U.S. and Indiana Fossil Fuel Use and Carbon Dioxide Emissions

Key Concepts:

- ✓ Carbon Dioxide
- ✓ Greenhouse Effect
- ✓ Carbon Cycle
- ✓ Fossil Fuel
- ✓ Social and Electric Sector
- ✓ Global Warming

WHAT YOU WILL LEARN

1. You will learn which fossil fuel releases the most carbon dioxide when burned.
2. You will learn about the global carbon cycle and greenhouse effect.
3. You will analyze U.S. and Indiana carbon dioxide emission data for different energy sources and social and electric sectors.
4. You will think about how to reduce carbon dioxide emissions and how that might impact fossil fuel use and global warming.

Engage Your Thinking

Fossil fuels (natural gas, coal, and petroleum) are energy sources used by people and the various social and electric sectors in society. For example: electrical companies use fossil fuels to generate electricity, industry and manufacturing use them to produce the goods and products we buy, the transportation sector uses them as fuel to transport people, goods, and materials from one location to another, and the commercial and residential sectors use them to heat stores, office buildings, homes, and schools. Although the burning of fossil fuels supports much of our society, the burning of fossil fuels also releases greenhouse gases into the atmosphere, specifically carbon dioxide. In this activity you will learn about the different social and electric sectors and how they contribute to atmospheric carbon dioxide levels. You will also analyze carbon emission data specific to Indiana. Before you start, however, answer the questions below based on what you already know.

1. Which fossil fuel do you think releases the most carbon dioxide into the atmosphere when it is burned?

2. Which social sector do you think uses the most fossil fuels, and which emits the most carbon dioxide into the atmosphere?

3. What is the global carbon cycle?

4. What is the greenhouse effect and how does carbon dioxide emissions impact the greenhouse effect?

Explore and Explain

Fossil fuels (coal, natural gas, and petroleum) are used by the various social and electric sectors as energy sources. Although the burning of fossil fuels supports much of our society, the burning of fossil fuels also releases greenhouse gases into the atmosphere, specifically carbon dioxide (CO_2). The amount of carbon dioxide released into the atmosphere depends on the amount of carbon stored in the fossil fuel. The amount of carbon varies according to the type of fossil fuel. Therefore, the burning of different fossil fuels releases different amounts of carbon dioxide into the atmosphere. Table 1 shows the amount of carbon dioxide emitted per equivalent amount of energy released by each fossil fuel type.

Table 1. Pounds of carbon dioxide (CO_2) emitted per million Btu of energy for various fossil fuels

Fossil Fuel Type	Pounds CO_2
Coal (Average of all types)	216.0
Diesel fuel and heating oil	161.3
Gasoline (without ethanol)	157.2
Natural gas	117.0

Think about it: Based on the data in Table 1, which fossil fuel releases the most carbon dioxide when burned? Which fossil fuel releases the least amount of carbon dioxide?

Carbon moves from fossil fuels to the atmosphere as carbon dioxide. This occurs when we burn the fossil fuel. Some of this atmospheric carbon dioxide is absorbed by the oceans and plants, but most remains in the atmosphere for up to 100 years. In essence, when we burn fossil fuels we add "extra" carbon dioxide to the atmosphere. We are releasing the carbon stored in the fossil fuel into the atmosphere. This movement of carbon is known as the global carbon cycle (See Figure 1).

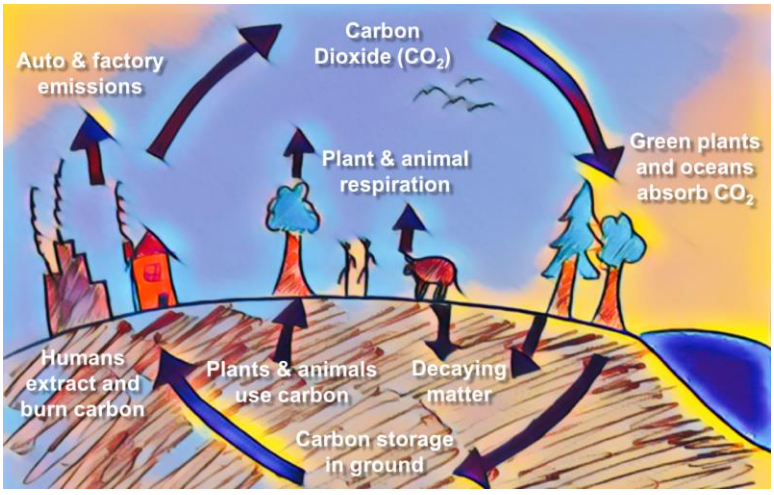


Figure 1. Global Carbon Cycle. The image shows how carbon moves through the Earth's systems.

Carbon dioxide is one of several greenhouse gasses found in the atmosphere. Greenhouse gases absorb infrared radiation (heat) emitted by the Earth's surface. This absorbed heat is then radiated in all directions, some back toward the Earth and some to space. This absorption and radiation of heat warms the atmosphere and the Earth. The greenhouse effect is a naturally occurring phenomena (Figure 2, Natural Greenhouse Effect). Without the greenhouse effect our planet would be much colder.

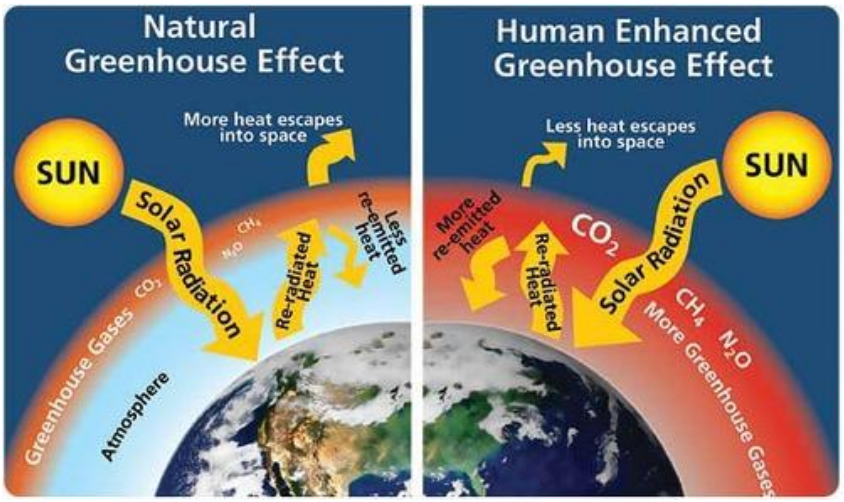


Figure 2. The Natural and Human Enhanced Greenhouse Effect. Source: EPA.

Since the Industrial Revolution, humans have been burning fossil fuels as a source of energy, emitting more and more carbon dioxide into the atmosphere. The greater the concentration of atmospheric carbon dioxide, the warmer the atmosphere and Earth become. Because humans have added this "extra" carbon dioxide to the atmosphere, the greenhouse effect is often called the Human Enhanced Greenhouse Effect or global warming (Figure 2, Human Enhanced Greenhouse Effect). The emission of this "extra" carbon dioxide has slowly increased atmospheric carbon dioxide levels, causing global temperature to rise over 1^{o}F.

Think about it: Draw a picture or diagram that shows the relationship between carbon dioxide, the carbon cycle, and the greenhouse effect. Be sure to label and explain your drawing/diagram.

Table 2. Mean Carbon Dioxide (CO_2) Levels at Mauna Loa Observatory, Hawaii

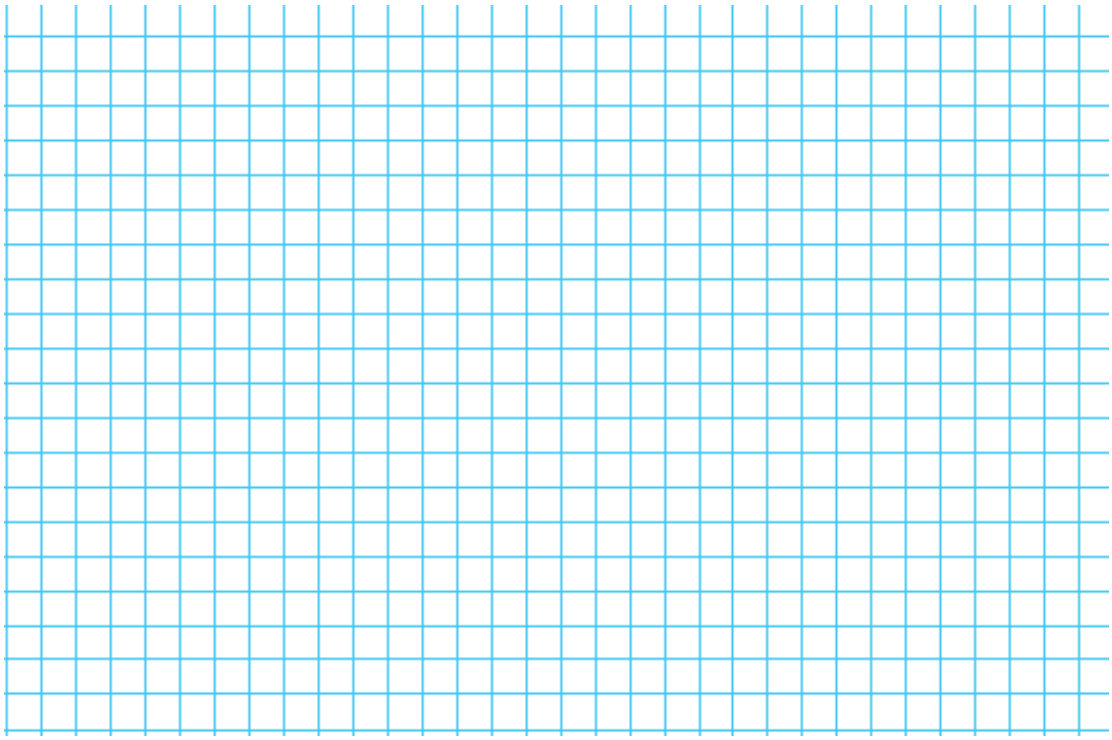
Year	CO_2 PPM	Year	CO_2 PPM	Year	CO_2 PPM
1960	316.91	1985	346.12	2010	389.90
1965	320.04	1990	354.39	2015	400.83
1970	325.68	1995	360.82	2020	414.50
1975	331.11	2000	369.55		
1980	338.75	2005	379.80		

Source: *Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/).* Note: If you are interested in the yearly data, you may access that at NOAA's website: www.esrl.noaa.gov/gmd/ccgg/trends/data.html.

Now let's look more closely at the atmospheric carbon dioxide levels as measured at Mauna Loa Observatory, Hawaii. The data in Table 2 shows the mean carbon dioxide levels at five-year intervals from 1960 to 2020.

Think about it: Making sense of the data in Table 2. Scientists make sense of data by first analyzing and interpreting the data, looking for patterns and trends. Next, scientists construct explanations using scientific concepts and principles that explain the patterns and trends observed in the data.

a) Scientists often create graphs to visualize data, making it easier to see trends and patterns. In the space below graph the data shown in Table 2 and describe the trends you see in the data.

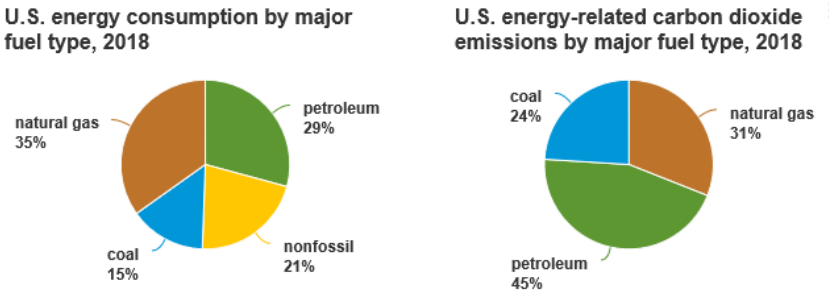


b) Now that you have graphed the data, what patterns and trends do you see in the data? How would you interpret the data?

c) Now that you have graphed and interpreted the data, how would you explain these trends?

Extend Your Thinking

Now that you understand where carbon dioxide comes from, the global carbon cycle, and the greenhouse effect, let's look at how specific social sectors use fossil fuels and see how that relates to carbon dioxide emissions. That is, how the different fossil fuels and social sectors might contribute to global warming.



Figures 3. U.S. Energy Consumption. Source: EIA

Think about it: Look at the data on U.S. energy consumption and carbon emissions (Figures 3 and 4). Answer the following questions:

a) First, let's look at which fossil fuel contributes the most to the U.S. energy consumption and which contributes the most to carbon dioxide emissions (Figure 3)? Rank order the fossil fuels based on their consumption and carbon dioxide emissions.

Rank Order, Fossil Fuel Consumption	Rank Order, Carbon Dioxide Emissions
1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

b) Now let's look at the **energy consumption** by social and electric sector data (Figure 4). Rank order the sectors by energy consumption. To determine how much energy the electric sector uses total the brown shaded bars.

1.
2.
3.
4.
5.

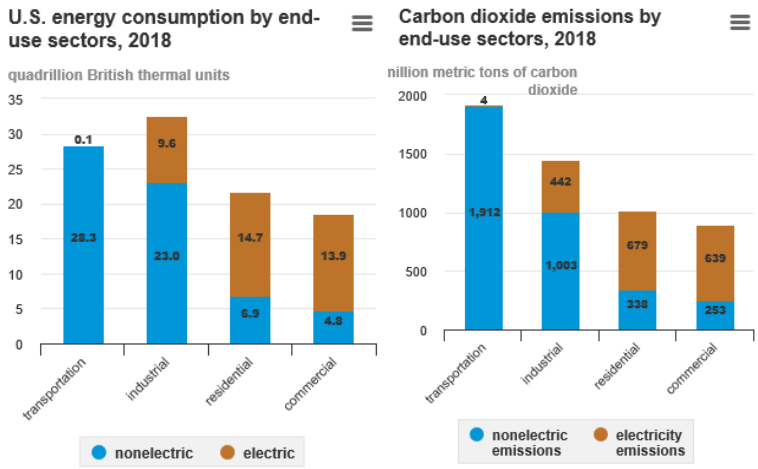


Figure 4. Energy consumption and carbon emissions by social and electric sectors. Source: EIA

c) Look at the **carbon dioxide emissions** by social and electric sector data (Figure 4), rank order the sectors by carbon dioxide emissions. To determine how much carbon dioxide the electric sector emits, total the brown shaded bars.

1.
2.
3.
4.
5.

d) Based on your answers to the above questions, what conclusions can you make about the relationship among energy use (fossil fuels), carbon dioxide emissions, and social and electric sectors.

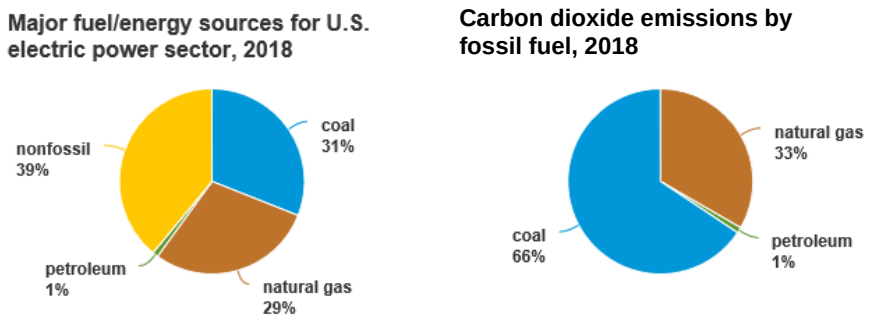


Figure 5. Energy Use and Carbon Dioxide Emissions for the Electricity Sector. Source: EIA.

Now let's look closer at electrical generation and the energy used to generate electricity and how that relates to carbon dioxide emissions. As you see in Figure 5, nonfossil fuel energy sources are used to generate about 39% of our electricity. Nonfossil fuels include wind, hydropower, and nuclear energy. These sources do not emit carbon dioxide during electrical generation. Thus, only coal, natural gas, and petroleum emit carbon dioxide when burned to generate electricity.

Think about it: If society wanted to reduce carbon dioxide emissions from the generation of electricity, which fossil fuel should be reduced and why?

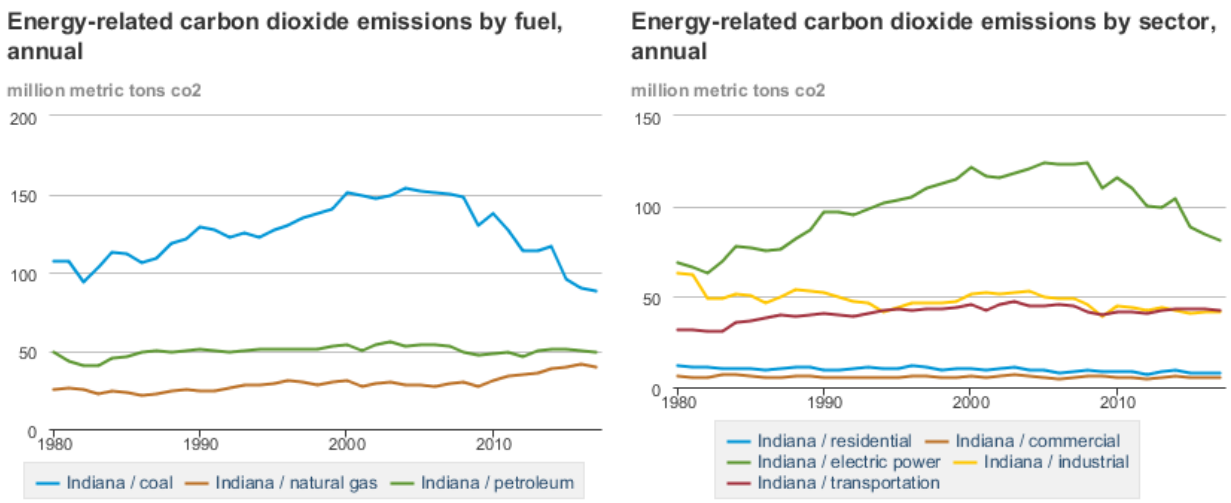


Figure 6. Carbon Dioxide Emission Data for Indiana. Source: EIA.

Now let's look at Indiana. In Indiana, we also use fossil fuels to generate electricity, heat our homes and businesses, manufacture goods, and transport products and people, as well as driver our cars. Figures 6 shows the carbon dioxide emissions for Indiana by fossil fuel and social and electric sector.

Think about it: Look at the carbon dioxide emission data for Indiana (Figure 6). Answer the following questions based on this data:

a) Which fossil fuel emits the most carbon dioxide in Indiana? Second most? Third most? How would you explain this data? (Hint: Think about the amount of carbon in each fuel type)

1.
2.
3.

b) Rank order the social and electric sectors by carbon dioxide emissions. How would you explain this data?

1.
2.
3.
4.
5.

Apply What You Have Learned

The burning of fossil fuels releases carbon dioxide into the atmosphere at a faster rate than the environment, the land, oceans and plants, can absorb it, consequently, the concentration of atmospheric carbon dioxide is increasing. This increase is contributing to global warming and climate change. Based on the energy use and carbon emission data you have analyzed, make a scientific and data-based policy recommendation that aims to reduce carbon emissions. Consider the pros and cons of your policy decision, and consider how energy prices, weather, and current government policy might impact energy use and carbon emissions. What policies should Congress enact in order to reduce carbon dioxide emissions? How might different stakeholders respond to your policy? Describe and explain your policy recommendation below:

Think about it: Explain how your policy for reducing carbon dioxide emissions might impact:

a) The use of fossil fuels.

b) The different social sectors that use fossil fuels.

c) The production and supply of fossil fuels.

Reflect on What You Have Learned

Now that you have completed this module on fossil fuel use and the impact of carbon dioxide emissions, reflect on how your initial ideas have changed and on what you have learned.

5) How have your ideas about the relationship between fossil fuels and carbon dioxide emissions changed?

6) How has your definition of the global carbon cycle changed?

7) How has your thinking about the relationship between the social sectors' use of fossil fuels and carbon dioxide emissions changed?

8) Please explain how your ideas and thinking about the greenhouse effect have changed.