2040 - Reducing Our Carbon Footprint

Name

Class

Teaching Sequence

Work through this resource material in the following sequence:

15 minutes – Part A: The Weight of Greenhouse Gas
15 minutes – Part B: CO_2 in the Atmosphere: Australia vs. The World
25 minutes – Part C: Our Carbon-Saving Household
10 minutes – Reflection

Part A: The Weight of Greenhouse Gas

Step 1.

If you completed the first lesson, **2040 - The Maths of Carbon - Years 5 & 6**, you might like to use the **Summary slides** to review the key points covered.

If you have **not** completed the first lesson in this Unit, **2040 - The Maths of Carbon - Years 5 & 6**, here are two short videos that explain climate change:

[Climate Change Explained in Less than 2 Minutes]

[2040 - Exploring the Themes] **Password: 2040_EDU**

Revise the following points with your class by way of introduction:

- Carbon Dioxide is not a large proportion of atmospheric gas, but it’s an important one. This is because CO_2 traps and holds *heat* in our atmosphere.
- We can graph a line graph that shows the *increase in CO_2 concentrations* since about 1950 - and show that this corresponds with an *increase in average temperatures* as our atmosphere has warmed up;
- This is definitely messing with our climate. We really need to take action now by *both* reducing *and* ‘drawing down’ carbon in the atmosphere.
- Fortunately, there are various ways we can do this…

Step 2.

Explain to students that today we’re going to look at a measure for CO_2 emissions, that is, CO_2 that has been released into the atmosphere by human activities. This is often referred to by scientists as ‘CO_2e' or 'carbon dioxide equivalent’. Importantly, we can consider and measure the amount of CO_2 produced by each of us as individuals, and within our families or households.

Let’s start with a container of water. This time have a container that can fit exactly one litre (1000 mL) in it:

For this demo, you’ll also need a one litre container of another denser substance (eg. custard, a litre of small pebbles); a container of less dense substance (eg. penne or rigatoni dry pasta); and a litre of water to fill the container.

You’ll also need a kitchen measuring scale; the electronic ‘nutrition scales’ are the best to use as you can easily set them to zero with the container sitting on the scale. If you don't have access to that sort of scale, you may just need to note and subtract the weight of the empty container.

What we want to show students here is that different substances - liquids, solids, and gases - have different densities, which means they weigh more or less in the same given volume. As you work through this activity in the following steps, invite students to fill in the weights of each substance on the Student Worksheet.

Step 3.

Set the nutrition scale to zero, then start with filling the litre container with water to exactly the 1000 mL mark - remind students that this is 1 Litre. Ask "*What do we notice the weight is?"* The weight of 1,000 mL of water is 1,000 grams - or exactly 1 kilogram. This is because we actually take the weight of 1 kg from exactly 1 Litre of water. Explain this to the students. Invite students to record this weight on the Student Worksheet.

Step 4.

Now, you will be looking at the weight of some other substances - say, the pebbles. Fill the 1 litre container with pebbles, up to the 1 Litre mark. Now, what's the weight? It should be a lot more than one kilogram. Invite students to record this weight on the Student Worksheet.

Ask students, *"What do we notice about the weight now?*", then *"Can anyone suggest why this is?"*

After discussion, explain this is because the pebbles are a solid and are much denser than water, which is a liquid. This literally means that the molecules of rock in pebbles are much closer together, so there's more 'stuff' in the pebbles within the same one litre volume.

Optional Extension: What is a molecule?

If this is a question your students ask - and it's a great question - then a quick crash course in molecular physics might be just the thing.

- *A molecule is a bundle of atoms that are bonded together by their chemical properties, to make up a chemical substance - such as water ('H_2O'), carbon dioxide (CO_2) or simple sugars.*
- *An atom is a tiny particle made up from numbers of protons, neutrons, and electrons, that make up the chemical building blocks from which molecules are structured. For example, water molecules are made up from two atoms of Hydrogen and an atom of oxygen; carbon dioxide molecules are made up from a carbon atom bonded with two oxygen atoms; sucrose molecules are made up from much more complex bundles of carbon, hydrogen, and oxygen.*

Step 5.

Ask for a prediction from students about the weight of the penne pasta (or other less dense substance) and have students record the actual weights in the space on the Student Worksheet.

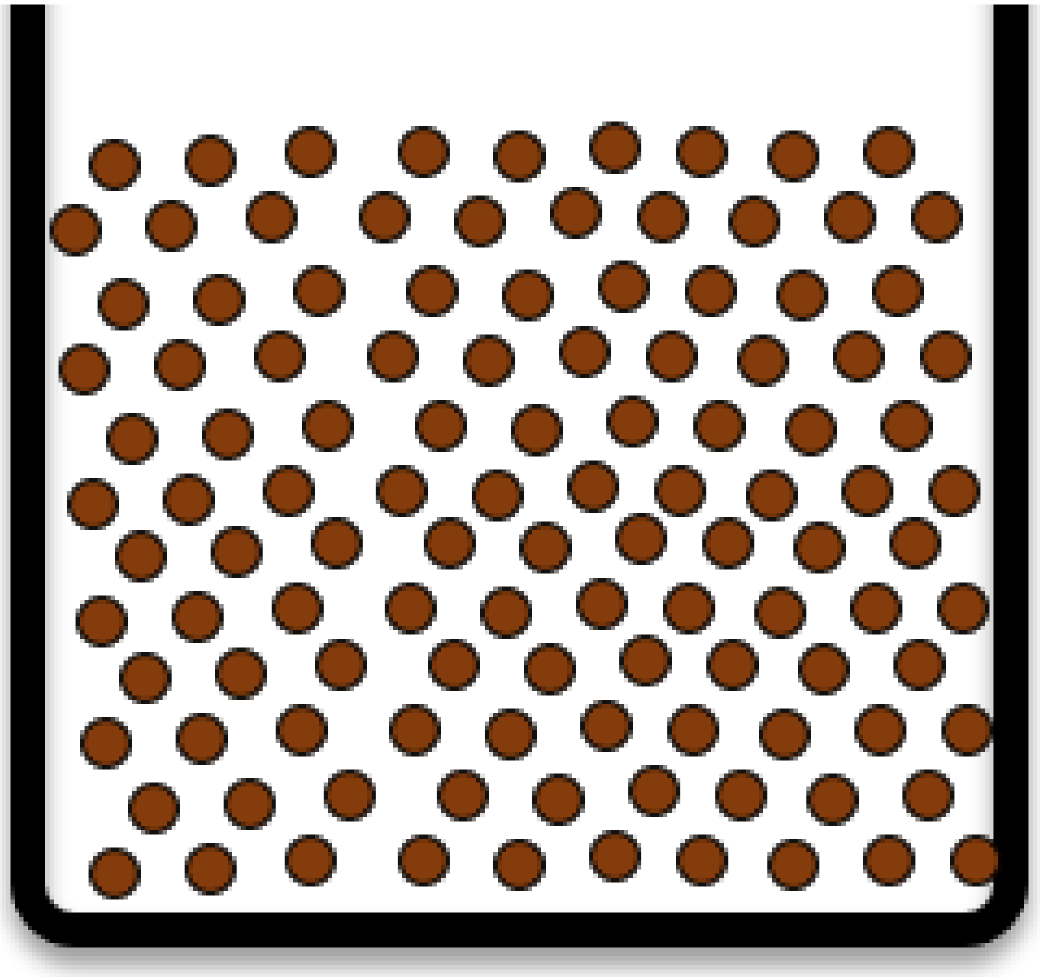
Eg. "What do you think will happen with the weight of a litre of penne pasta?"

Weigh the litre of pasta (it should be much less than 1 kilogram), have students record it and then ask,

"Pasta is a solid… why is this so light?"

After discussion, reinforce that the reason that the pasta is so light is that the holes or gaps in the pasta shells contain air (which is a type of gas) and gas is much less dense than most liquids and solids at room temperature. In gases (such as the mix of gases that make up our 'air' at room temperature), the molecules are much further apart and so there is less 'stuff' in a given volume (such as one litre) of gas.

A simple diagram on the board can be drawn to illustrate this:



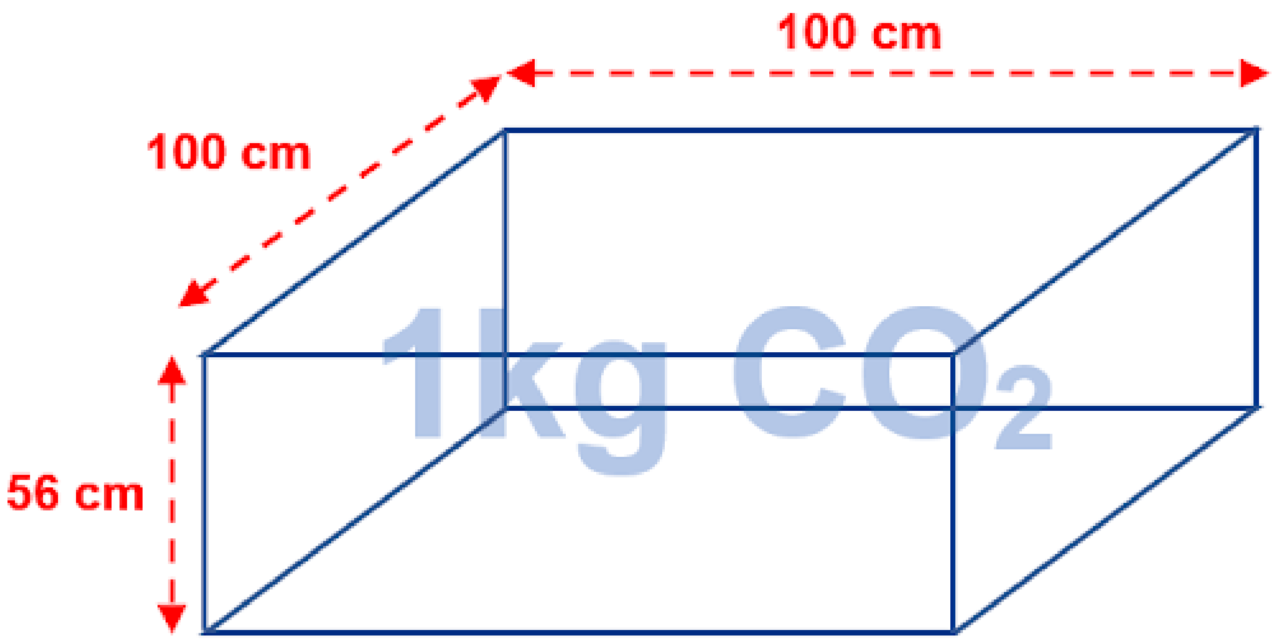
Solid – Molecules close together = more ‘stuff’ in a given volume (denser and heavier)

Step 6.

To finish this section, explain that as a gas, CO_2 is not at all dense - but it does still have weight. This means that a whole kilogram of CO_2 would take up a lot of space.

In fact, let’s make it easy. Explain and/or write up onto the whiteboard:

“1 kg of CO_2 at room temperature (and not under any pressure, such as pushed into a gas bottle or cylinder) would take up the same space as a large container that measures:



100 cm x 100 cm x 56 cm = 560 000 cm3

Note: This image can be downloaded here.

Step 7.

At this point, you could take the opportunity to remind students of the calculation of cubic capacity (as shown above), and then have them convert this into a volumic measure. Remind the class that 1 cm^3 = 1 mL in volume, and there is 1,000 mL in 1 Litre.

Ask students, “so, what would be the volume taken up by 1 kilogram of CO_2 (at normal room temperature), in Litres?' Answer- 560,000 cm^3 capacity = 560,000 mL volume = 560 Litres.

To give students an idea in practical terms, just 1 kg of CO_2 gas takes up the same amount of room as a large car boot or a small refrigerator.

Optional Extension: The Carbon Cycle

If you would like to explore with the class how carbon behaves in the environment consider the following activity.

When CO_2 is ‘drawn down’ from the atmosphere - such as when it is absorbed by plants - it’s transformed by the process of photosynthesis into more stable molecular compounds. Oxygen from the CO_2 is released into the atmosphere and the carbon atoms are stored in more complex and stable molecular structures within solids such as sucrose (simple sugars).

When plants and animals die and break down on the surface of the Earth, or are burned, the carbon atoms are again oxidised and released back into the atmosphere as carbon dioxide. This process of carbon drawdown, sequestering and return into the atmosphere is known as the **carbon cycle**. You might like to share this **video** with your students.

You might like to show students this picture from ***2040: A Handbook for the Regeneration*** to demonstrate how carbon is stored and distributed:

Part B: CO_2 in the Atmosphere: Australia vs The World

Step 1.

Now your class knows what the volume of a kilogram of CO_2 is, they can start thinking about just how much CO_2 is used by people daily - and also how much can be saved from going into the atmosphere through renewable energy technologies like solar energy, and incredibly how much can be absorbed by trees and other green plants. Explain to the class that thinking about our daily use of carbon is will be the next part of this class.

Step 2.

Explain that you will be showing a clip from the documentary 2040 that explores energy use that actually helps solve some of the problems with carbon in the atmosphere that they have been exploring.

Challenge students to keep their eye out for the ‘ice cart’ at the start of the video. The load of ice on the back of this man’s cart is about the same volume as 1 kg of carbon dioxide, at room temperature - about 26 degree Celcius.

Now, show this clip from 2040:

What's Your 2040 - For Energy? Password: 2040_EDU
(https://vimeo.com/showcase/6167669/video/336504721)

Step 3.

Invite students to use the 'Connect, Extend, Challenge' framework on the Student Worksheet to summarise their thoughts, those of their partner and then those of the whole class, before proceeding.

Connect – Extend – Challenge

Connect: How are the ideas presented connected to what you already knew?
Extend: How has this information extended your understanding of this topic?
Challenge: What is still challenging to you? What questions do you still have about this topic?

Take 3 to 6 minutes to conduct this session and summarise the class's thoughts about the video on the board.

Step 4.

Putting some metrics around the carbon footprint of Australians can be a bit depressing - and that's NOT the intention of this lesson. Unfortunately, the fact is we have one of the largest carbon footprints in the world, at over 15 metric tonnes* per person per year, largely due to our reliance on coal-fired electricity and on petrol motor vehicles. (See https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?view=map)

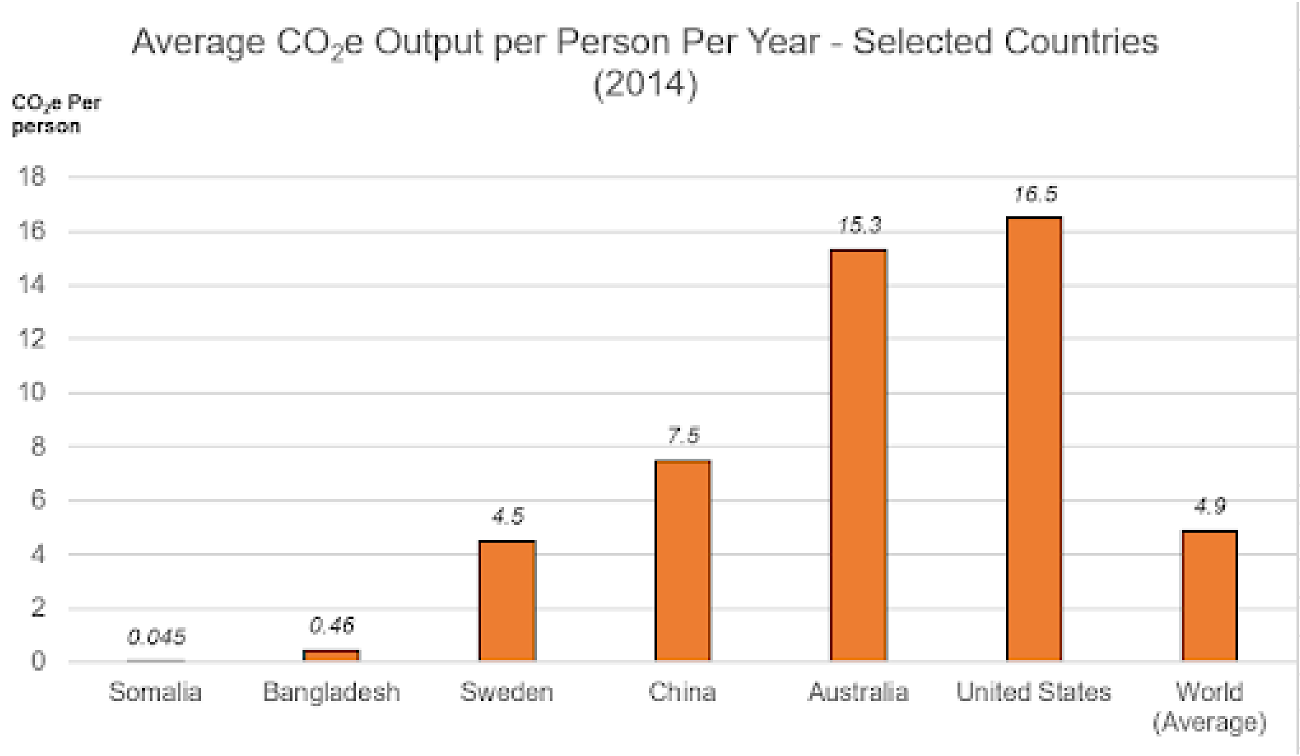
Distinguishing between 'tonnes' and 'tons'. Care should be taken here, especially if students are investigating mass or weights on the Internet, to draw the distinction between an Imperial 'ton' and a metric 'tonne'. The USA still routinely use the Imperial measure of 'ton', which is 2,000 pounds (another Imperial measure). A 'metric tonne' (or 'metric ton' if in the USA, Canada or the UK), refers to 1,000 kilograms. To convert USA Imperial tons into metric tonnes, we need to multiply by 0.907185; to reverse this (ie, tonnes into tons), multiply by 1.10231.

Explain to the class that according to 2014 figures from the World Bank, the world average carbon footprint is 4.9 metric tonnes. When you look at the CO_2 output of the average Bangladeshi in a year at only 460 kg (0.46 tonnes), our carbon footprint is massively disproportionate. We Aussies really need to start to shed our ‘Carbon Kilos’ - and fast. That is what your students will be working on today to build a better tomorrow.

Step 5.

Start your explanation for your students by popping those three figures up on the board and/or showing them **this graph**:

- Average Aussie CO_2 output per year = 15.3 metric tonnes
- Average Swedish CO_2 output per year = 4.5 metric tonnes
- Average World CO_2 output per year = 4.9 metric tonnes
- Average Bangladeshi CO_2 output per year = 0.46 metric tonnes.
  (World Bank, 2014)



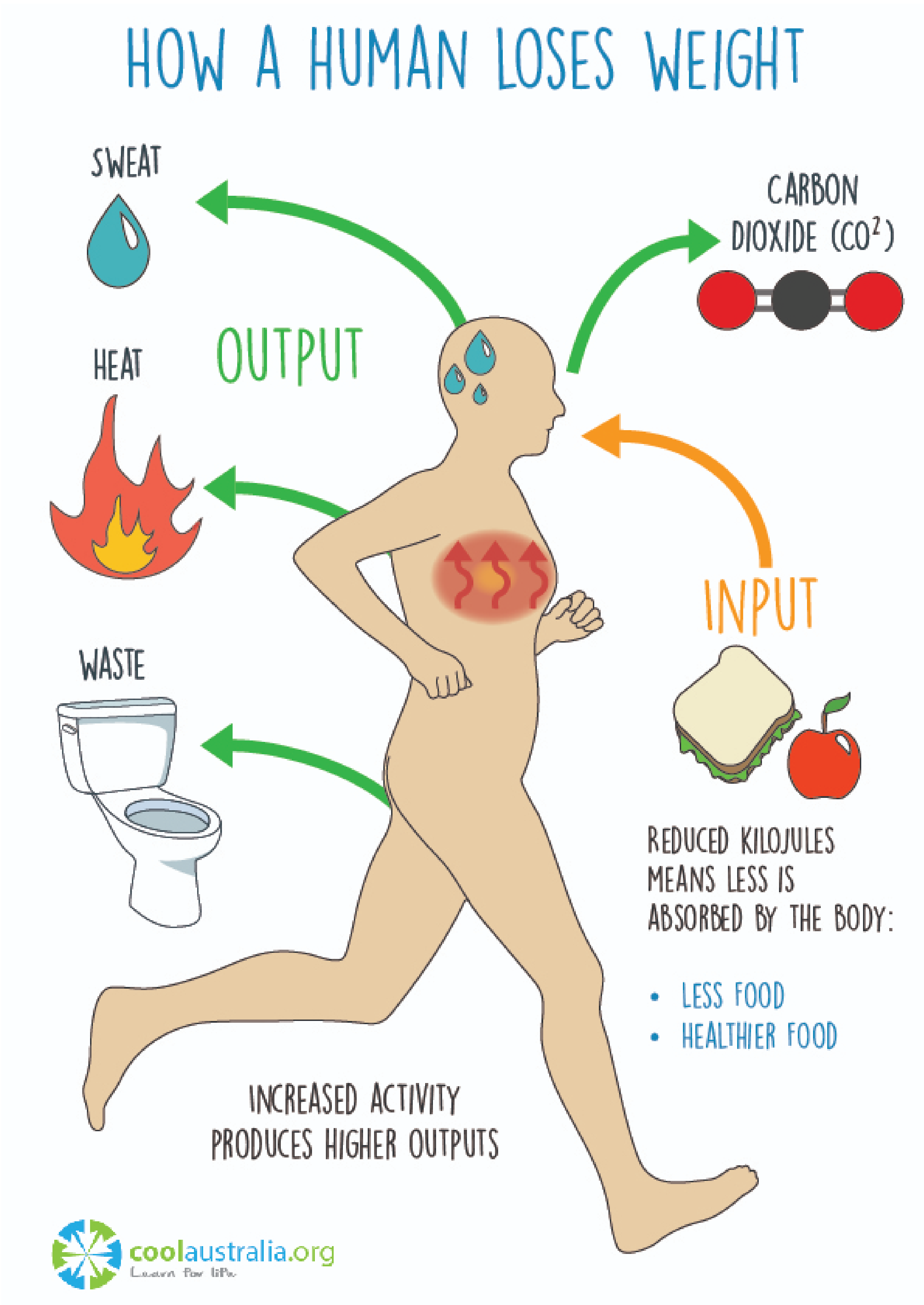
Ask for some comments from your class about these figures. Hopefully, your students will see that, in Australia, we consume more than our fair share of carbon-emitting energy, and that this implies we have an obligation to reduce this!

Step 6.

At this point, ask the class: “When people want to lose weight, what can they do?”

Discuss this with students and then summarise the discussion into two main strategies:

1. People can reduce the kilojoules (energy) going into their body, for instance by eating less, AND
2. People can ‘burn off’ the existing stored kilojoules (energy) in their body by being active and getting regular healthy exercise (which is similar to drawing down carbon).



Explain to students that reducing our carbon footprint - the amount of CO_2 we're responsible for putting into the atmosphere - like the process of an adult trying to gain a healthier weight:

1. We can REDUCE the kilograms of CO_2 going into the atmosphere by consuming less energy and reducing our reliance on fossil fuels, AND
2. We can DRAW DOWN the existing stored CO_2 going into the atmosphere by planting and protecting trees and green plants (which absorb carbon dioxide as they grow and photosynthesise).

Discuss with the class how, in the video, Bangladeshi neighbourhoods had found smart ways of working together to reduce their carbon dioxide emissions through solar energy sharing ‘mini-grids’. However, their reliance on fossil fuels in the first place is very low (not many Bangladeshis drive cars, for instance, and neither do they generate much electricity through coal or gas power plants).

Finally, explain to students that in the next activity, we’re going to play around with some things that CAN help us Australians both reduce our household carbon dioxide emissions, as well as draw down some of the CO_2 that we’ve already put into the atmosphere!

Part C: Our Carbon Saving Household

Step 1.

In this activity, students should ideally work in groups of 3 (one or two groups of 2 will be okay if three can’t work with your class numbers). This is because the average Australian household in 2016 had 2.6 people living there.

To start, each group should be given a ‘house’ (see ‘**Our CO_2 Saver Household**’ Worksheet), that shows that the average Australian household (with 2 to 3 persons) uses about 40 metric tonnes of CO_2 per year (including transport energy). For added ‘classroom dynamic’ (and to prevent ‘cheating' later on), have each team write their names onto their ‘House’ and then pin it on the board out the front of the room.

Each team is also given the full first set of cards, the ‘**CO_2 Saver Choice Cards & Facts**’ (see Resources); there are 8 of them. Do not give the second page of this factsheet with the answers on it yet.

Explain to the class that, without access to the Internet, their teams must decide on which 4 of these strategies (maximum) their household is going to implement, in order to have the biggest reduction on their household’s carbon dioxide footprint.

Give teams about 5 minutes to decide on their 4 strategies. Once they have their 4, they can then come and stick their 4 strategies onto their household out the front.

Step 2.

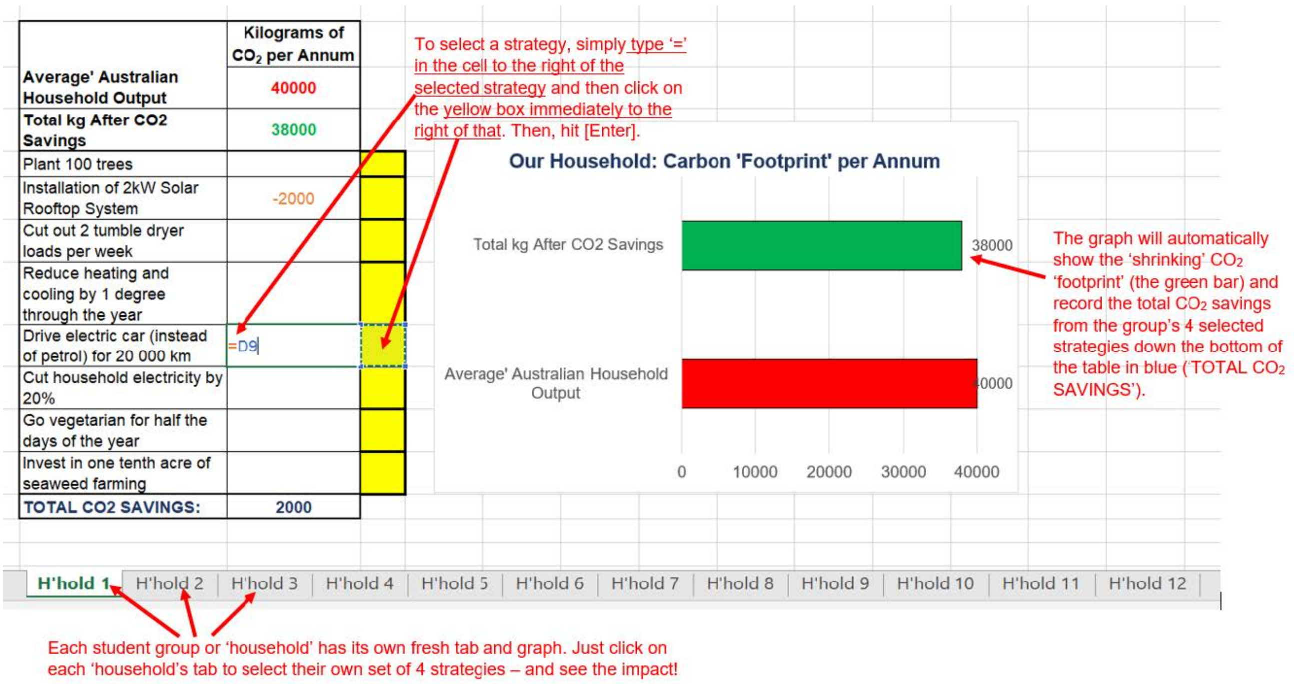
Now for the fun part. Once students have stuck their 4 selected strategies onto their household out the front, have them sit down again.

Hand out the 8 ‘**CO_2 Saver Fact Cards**’; give 1 card each to any 8 students selected at random i.e. one cut out fact card for each of the 8 selected students. In turn (starting with 1 and finishing with 8), have these students read out the fact on their card, and the subtraction instruction in red as well.

As each card is read out, have groups use working paper to work out both the cumulative CO_2 savings they are making with each of their 4 selected strategies, as well as the reduced total CO_2 footprint as they subtract each amount from their total.

Step 3.

Finally, for fun (and checking), use the '**Household CO_2 Calculator**' Spreadsheet to work through the amount of CO_2, in kg per year, that can be deducted from their household (either because they have reduced OR drawn down atmospheric carbon), for each strategy. The graphic will show the effect of each strategy on the amount of CO_2 that can be saved from an annual average household carbon footprint of 40 000 kg (40 tonnes) per annum:



Note: The annotated graphic above can be downloaded, **HouseholdCO2CalculatorDemo**.

Step 3.

Having calculated all teams' CO_2 savings and reduced household per annum footprint, have the following discussion with students:

1. What were the surprises here? Which CO_2 saving strategies were larger than you expected and which were smaller?
2. What were the 4 most effective (biggest impact) strategies?
3. Which strategies do they think would be the easiest for a household to implement? Why?
4. Which strategies do they think would be the hardest for a household to implement? Why?
5. How much CO_2 could a household save by implementing ALL 8 strategies? (Use the spreadsheet to show this!)
6. Even though some of these strategies don't seem to make a big difference overall, why is it still worth implementing them?
7. If the 'households' in our game today were a neighbourhood or small town, how many kilograms (and tonnes) of CO_2 could the neighbourhood save altogether in a year? Optional: How many LITRES of CO_2 would this be? (Refer back to Part 1, showing that 1 kg of CO_2 at room temperature is = 560 Litres).

Reflection

Step 1.

Reinforce for students the following main points:

- *When compared with the rest of the world, Australians have a pretty large 'carbon footprint' because we produce more tonnes of CO_2 per person per year than most other people in other parts of the world - like Bangladesh.*
- *However, just like the community solar grids we were shown in Bangladesh in the video clip from 2040, we can implement simple household strategies, and use existing smart technologies, to both reduce our CO_2 output and to draw down the existing CO_2 in the atmosphere.*

To conclude the lesson, challenge students and have a class discussion around the following points:

- Which two, three, maybe four of the strategies mentioned in Part C could you introduce to your home? What changes could your household and family make, even if it only makes a little difference?
- What if each person in the class's household was able to reduce their carbon footprint by just one tonne (1,000 kg) of carbon dioxide in a year?
- How much carbon saving would that be in the class altogether?
- What about if each class member planted 10 trees? How much carbon would we draw down as a group?
- What if the whole school got involved - how much then?

Step 2.

Perhaps your class - or school - might like to build a 'carbon saving graph' for the classroom wall, to measure just how much carbon savings they can make as a group.

Students could research and estimate the kg of CO_2 per person different environmental measures could make, and have these submitted to a supervising teacher or group of students, and then recorded as carbon savings on the group chart or graph.

Differentiated Learning

Extension - Students could undertake a detailed carbon footprint audit at home and report back to the class. To do this they could use the 'Ecological Footprint Calculator' (**https://www.footprintcalculator.org**), or a similar website, and then simplify the components of their home's carbon emissions budget in a column graph presented to the class.

Provisions for Learning Support -

- Pair students of differing ability in the warm-up and the whole-class group work activity to assist students experiencing difficulty with addition and subtraction of the carbon dioxide kilograms.
- Assist students to break down larger numbers, such as kilograms per annum subtracted and added to overall ‘household’ CO_2 footprints - eg:
  40,000 - 180
  = 40,000 - 100 - 80
  = 39,900 - 80
  = 39,820.

  Hint: Using drawn number lines and bottom-up 100s charts can also assist with these number operations.
- Practice multiplying and dividing by 1,000 to convert between kilograms and tonnes. This will support students experiencing difficulty with unit conversions, eg. ‘How many kgs in 34 tonnes? → 34 x 1,000 = 34,000 kg’; ‘How many tonnes in 3,450 kg? → 3,450/1,000 = 3.450 (or 3.45) tonnes.’

Take It Further

To expand on student's learning in this activity, consider following up with this lesson; **Taking Action For Your 2040**.

Teacher Reflection

Take this opportunity to reflect on your own teaching:

- What did you learn about your teaching today?
- What worked well?
- What didn't work so well?
- What would you share?
- Where to next?
- How are you going to get there?

What's Your 2040?

Record your students' work in their communities with the hashtag #whatsyour2040 and share their visions in the '2040: **The Regeneration' Facebook Group**.

The 2040 crew would love to see your class's work.

These lessons have been created in partnership with

2040, Good Thing Productions