The Greenhouse Effect

Time needed for session:	Location:	Context:	Equipment:
Approx. 1 hour	Classroom	This lesson plan outlines what greenhouses gases are and demonstrates their impact on the atmosphere through a simple experiment.	Ice Cubes - 3 x plastic 2 litre bottles or large glass jars – Scissors - Sunny window ledge or a lamp - Cling film - Vinegar – Teaspoon - Baking soda/ sodium bicarbonate - 3 x plastic cups that fit inside the bottles/jars - Marker pen - Stopwatch.

LESSON PLAN NOTES

Since the start of the industrial revolution, humans have been extracting fossil fuels such as oil, coal and gas and burning them for energy. The energy produced has driven human development and expansion across the world.

Burning these fossil fuels and other activities emits gases into the atmosphere that are very good at trapping and emitting the heat that is reflected from the earth's surface when it is warmed by the sun. These are called greenhouse gases. The main greenhouse gases and common sources are:

- **Carbon Dioxide** (the main gas) - Burning petrol, diesel, gas, and coal, and some manufacturing processes.
- **Methane** - Gas leaks, gas extraction, ruminant animals like cows and sheep, organic waste in landfill.
- **Nitrous Oxide** – Burning fuels and the use of nitrogen-based fertilizers on agricultural land.
- **Fluorinated Gases** – Aerosol cans and leaks from refrigeration.

Water vapour is also a greenhouse gas, but this forms part of the water cycle and any additional vapour from human activities doesn't stay around long enough to create additional warming. This is why we focus on carbon dioxide and other gases.

Human activities have continued to add these gases into the atmosphere much faster than carbon dioxide can be removed and stored by trees and vegetation. As a result, greenhouse gas concentrations in the atmosphere have grown significantly creating a world that is approximately 1.1°C warmer than it was in the late 1800s – that is a lot of additional energy being trapped.

This additional warming is causing global long-term weather patterns and temperatures to change, called Climate Change. This causes more extreme weather such as high temperatures, droughts, flooding, more powerful storms, and also rising sea levels which can have a significant impact on society and nature, including:

- Damaged homes
- Poor health and strain healthcare services
- Food shortages and cost of living increases
- Economic impacts
- Loss of business

To address this problem, countries around the world have agreed under the Paris Climate Agreement to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels". To do this, countries, organisations and people are reducing their greenhouse gas emissions by being more energy efficient, producing energy through renewables, using greener ways to travel, and buy more sustainable products. Any remaining emissions are hoped to be balanced by nature and carbon capture removing and storing carbon dioxide from the atmosphere. This is called Net Zero.

Greenhouse gases are invisible, and climate change is a relatively slow process compared to our fast-paced lives, so it is easy to not see these problems occurring.

This activity looks to show climate change happening in real-time through an experiment that reacts vinegar and sodium bicarbonate to create high levels of carbon dioxide in an enclosed environment. The effects of high levels of carbon dioxide can then be observed through the use of melting ice and thermometers.

ACTIVITY NOTES

Learning Objectives

By the end of the session, learners will be able to:

- Understand what a greenhouse gas is and where man-made greenhouse gases come from.
- Recognise and measure the effects of high levels of carbon dioxide in the experiment and applying that to the wider world.
- Begin considering how man-made greenhouse gases can be reduced.

Activity Notes

Ask Learners;

- Which set of ice do you think will melt the fastest?
- What is the effect of the clingfilm?
- What is the purpose of Bottles A and B?
- What is the effect of carbon dioxide?
- What improvements could you do to this experiment to represent the earth (e.g., land, clouds)?

Other Notes

- The reaction between vinegar and sodium bicarbonate is endothermic, meaning it reduces in temperature and does not add heat into the atmosphere.
- Sea level rise mostly occurs from land-based ice melting (e.g., Greenland and Antarctic ice sheets) and the melt-water entering the sea. Sea ice already displaces the majority of its mass, so it has much less of an effect when it melts.

ACTIVITY INSTRUCTIONS

Experiment

Place your learners into groups, so they can work together creating the following experiment.

Step 1 - Take the 2 litres bottles and cut each one in half, retaining the bottom half. The top section should be kept for future use or recycled.

Step 2 - Label each bottle A, B and C.

Step 3 - Bottle A: Earth with no atmosphere; Bottle B: Earth with a thin atmosphere, Bottle C: Earth with an atmosphere with additional carbon dioxide.

Step 4 - Place an equal amount of ice into each bottle filling to at approximately 25%. The more ice, the more noticeable the effect will be.

Step 5 - Add 3 teaspoons of bicarbonate of soda into a plastic cup and put this inside Bottle C with the ice. Place an empty cup on the ice in Bottles A and B. These bottles can be compared with the Bottle C.

Step 6 – Using cling film, cover the top of Bottle B and ensure is it sealed. Bottle A does not require clingfilm.

Step 7 – For Bottle C, slowly add vinegar into the cup. This will start reacting with the sodium bicarbonate to create carbon dioxide. The reaction will result in a foam being produced, stop pouring when the foam nears the top of the cup to avoid overspill. Now cover the bottle with cling film to trap the carbon dioxide.

Step 8 - Place all three bottles on the window ledge to expose them to sunlight or use a big lamp to represent the sun if it's a cloudy day.

Step 9 – Every 15 minutes, monitor how much of the ice has melted in each bottle drawing a line at the level.

Step 10 – Ask the learners to discuss what is happening in their experiment and how their observations might be occurring in the wider world.

Step 11 – Using the other Wales Climate Week lesson plans or School Climate Toolkit, you can engage further with learners to discuss ideas to reduce greenhouse gas emissions at school and home.

Observations

In this experiment, learners should observe the ice in Bottle C is melting more quickly than Bottles A and B. This is because the water vapour and carbon dioxide from the reaction is trapped by the clingfilm, that when exposed to light retains the heat more effectively than the other bottles

Bottle B should see ice melting more quickly than Bottle A because it has a thin atmosphere created by the clingfilm.

Activity adaptations

- Place a thermometer inside each bottle (away from the ice) and observe how the temperature changes over time.

RECAP

- The experiment is looking to replicate the continued emission of greenhouse gases from burning fuels.
- Carbon dioxide and other gases trap the earth's heat when it is warmed by the sun.
- A warmer atmosphere changes weather patterns and causes ice to melt such as glaciers and ice sheets.
- As we continue to burn fossil fuels, global warming and climate change will continue.
- Learners should observe that additional carbon dioxide in Bottle C is causing the ice to melt by trapping heat from the sun or lamp. They should consider how this is occurring in the wider world and what solutions are available now.

Net Zero Activity

Time needed for session:	Location:	Context:	Equipment:
15 minutes	**Classroom**	**Demonstrate the current greenhouse gas problem, and solve it to meet Net Zero**	**Items such as balls, Lego bricks or similar to represent greenhouse gases.** **A container, tray or hula hoop (representing earth's atmosphere)** **Emission Source Cards** **Emission source solutions**

LESSON PLAN NOTES

This activity investigates the balance of greenhouse gas emissions and removals in the atmosphere in the present day and where they need to be in the future to stop further global warming.

Pre-Industrial Revolution – Atmospheric greenhouse gas concentrations have been in relative balance for thousands of years before humans industrialised, gradually fluctuating due to natural events.

Present Day – By burning fossil fuels in power stations, factories, cars and homes, humans are adding more greenhouse gas emissions into the atmosphere than are removed by trees and other vegetation.

Future Need – Man-made greenhouse gas emissions are reduced, and carbon removals have increased through activities like tree-planting. The quantity of emissions and carbon removals are equal (Net Zero).

Organisations and countries around the world have set Net Zero targets where they are currently reducing their greenhouse gas emissions as much as possible. For Wales, there is a target to reach Net Zero by 2050, and the Welsh Public Sector has ambition to reach this by 2030.

By making strong efforts now to achieve Net Zero, humans will limit the amount of global warming to the internationally agreed targets.

ACTIVITY NOTES

Objectives

- Demonstrate the Present Day and Future balance of man-made greenhouse gasses in the atmosphere.
- Learners understand how different changes to human activity can help address global warming.

ACTIVITY INSTRUCTIONS

Step 1 – Split learners into two groups. Group 1 are emission sources, and Group 2 represent carbon removals (e.g., trees and other vegetation). Place the groups opposite each other with a container/hula hoop that represents the earth's atmosphere in between them. Place a few items (greenhouse gases) inside the 'atmosphere' to represent the natural quantity of greenhouse gases.

Step 2 - Provide Group 1 with a box of items (e.g., balls, Lego, card, etc.). These will represent greenhouse gases.

Step 3 – Using the Net Zero Power Point slide 2, show examples of emission sources, explaining what emission sources are and how too many of them are currently going into the atmosphere. There should be a high number of learners in Group 1 that are representing the emission sources. Next state how human development has removed a lot of trees and habitat. Group 2 should have about a quarter of learners compared to Group 1.

Step 4 - On the count of three, ask each member of Group 1 to add an item (Greenhouse gas) into the 'atmosphere' one at a time as quickly as they can. At the same time, ask each member of Group 2 to remove one item at a time from the 'atmosphere' as quickly as they can. The number of items in the 'atmosphere' will grow as Group 1 can add more greenhouse gases than Group 2 can remove.

Step 5 – Explain this is the current situation with our atmosphere, and that more greenhouse gases are causing the earth to warm resulting in climate change.

Step 6 – Reset the 'atmosphere' as in **Step 1**. Using the Net Zero Power Point slide 3, present a number of solutions to man-made emission sources. Using slide 4, ask learners to match the solution to the emission source.

Step 7 – With emission sources matched to their solution, emissions will be reduced and removals increased. Put an equal number of learners in each group and repeat **Step 3**. During the activity, the number of items in the 'atmosphere' should not change as there is balance between emissions and removals.

This is Net Zero. Achieving this status will stop global warming from increasing further.

RECAP

- Ask learners to describe what net zero means.
- Discuss with learners what activities they do at home that creates carbon emissions, and what they can do to reduce them.

Statistics

Flintshire County Council is working towards the Public Sector Net Zero target of 2030, and Wales is aiming for Net Zero by 2050.

The earth is currently 1.1°C warmer than it was since the late 1800s.

Globally agreed targets are aiming to limit this to well below 2°C, with efforts to achieve 1.5°C. Net Zero targets and pathways aim to achieve these targets.