

# Generating Heat

## Student Activity

### Method:

Students graph carbon emissions and population growth over time and comment on trends they observe.

### Introduction:

Carbon dioxide (CO<sub>2</sub>) is the primary greenhouse gas contributing the most to global climate change. A **greenhouse gas** is a gas that absorbs the sunlight that is reflected back towards space as infrared radiation (heat), trapping the heat in the atmosphere. As the world's population grows, so does the impact of human activities, including the burning of fossil fuels. Over the past 250 years, such activities have raised carbon dioxide into the atmosphere to a level significantly higher than it has been for hundreds of thousands of years. Scientific evidence shows a correlation between high CO<sub>2</sub> levels in the atmosphere and rising global temperatures. In this activity, students will graph and observe the correlation between human population growth and CO<sub>2</sub> emissions over time.

### Procedure:

Have students work either individually or in small groups. Distribute the student worksheets. For the graphing segment of the activity, they may either use graph paper or copy the data into a Microsoft Excel spreadsheet, in order to create the graph on the computer. Steps for creating an Excel graph are provided on the Student Worksheet. See the sample graph for an idea of what student graphs should look like. Go over the discussion questions as a class, after students have had time to evaluate their graphs.

### Discussion Questions:

1. What does the graph suggest about the relationship between population growth and carbon emissions?

*As population has grown, emissions have grown at an even faster rate.*

2. What do you think accounts for the growth in CO<sub>2</sub> emissions?

*Increased technology and urbanization have required energy. The ways of producing this energy, such as by burning coal or oil, often result in carbon emissions. Trees absorb carbon dioxide, so deforestation and harvesting of trees have also increased the amount in the atmosphere.*

3. Today, most of the world's population growth is occurring in the world's poorest countries. Do you think carbon emissions will tend to increase with increasing population growth in these countries? Why or why not?

*It is likely to. Even if these countries do not further industrialize, more people still means more cars and factories to emit carbon dioxide. In all likelihood, however, many of these countries will further develop and industrialize, needing more energy per capita as well as more energy overall. If these poorer countries get richer, they will want much of the technology that more developed countries have and that results in our high amount of energy consumption.*

4. China and India are the world's largest populations. Both countries are rapidly industrializing, creating greater affluence, but also more carbon emissions. The United States, with a smaller population size and slower growth rate, is still the largest per capita carbon emitter in the world. Is it fair to ask developing countries to curb carbon emissions? Should the U.S. and other developed countries cut their emissions more to allow developing countries greater fossil fuel use than they've had in the past? Is there a strategy that would create an equitable balance of carbon use?



### Concept:

Carbon emissions, produced by burning fossil fuels, contribute to global warming. Population growth, along with rapid industrialization over the past two centuries, has increased the world's carbon emissions significantly.

### Objectives:

Students will be able to:

- Graph data over time from population growth and carbon emissions.
- Discuss the correlations between population growth and carbon emissions, as well as the future implications and responsibilities that come with growing affluence around the world.

### Subjects:

Environmental science, social studies, mathematics, civics/government

### Skills:

Graphing, critical thinking, research, writing, decision making

### Materials:

Copies of Student Worksheet  
Graphing paper or access to Microsoft Excel

### Key Terms: greenhouse gas

Answers will vary. Students may suggest that such demands on developing nations are only reasonable as long as the U.S. is leading the way in reducing carbon emissions, or that as new technology is developed that is more eco-friendly, developing nations should use it. Carbon emissions trading can be seen as a way to prevent growth in emissions, or perhaps multilateral agreements such as the Kyoto Protocol.

5. What does this tell you about the relationship between population growth and carbon emissions? Does it have to be a positive relationship?

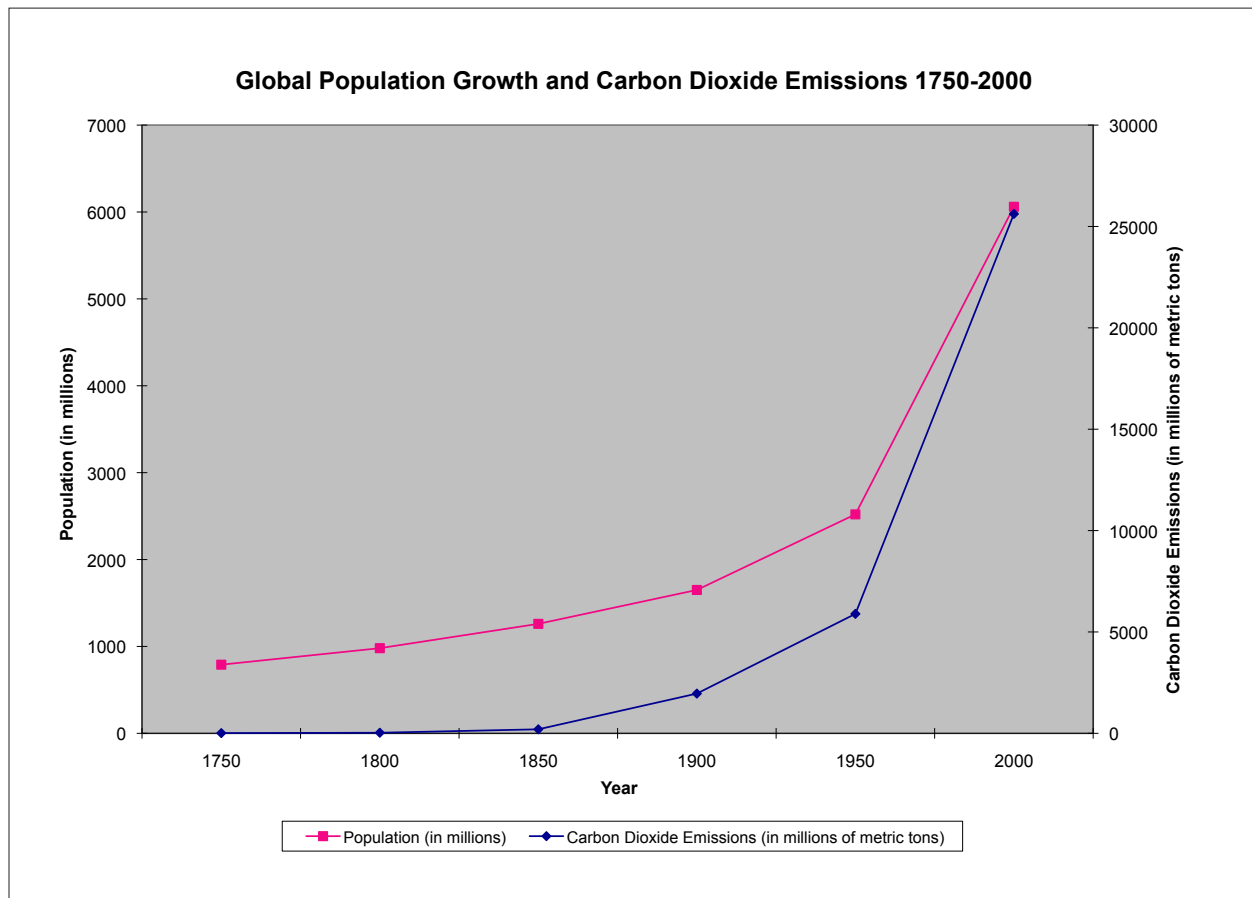
Not necessarily. People's consumption can grow without the population growing, or the population could grow while per capita energy use decreases and thus overall emissions decrease.

### Follow-up Activity:

Have student research any of the many proposals put forth by scientists or policymakers to reduce carbon emissions (cap and trade system; greater use of alternative energy; changes in individual lifestyles, etc.) and create a short report.

### Assessment Ideas:

The students' completed graphs, thoughtful commentary on them, and possible reports from the Follow-up Activity can serve as assessment tools.



# Generating Heat:

## Student Worksheet

Year	Population (in millions)	Carbon emissions (in millions of metric tons)
1750	790	11
1800	980	29
1850	1,260	198
1900	1,650	1,960
1950	2,520	5,982
2000	6,060	25,620

Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory; <http://cdiac.ornl.gov>.

"Total midyear Population for the World 1950-2050," U.S. Census Bureau, International Database, June 2011 <http://www.census.gov>.

### Part I: Graph the Trends

Using the table above, graph the population and carbon emissions for each year. Then answer the discussion questions below. You may use graphing paper or Microsoft Excel to create your graph.

If using Excel 2003, follow these steps:

1. Copy the table above into Excel exactly as it is written (including all 3 columns and 7 rows)
2. Highlight only the number data in the table by clicking on 1750 and dragging down the box to 25,620, so that all the number data is highlighted. Go to the tool bar above, click "Insert," and select "Chart" from the drop-down menu.
3. Select "Custom Types" and then click on the "Lines on Two Axes" graph. Click "Next."
4. Select "Series" and remove "Series 2."
5. Label Series 1 as "Population (in millions)" and Series 3 as "Carbon Dioxide Emissions (in million metric tons)."
6. Click on the inside of the "Category (X) axis labels" box. Now, click on the table and highlight the years 1980 through 2020. Click "Next."
7. Click on "Titles." Click on "Values (Y) axis" and write "Population (in millions)." Click on "Second Value" (Y axis) and write "Carbon Emissions (in millions of metric tons)."
8. Label the "Category (X) axis: "Year." Leave the "Second category (X) axis" blank. Give your graph a title. You can use "Global Population Growth and Carbon Emissions from Burning of Fossil Fuels" as your title or choose another title that is related to the trends you see.
9. Now, click "Next." You will see "Step 4 of 4: Chart Location." Click "As New Sheet: Chart1." Then click "Finish."

If using Excel 2007, use these steps:

1. Copy the table above into Excel exactly as it is written.

2. Highlight the number data in the second and third columns on the table by clicking on 790 and dragging down the box to 25,620.

3. Click on the "Insert" tab on the Toolbar. In the "Charts" menu on the Toolbar, select the type of chart as follows: (Note: You will eventually create a line graph with 2 y-axes, but you will start with 1 axis (population.)

The x-axis will display the year.)

a. Click on the "Titles" button.

Click on the "Values (Y) axis" and write "Population (in millions)." Click on the "Secondary Values (Y) axis" and write "Carbon Emissions (in millions of metric tons)."

4. Place the cursor on the line showing CO<sub>2</sub> and left click to highlight it. Then right click and choose "Format Data Series." Select "plot series on the secondary axis."

5. To set the data for the x-axis, click on the x-axis, then click "Select Data." Under "Horizontal (category) Axis

Labels” click the “Edit” button. This will bring up a window for you to enter the Axis-Label Range. Highlight the dates in Column A of your data table (1790, 1800 ...) and click “OK.”

6. To add the chart title, x- and y-axis titles, and a legend:
  - a. Excel 2007: To make all edits, bring up "Chart Tools" by simply clicking on the plot area of your chart.
  - b. Excel 2013: To edit the chart and axes titles, click anywhere on the chart and select "Chart Elements" (the green plus sign.) To edit the legend, right-click anywhere on the chart and select "Select Data." To edit a series name, select one of the series and click the edit button.

## **Part 2: Graph Analysis and Discussion**

1. What does the graph suggest about the relationship between population growth and carbon emissions?
  
  
  
  
  
  
  
  
  
  
2. What do you think accounts for the growth in CO<sub>2</sub> emissions from 1750-2000?
  
  
  
  
  
  
  
  
  
  
3. Today, most of the world’s population growth is occurring in the world’s poorest countries. Do you think carbon emissions will tend to increase with increasing population growth in these countries? Why or why not?
  
  
  
  
  
  
  
  
  
  
4. China and India are the world’s largest populations. Both countries are rapidly industrializing, creating greater affluence, but also more carbon emissions. The United States, with a smaller population size and slower growth rate, is still the largest carbon emitter in the world per capita. Is it fair to ask developing countries to curb carbon emissions? Should the United States and other developed countries cut their emissions more to allow developing countries greater fossil fuel use than they’ve had in the past? Is there a strategy that would create an equitable balance of carbon use?
  
  
  
  
  
  
  
  
  
  
5. What does this tell you about the relationship between population growth and carbon emissions? Does it have to be a positive relationship?