate the yearly usage. If one pound of coal is burned for every kilowatt-hour used how many pounds of coal did your family use to produce your electricity? _____

5. If 2 pounds of CO_2 are produced for every pound of coal burned to produce electricity, how many pounds of carbon dioxide did your family add to the atmosphere to produce electricity last year? _____

6. Think about the different things we use electricity for. Do you think that our home use of electricity is the same every month? If not, when and why would we use different amounts during the year?

7. Flying one mile in an airplane generates approximately 1 pound of CO_2 per passenger.
Where did your family travel by airplane? _____
How far did your family travel? _____ miles
How many pounds of CO_2 did your family generate by flying last year? _____

8. Add the total amounts of CO_2 from questions 3, 5, and 7 above to calculate your family's direct production of CO_2. _____

9. Now double that figure to account for the CO_2 produced indirectly through the purchase of goods and services: _____

10. How many pounds of CO_2 is that altogether for your family (add answers from questions 8 and 9)? _____

11. One ton is 2,000 pounds. How many tons of CO_2 does your family emit each year? _____

12. Divide this figure by the number of people in your family to determine the tons of CO_2 per person. _____

13. Multiply this figure by 300 million to determine the national emissions of CO_2 if everyone in the country had emissions similar to yours: _____.

14. The U.S. is expected to have 420 million people by 2050. Multiply the figure from question 11 by 420 million to determine total emissions at that time: _____.

15. On average, each forest tree absorbs 13 pounds of CO_2 per year and each acre of forest absorbs approximately 5 tons of CO_2 per year.[6] How many acres would you need to plant (or save by recycling paper) to absorb the CO_2 you produce each year in your normal routine? _____

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Name _____ Date _____

Student Worksheet, Page 3

Global Warming Begins at Home USA

To put this in perspective, worldwide releases of CO_2 from fossil-fuel combustion are 27 billion tons per year,[7] and the world population is 6.5 billion.[8] Experts think that stabilizing the climate will require a reduction in CO_2 emissions by 50 - 80% by the year 2050. Our planet's population is expected to reach 9.3 billion by then.[9]

16. If the releases now were divided evenly among the world population, what would the average release per person be? _____

17. Is your current share more or less than the average? _____

18. In 2050, what will be the recommended CO_2 production per person? _____

19. Would your family need to alter their CO_2 production to reach the goal set for 2050? _____

20. What could you do to reduce your family's production of CO_2?

21. What would be the impact(s) to you and your family members?

Part 3: Choices

1. Your brother just turned 16 and he has decided to drive the five miles to school rather than taking the bus. If he drives 10 miles roundtrip to school in a car that gets an average of 22 mpg, how many gallons of gas are consumed driving to and from school each day? _____

2. If he picks up four friends for the ride, how many gallons of gas are consumed per person? _____

3. If other students ride a bus that drives these same 10 miles but only averages 6.5 mpg how much gas does the bus consume? _____

4. If an average of 30 students ride that bus, what is the per person gas consumption on the bus? _____

5. If your brother drives 10 miles to and from school in the car in question 1 for 150 days of his school year, how much CO_2 did he add to the atmosphere? _____

6. How many pounds would he have saved if he had ridden the bus? _____

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