Carbon Footprint – Teacher's Notes

Carbon, fossils fuels and CO_2

Carbon is one of the building blocks of life. Humans, animals and plants are made up of organic compounds. We burn wood and fossil fuels to produce energy and power transport, inadvertently releasing the greenhouse gas, CO_2 into the atmosphere. Students will become more aware of the facts and figures that link the carbon cycle with CO_2 emissions and the jargon that is used in the news and in global climate politics.

Chemistry in the activity

Calculating the energy from combustion of different fuels is related to the number of Carbon atoms these hydrocarbons contain. The amount of CO_2 produced upon combustion is our way of measuring the Carbon footprint of energy sources. Electricity is generated from various forms of energy in each country´s electricity mix and the more renewables and the fewer inefficient coal power plants there are, the less CO_2 is released per kWh electricity used. The UK is trying to go below 100 g of CO_2 released per kWh by 2030 and is likely to achieve this before that date.

In the associated worksheet the students will carry out calculations based on a range of information they will find in the corresponding information sheet. They will become familiar with conversions between tons of Carbon and tons of CO_2, the volume of CO_2 and other factors they may hear in the news or that relate to their personal, a country´s or organisation´s carbon emissions.

They will go to websites that provide current global CO_2 levels and a breakdown of the UK´s electricity supply, with the corresponding kg of CO_2 this will emit per unit electricity used. Questions 1&2 use numeracy skills to evaluate and compare different forms of energy and different technologies.

Question 3 is best used as a classroom discussion and covers carbon neutrality, achieving the UK´s Carbon neutrality goals and calculate how many trees they would have to plant to neutralise this year´s CO_2 emissions.

1. Which fuels or activities produce more CO_2?

QUESTIONS

Which of these activities produces more CO_2 emissions? (calculate them in kg of CO_2)

- **Driving** 100 miles?

(Using 13 litres of petrol or 10 litres of diesel)

Petrol = 2.3 x 13, Diesel = 2.7 x 10 = 29.9 kg CO_2 for petrol and 27 kg for diesel

- Using your **LED TV** for 5 hours a day during a week?

(A 50" LED TV uses 100 watts, to convert to kWh, multiply kW by number of hours)
5 x 7 hours at 100 watts = 3.5 kWh = 3.5 kg CO_2

- **Boiling water** in the electric kettle for a family for a week?

(A kettle uses 1200 W and it takes 3 minutes to boil water and this is done 10 times a day – or does your family drink more tea?)
1200 x 10 x 3 x 7 = 210 minutes (3.5 hours) or 4.2 kWh x 0.283 = 1.19 kg CO_2

- Heating the water with natural gas for a week of daily 5 minute **showers**?

(Heating 30 litre of water to 40°C uses 1.1 kWh in the form of gas, where emissions from natural gas are 0.2 kg CO_2/ kWh burned)
Heating the water for a week uses 7.7 kWh so 0.2 x 7.7 is 1.54 kg CO_2

- Mobile phone usage for the family in a week. Assume the family does an average of two full charges a day.

(Typical phone charges at 0.015 kWh and takes 2 hours to charge fully)

4 x 7 x 0.005 = 0.014 kWh x 0.283 = 0.396 kg CO_2

- Play station for 20 hours a week

(A Playstation 4 Pro uses 139 W)

139 x 20 = 2.4 kWh = 7.87 kg CO_2

2. How to quantify CO_2 emissions in terms of volume and mass?

QUESTIONS

- *How many cubic metres of CO_2 would 5000 kg CO_2 occupy? 2500 m^3*
- *A factory states that it releases 10 tons C per year (for its greenhouse gas emissions). How many m^3 of CO_2e is this? 10,000 kg x 44/12 = 36,667 kg CO_2, so ½ x this is 18,333 m^3*
- *If UK car emissions released 3 GtC in a year and all the CO_2 remained in the atmosphere, by how much would the* CO_2 concentration increase?

0.47 x 3 = 1.41 ppmv

- *Go to see 2019´s UK Carbon emissions published by the government (Provisional GHG emissions). In 2019 it was 351.5 Mt CO_2 Considering the UK population is 63 million and world population is 8.3 billion, are our carbon emissions representative of global average emissions? ((World emissions in 2017 were 36 Bt)*

63m/8.3b =0.81 % of population and CO_2 emissions are 351.5Mt/36000Mt = 0.98 %, so the population of the UK creates more CO_2 than their population dictates, we produce 0.98/0.81 =1.21 times more CO_2 than the average world population

- *What is today´s CO_2 concentration at Mauna Loa (https://www.esrl.noaa.gov/gmd/ccgg/trends/)? How much has it increased since 1950? How much has it increased since the same month in 2018?*

(figures for 2020) 500 ppm; increase of 100 ppm between 1950 and 2020 (in 70 years), that is a 0.7 ppm average increase; it has increased 4 ppm since 2018 (in 2 years), 2 ppm increase per year. The rate of increase of CO_2 concentration has increased since the 1950s.

- *Why has CO_2 concentration not decreased in 2020 if CO_2 emissions have dropped?*

The lifetime of CO_2 means that it stays around in the atmosphere for many years and you will not see a decrease in the CO_2 from the year that you stop releasing it, it will gradually level off, that is why we need to reach our CO_2 emission peak as early as possible, to see the results a few years later.

3. Steps towards reaching carbon neutrality

QUESTIONS to discuss as a class

- Do you think the UK is on its way to becoming a low carbon economy? Why do you think some countries like Estonia are way behind the UK and countries like Sweden are way ahead? (http://www.globalcarbonatlas.org/en/CO2-emissions is a useful information source)

Estonia still burns a lot of coal, hence its high CO_2 emissions. Sweden has 80 % of its electricity from nuclear and renewables

- The UK has a goal of reaching Carbon neutrality by 2050- do you think we are on our way to reaching that?
- What percentage of our anthropogenic (human) CO_2 emissions are absorbed by the oceans?

31 %

- If a fully grown tree absorbs 22 kg of CO_2 per year and an acre of forest, 2.5 tons of Carbon, if we wanted to neutralize our country-wide annual emissions of 351.5Mt* CO_2, how many more trees or acres of forest would we need?**

351500/2.5 = 140600 acres. There are 60 million acres in the UK, so actually, only adding 0.234 % of the land as forests would do this!

*The latest government statistics on UK annual CO2 emissions (for 2019) was 351.5 Mt CO2 equivalent

UK forests absorbed 21 million tonnes **CO_2 in total in 2020, so they are working away continuously at helping to neutralise our emissions!