



# Greenhouse Gas Game

Through interactive play on a life-sized game board, students are introduced to three of the most common greenhouse gases and the role these have in the natural and enhanced greenhouse effect. Teams add or remove greenhouse gases from their shared atmosphere to experience the affects of human actions.

## Grade Level

- 4–12

## Activity Time

- Warm-up: 10–20 minutes
- Activity: 20–30 minutes
- Wrap-up: 10–20 minutes

## Setting

- Large open space in gymnasium or outdoor playing area
- Classroom (introduction and debrief)

## Materials

- 28 game board playing pieces, representing spaces
- Tokens, three types (e.g., colour or shape), approximately 50 per type (150 total) to represent greenhouse gases
- Bags to hold tokens, one per team\*

- Blackboard, flip chart, or other large surface to record greenhouse gases and create key for token type; alternatively, card size key for each team\*
- Clipboards, weights and/or tape to hold down game board playing spaces
- Four to eight large dice: one per team\* OR one shared between two teams
- Optional: square cardboard boxes to make dice

\* Note: Four students per teams is ideal; thus a class of 28 will have seven teams

## Subject Areas

Science, Social Studies, Language Arts, Physical Education

## Keywords

Atmosphere, carbon dioxide (CO<sub>2</sub>), climate change, greenhouse effect, greenhouse gas, visible light, heat energy, methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O)

## Introduction and Background

Students have probably heard about climate change but they may not fully understand how human activity, including what they do each day, increases the amount of greenhouse gases in the atmosphere. The result is a rise in the average global temperature, leading to climate change. Connecting how our individual and collective use of fossil fuels as a source of energy, along with other activities, affect greenhouse gas emissions is often difficult. Understanding the role and sources of greenhouse gases can help students make decisions regarding their daily actions that may reduce the amounts of greenhouse gases released to the atmosphere.

Greenhouse gases exist naturally in our atmosphere in very small amounts. Unique from other gases, they have the ability to absorb heat energy (infrared radiation). By absorbing and re-emitting heat energy from the earth's surface back into the atmosphere, greenhouse gases keep the global temperature at the life-sustaining level of +15°C. This is called the 'natural' greenhouse effect. Without these greenhouse gases in the atmosphere, the earth would have an average temperature of -18°C. There is a finely tuned, balanced cycle in which processes such as forest fires, volcanic eruptions, digestion, respiration, and decomposition release greenhouse gases into



the atmosphere while other processes such as photosynthesis by plants and algae, remove greenhouse gases.

In the last two hundred years human activities have greatly increased the amount of greenhouse gases emitted to the atmosphere. Activities such as burning fossil fuels, clearing forests, expanding agriculture, and the creation of pollution as a by-product of industrialization, have increased the levels of natural greenhouse gases and human made greenhouse gases in the atmosphere. This is called the 'enhanced' greenhouse effect. The result has been an increase in average global

temperature of 0.6 °C in the 20<sup>th</sup> century and this is expected to continue to rise throughout the 21<sup>st</sup> century.

Note: See the *Primer* for a full description of the natural and enhanced greenhouse effect and the role of greenhouse gases.

Many simple lifestyle changes can reduce the amount of greenhouse gas we each contribute to the total level of greenhouse gas emissions. This game helps students to become aware of these actions and the potentially positive impact they will have.

**TABLE: MOVEMENT OF MAIN GREENHOUSE GAS**

Greenhouse Gas	Released into atmosphere by...	Removed from atmosphere by...
<b>Carbon Dioxide</b> (CO <sub>2</sub> )	<p><i>Human Activity:</i> burning and production of fossil fuels, clearing of land using fire (combustion)</p> <p><i>Natural Activity:</i> Volcanic activity, forest fires, respiration by organisms, decomposition</p>	<p><i>Human Activity:</i> less CO<sub>2</sub> is removed by natural activity because of deforestation, degrading of soils, and wetland destruction</p> <p><i>Natural Activity:</i> Plants and algae (photosynthesis); oceans (go into solution)</p>
<b>Methane</b> (CH <sub>4</sub> )	<p><i>Human Activity:</i> Digestive processes of grazing domestic animals, decomposition (anaerobic or without air) in solid waste landfills, fossil fuel production</p> <p><i>Natural Activity:</i> Decomposition in swamp and wetland areas, melting of permafrost, digestive process of grazing animals</p>	<p><i>Human Activity:</i> Burning as a source of energy-forms carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O)</p> <p><i>Natural Activity:</i> chemical reactions in the upper atmosphere, soil, ocean sediments</p>
<b>Nitrous Oxide</b> (N <sub>2</sub> O)	<p><i>Human Activity:</i> Agriculture, especially the use of synthetic nitrogen fertilizers and raising of cows, pigs and chickens; burning of fossil fuels; creation of synthetic nitrogen based fabric (e.g. nylon)</p> <p><i>Natural Activity:</i> Emitted by bacteria in soils and oceans</p>	<p><i>Natural Activity:</i> Bacteria (especially nitrogen fixing bacteria)</p>



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## Procedure

### Setup

- 1 Copy or print Black Line Masters (BLM) for the game board playing pieces onto heavy paper. If possible, laminate each piece or put in a plastic sleeve. The playing pieces represent the “spaces” on a board game.

To encourage students to read all the information on the spaces, cover the instruction part of each game board piece with a piece of paper and attach it so that it can be easily lifted to read.

- 2 Collect three types of tokens, approximately 50 of each. If possible, use recycled items with three different colours, shapes and/or sizes such as caps or lids from containers.

Create a key indicating the type of token and which Greenhouse Gas it represents (e.g. red tokens represent carbon dioxide). Ideally, the lightest or smallest token should represent carbon dioxide ( $\text{CO}_2$ ), the least potent greenhouse gas, and the darkest or largest token the most potent, nitrous oxide ( $\text{N}_2\text{O}$ ).

Record the key on flip chart paper, with chalk on concrete (if played outdoors), or on small cards for each team. Students can help to make the key(s) as part of the Warm-up.

- 3 If playing outdoors, attach the each game board piece onto clipboards (28) to hold them down or collect weighted objects such as rocks to put on top of them. If playing indoors, use clipboards or tape to help keep the game board pieces in place.
- 4 Lay-out the game board pieces in a classic square board game shape. In other words, in each corner, place one of the four “Green Space” pieces. Along each side, place six game board pieces. The order does not matter. Ideally, use the full gym floor or part of a large playing field, thus allowing plenty of room for the whole class to play and encouraging a high degree of physical activity.

- 5 Find the largest dice possible. If necessary and time permits, make large dice by obtaining square boxes from a gift store or baker or cut foam blocks (approximately 15cm per side) and label each side with one to six.

### Warm Up

- 1 Ask the students, “What is a greenhouse? What are they used for? What does it feel like inside a greenhouse compared to outside one? Is it possible that it could become too hot inside a greenhouse? How does a gardener or farmer control the temperature inside a greenhouse?”

A: Greenhouses or “glasshouses” are used to enhance growth of plants by increasing the temperature inside the greenhouse compared to outside, as well as to protect plants from wind and precipitation. The glass or plastic permits sunlight to enter, but slows heat from escaping. Gardeners control the temperature by opening and closing windows to allow the heat to escape faster and/or by covering the clear roof for shade.

- 2 Explain how the atmosphere of the earth acts in a similar way to a gardener’s greenhouse and is called the “natural greenhouse effect.” Ensure they understand that the natural greenhouse effect maintains a global average temperature of  $15^\circ\text{C}$ , warm enough for life to exist.

Explain that it is the greenhouse gases in the atmosphere that helps to keep heat in the atmosphere and has done so for millions of years. Note how the action of these gases is similar to the glass of a greenhouse. Review the composition of the atmosphere: mostly nitrogen and oxygen, plus very small amounts of other gases, including greenhouse gases (GHG). Introduce the three main greenhouse gases: carbon dioxide ( $\text{CO}_2$ ), methane ( $\text{CH}_4$ ) and nitrous oxide ( $\text{N}_2\text{O}$ ).

- 3 Explain how the natural greenhouse effect works, focusing on the basics of **visible light** transforming to **heat energy** (infrared radiation) at the surface of the earth (or being reflected back to space) and how greenhouse gases absorb and re-emit this heat energy (infrared radiation) back into



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the atmosphere as well as space.

- 4 Review the major natural sources of each of the three greenhouse gases (see table in Introduction and Background section).
- 5 Tell students that in the past two hundred years **human activities** have resulted in an **increase in the amount of greenhouse gases** in the atmosphere. Ask students if they can think of what these activities may be that increase greenhouse gases. What has changed in the past few hundred years? *A: cars, urbanization, industrial manufacturing, air travel, mass transportation of goods, etc.*

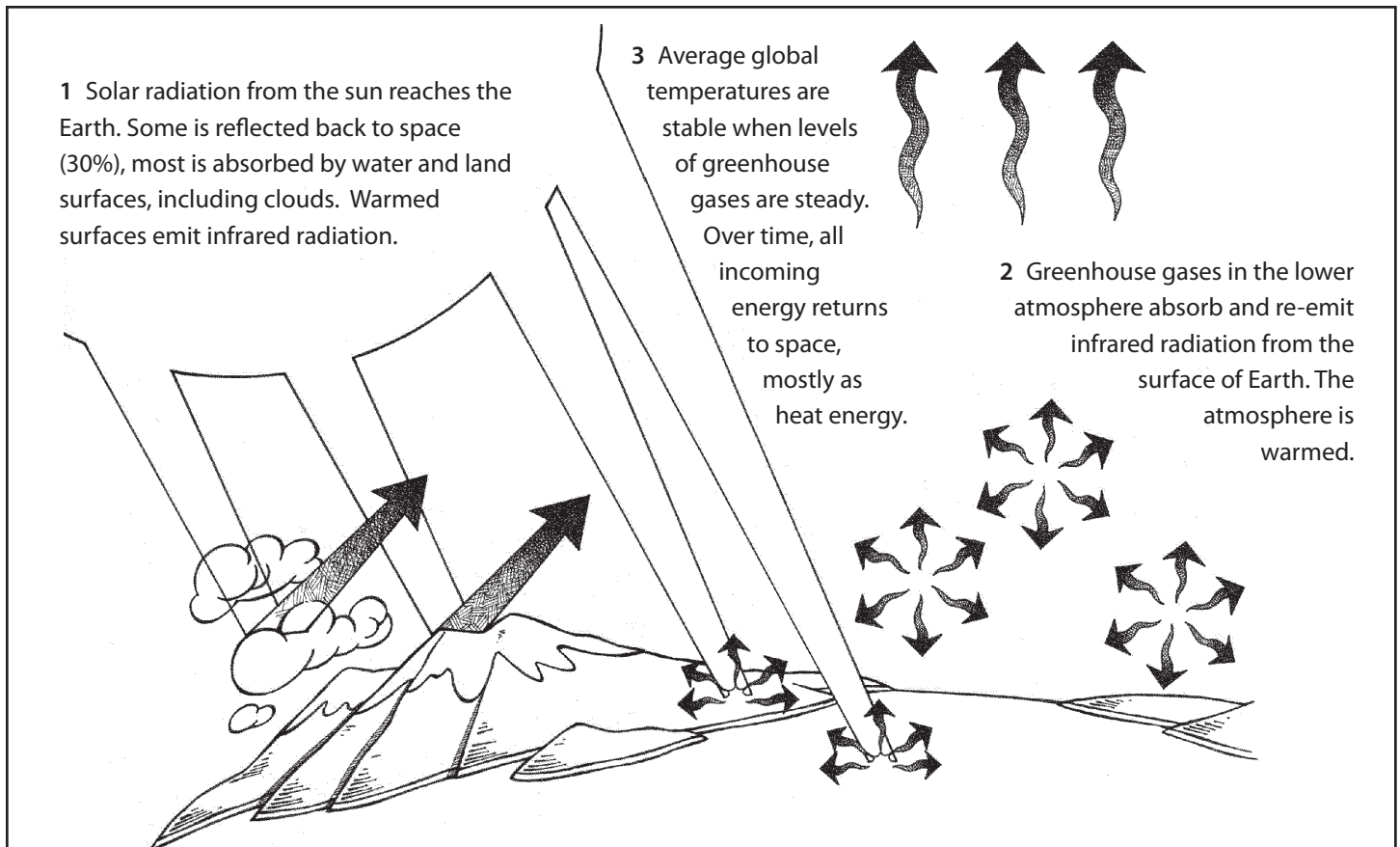
Review the major human activities that increase the amount of each of the three main greenhouse gases emitted to the

atmosphere (see table). Another way of saying this is that human activity has resulted in high levels of **greenhouse gas emissions**. Tell the students that there are other greenhouse gases, including ones that were not present before human industrial activities, but today we are focusing on three of the most common ones and what we can do to reduce our current level of greenhouse gas emissions.

## Activity

- 1 Tell the students they are going to play the **life-sized board game** called the "Greenhouse Gas Game". Inform the students the purpose of the game is to become familiar with the human activities that either increase or decrease the amount of greenhouse gases released into the atmosphere, in other words increase or decrease **greenhouse gas emissions**.

## Greenhouse Effect Diagram





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Divide the class into **teams** of four students. Give each team a bag to keep their greenhouse gas tokens in and explain the bags represent their total greenhouse gas emissions. Each team will start with nine tokens in their bag that represent their current level of greenhouse gas emissions. The goal of the game is to figure out what will reduce their level of emissions.

Pass out one die per team or pair of teams if sharing. Inform the students that each team is acting as the marker that moves around the game board based on the roll of the die.

**Note:** Ideally, for **every move** along the game board, **each team member has a role**. One student rolls the die, the second reads the information and instructions, the third drops off or collects greenhouse gas tokens and the fourth team holds the atmosphere bag. The students should take turns doing each role.

- 2 Pass out nine greenhouse gas tokens, three of each type, to each team and then place the rest of different types of “greenhouse gas” tokens in the centre of the game board area. Show the students the **key** and go through how **each type of token represents a particular greenhouse gas**. Stress that the bag is their current level of greenhouse gas emissions and they will be adding and removing various greenhouse gases based on the instructions in the space they land on.
- 3 Four teams start, one team at each of the corners of the game board labelled “Green Space”; the next teams can start once the first four teams have moved off the corner spaces.

Students take turns rolling the die for their team. The whole team then moves **clockwise** the number of spaces indicated on the die. Remind the students to walk next to the spaces, not directly on them. Instruct the students to take turns **reading aloud all the information** on the space they landed on and **then follow the instructions**.

- 4 When the space indicates the team is to **add greenhouse gases** to their “atmosphere”, one team member runs to the centre and **picks up** the required number and type of

tokens. If the space indicates that the team should **remove greenhouse gases** then one team member runs to the centre to **drop off** the required number of tokens. For most spaces, only one team member should pick up or drop off the tokens. However, for some spaces the whole team is instructed to pick up or drop off tokens, representing a significant input or removal of greenhouse gases from their atmosphere.

- 5 If necessary, walk through a demonstration of the movements and process for the game. Remind students that they may have to wait until a team in front of them moves from a space before they can take their turn. Also remind them to avoid stepping directly on the spaces, as they may slip.
- 6 Play the game until each team member has had two turns at rolling the die. Stop the game momentarily; have the teams check their atmosphere and tally the number of each type of greenhouse gas present. Have each team report the state of their atmosphere (tally) and record each team’s tally on a piece of flip-chart paper. Ask if they think it would make a difference to continue. What do they predict will happen if they continue? Play another round and make a final tally.

## Wrap-up

- 1 Compare the two tallies for each team and discuss the results. For example, ask: How did each team do? Why? Did repeating the second round make a difference to their tally? Guide the students to understand that this game is a game of chance and so the final tally of greenhouse gas emissions is mostly dependent upon the squares landed on.
- 2 **Discuss and summarize the human activities** that have an impact on the amount of greenhouse gases (GHG) released to the atmosphere, in other words, the level of greenhouse gas emissions. **First**, discuss those that **increase the level of greenhouse gas emissions** to the atmosphere. Refer back to the information covered in the warm-up, and encourage discussion of how some carbon dioxide, methane and nitrous oxide is necessary for the natural greenhouse effect to exist and function, but if more of these are added to the atmosphere, there is an “enhanced” greenhouse effect.



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Remind students there are other GHG, including water vapour, trace gases, and human made GHG as well that contribute to the enhanced greenhouse effect.

- 3 Next, focus on the positive human activities, including lifestyle choices that we can make as individuals and families that **reduce the level of greenhouse emissions**. Ask the students if it is possible to have an atmosphere with less greenhouse gases? Remind the students that it is extremely difficult to actually remove greenhouse gases from the atmosphere; we can, with a little effort, reduce the amount that is released.
- 4 Discuss how the increasing average global temperatures that we are experiencing on Earth are a result of increased greenhouse gases in the atmosphere. Connect the discussion to the gardener's greenhouse metaphor, noting how unlike a greenhouse, we cannot open windows or create shade to reduce the temperature: our only option is to reduce our greenhouse gas emissions.
- 5 Ask students to predict the possible impact of everyone making simple changes to their lifestyle that decreases their greenhouse gas emissions. Invite students to share some of the actions they are already doing regularly that decrease their greenhouse gases emissions. Discuss possible action projects the class could do to decrease the amount of greenhouse gases, especially carbon dioxide, released to the atmosphere, for example: regular walk/cycle/bus to school days, recycle and buy recycled products, regular garbage free lunches, idle free zones around school etc.

## Assessment

- 1 Have students draw a diagram to explain the natural greenhouse effect. The diagram should include a representation of:
  - visible light from the sun reaching the earth and its atmosphere,
  - what happens to it (reflected or absorbed and transformed at the surface of the earth, then enters the atmosphere as heat energy), and

- the role of the greenhouse gases (absorb and re-emit the heat energy into the atmosphere and space).
- 2 In a story that compares two possible futures, students identify the main natural and human related activities that release each of the three discussed greenhouse gases to the atmosphere. In one future, humans have altered their lifestyles and actions so that there are no further increases in greenhouse gas emission while in the other future, things stay the same. In each story, look for evidence that the student understands the basic ideas behind natural and enhanced greenhouse effect and the role of humans in releasing more greenhouse gases.
  - 3 Students create a poster identifying an action that will reduce the level of greenhouse gas emissions from the school and/or community. The poster should include the action, as well as how this action will reduce emissions, and why this is important.

## Extensions

- 1 Have students research the source and potency of each greenhouse gas, along with other greenhouse gases, and create a chart comparing each one. Use this information to create a new version of the game, using a regular sized game board with blank spaces. Students decide what to include in each space and number of tokens added/removed from a player or team's atmosphere. Once a player goes around the board once, tally the greenhouse gases in their atmosphere.
- 2 Have students research current governmental initiatives and actions to reduce greenhouse gas emissions.
- 3 As a class watch "Turning Down the Heat: The New Energy Revolution" available through the National Film Board of Canada. <http://www.nfb.ca/collection/films/fiche/?id=33718>
- 4 Have students and family members calculate their carbon footprint as a stepping stone for families to discuss how they might take action. There are several on the internet, including:



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<http://www.carbonfootprint.com/calculator.aspx>  
[http://www.nature.org/initiatives/climatechange/  
calculator/](http://www.nature.org/initiatives/climatechange/calculator/)  
[http://www.epa.gov/climatechange/emissions/  
ind\\_calculator.html](http://www.epa.gov/climatechange/emissions/ind_calculator.html)

## Source

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