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 CO₂ 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 CO₂ as a useful resource. This lesson focuses on the latter.

Learning objectives:

- Describe the link between combusting fuels and climate change.
- Explain how using CO₂ as a resource could tackle climate change.
- Evaluate the pros and cons of this new technology.
- Use persuasive language to write to a politician.

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 CO₂?
- pros and cons of using CO₂ to generate electricity.
Can we recycle greenhouse gases?

Starter activity: exploring greenhouse gas
(Approximately 10 minutes)

Pre-prepare a demonstration 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 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.

<table>
<thead>
<tr>
<th>Emissions from</th>
<th>Megatonnes of CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel combustion for electricity generation</td>
<td>136.4</td>
</tr>
<tr>
<td>Flying, driving, railways, shipping, fishing</td>
<td>118.8</td>
</tr>
<tr>
<td>Combustion in business, e.g. refrigeration and air conditioning</td>
<td>68.6</td>
</tr>
<tr>
<td>Fuel combustion for heating, cooking, garden machinery etc.</td>
<td>63.4</td>
</tr>
<tr>
<td>Industry</td>
<td>12.1</td>
</tr>
<tr>
<td>Agriculture</td>
<td>5.2</td>
</tr>
<tr>
<td>Waste disposed of in landfill, burning, and the treatment of waste water</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Adapted from The potential and limitations of using carbon dioxide policy briefing from the Royal Society (page 4).
**Activity A: what to do about CO₂**

(Approximately 45 minutes)

**Part A**

Discuss with the class their ideas on “How can we prove that burning fuels releases CO₂?”. Students may recall the limewater test for carbon dioxide (limewater turns cloudy in presence of CO₂).

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.

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 CO₂ than fuels like methane.

**Part B**

Explain to students that because of the CO₂ 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

<table>
<thead>
<tr>
<th>Drawbacks</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using carbon dioxide as a fuel is only likely to account for less than 1% of global emissions reduction.</td>
<td>5 – 6% of global carbon dioxide emissions could be removed from the atmosphere to make new fuels!</td>
</tr>
<tr>
<td>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.</td>
<td>Using carbon dioxide to manufacture fuels, chemicals and materials could reduce the need to extract and use fossil fuels.</td>
</tr>
<tr>
<td>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.</td>
<td>Oil makes the majority of plastics. Oil is running out.</td>
</tr>
<tr>
<td>We can’t actually do this yet – more research is needed!</td>
<td>CO$_2$ is an alternative source of fuel, increasing the UK’s security of supply and reducing its dependence on oil and gas imports.</td>
</tr>
<tr>
<td>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.</td>
<td>Fuels from CO$_2$ have the capacity to be combusted in a cleaner manner (release fewer greenhouse gases).</td>
</tr>
<tr>
<td></td>
<td>Technology to do this can be added to existing buildings – we don’t need to spend energy building new ones.</td>
</tr>
</tbody>
</table>

### 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.
Plenary:
(Approximately 5 minutes)

A lot of ‘green technology’ like CO₂ 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.

Fig 2: Budget spending per sector by the UK in 2018.
Resource Appendix: Card sort: which part of society releases the most CO₂?

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

<table>
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<tr>
<th>Industry</th>
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