Sustainable Farms - Session 2

Can the right balance be found?

Context:
Learners explore the concept of sustainability in the context of farming, in particular arable farms. They learn about different processes on farms that either add or remove greenhouse gases from the atmosphere. Learners explore how agricultural engineers are finding solutions to support farmers to reduce processes that emit greenhouse gases and increase the activities that remove them. In doing so, the complexity of this problem is exposed, and pupils appreciate that 'finding the right balance' is the key to finding a solution.

Engineering focus:
Learners will be working as an engineer by asking questions to identify problems.

Learning time:
2 hours

Suggested age group:
11-14 years old

Keywords
greenhouse gas
carbon dioxide
atmosphere
nitrous oxide
methane
fertiliser
efficiency
emissions
biomass
cultivation
fossil fuels
renewable sources
intensive farming
transportation

Curriculum links:
Chemistry and Working Scientifically
Leaners will:

- Learn about the production of carbon dioxide by human activity and the impact this has on climate.
- Develop skills in working scientifically through investigation, data gathering, analysis and evaluation.

Resources:
Sustainable farms session 2 PPT
NFU and RGS Video - Farming and the Carbon Cycle
Card Sort Activity

Per group:

- 2x 2 litre drinks bottle
- 2 x thermometers or temperature sensors
- Water
- Plasticine
- 2-4 Antacid tablets
- Desk lamp (100W+ bulb)
- Stopwatch

Suggested Activities

1

What does sustainability mean to you?

Elicit the learners' understanding about ideas linked to sustainability. Display the range of words on Slide 2, and ask them to work in pairs to develop a concept-map. Use directional arrows and link phrases to describe their understandings.

Ask pairs to share their concept maps with the group, so they support each other in identifying useful prior knowledge. Ask learners to consider what they think we mean by **sustainable farming**.

2

Which crops have higher carbon emissions?

Ask learners to predict which of the crops of slide 3 have the highest carbon footprint - they could sort the produce into order on a post-it note. Reveal the mass of carbon dioxide gas released for every kg produced of each crop (slide 4) and ask learners to compare their predictions with the reality. What were they right about? What were they wrong about?

Explore learners thinking about why certain crops have larger carbon footprints and reveal where each of the crops were produced (Slide 5) and challenge misconceptions that it is all about distance. There are other factors such as artificial heating and lighting for growth and refrigeration that contribute as well.

3

Why does farming need to become more sustainable?

Engage the pupils in recalling their scientific knowledge and ideas about what greenhouse gases are. They are likely to be familiar with CO_2 (Carbon Dioxide), NO_2 (Nitrogen Dioxide) and CH_4 (Methane). Reinforce that the proportion of these gases in the atmosphere is closely connected to global warming resulting from human activity and discuss ideas about how increased greenhouse gases lead to temperature increases for the planet (Slide 6).

Ask them for a quick-fire response to estimate the % of greenhouse gas emissions -they think comes directly from farming and agriculture. Use Slide 7 to illustrate that nearly one tenth of the world's greenhouse gases are a result of farming. Given that farming is essential to feed our vast populations, it is not a negotiable. We have to have farming! So finding innovative technological solutions is the key to reducing emissions if progress towards net zero and carbon neutral farming is to happen.

Does carbon dioxide gas heat up differently to air?

4

Carry out a simple investigation to compare the effect of heating air and carbon dioxide with a radiant source of heat/light (slide 8).

- Partially fill both empty 2 litre bottles with water (approximately 1/3 full).
- Cover the top of one bottle with a ball of plasticine to trap the air inside, carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the air inside the bottle.
- Drop an antacid tablet in the other bottle and cover immediately with plasticine, again carefully push a thermometer through the plasticine (making a tight seal) so it is measuring the temperature of the carbon dioxide building up in this bottle.
- Turn on the high power lamp and make sure it is shining directly and evenly on both bottles.
- Observe and record the temperature of the gas in each bottle every 5 mins for the next hour. Findings should be recorded in a table and the analysed using a line graph.

Challenge learners to use their data to answer the following questions:

- What does this mean for the effect that carbon dioxide has on atmospheric temperature?
- How does this activity demonstrate the greenhouse effect that naturally occurs in Earth's atmosphere?

Alternatively you could carry out the Royal Society of Chemistry's -Modelling the greenhouse effect demonstrations

5

Farming and the carbon cycle

Support learners in connecting their findings from the enquiry with farming by watching the short animated film from the NFU and the Royal Geographical Society which explains how farming links to the carbon cycle.

How do we find a balance?

Use the Card Sort Activity (Slide 9), organising learners in groups of 3-4. The cards describe activities on farms which can be grouped into two piles: Activities that emit greenhouse gases and Activities that remove greenhouse gases from the atmosphere.

6

Review the learners' ideas using Slide 10. Explain that farms can be thought of as systems with different activities and processes working together -one activity knocking onto another, to create an overall impact. A key learning point is that even with new innovations to reduce greenhouse gas emissions, there will always be things that have to happen on farms that release greenhouse gases but there are things that we could do more of on farms to absorb them and keep the balance.

The job of the agricultural engineer is to work with farmers to reduce or capture greenhouse gases for a more sustainable farming future... the system is a complex system.

Activities causing greenhouse gas emissions	Activities reducing greenhouse gas emissions
Increasing numbers of livestock needed on farms to feed growing populations. Transportation of food crops from farms for processing and then on to the consumer. Fertilisers not taken up by crops are washed away into the waterways or broken down by microbes in the soil to to release nitrous oxide into the atmosphere. Artificial fertilisers are made under high pressure and at very high temperatures which require lots of energy that comes from burning fossil fuels. Manure decomposes releasing nitrous oxide and methane gases. Cows have a problem with incessant burping as they get rid of the methane produced in their four stomachs by digesting tough plant material. Breaking up the soil with a plough and other machinery exposes carbon in the soil to oxygen in the air which allows microbes to convert it into CO2. Soil becomes compacted with heavy equipment driving across it, restricting plant growth and increasing waterlogging which leads to the production of nitrous oxide (N2O) Hedgerows are removed to create larger fields for large scale intensive farming. Farm machinery and heating is mainly powered by the burning of fossil fuels.	Enhancing and increasing hedgerows Adding additives to the food for cattle and sheep to rescue methane (CH4) emissions. Precision farming for crops to deliver nutrition and crop protection more efficiently. Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N2O emissions. Improve health of cattle and sheep to reduce methane emissions and boost growth rates. Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy. Be more energy efficient to to reduce the use of fuels and electricity. Increasing woodland on farms. Biomass materials used in construction on farms. Reduce use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

7

Working like agricultural engineers

Support learners in reflecting on how they have been working like agricultural engineers in the 'ask' stage of the Engineering Design Cycle - asking questions to better understand the impact of farming on the environment and the scientific ideas behind the impact farming practices have on carbon emissions (slide 11).

Be more energy efficient to to reduce the use of fuels and electricity.

Improve health of cattle and sheep to reduce methane emissions and boost growth rates.

Increasing woodland on farmland.

Introduce anaerobic digestion to convert animal manures, crops and crop by-products into renewable energy.

Biomass materials used in construction on farms.

Reduce the use of fossil fuels on farms and shift towards electricity from renewable sources (Solar/wind/bioenergy).

Adding additives to the food for cattle and sheep to rescue methane (CH_2) emissions.

Precision farming for crops to deliver nutrition and crop protection more efficiently.

Farm machinery and heating is mainly powered by the burning of fossil fuels.

Loosening compacted soils to prevent soil compaction, reducing the need for cultivation and minimising N_2O emissions.

Increasing numbers of livestock needed on farms to feed growing populations.

Fertilisers not taken up by crops are washed away into the waterways or broken down by microbes in the soil to to release nitrous oxide into the atmosphere.

Transportation of food crops from farms for processing and then on to the consumer.

Manure decomposes releasing nitrous oxide and methane gases.

Breaking up the soil with a plough exposes carbon in the soil to oxygen in the air which allows microbes to convert it into CO_2.

Hedgerows are removed to create larger fields for large scale intensive farming.

Soil becomes compacted by heavy equipment, this restricts plant growth and increases waterlogging which leads to the production of Nitrous oxide (N_2O).

Enhancing and increasing hedgerows.

Artificial fertilisers are made under high pressure and at very high temperatures which requires lots of energy that comes from burning fossil fuels.

Cows have a problem with incessant burping as they get rid of the methane produced in their stomachs from digesting tough plant material.