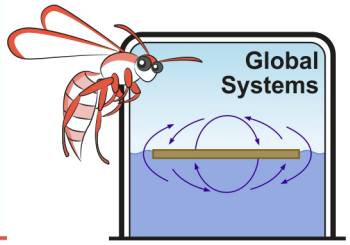


Carbon Offsets – Teacher Notes

Adapting to a Changing Climate

The issues associated with the current changes in the climate can be overwhelming for students. This resource highlights some of the positive actions that are being adopted globally to adapt to the changing climate and demonstrates that individual actions can contribute.

Background
Through geological time, Earth's climate has fluctuated, including cycles of extreme warming and cooling which have impacted on the plant and animal species that inhabit the planet.

There is clear evidence to indicate that the Earth is currently in a trend of climatic warming. This change is rapid and is most likely (>95% probability) as the result of human activity (NASA Global Climate Change, 2021).

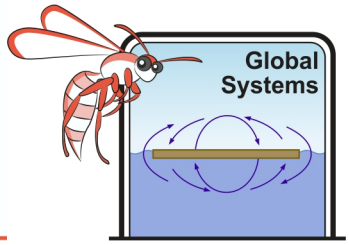
NASA has been monitoring long term changes in the global climate and, in 2008, reported nine indicators of rapid climate change.

- Global temperature rise
- Warming ocean
- Shrinking ice sheets
- Glacial retreat
- Decreased snow cover
- Sea level rise
- Declining Arctic Sea ice
- Extreme events
- Ocean acidification

ACTIVITY: Visit https://climate.nasa.gov/evidence/) to complete the table of rapid climate change indicators.

Indicator	Change
Global temperature rise	Average surface temperature rise of 1.18^{0}C since the late 19thC
Warming ocean	Top 100m of ocean warming more than 0.33^{0}C since 1969
Shrinking ice sheets	Greenland lost an average of 253 billion tonnes of ice per year between 1993 and 2019; Antarctica lost about 134 billion tonnes of ice per year
Glacial retreat	Global glacial retreat
Decreased snow cover	Spring snow cover in the northern hemisphere has decreased over the past five decades and snow is melting earlier
Sea level rise	Global sea levels rose about 20cm in the last century, rate is accelerating
Declining Arctic Sea ice	Extent and thickness of Arctic Sea ice has rapidly declined over the last several decades
Extreme events	Number of record high temperature events is increasing; number of record low temperature events is decreasing
Ocean acidification	Acidity of surface ocean water has increased by about 30%

Source: https://climate.nasa.gov/evidence/



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Locally, communities are noting changes to their surrounds that can be attributed to a warming climate. Recent studies have identified impacts on humans such as loss of homes and agricultural lands with a rise in sea level, and changes to animal behaviour including an alteration to the wintering sites of marine animals (Reyes-García, V., Fernández-Llamazares, Á., Guèze, M., Garcés, A., Mallo, M., Vila-Gómez, M., & Vilaseca, M., 2016).

Global Action

Source: United Nations

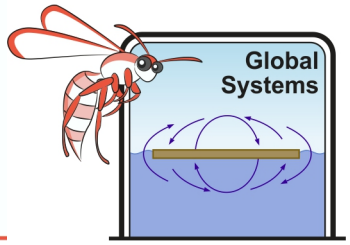
Leaders around the world have recognised that global warming is a major environmental issue that will change the way we live. In 1997, the United Nations (UN) established a goal to maintain or decrease atmospheric greenhouse gas concentrations at their current levels across the planet. By achieving this goal, the UN Sustainable Development Goals will also be achieved.

A collaborative commitment to this goal was made by 195 countries through the Intergovernmental Panel on Climate Change (IPCC).

The commitments are detailed in two agreements – the Kyoto Protocol and the Paris Agreement (United Nations Framework Convention on Climate Change, 2021).

The Kyoto Protocol

The main goal of the Kyoto Protocol is to control greenhouse gas emissions from human activity. Enacted in 2005, industrialised nations formed an agreement to reduce their annual greenhouse gas emissions in accordance with the Protocol.



Carbon Offsets – Teacher Notes

Seven greenhouse gases were targeted for reduction:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Perfluorocarbons (PFCs)
- Hydrofluorocarbons (HFCs)
- Nitrogen trifluoride $(NF_3)_3$
- Sulfur hexafluoride (SF_6)

Each of these greenhouse gases traps reradiated infrared radiation from the Earth's surface, leading to warming. Carbon dioxide (CO_2) is the most common greenhouse gas released by human activity. It is assigned a global warming potential (GWP) of 1. The GWP of the other greenhouse gases are measured against CO_2, providing an indication of their impact on the warming climate. This measure is called the carbon dioxide equivalent, or CO_2e.

The table below compares the GWP of the seven greenhouse gases.

ACTIVITY: Research to identify the main source of each of these greenhouse gases

Gas	Global warming potential (GWP)	Source
Carbon dioxide (CO_2)	1	Burning fossil fuels
Methane (CH_4)	25	Intensive agriculture
Nitrous oxide (N_2O)	298	Intensive agriculture / land use change
Perfluorocarbons (PFCs)	12 200	Aluminium production process
Hydrofluorocarbons (HFCs)	14 800	Refrigerator and air-conditioner coolant
Nitrogen trifluoride $(NF_3)_3$	17 200	Refrigerator and air-conditioner coolant
Sulfur hexafluoride (SF_6)	22 800	Insulators in electrical equipment

ACTIVITY: Calculate the CO_2e from the release of the following amounts of greenhouse gases

Amount of Gas	GWP	Calculation	CO_2e
1kg methane	25	1kg CH_4*25	25kg
20g SF_6	22 800		456kg (456 000g)
1 tonne CO_2	1		1 tonne
500g $(NF_3)_3$	17 200		8 600kg (8 600 000g)
1.5kg N_2O	298		447kg
50g Hydrofluorocarbon	14 800		740kg (740 000g)

Carbon Offsets – Teacher Notes

Industry Actions

Source: World Economic Forum

The Paris Climate Agreement

The Kyoto Protocol was live until 2020. This is replaced by the Paris Agreement, in which nations agree to individual actions to reduce their greenhouse gas emissions through long-term development strategies.

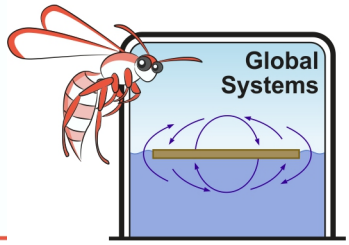
Under the Paris Agreement, countries, regions, cities, and companies are establishing targets to reduce the amount of atmospheric greenhouse gases. One of the actions that can be taken to reduce atmospheric greenhouse gases includes creating carbon offsets.

Actions to generate carbon offsets include planting trees and protecting natural areas from deforestation to remove greenhouse gases from the atmosphere or installing renewable energy generators to reduce and prevent emissions. Being a global issue, the activity can occur across the world, often providing economic and social benefits to the local communities in which these projects take place.

Meeting net zero targets – carbon offsets

Emissions reduction activities can measure how much an action reduces the amount of greenhouse gas released into the atmosphere or how much it removes. An emissions reduction activity can:

- Prevent the release of greenhouse gases, e.g., switching to 100% renewable energy power generation
- Reduce the amount of greenhouse gas that is released, e.g., using a hybrid system to generate power
- Remove greenhouse gases that are already in the atmosphere, e.g., planting trees to remove CO_2



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The Paris Agreement has set clear goals for greenhouse gas emission reductions. This has provided the opportunity for Australian companies, both large and small, to set emission reduction goals in accordance with the goals of the Paris Agreement.

Review the following sites to compare the two case studies below:

Case Study 1: Large Industry – Woodside Energy Ltd
AIM - net zero in their direct emissions by 2050 or sooner
Part of a lower carbon future, November 2020

Case Study 2: Small Industry - Red Rock Drilling
AIM - net zero in their direct emissions, effective immediately
Resourc.ly, February 2021

ACTIVITY: Use your research to complete the table

Industry	Emissions reduction and carbon offset activities
Woodside Energy Ltd	• Alternative energies – hydrogen • Research carbon capture and storage options • Battery storage for power generation offshore; increased operational efficiency • Native tree planting • Acquiring and protecting reserves
Red Rock Drilling	• Switch to renewable energies for appliances • Change office lights to LED alternatives • Vehicles with lower CO_2e outputs • Support the Chakala Wind Power Project in India

Individual – my CO_2e?

The warming climate is a global issue. Each of us contributes to the amount of greenhouse gases in the atmosphere. How much do we contribute individually? As individuals, can we offset our own carbon emissions?

The first step is to measure our CO_2e. As a starter, the following activity investigates one component of our daily life – how we get to and from school each day.

ACTIVITY: Work through the activity steps to calculate your CO_2e for your commute. Calculate for your most common daily transport form.

1. Work in groups of four students
2. Using the following website, complete the details for each member of your group: https://www.greenvehicleguide.gov.au/. Use Google Maps to accurately measure the distance of your return journey from home.

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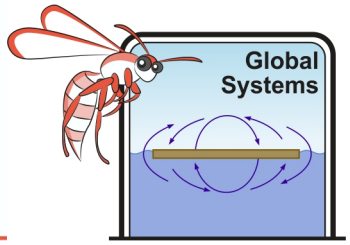


Student name	Transport type	Fuel type	Tailpipe CO_2 – Urban (g/km)	Return distance from home to school (km)	Calculate CO_2e (g) (CO_2*distance)
			AVERAGE		

Worked Example:

Student name	Transport type	Fuel type	Tailpipe CO_2 – Urban (g/km)	Return distance from home to school (km)	Calculate CO_2e (g) (CO_2*distance)
W	Honda Jazz VTi	Petrol	181	12	2172
X	Land Rover Discovery Sport 180D	Turbo Diesel	206	16	3296
Y	Toyota Prius 1.8L	Hybrid – Electric / Petrol	78	12	936
Z	Bike		0	6	0
			AVERAGE	**(W+X+Y+Z)/4 = 1601**	

3. Create a column graph of the CO_2e for each student.

4. Calculate the average CO_2e of the group (add each student's CO_2e and divide by the number of group members)

5. Discuss your thoughts on being assigned an average CO_2e if you rode your bike or walked to and from school (i.e., moving from zero CO_2e to an average CO_2e)

   Relate this to the global issues of a warming climate if you are a nation or organisation which has low greenhouse gas emissions.

6. If you have time, construct a table or graph of group CO_2e averages for the class and discuss.

7. Extension:

   Design an investigation to measure other ways in which you release greenhouse gases.

Carbon Offsets – Teacher Notes

Source: Wikimedia

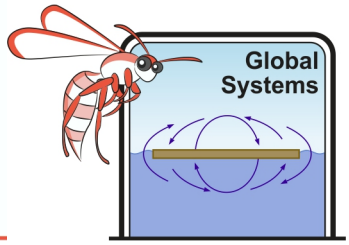
Now that you have a measure of how much CO_2e you generate each day, you can start to investigate ways to offset your greenhouse gas emissions.

ACTIVITY: In your groups, suggest activities to offset your carbon. Research how much CO_2e each activity will offset and record in the table.

Student	Prevent	Amount of CO_2e offset	Reduce	Amount of CO_2e offset	Remove	Amount of CO_2e offset
	Walk or bike to school	individual	Catch the bus; carpool	Calculation required	Plant trees	Approximately 20kg p.a. / tree

To get you started, consider the following:

- Find ways to get to and from school without generating CO_2e
- Participate in a local planting event
- Plan a space in the school / community for tree planting
- Calculate the carbon footprint of your school and investigate ways to reduce this at https://www.climateclever.org/schools
- Visit https://www.gviaustralia.com.au/blog/6-critical-global-issues-what-are-the-worlds-biggest-problems-and-how-i-can-help/
- Explore other ways you generate CO_2e by calculating your Carbon Footprint at https://calculator.carbonpositiveaustralia.org.au/



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Future thinking

IS IT POSSIBLE TO REMEDIATE A GLOBAL PROBLEM?

Research other examples of nations collaborating across the world to manage a global issue, e.g. Reducing the use of chlorofluorocarbons (CFCs) to prevent excessive depletion of the ozone layer.

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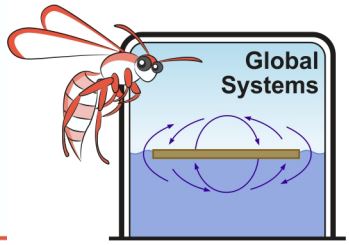

AUSTRALIAN CURRICULUM MAPPING

Science understanding

Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)

Elaborations

Investigating how human activity affects global systems

Modelling a cycle, such as the water, carbon, nitrogen or phosphorus cycle within the biosphere

Explaining the causes and effects of the greenhouse effect

Investigating currently occurring changes to permafrost and sea ice and the impacts of these changes

Science as a human endeavour

Use and influence of science (ACSHE16 and ACSHE228)

Science inquiry skills

Processing and analysing data and information (ACSIS169 and ACSIS170)

Evaluating (ACSIS172)

Communicating (ACSIS174)

Cross-curricula priorities

Sustainability