ScienceNews

EDUCATOR GUIDE

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The Road to Net-Zero

SOCIETY FOR SCIENCE

SN EDUCATOR GUIDE

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The Road to Net-Zero

About this Guide

Human activities pump a lot of greenhouse gases into the atmosphere, and those emissions are driving climate change. In this Guide, students will review greenhouse gases and their sources and learn about ways to reduce emissions.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "It's possible to reach net-zero carbon emissions. Here's how," which explores various solutions to decrease greenhouse gas emissions. A version of the article, "The road to net-zero," appears in the January 28, 2023 issue of *Science News*. Related standards include NGSS-DCI: HS-ESS2; HS-ESS3; MS-ESS2; MS-ESS3.

Student Comprehension Worksheet — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will review, discuss and diagram atmospheric greenhouse gases and their impact on Earth. Then students will analyze a graph to begin thinking about what it will take to achieve net-zero emissions. Learning Outcomes: Reviewing greenhouses gases and their impact on Earth, diagramming human impact, understanding the idea of net-zero emissions. Related standards include NGSS-DCI: HS-ESS2; HS-ESS3; MS-ESS2; MS-ESS3.

Student Discussion Worksheet — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: Ask students to read the online *Science News* article "It's possible to reach net-zero carbon emissions. Here's how," which explores various solutions to decrease greenhouse gas emissions, and answer the following questions. Questions are broken up by article section. You may want to direct students to answer the first two sets of questions, then break them into groups to answer one of the remaining sets of questions. Groups can then share their answers with the class. A version of the article, "The road to net-zero," appears in the January 28, 2023 issue of *Science News*.

Introduction

1. What does the phrase "net-zero emissions" mean?

Net-zero emissions refers to balancing the greenhouse gases emitted into the atmosphere with those taken out. The idea is that removing greenhouse gases from the atmosphere effectively cancels out the gases that are emitted.

2. What problem do scientists hope net-zero emissions will help solve?

Scientists hope that this net-zero strategy will help keep Earth's climate from warming 1.5 degrees Celsius above preindustrial levels, which would make rising sea levels, extreme weather and other impacts worse than they already are.

Section 1: The current state of CO_2

3. What are the greenhouse gases that researchers want to remove from Earth's atmosphere? What are sources of these greenhouse gases, and how much did each greenhouse gas contribute to total U.S. emissions in 2020?

Carbon dioxide: Comes from sources such as vehicles and coal-burning power plants. Accounted for 79 percent of U.S. greenhouse gas emissions in 2020.

Methane: Comes from oil and gas operations as well as livestock, landfills and other land uses. Accounted for 11 percent of U.S. greenhouse gas emissions in 2020.

Nitrous oxides: Come from sources such as crop fertilization and burning fuels. Accounted for 7 percent of U.S. greenhouse gas emissions in 2020.

Fluorinated gases: Accounted for 3 percent of U.S. greenhouse gas emissions in 2020.

4. How has the United States contributed to climate change? What is the United States' goal for reaching net-zero emissions?

The United States has historically been responsible for most of the greenhouse gas emissions. It currently emits around 5 billion metric tons of CO_2 annually. President Joe Biden said the country's goal is to reach net-zero emissions by 2050.

Section 2: Make a lot more clean electricity

5. In your own words, summarize the article section's main point.

Countries can work toward reaching net-zero emissions by scaling up the amount of clean energy they produce via existing renewable energy technologies, such as wind and solar power.

6. How could the United States use the solution to reach its goal of reaching net-zero emissions by 2050? What are some challenges to boosting the production of clean electricity?

The United States would have to quadruple its wind and solar power production by 2030 to reach net-zero emissions by 2050. Challenges include figuring out how and where to build new wind and solar farms, how to store and distribute the electricity, and overcoming public resistance to other types of low-carbon power such as hydropower and nuclear power.

Section 3: Get efficient and go electric

7. In your own words, summarize the article section's main point.

Countries can work toward reaching net-zero emissions by boosting the energy efficiency of manufacturing and infrastructure such as heating and transportation, and electrifying these sectors as much as possible.

8. How could the United States use the solution to reach its goal of reaching net-zero emissions by 2050?

The United States could increase the amount homes heated via electric heat pumps from 10 percent in 2020 to about 80 percent by 2050, and have electric vehicles make up half of all new vehicle sales by 2030.

Section 4: Make clean fuels

9. In your own words, summarize the article section's main point.

Countries can work toward reaching net-zero emissions by substituting fossil fuels with low- or zero-carbon fuels made from plants and other biomass.

10. How could the United States use the solution to reach its goal of reaching net-zero emissions by 2050?

The United States could build many biomass conversion plants, probably in the Midwest and Southeast where crops are grown, by 2050.

Section 5: Rein in other greenhouse gas emissions

11. In your own words, summarize the article section's main point.

Countries can work toward reaching net-zero emissions by cutting methane, nitrous oxides and fluorinated carbon emissions via new regulations, improving soil management techniques and revamping production and recycling processes.

12. How could the United States use the solution to reach its goal of reaching net-zero emissions by 2050?

The United States could place new regulations on oil, gas and coal operations, which account for one-third of the country's methane emissions. Recently, the United States joined an international pledge to reduce global methane emissions.

Section 6: Sop up as much CO_2 as possible

13. In your own words, summarize the article section's main point.

To reach net-zero emissions, countries will need to remove and store an equivalent amount of carbon to what they still emit after cutting as much as possible. Ways to do this include carbon capture and storage, converting farmland into forests and preserving the forests Earth still has, such as the Amazon.

14. How could the United States use the solution to reach its goal of reaching net-zero emissions by 2050?

The United States could add carbon capture technology to its industrial plants, turn the CO_2 into a liquid and pipe it deep underground where it can be stored long term.

Section 7: No time to waste

15. In your own words, summarize the article section's main point.

Reaching net-zero by 2050 will require balancing major financial and technological investments over the next decade with ensuring that the lives of people in developing countries aren't made worse by the transition.

16. Is the United States' goal of reaching net-zero emissions by 2050 realistic? Explain based on evidence given in the article.

Student answers will vary. Encourage students to use data and information from the article to help support their answer. Students' answers should suggest that the United States already has the primary technology for slashing and sopping up emissions. The country also has the innovation to create new technologies that could help.

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Student Comprehension Worksheet

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Introduction

1. What does the phrase "net-zero emissions" mean?

2. What problem do scientists hope net-zero emissions will help solve?

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Section 4: Make clean fuels

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Section 5: Rein in other greenhouse gas emissions

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Cross-curricular Discussion, Q&A

Directions for teachers: Ask students to skim the *Science News Explores* article "Explainer: CO_2 and other greenhouse gases" and answer the first set of questions. Then ask students to read the introduction of the *Science News* article "It's possible to reach net-zero carbon emissions. Here's how" and answer the remaining questions. A version of the article, "The road to net-zero," appears in the January 28, 2023 issue of *Science News*.

Check out our Grappling with graphs and other data visualizations lesson plan for more graphical analysis questions.

Want to make it a virtual lesson? Post the online *Science News* and *Science News Explores* articles to your virtual classroom. Discuss the article and questions with your class on your virtual platform.

Reviewing greenhouse gases

1. Name at least three greenhouse gases. Where do they come from?

Carbon dioxide, methane, nitrous oxide and fluorinated gases are greenhouse gases. Carbon dioxide is produced by plants and is part of Earth's natural carbon cycle. Humans release additional carbon dioxide into the atmosphere by burning fossil fuels such as coal and oil. Other greenhouse gases such as methane and nitrous oxide are also naturally present in the Earth's atmosphere. Humans emit extra amounts of these gases into the atmosphere via agricultural processes and the production and combustion of fossil fuels.

2. What effect do greenhouse gases have on the Earth? Why does the article compare greenhouse gases to a blanket or a window of a greenhouse? Come up with your own metaphor to describe the effect of greenhouse gases in the atmosphere.

Greenhouse gases trap heat in the atmosphere and warm Earth like how a blanket traps body heat to keep us warm or a greenhouse window traps the sun's energy to keep plants warm and help them grow when it is cold outside. Another metaphor could be a jacket.

3. How do human activities impact the atmosphere's concentration of greenhouse gases? What effect does that impact have on climate and weather?

Human activities release additional amounts of greenhouse gases into the atmosphere at an increased rate, which increases the concentration. As a result, Earth's global average temperature is increasing, sea levels are rising and oceans are absorbing extra carbon dioxide and becoming more acidic, which affects marine organisms. The frequency, intensity and duration of extreme weather events are also increasing.

4. With your partner, draw a simple diagram depicting the relationship between Earth's temperature and the concentration of greenhouse gases in the atmosphere. Make sure that your diagram includes various sources of greenhouse gases. Your diagram should also indicate how human activities impact the natural cycle and concentration of greenhouse gases in the atmosphere over time.

Student answers will vary but should show how some greenhouse gases are emitted naturally and warm the atmosphere. Diagrams should then indicate that human activities continue to increase the concentration of the gases in the atmosphere and therefore the global average temperature.

Achieving net-zero

1. Before reading the *Science News* article, discuss with a partner what you think the term "net-zero" means.

The term "net" generally means the sum of all, so "net-zero" means the sum of all is equal to zero.

2. After reading the *Science News* article, discuss what "net-zero" means in the context of the article. Then, look at the graph titled "Carbon dioxide emissions by sector in one net-zero scenario," and discuss how changes in each of the sources of carbon dioxide could help achieve net-zero emissions by 2050.

In the article, "net-zero" refers to the sum of all human-made greenhouse gas emissions equaling zero. The graph shows a scenario where over the course of about the next 30 years, electricity and heating as well as "other" sources will take more carbon dioxide out of the atmosphere than they emit. Industry and transport sources will reduce the amount of carbon dioxide they emit, but those sectors may not achieve zero emissions by 2050. Still, if other industries take more carbon dioxide out of the atmosphere than they emit, net-zero emissions may still be achievable by 2050.

3. If you are reading the story in print, check out the at-home and industrial milestones shown below the graph. Discuss which milestone would impact you and your local economy the most. What might be some benefits and challenges of the change?

Student answers will vary.

4. The article states that "the key to a decarbonized future lies in producing vast amounts of new electricity from sources that emit little to none of the gases." Discuss this statement with your partner and draw a diagram to help explain why it's true.

Electricity from renewable sources such as the wind, the sun and water is important to shrinking society's carbon footprint. If electricity continues being made by burning fossil fuels and emitting greenhouse gases, then new technologies or tools that depend on electrification won't be truly carbon-free, or "clean."

Diagrams should indicate how new, electrified technologies would still produce greenhouse gases if they do not run on clean electricity.

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Reviewing greenhouse gases

1. Name at least three greenhouse gases. Where do they come from?

2. What effect do greenhouse gases have on the Earth? Why does the article compare greenhouse gases to a blanket or a window of a greenhouse? Come up with your own metaphor to describe the effect of greenhouse gases in the atmosphere.

3. How do human activities impact the atmosphere's concentration of greenhouse gases? What effect does that impact have on climate and weather?

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