Can we recycle greenhouse gases?

This resource was developed by teachers within the Royal Society Schools Network

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Curriculum key words

Combustion
Climate change
Global warming
Greenhouse gas
Limewater

Curriculum links

- KS3 Science Programme of Study p.9
- AQA Science KS3 Syllabus 3.7.3,
- AQA Science KS3 Syllabus 3.7.4

Equipment needed (optional demo)

- 2 x 2 litre bottle;
- bung with integrated electronic temperature probe;
- methane tap.

Resources

- card sort: which part of society releases the most CO_2?
- pros and cons of using CO_2 to generate electricity.

KS3

Lesson time: 1 hour

Introduction

A key aim of the National Curriculum for KS3 Science is to equip students 'with the scientific knowledge required to understand the uses and implications of science, today and for the future'. Arguably no endeavor is more important than fighting climate change, and students need to be able to understand and make decisions about it.

This lesson shows students that CO_2 is released when fuels are burned, proves that this causes a greenhouse effect, and leads them onto the most up-to-date research into 'green technologies' to mitigate the effects of climate change. Current technologies include greenhouse gas removal, 'green' hydrogen, and, excitingly, the use of CO_2 as a useful resource. This lesson focuses on the latter.

Learning objectives:

- Describe the link between combusting fuels climate change.
- Explain how using CO_2 as a resource could tackle climate change.
- Evaluate the pros and cons of this new technology.
- Use persuasive language to write to a politician.

Can we recycle greenhouse gases?

Starter activity: exploring greenhouse gas

(Approximately 10 minutes)

Pre-prepare a demonstation by setting up two 2 litre bottles by a lamp that gives out a lot of heat (infrared heaters are great for this). Fill one with air and one with methane from the gas tap. In the top of the bottles place bungs with electronic temperature probes threaded through them.

With the class, discuss the what is meant by 'greenhouse gas', and ask the students to write down their individual predictions as to what will happen to the temperature gauges in each bottle. Collect the student's predictions.

Leave the demonstration to run until the end of the lesson (if time, set these up a few hours in advance of the lesson and leave to run for longer. The temperature change is subtle, but helps illustrate that for life-threatening climate change, only small temperature increases are necessary).

Alternative: give students the cards (please see resource appendix) with different uses of energy on. Get them to move these about and suggest an order. The answers are below.

Emissions from	**Megatonnes of CO_2**
Fuel combustion for electricity generation	136.4
Flying, driving, railways, shipping, fishing	118.8
Combustion in business, e.g. refridgeration and air conditioning	68.6
Fuel combustion for heating, cooking, garden machinery etc.	63.4
Industry	12.1
Agriculture	5.2
Waste disposed of in landfill, burning, and the treatment of waste water	0.3

Adapted from The potential and limitations of using carbon dioxide policy briefing from the Royal Society (page 4).

Activity A: what to do about CO_2

(Approximately 45 minutes)

Part A

Discuss with the class their ideas on "How can we *prove* that burning fuels releases CO_2?". Students may recall the limewater test for carbon dioxide (limewater turns cloudy in presence of CO_2).

The following could be undertaken as a demonstration or class practical if students are unfamiliar with the limewater test. Younger students may find the set up tricky, in which case a demonstration would be more suitable.

Choose a fuel to burn (e.g. methane, propanol, wood, coal).

Set up the apparatus as shown in fig 1.

Show that the limewater goes cloudy over time.

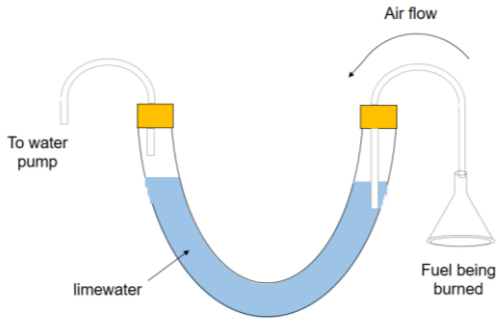


Fig 1. Apperatus set up of limewater test.

You could give different groups different fuels and get them to time how long it takes for the limewater to go cloudy.

As a class, discuss the flaws in this investigation. Key points that should be elicited from the students should include:

- the amount of fuel burned (variable);
- the definition of 'cloudy' for different people;
- If you tried different fuels, the students should find fuels like coal give off more CO_2 than fuels like methane.

Part B

Explain to students that because of the CO_2 released from burning fuels such as these, the Earth is getting warmer which has affected our climate, causing change. Scientists at an important summit decided they needed to limit the Earth's temperature increase to 2°C above pre-industrial levels (this may need explaining).

Watch the Royal Society's short animation An introduction to climate change in 60 seconds (1.00min). You can find more information about each of the areas featured in the video explained on the webpage.

Now the students know the causes and effects of climate change, give them post-it notes and ask them to suggest solutions to climate change. They can be as creative as they like. Stick their post-it notes to the board (see if you can group them according to any themes e.g. carbon capture and storage, renewable energy etc).

Part C

From the animation, the students may remember that the biggest releaser of CO_2 was burning fuels for electricity generation. Ask the students to imagine if they could turn this CO_2 back into a fuel and use it again. We can use CO_2 to make cleaner fuels, polymers, and replace the use of fossil fuels (not entirely…). Scientists are still working to make this technology better, faster, cheaper.

Watch this short YouTube video from VICE on HBO How CO2 Could Be The Future Of Fuel (3:47 min).
Note: this is not made by the Royal Society, and does not necessarily reflect the advice given in their latest policy document *The potential and limitations of using carbon dioxide*.

Students should use the grid of benefits and drawbacks of using CO2 to generate electricity, as well as information from the video, to write to the Prime Minister explaining whether or not they should invest in more research. They can decide either way, but must include some facts and finish with a conclusion.

Pros and cons of using CO_2 to generate electricity

Drawbacks	**Benefits**
Using carbon dioxide as a fuel is only likely to account for less than 1% of global emissions reduction.	5 – 6% of global carbon dioxide emissions could be removed from the atmosphere to make new fuels!
Once carbon dioxide is re-released from the fuels we make, it must be recaptured, which will make it expensive and could use more energy.	Using carbon dioxide to manufacture fuels, chemicals and materials could reduce the need to extract and use fossil fuels.
CO_2 is hard to break down, so needs a lot of energy to turn it into a fuel. Low carbon sources of energy would be needed to do this.	Oil makes the majority of plastics.Oil is running out.
We can't actually do this yet – more research is needed!	CO_2 is an alternative source of fuel, increasing the UK's security of supply and reducing its dependence on oil and gas imports.
Full lifecycle assessments have not been done so we aren't sure how much energy this saves us, and how much CO_2 it removes from the atmosphere.	Fuels from CO_2 have the capacity to be combusted in a cleaner manner (release fewer greenhouse gases).
	Technology to do this can be added to existing buildings – we don't need to spend energy building new ones.

Suggested mark scheme - Award up to 6 marks.

Level 3 (5–6 marks) Answer gives full details of both advantage and disadvantage. Quality of written communication does not impede communication of the science at this level. Gives a conclusion with logical reasoning.

Level 2 (3–4 marks) Answer gives some details of both advantage and disadvantage, or one in full detail. Quality of written communication partially impedes communication of the science at this level. Gives a conclusion based on some evidence.

Level 1 (1–2 marks) Answer relates only to advantage or disadvantage in limited detail, not both. Quality of written communication impedes communication of the science at this level. Level 0 (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.

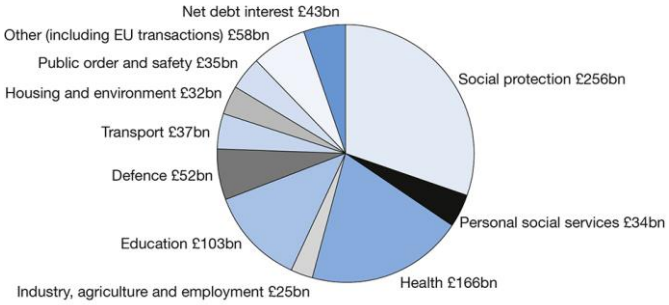
Plenary:

(Approximately 5 minutes)

A lot of 'green technology' like CO_2 for fuel production requires more research by scientists.

How much money do you think governments around the world should invest in this field, as opposed to medical research or space travel? (2018 Government spending is given in the fig to the right for reference).

Don't forget! Go back to the bottles you set up at the start of the lesson and see if the temperatures in the bottles are now different.



Figures may not sum due to rounding.
Illustrative allocations to functions are based on HMT analysis including capital consumption figures from the Office for National Statistics.

Source: Office for Budget Responsibility and HM Treasury calculations.

Fig 2: Budget spending per sector by the UK in 2018.

Resource Appendix: Card sort: which part of society releases the most CO_2?

The following sheet contains four sets of cards. Print out and cut up, or let the students asign a ranking number to each row if used as a table.

Industry		Industry
Flying, driving, railways, shipping, fishing		Flying, driving, railways, shipping, fishing
Agriculture		Agriculture
Waste disposed of in landfill, burning, and the treatment of waste water		Waste disposed of in landfill, burning, and the treatment of waste water
Fuel combustion for electricity generation		Fuel combustion for electricity generation
Combustion in business, e.g. refridgeration and air conditioning		Combustion in business, e.g. refridgeration and air conditioning
Fuel combustion for heating, cooking, garden machinery etc.		Fuel combustion for heating, cooking, garden machinery etc.