MAPPING GREENHOUSE GAS EMISSIONS WHERE YOU LIVE

DESCRIPTION

In this lesson plan, students learn about some of the of greenhouse gas emissions sources in their community using the Environmental Protection Agency's (EPA) Facility Level Information on GreenHouse gases Tool (FLIGHT). The FLIGHT Tool is a publicly accessible repository of data submitted to EPA by power plants, factories, refineries, and other U.S. facilities that emit large amounts of greenhouse gases.

TIME:

45–60 minutes

LEARNING OBJECTIVES:

Students will:

- Learn about greenhouse gases and where they come from
- Learn about the largest source of greenhouse gas emissions in the United States
- Learn how to use environmental data presented in an online data publication tool
- Analyze greenhouse gas emissions in their community
- Learn about opportunities to reduce greenhouse gas emissions

NATIONAL SCIENCE STANDARDS:

- Content Standard A: Science as inquiry
- Content Standard D: Earth and space science
- Content Standard E: Science and technology

BACKGROUND

Since the start of the Industrial Revolution around 1750, people have been adding substantial amounts of carbon dioxide (CO_2) and other greenhouse gases (such as methane, nitrous oxide, and fluorinated gases) to the atmosphere. Greenhouse gases trap heat in the atmosphere, which makes the Earth warmer. (See the lesson "Getting at the Core: The Link Between Temperature and Carbon Dioxide").

Different types of greenhouse gases have different impacts on the climate, depending on such factors as how much of the gas is produced, how long it stays in the atmosphere, and how much heat it traps. "Carbon dioxide equivalent" (or CO_2e) is a unit of measurement that allows the effects of different greenhouse gases to be compared using CO_2 as a standard unit for reference.

The primary sources of greenhouse gas emissions in the United States are:

- **Electricity production**: Electricity production generates the largest share of greenhouse gas emissions in the United States. More than 70 percent of our electricity comes from burning fossil fuels, mostly coal and natural gas.
- **Transportation**: Greenhouse gas emissions from transportation primarily come from burning fossil fuels for cars, trucks, ships, trains, and airplanes.
- **Industry**: Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.
- **Commercial and residential**: Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.
- **Agriculture**: Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.

- **Land use and forestry**: Plants and soil can act as an overall "sink" (absorbing CO_2 from the atmosphere) or as a source of greenhouse gas emissions. In some countries, large amounts of forest are being burned or cut down, which ends up adding CO_2 emissions to the atmosphere. In the United States, however, forests are growing overall. As forests grow, they help to remove CO_2 from the atmosphere.

See the "U.S. Greenhouse Gas Emissions by Sector and by Gas" pie charts at the end of this lesson for comparisons of the different gases and sources.

In the United States, the U.S. Environmental Protection Agency (EPA) collects data about greenhouse gas emissions by source, industry type, and type of gas. EPA collects and publishes information about greenhouse gas emissions in the United States in two ways:

- **By collecting data reported by large facilities that directly emit greenhouse gases into the atmosphere.** EPA's Greenhouse Gas Reporting Program collects greenhouse gas data from facilities that *directly* emit more than 25,000 metric tons of CO_2e per year. Direct emitters are facilities like power plants that burn coal or natural gas and emit greenhouse gases directly into the atmosphere. The Greenhouse Gas Reporting Program does not require indirect emitters to report, such as homes that consume electricity. The Greenhouse Gas Reporting Program also does not cover direct emissions from cars, trucks, airplanes, and other kinds of motor vehicles, which are responsible for a large portion of U.S. greenhouse gas emissions. EPA makes the data it collects available to the public through the "Facility Level Information on GreenHouse gases Tool (FLIGHT)." This online tool allows users to view and sort the data by type of greenhouse gas, facility location, industry type, and emissions amount. You can learn more information about EPA's Greenhouse Gas Reporting Program at http://www.epa.gov/ghgreporting/ghgdata/index.html.
- **By developing an annual inventory of total U.S. emissions.** Each year, EPA develops a report called the *Inventory of U.S. Greenhouse Gas Emissions and Sinks,* which contains estimates of national-level emissions by source, economic sector, and greenhouse gas. EPA collaborates with hundreds of scientists and uses national energy data, data on national agricultural activities, and other national statistics to track national trends in emissions. You can learn more about the inventory at EPA's climate change website: http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.

Collecting information about U.S. greenhouse gas emissions helps people better understand where greenhouse gas emissions are coming from. This information can also help people make informed policy and business decisions about ways to reduce greenhouse gas emissions. Reducing emissions can help reduce the impacts of climate change.

MATERIALS

- Internet access
- A copy of the "Top Five List" worksheet for each pair of students
- A copy of the "U.S. Greenhouse Gas Emissions by Sector and by Gas" pie charts for each student

VOCABULARY

Carbon dioxide (CO_2): Carbon dioxide is the greenhouse gas people talk about the most. That's because people produce more carbon dioxide than any other greenhouse gas, and it's responsible for most of the warming. Whenever we burn fossil fuels such as coal, oil, and natural gas—whether it's to drive our cars, use electricity, or make products—we are producing carbon dioxide. This extra carbon dioxide is the main cause of climate change.

Carbon dioxide equivalent (CO_2e): A unit of measurement that can be used to compare the emissions of various greenhouse gases based on how long they stay in the atmosphere and how much heat they can trap. For example, over a period of 100 years, 1 pound of methane will trap as much heat as 25 pounds of carbon dioxide. Thus, 1 pound of methane is equal to 25 pounds of carbon dioxide equivalents.

Emission: The release of a gas (such as carbon dioxide) or other substance into the air.

Fluorinated gas: A group of powerful greenhouse gases that can stay in the atmosphere for hundreds to thousands of years. Fluorinated gases are artificially produced; they do not occur naturally. They are used in refrigeration and air-conditioning systems, fire extinguishers, foam products, and other products.

Greenhouse gas: Also sometimes known as "heat-trapping gases," greenhouse gases are natural or human-produced gases that trap heat in the atmosphere and contribute to the greenhouse effect. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and fluorinated gases.

Greenhouse Gas Data Publication Tool (Pub Tool): A publicly accessible repository of emissions data submitted by large facilities that emit or supply greenhouse gases or fossil fuels. The Pub Tool consists of total facility emissions by major greenhouse gases, total facility emissions by source category, name of each reporting facility, and address or geographic coordinates of each reporting facility.

Methane: A colorless, odorless greenhouse gas. It occurs both naturally and as a result of people's activities. Methane is produced by the decay of plants, animals, and waste, as well as other processes. It is also the main ingredient in natural gas.

Nitrous oxide: A colorless, odorless greenhouse gas. It occurs both naturally and as a result of people's activities. Major sources include farming practices (such as using fertilizers) that add extra nitrogen to the soil, burning fossil fuels, and certain industrial processes.

Parts per million (ppm): a concentration of 1 ppm for a given gas means there is one part of that gas in 1 million parts of a given amount of air.

INSTRUCTIONS

Homework in Advance

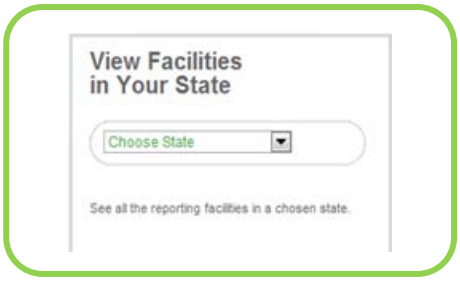
1. Ask students to visit EPA's *A Student's Guide to Global Climate Change* website (http://www.epa.gov/climatechange/students) and read the following sections:
   - "Learn the Basics: Today's Climate Change: Greenhouse Gases" (http://www.epa.gov/climatechange/students/basics/today/greenhouse-gases.html)
   - "Learn the Basics: Today's Climate Change: All About Carbon Dioxide" (http://www.epa.gov/climatechange/students/basics/today/carbon-dioxide.html)

In-Class Activity

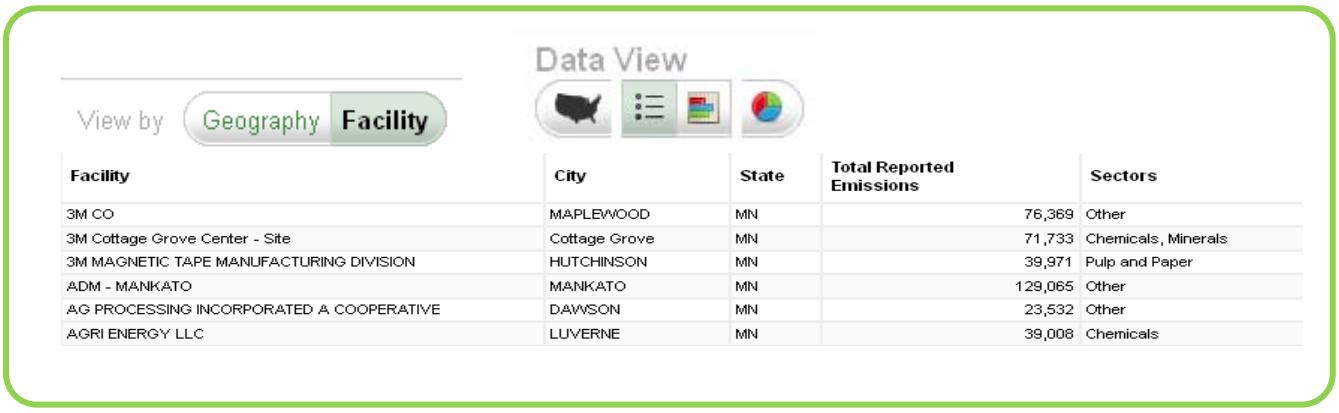
1. Discuss the major greenhouse gases with students (see http://www.epa.gov/climatechange/students/basics/today/greenhouse-gases.html). Using information in the "Background" section above and using the "U.S. Greenhouse Gas Emissions by Sector and by Gas" pie charts, list the major greenhouse gases and discuss where each of them comes from and which ones are emitted in the largest quantities as a result of people's activities. (Note that other lesson plans focus on CO_2 and the greenhouse effect, but you might still want to briefly discuss these concepts here.) Key discussion points include:
   1. Greenhouse gases trap heat in the atmosphere, which makes the Earth warmer. The effect of each gas on the climate depends on how much of it is produced, how long it stays in the atmosphere, and how much heat it traps.
   2. Greenhouse gases come from burning fossil fuels for all sorts of everyday activities, such as using electricity, heating our homes, and driving vehicles. Greenhouse gas emissions can be tied to direct activities (such as burning coal or natural gas to produce electricity) or indirect activities (such as using this electricity in our homes and businesses).
   3. Greenhouse gases that people are adding to the atmosphere include carbon dioxide, methane, nitrous oxides, and fluorinated gases.

2. Explain that people can learn about the amount and types of greenhouse gases being emitted into the atmosphere by using EPA's Facility Level Information on GreenHouse gases Tool (FLIGHT tool)(http://ghgdata.epa.gov/ghgp/main.do). Explain that the tool is an online database of greenhouse gas emissions that lets people view what types of greenhouse gases are emitted by large facilities. People can zoom out to a national level and identify the states or counties that are the largest emitters of particular greenhouse gases such as carbon dioxide. They can also look at their own state or county. The data in the tool comes from facilities that directly add large amounts of greenhouse gases to our atmosphere. Discuss why this information is important. [Answer: This information can help people see what kinds of facilities are releasing greenhouse gases into the atmosphere, what types of greenhouse gases they produce, and how much they produce. This information can also help governments and law makers make informed policies and regulations.] Ask students what individual facilities might do with this information. [Answer: They can better track their emissions and figure out ways to reduce them.]

3. Divide students into pairs. Have each pair of students log onto the FLIGHT Tool (http://ghgdata.epa.gov/ghgp/main.do) in the classroom. In the first window that appears, "Explore Greenhouse Gas (GHG) Emissions from Large Facilities," have the students choose your state. Have the students choose all the greenhouse gases listed in the box on the top left and click the "APPLY" button.

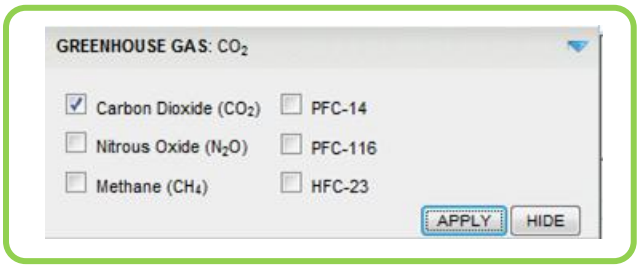


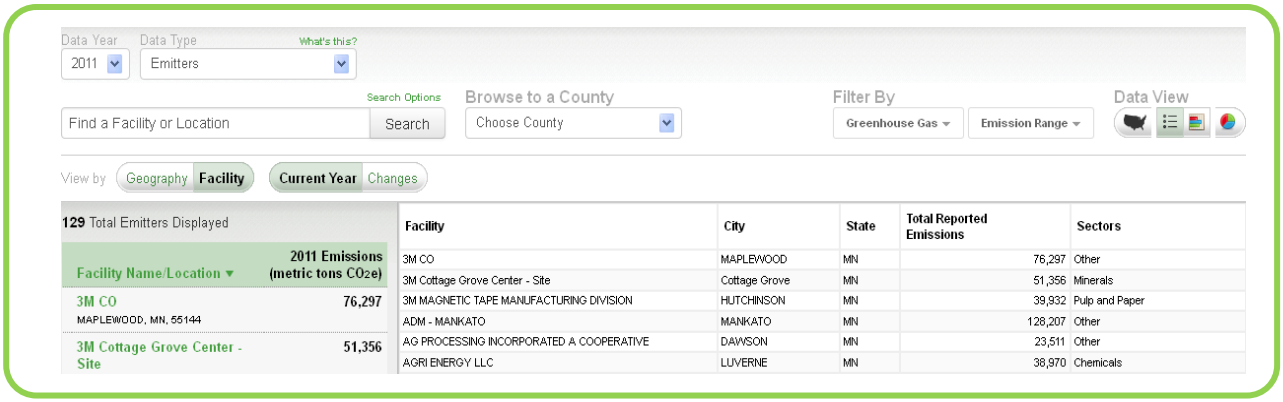
4. A list of facilities will appear to the left of the map. It will list all emitters in the state alphabetically. The students can also view facility and "sector" information by clicking on the second icon in the "View" tool at the top of the page and then clicking "Facility." They will then get a listing of all the facilities emitting greenhouse gases in your state and how much each facility emits.



Facility	City	State	Total Reported Emissions	Sectors
3M CO	MAPLEWOOD	MN	76,369	Other
3M Cottage Grove Center - Site	Cottage Grove	MN	71,733	Chemicals, Minerals
3M MAGNETIC TAPE MANUFACTURING DIVISION	HUTCHINSON	MN	39,971	Pulp and Paper
ADM - MANKATO	MANKATO	MN	129,065	Other
AG PROCESSING INCORPORATED A COOPERATIVE	DAWSON	MN	23,532	Other
AGRI ENERGY LLC	LUVERNE	MN	39,008	Chemicals

5. Have the students scroll through the facilities listed and find the top emitters in the state. Have students write down the top five facilities, what sector each facility is listed under, and the amount of total greenhouse gases each is emitting on the "Top Five List" worksheet. Now have the students conduct another search for your state by selecting only "CO_2"in the Greenhouse Gas" category on the tool. Have them again click on the second icon in the "View" tool at the top of the page and then have them click the "Facility." Ask the students to list the top five CO_2-emitting facilities on the worksheet.

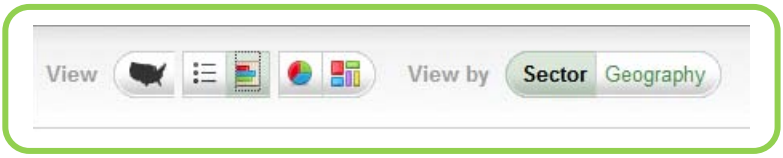




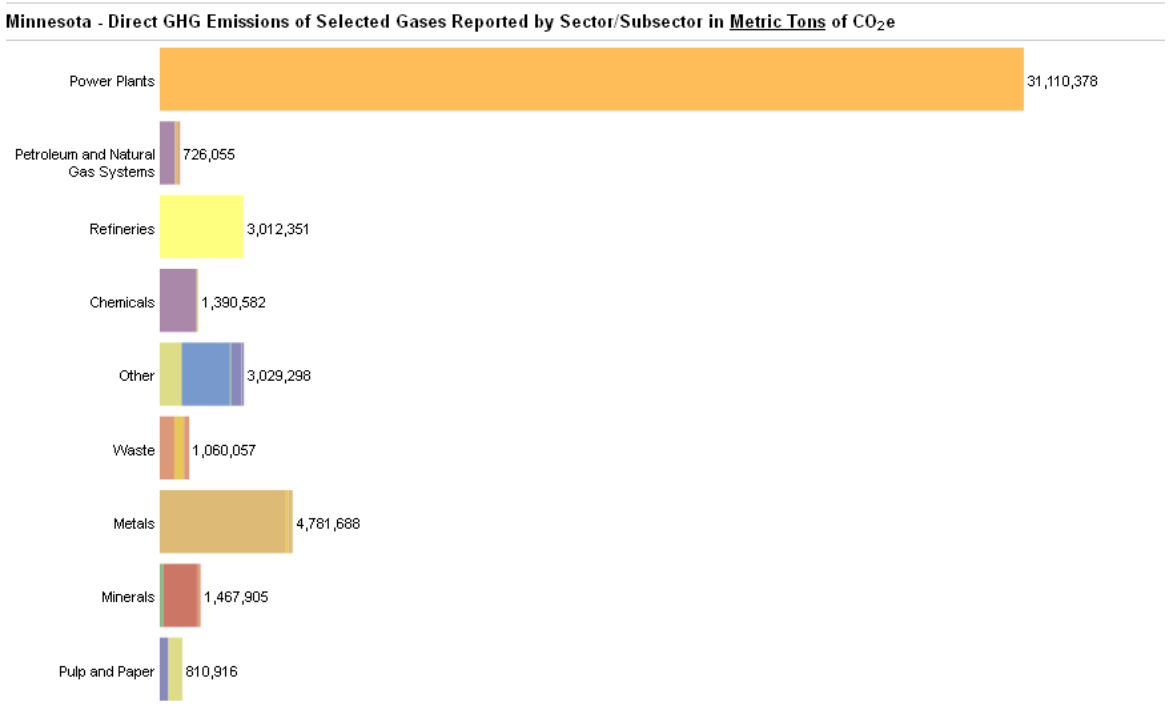
6. Have the students look at the facilities listed on their worksheets. Are any facilities on both lists? What kinds of facilities are they? Hand out a copy of the "Total U.S. Greenhouse Gases Emissions by Sector" pie chart and go over each sector. Ask students what kinds of facilities in the United States produce the most greenhouse gases. [Answer: Electric power plants produce the largest share of greenhouse gas emissions.]

Tell the students that the emissions data in the FLIGHT Tool do not reflect all the greenhouse gas sources in the United States. Explain the FLIGHT Tool includes direct emissions from sources that emit more that 25,000 metric tons of CO_2e per year. As a result, it includes most emissions from power plants and other large industrial plants, but it does not include emissions from other major activities that release greenhouse gases, such as driving cars, agriculture, and handling waste.

Now have students go back to the FLIGHT Tool. Have them again choose all the greenhouse gases listed in the box to the left. Now, have the students choose the third bar chart icon under the "View" tool, and select "Sector." Students will be able to see a bar chart that shows how much greenhouse gases each "sector" or kind of facility emits. Under the bar chart, there is a listing of the number of facilities that are categorized under each sector.



MAPPING GREENHOUSE GAS EMISSIONS WHERE YOU LIVE



Sector (SELECT ALL / DESELECT ALL / APPLY)	Power Plants	Petroleum and Natural Gas Systems	Refineries	Chemicals	Other	Waste	Metals	Minerals	Pulp and Paper
2011 GHG Emissions (million metric tons CO_2e)	31	0.7	3	1.4	3	1.1	4.8	1.5	0.8
# of Reporting Facilities	39	12	2	4	40	32	10	8	7

7. Students can see a similar display by choosing only the CO_2 option in the greenhouse gases listing and then once again clicking on the bar chart icon and "Sector." They can also see the data displayed in different ways by clicking on the pie chart icon in the "View" tool.

8. As a class, discuss the sectors or types of facilities that produce the most greenhouse gas emissions in your state. You can have the students refresh the tool, return to the window entitled "Explore Greenhouse Gas (GHG) Emissions from Large Facilities," and have the students click on the "View U.S. Facility Map." They can click on the bar chart or pie chart options on the "View" tool to see which sectors are the largest emitting sectors for the nation as a whole. They can also view other states.

9. Ask students to think about how these facilities relate to their everyday lives. Some possible points for discussion:

- **Power plants:** We use electricity for many things, and it has to come from somewhere! Ask students to think how they used electricity today. [Answers could include using a toaster or oven to make breakfast, putting on lights to get dressed, using lights in the classroom, using a computer in the classroom, etc.]
- **Refineries:** If you travel in a vehicle that burns gasoline or diesel, that fuel was produced at a refinery.
- **Chemicals:** Think about all the products in your life that are made from plastic or rubber. Those materials originally came from a chemical plant. Chemicals are also used to make fabrics, medicines, paints and dyes, and many other everyday products.
- **Other industrial:** This sector includes facilities that produce food, clothing, wood and metal products, computers and other electronics, cars, and many other everyday products.

You can learn more about each of the sectors in the FLIGHT Tool at: http://www.epa.gov/ghgreporting/ghgdata/index.html.

In your discussion, emphasize that facilities emit greenhouse gases because they are producing things that people want or need. We all play a role in climate change because we all contribute to greenhouse gas emissions whenever we use electricity, travel in a motorized vehicle, use just about any type of product, throw something in the trash, etc.

10. Ask students what they think facilities can do to reduce their greenhouse gas emissions. Discuss their suggestions as a class. Ideas might include:

- Producing less "stuff"—but what if that "stuff" is something people want to buy? Or something they need?
- Becoming more energy-efficient—producing the same amount of "stuff" but burning lower amounts of fossil fuels to do it.
- Switching to alternative sources of electricity, such as solar or wind power.
- Power plants create extra heat. Some plants use this extra heat to produce steam for heating nearby buildings, so those buildings don't need to burn more fuel to produce heat. This is called "cogeneration" or "combined heat and power."

- Avoid using excessive packaging – both by manufacturers and consumers buying products
- A few facilities are experimenting with technologies that capture CO_2 before it can leave the smokestack. This captured CO_2 is then buried deep underground. This is called "carbon capture and sequestration."
- Landfills usually emit methane, which is a stronger greenhouse gas than CO_2. Methane is the main ingredient in natural gas, so landfills can capture this methane and burn it to produce electricity for homes and businesses nearby. This emits carbon dioxide, but that's still better for the environment than methane.

11. Ask students what they think *they* and their families can do to reduce greenhouse gas emissions at home, at school, and on the road. Discuss the tips in the "What You Can Do" section on EPA's climate change website (http://www.epa.gov/climatechange/wycd/).
Note: Teachers can also turn these discussion topics into essay question assignments or group projects where groups must create a presentation exploring one of these topics

EXTENSION

For homework, have students calculate their carbon footprint and learn about simple steps to reduce their impacts using the calculator at: http://www.epa.gov/climatechange/students/calc/index.html. Have students choose one action that they will commit to carrying out for the next month (or longer), such as recycling more, biking to school, etc.). Have each student create a pledge card to bring into class on an index card. The card should state each student's pledge and include a picture of what he or she plans to do. Discuss the results of the calculator activity and the students' pledges. Post the pledges on a bulletin board.

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TOP FIVE LIST

Top Ranking Facilities for All Greenhouse Gases in My State			
Rank	Facility name	Sector	Amount/CO_2e
1			
2			
3			
4			
5			

Top-Ranking Facilities for CO_2 in My State			
Rank	Facility name	Sector	Amount/CO_2e
1			
2			
3			
4			
5			

MAPPING GREENHOUSE GAS EMISSIONS WHERE YOU LIVE

U.S. GREENHOUSE GAS EMISSIONS BY SECTOR AND BY GAS

All emission estimates are from the [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010.]