

# Generating Heat



## Introduction:

Carbon dioxide (CO<sub>2</sub>) is the primary greenhouse gas contributing to global climate change. A greenhouse gas is a gas that absorbs the sunlight being reflected back towards space as infrared radiation (heat), trapping the heat in the atmosphere. Climate change has been a natural feature of Earth's history for many millennia. However, since the Industrial Revolution, humans have been altering the Earth's climate at an accelerated rate with the increase of CO<sub>2</sub> emissions from burning fossil fuels. 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 in 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 observe a creative on-line simulation of population change and carbon emissions in real time. They will also graph and observe the correlation between human population growth and CO<sub>2</sub> emissions over time.

## Materials:

Graphing paper or access to Microsoft Excel  
Internet access  
Student Worksheets

## Part 1: Breathing Earth

### Procedure:

A thought-provoking website, [www.BreathingEarth.net](http://www.BreathingEarth.net), was developed by designer David Bleja to broaden awareness of the relationship between population growth and carbon emissions worldwide. Allow students time to view the website simulation for several minutes either as a class or working independently on school or home computers. The "?" button at the top left of the screen will orient viewers to what they are seeing. They can then answer the questions on Student Worksheet 1, **Breathing Earth**.

## Part 2: The Growth of Carbon Emitters

### Procedure:

In this activity, students will graph the growth in world population and carbon dioxide emissions over time. Have students work either

## 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:

- Analyze an on-line simulation of carbon emissions and population change.
- Graph historical data for global population growth and CO<sub>2</sub> emissions.
- Discuss the relationship between population growth and carbon dioxide emissions, as well as the future implications and responsibilities that come with growing affluence around the world.

## Subjects:

Civics, Environmental Science, Mathematics, Social Studies

## Skills:

Data analysis, graphing, critical thinking, research, writing

## Method:

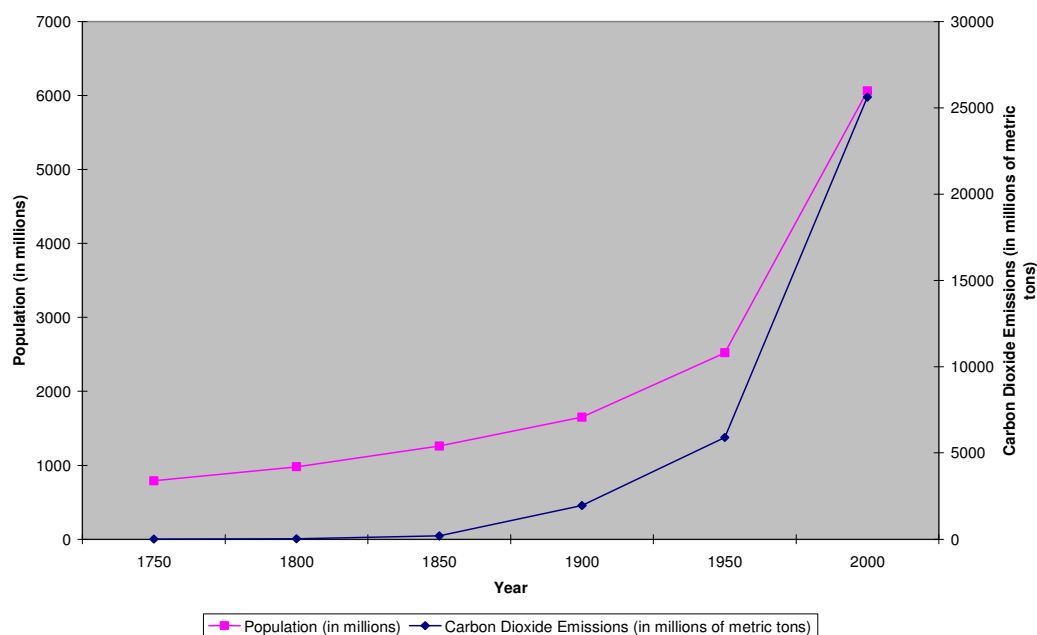
Students observe and comment on a computer simulation of current carbon emission and population growth trends. They then graph historical trends on population and CO<sub>2</sub> emissions and analyze the data.



individually or in small groups. Distribute Student Worksheet 2, **The Growth of Carbon Emitters**. 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 a chart in Excel 2003 and Excel 2007 are provided on the Student Worksheet. See the sample graph for an idea of what student charts should look like.

Go over the discussion questions as a class, after students have had time to evaluate their charts.

**Global Population Growth and Carbon Dioxide Emissions 1750-2000**



### Follow-Up Activity:

Have students 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.



Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Generating Heat

### Student Worksheet 1 - Breathing Earth

Visit the website, [www.BreathingEarth.net](http://www.BreathingEarth.net). Watch this real-time simulation for 3-5 minutes (longer if you like). The time elapsed is in the lower right corner of the screen. Clicking on the “?” button in the top left of the screen will orient you to what the symbols and colors represent. Answer the following questions.

1. What is the sound you hear supposed to represent?

\_\_\_\_\_

2. When a country turns red, it is emitting 1,000 tons of CO<sub>2</sub>. Which countries turn red during the time you’re watching? Which ones glow red most frequently?

\_\_\_\_\_

\_\_\_\_\_

3. Roll your cursor over the countries that turn red most frequently. What do you observe about the birth and death rates in those countries?

\_\_\_\_\_

\_\_\_\_\_

4. In which two countries do the “1 birth” symbols pop up most frequently? How about the “1 death” symbols? Why would that be?

\_\_\_\_\_

\_\_\_\_\_

5. CO<sub>2</sub> emissions have increased in most countries over the past four years (as indicated by a red “up” arrow when you scroll over the countries). Scroll over the world map to find examples of countries with green “down” arrows, which indicate a decrease in CO<sub>2</sub> emissions over the past four years. What do you think accounts for the drop in emissions? Are the reasons different depending on how developed and prosperous the country is? Explain.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. What point(s) do you think the website developer is trying to make with “Breathing Earth”?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Generating Heat

### Student Worksheet 2 - The Growth of Carbon Emitters

Year	Population (in millions)	Carbon Dioxide Emissions (in million 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

Sources: 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, 18 June 2008, International Data Base, 28 August 2008 <<http://www.census.gov/ipc/www/idb/worldpop.html>>

#### Part I: Graph the Trends

Using the table above, graph the population and carbon emissions for each year. 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 three columns and seven 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 on "Insert," and select "Chart" from the drop-down menu.
3. Select "Custom Types" and from the list of Chart types, choose "Lines on 2 Axes." Click "Next."
4. Select "Series" and remove "Series 2."
5. Name Series 1 as "Population (in millions)" and Series 3 as "Carbon Dioxide Emissions (in million metric tons)."
6. Click inside of the "Category (X) axis labels" box. Now, click on the table and highlight the years 1750 through 2000. Click "Next."
7. Click on "Titles." In the box for "Value (Y) axis" write "Population (in millions)." In the box for "Second Value (Y) axis" write "Carbon dioxide 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 Dioxide Emissions 1750-2000" 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 on "As New Sheet: Chart 1." 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: “Line,” “2-D Line,” then “Line with Markers” (the fourth chart). (Note: You will eventually create a line graph with two y-axes, but you will start with one axis (Population). The x-axis will display the year.)
4. Place the cursor on the line showing CO<sub>2</sub> emissions 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 (1750, 1800, . . .) and click “OK.”
6. Go to the Chart Tools Layout menu to add the chart title, x and y-axis titles and a legend. To bring up “Chart Tools,” simply click on the plot area of your chart.

## **Part II: 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 dioxide 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. 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 direct relationship (an increase in one meaning an increase in the other?)

---

---



## Generating Heat

### Student Worksheet Answers: Breathing Earth

1. What is the sound you hear supposed to represent? *It is supposed to be the sound of the Earth breathing.*
2. When a country turns red, it is emitting 1,000 tons of CO<sub>2</sub>. Which countries turn red during the time you're watching? Which ones glow red most frequently? *Answers may vary, but will likely include the U.S., China, India, Germany, Canada, France, Indonesia, Russia, Saudi Arabia and the U.K. The U.S. and China are the ones that turn red most frequently.*
3. What do you observe about the birth and death rates in those countries? *In most of the countries, the birth rates are higher than the death rates (births happening more frequently than deaths).*
4. In which two countries do the "1 birth" symbols appear to pop up most frequently? *China and India.* How about the "1 death" symbols? *Also China and India.* Why would that be? *China and India have the largest populations (over one billion each) so there are more frequent births and deaths due to the sheer size of the populations.*
5. What do you think accounts for the drop in emissions in some countries? Are the reasons different depending on how developed and prosperous the country is? *In the wealthier countries such as Norway and Sweden, the drop in CO<sub>2</sub> emissions can be attributed to a stable population and greater energy efficiency and green technologies. In poorer countries in Sub-Saharan Africa, Latin America and Southeast Asia, this drop is likely caused by a stagnation of development, where there is a lack of industry and insufficient household energy use to raise the standard of living.*
6. What point(s) do you think the website developer is trying to make with "Breathing Earth"? *Answers will vary but students should understand that the site is designed to show correlations between population growth, population size and carbon emissions.*

### Student Worksheet Answers: The Growth of Carbon Emitters

1. What does the graph suggest about the relationship between population growth and CO<sub>2</sub> emissions? *As the 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 has 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 of CO<sub>2</sub> in the atmosphere.*
3. Today, most of the world's population growth is occurring in the world's poorest countries. Do you think CO<sub>2</sub> emissions will tend to increase as the populations of these countries grow? Why or why not? *It is likely to increase. 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 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? *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.*
5. What does this tell you about the relationship between population growth and carbon emissions? Does it have to be a direct 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.*