6.2 Energy Use and the Atmosphere

Purpose

Explore one of the global environmental issues associated with increased combustion of fossil fuels.

Introduction

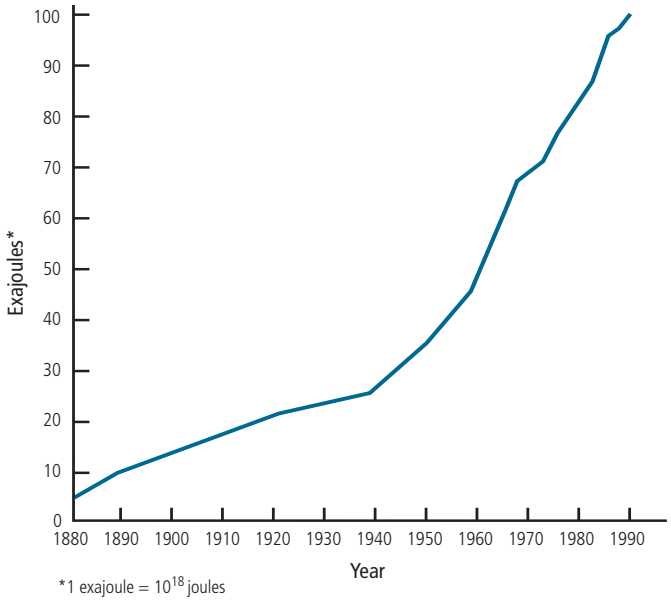
Carbon dioxide (CO_2) is a colorless, odorless gas. It is a natural part of Earth's atmosphere and is important to all life on our planet. All plants and animals release CO_2 to the atmosphere during respiration. Green plants and other producers remove some of this CO_2 for use during photosynthesis. Large amounts of atmospheric CO_2 become dissolved in Earth's bodies of water, especially the oceans. Nature has evolved to create a balanced situation in which annual CO_2 inputs to the atmosphere and CO_2 outputs from the atmosphere are roughly equal.

In recent years, standards of living and levels of technology use have risen considerably throughout the world, particularly in the United States. As a result, energy use has also risen considerably, as shown in the graph in Figure 2. Much of the energy used in the United States comes from the burning of **fossil fuels**, which include coal, natural gas, and petroleum. Burning these fuels produces not only heat and light, but also considerable amounts of CO_2.

What are the possible global consequences of this increase in CO_2 production? Have increases in CO_2 production affected the natural balance of CO_2 in the atmosphere?

The "smoke" from this factory's chimneys consists primarily of water vapor and carbon dioxide, two products of the combustion of fossil fuels.

Figure 2 Energy Use in the United States



*1 exajoule = 10^{18} joules

Materials

For each student

1 sheet of graph paper

Procedure

1. Based on the data provided in Table 2, make a line graph that shows the amount of CO_2 released into the atmosphere as a result of fuel combustion from 1860 to 1990.
2. Based on the data provided in Table 2, make a **scatterplot** that shows Earth's average surface temperature from 1860 to 1990.
3. Draw a line of best fit that allows you to predict future average surface temperatures. Record your predicted temperature for the year 2050.

Table 2 Global Carbon Dioxide Emissions and Surface Temperatures

Year	CO_2 Emissions from Fuel Combustion (in billions of tons)	Average Surface Temperature (in °C)	Year	CO_2 Emissions from Fuel Combustion (in billions of tons)	Average Surface Temperature (in °C)
1860	1	13.5	1930	4.5	13.8
1870	1	13.7	1940	5	14.0
1880	1.5	13.7	1950	6	13.8
1890	2	13.6	1960	10	14.0
1900	2.5	13.9	1970	13	14.0
1910	3	13.5	1980	18	14.1
1920	3.5	13.8	1990	22	14.4

Analysis

Group Analysis

1. Briefly describe what you think could be a possible global consequence of an increase in Earth's average surface temperature.
2. Some people claim that having access to many goods and services can lead to a decrease in health and well-being. Could the information presented in this activity be used to support or refute this claim? Explain your reasoning.

Individual Analysis

3. Compare your two graphs. Explain whether or not they provide any evidence to support the claim that increased levels of CO_2 in the atmosphere lead to increased surface temperatures.
4. What additional information would you like to have before you would be confident in saying that increased levels of CO_2 in the atmosphere definitely do or do not lead to increased surface temperatures? Explain why this information is important.
5. Do you think society should take steps to reduce the emission of CO_2 into the atmosphere? Explain your reasoning.

Carbon Dioxide in the Atmosphere

A Comparison of the Composition of Inhaled and Exhaled Air

Components of Earth's Atmosphere	Composition of Air Breathed In (%)	Composition of Air Breathed Out (%)
Nitrogen	78	75
Oxygen	21	16
Argon	0.9	0.9
Carbon dioxide	0.035	4.0
Water vapor	0.4	4.0

Comparing Atmospheric Inputs and Outputs of CO_2

Current Annual Release of CO_2 to the Atmosphere

Process	Amount (billions of tonnes)
Respiration	54–55
Decomposition	55
Biological/chemical oceanic processes	90
Wood and fossil fuel combustion	6
Total	206

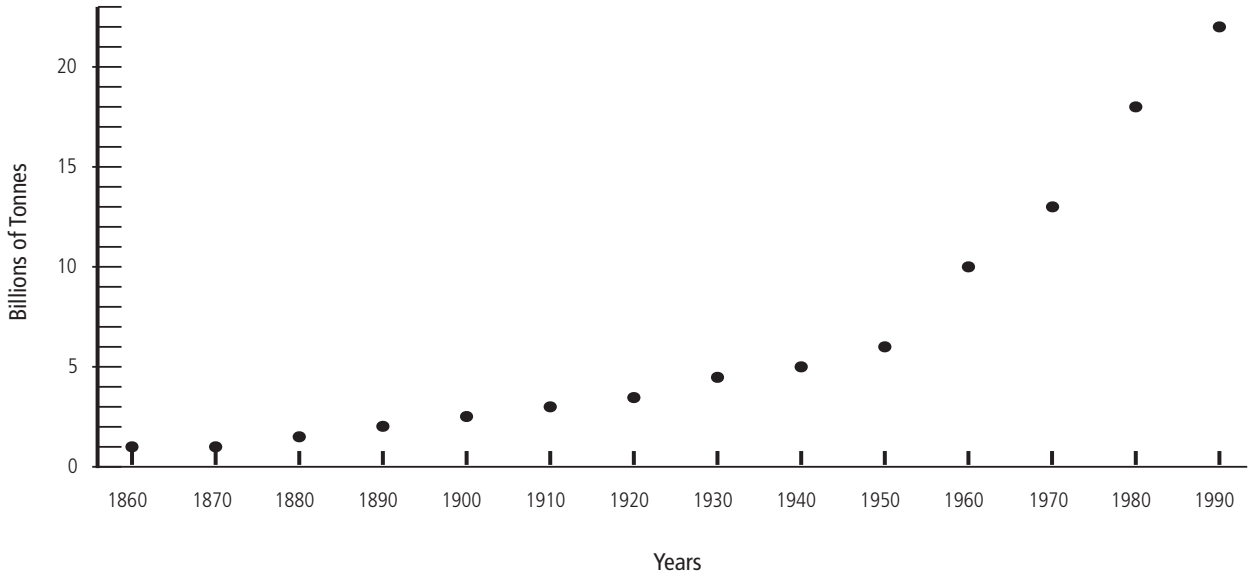
Current Annual Absorption of CO_2 From the Atmosphere

Process	Amount (billions of tonnes)
Biological/chemical oceanic processes	93
Photosynthesis	110
Total	203

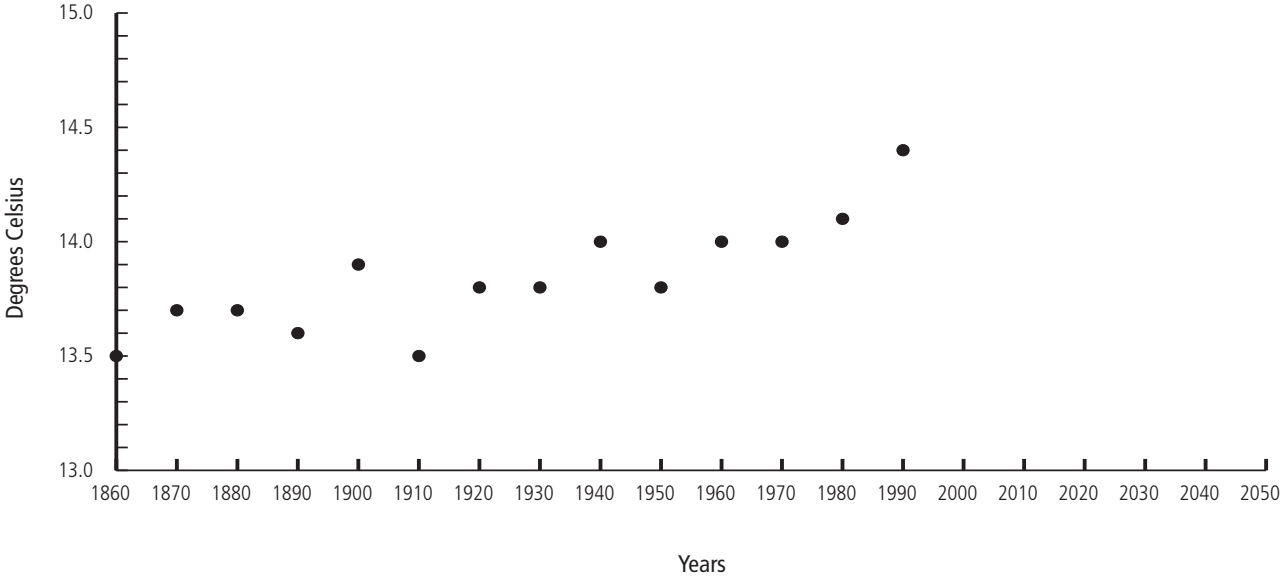
Net gain of CO_2 to the atmosphere: 3 billion tonnes per year

Comparing Trends of Surface Temperature and Carbon Dioxide Emissions

Worldwide CO_2 Emissions From Fuel Combustion

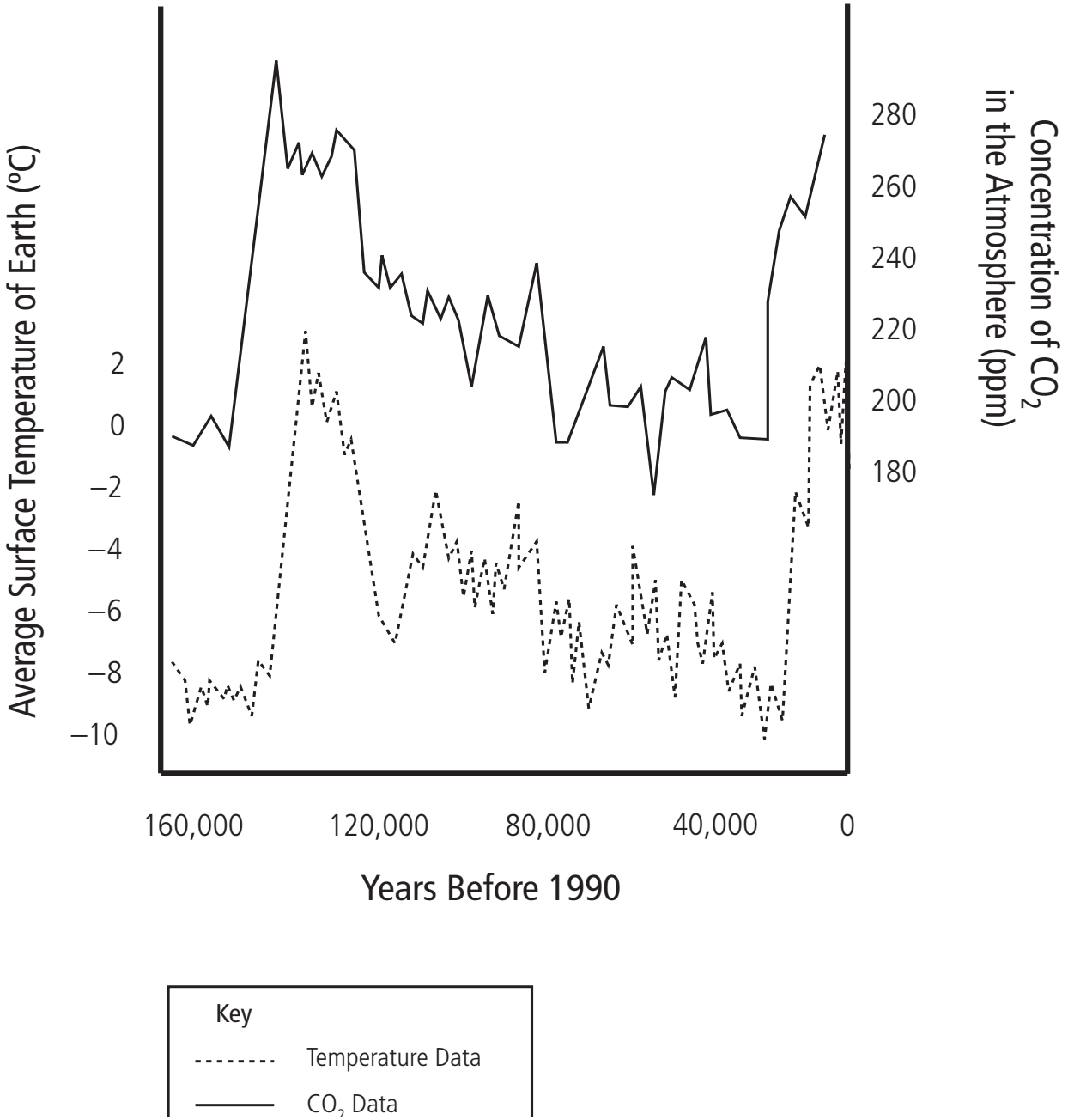


Average Surface Temperature of Earth



Data source: Committee on Environment and Natural Resources, National Science and Technology Council

Surface Temperature and Carbon Dioxide Levels During the Past 160,000 Years



Data source: Intergovernmental Panel on Climate Change

INQUIRY SCORING GUIDES FOR HIGH SCHOOL

1. Designing Investigations (DI)

2. Analyzing Data (AD)

from SEPUP (Science Education for Public Understanding Program)

Scoring Guide: Designing Investigations (DI)

What to Look For

Response states a design and specifies data to be collected for the investigation. Procedures are described completely and accurately.

Level 4 *Above and beyond*	Student accomplishes Level 3 and goes beyond in some significant way such as: • identifying alternate procedures. • suggesting improved materials. • relating clearly to scientific principles and approaches.
Level 3 *Complete and correct*	Student's design is appropriate and has a reproducible procedure, if required.
Level 2 *Almost there*	Student's design or procedure is incomplete AND/OR has significant errors.
Level 1 *On your way*	Student's design or procedure is incorrect or demonstrates a lack of understanding of the goals of the investigation.
Level 0	Student's design or procedure is missing, illegible, or irrelevant.
X	Student had no opportunity to respond.

Scoring Guide: Analyzing Data (AD)

What to Look For

Response accurately summarizes data, detects patterns and trends, and draws valid conclusions based on the data used.

Level 4 *Above and beyond*	Student accomplishes Level 3 AND goes beyond in a significant way, such as • explaining unexpected results. • judging the value of investigation. • suggesting additional relevant investigation.
Level 3 *Complete and correct*	• Student analyzes and interprets data correctly and completely • Student's conclusion is compatible with the analysis of the data.
Level 2 *Almost there*	Student notes patterns or trends BUT does so incompletely.
Level 1 *On your way*	Student attempts an interpretation, BUT • ideas are illogical OR • ideas show a lack of understanding.
Level 0	Student's analysis or interpretation of data is missing or illegible.
X	Student had no opportunity to respond.

Activity:_____ Variable:_____

Date:_____

Student ID	MODERATORS						Moderated Score
	A	B	C	D	E	F	

Exemplars of Student Work

AD (Analyzing Data)

***Science and Sustainability* Activity 6.2, Question 3**

The question

Compare your two graphs. Explain whether or not they provide any evidence to support the claim that increased levels of CO_2 in the atmosphere lead to increased surface temperatures.

What to look for

Response accurately summarizes data, detects patterns and trends, and draws valid conclusions based on the data used.

Student Work

Student A

The graph of the average surface temperature increased, but it did not increase a whole lot. The temperature only increased almost one whole degree in 130 years. The graph of the CO_2 emissions also increased and it increased more than the temperature. The CO_2 emissions increased by 21 billion tons. Even though both graphs increased, I do not think that the amount of CO_2 in the atmosphere causes the surface temperature to rise. I think this because in some years, when the CO_2 emissions were higher than they were the year before, the surface temperature decreased from the year before. Therefore I don't think that my graph has the evidence to support the claim that increased levels of CO_2 in the atmosphere lead to increased temperatures.

Student B

Both graphs go up slow until about 1950. Then they both go up faster. The CO_2 must be causing the temperature to go up. I've heard of global warming. It's a big problem.

Student C

The CO_2 increased a lot and the temperature increased a little bit so, my graphs provide a lot of evidence to support that increased levels of the carbon dioxide caused temperature increases every decade and it also shows if it decreases or not. It shows how much the increase is and what is going to happen in the future with our atmosphere.

Student D

The reason that they go up because of the CO_2 is giving the plants and all oxygen. Plants make oxygen and since we're cutting down rainforests, ther is less oxygen, which makes more room for CO_2.

Student E

The Earth's average surface temperature increased about 1 degree from 1860 to 1990. The CO_2 emissions increased a lot more than the temperature. Sometimes the temperature went down, even when the emissions went up (for example in 1950). I think this could be because the surface temperature depends on the weather. The weather changes for lots of reasons from one year to the next. I think the graphs show that increased levels of CO_2 in the atmosphere may lead to increased temperatures on average. But that isn't the whole picture. Other things can affect the temperature of the Earth.

Student F

There is a sufficient amount of evidence that increased levels of carbon dioxide in the atmosphere lead to increased temperatures. From 1860 to 1910 however, the relationship is inconclusive because the temperature in 1860 is the same as it is in 1910, while the carbon dioxide emissions were steadily increasing. The obvious similarities started in 1920, possibly because there were 60,000 automobiles in the U.S. in 1911, a large increase from just 10 years earlier. From 1920 on, the temperature continued to rise as the carbon dioxide emissions rose as well. The most obvious similarities were in 1990, when the amount of carbon dioxide emissions jumped from 18 billion tons in 1980 to 22 billion tons in 1990, we also see the largest rise in temperature. Although there were a few years when CO_2 emissions and temperature did not follow the same trend, it appears that there is a relationship between them. I believe that the effect of the increased use of automobiles should be investigated further as a possible cause for both the increase in CO_2 emissions and the increase in temperature.

Student G

I think that it had to increase when every time the temperature increased or dropped, the CO_2 combustion went up a little bit, but the temperature had to increase in order for the combustion to go up. Where if the temperature remained the same, the combustion remained the same.

