# Topical Applications of Mathematics

## Carbon Footprint

## TEACHER INFORMATION

**Key Stage**     3 or 4

**Target**     Pupils of any ability, as the mathematical level is not high.

**_MEP_ references**     Year7, Unit 6  or  GCSE Unit 2

**Teaching notes**     This is a very topical issue that has become relevant to many of the activities that we engage in, at home, away and at work.

There is some agreement (even if reluctantly by the USA, which had the highest man-made carbon dioxide emissions of any county in 2004) that the world increase in carbon emissions is in fact damaging the planet through the greenhouse effect whereby the temperature of the planet is gradually rising. For figures on carbon dioxide emissions see

**http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions**

This resource is not in any way meant to be political but rather to introduce pupils/students to the mathematical models, in simplified forms, behind carbon emission measurement and the concept of carbon footprints.

The mathematical model on which the calculations are based is at the heart of this resource bearing in mind that the calculations are, at best, only approximations of the reality.

It is though important to see how mathematics is used; without the calculations we could not use the measure of a 'carbon footprint'. In the future these calculations could be vital if a government attempts to mitigate global warming by imposing upper limits on personal carbon footprints (this concept is gaining popularity in some political arenas).

There is a wealth of relevant material on the internet, both for your own background reading and for pupils/students to use for future research. Of particular relevance are:

- Glossary of terms used
      **http://www.epaw.co.uk/carbon/glossary.html**

- A carbon calculator (there are several) can be freely used online at
      **http://actonco2.direct.gov.uk/index.html**

- Helpful information is given on the Wikipedia site
      **http://en.wikipedia.org/wiki/Carbon_footprint**

   and on the BBC site
      **http://bbc.co.uk/climate/**

In this resource we have used basic calculations for the travel component of a carbon footprint. There are many other similar calculations that can be made, including finding the carbon footprint of a house.

### Solutions and Notes for material in the Pupil Text

Many of the responses to the Activities are items for discussion; key pointers are given below.

### *Activity 1*

The main components come from *travel, heating* and *cooking* but smaller amounts from any activities that use, for example, *electricity*.

### *Activity 2*

The main result of the Kyoto Protocol is an internationally binding agreement (under the UN Framework Convention on Climate Change that set greenhouse gas targets for signatories to abide by). It was drawn up in 1997 and came into effect in 2005, requiring *developed* countries to reduce emissions by 5%, compared with 1990 levels, by the year 2012.

The United States (US), although a signatory to the Kyoto Protocol, has neither ratified nor withdrawn from the Protocol. The signature alone is symbolic, as the Kyoto Protocol is non-binding on the United States unless ratified. The United States was, as of 2005, the largest single emitter of carbon dioxide from the burning of fossil fuels.

You can find information on the Kyoto Protocol, and also the United Nations Climate Change Conference held in Bali in December 2007, at

http://unfccc.int

Data on carbon emissions by each country can be found at

http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

### *Activity 3*

The 2012 target is $600 \text{ million} \times 0.05 = 570 \text{ million tonnes}$. As the 2005 value is 680 million tonnes, then the required reduction is 110 million tonnes over a 7-year period. If the reduction is linear, then each year we need to reduce by $\frac{110}{7} \approx 16 \text{ million tonnes}$ per year.

This would give the following yearly targets.

| Year | Million tonnes | Reduction |
|------|---------------|-----------|
| 2005 | 680 | 16 |
| 2006 | 664 | 16 |
| 2007 | 648 | 16 |
| 2008 | 632 | 16 |
| 2009 | 616 | 16 |
| 2010 | 600 | 16 |
| 2011 | 584 | 16 |
| 2012 | 568 | 16 |

So this would just reach the 2012 target of 570 million tonnes.

### Activity 4

Discuss question; answers might include

- more use of public transport
- low energy light bulbs
- switching off lights when not needed
- not keeping appliances on standby
- turning down central heating thermostats.

### Activity 5

a)  *CAR* emissions will depend on engine size, type of fuel and number of passengers.

b)  *TRAIN* emissions will similarly vary according to the type of train (and stopping pattern) and number of passengers.

### Activity 6

Trains do not always provide a service to the exact location needed; timings might not be suitable; you might also need a taxi or car at each end of the journey.

### Activity 7

| Type of car | Total carbon emissions (kg) |
|---|---|
| Small, petrol | 36 |
| Medium, petrol | 44 |
| Large, petrol | 60 |
| Small, diesel | 30 |
| Medium diesel | 38 |
| Large diesel | 52 |

### Activity 8

Reduce car tax on smaller, diesel cars; reduce fuel prices for such cars.

### Activity 9

Scope for all pupils to be involved in discussions and calculations. Distances between destinations can be found at the website

http://www.geobytes.com/CityDistanceTool.htm?loadpage

# Topical Applications of Mathematics

## Carbon Footprint          SAMPLE LESSON PLAN

| Activity | | Notes |
|---|---|---|
| | | T: Teacher     P: Pupil |
| **1** | **Carbon footprint**<br><br>T: What do you understand about the term 'carbon footprint'?<br><br>T: How is this related to global warming?<br><br>T: The air temperature has risen by about $1°C$ over the past 100 years. Scientists believe that it will probably rise by $5°C$ over the next 100 years.<br><br>T: What items contribute to your (or your family's) carbon footprint?<br>*(Travel by car, bus, train, plane; energy use for heating, cooking, lighting, etc.)*<br><br>T: What do you know about the Kyoto Protocol?<br><br>T: It came into effect in 2005 for each of the countries that had signed and ratified the Protocol. Each of these countries is required to reduce their carbon emissions by 5% on their 1990 level, by 2012.<br><br>T: If the 1990 figure was 600 million tonnes of carbon dioxide and the 2005 figure was 680 million tonnes, work out an effective plan to achieve this reduction over the remaining years until 2012.<br><br>T: What figure is the UK aiming for?<br>*(570 million tonnes)*<br><br>T: From what figure, and in how many years?<br>*(680 million tonnes in 7 years, 2006 - 2012)*<br><br>T: How can this be achieved?<br><br><br>*15 mins* | It is really important to firstly find out what Ps know about carbon footprints and global warming, etc. The class should discuss these topics in a non-judgmental way. We can look at the evidence that the planet is warming up and that the Kyoto Protocol (Agreement) is in place to reduce carbon emissions. How worrying this is for future generations is still speculation!<br><br><br>This could have been set as preparatory work.<br><br><br>Discuss different models of reduction with the class.<br><br><br>Ps work together in pairs. Allow them 5 minutes to complete this and then review interactively along the lines opposite.<br><br><br>You could start the discussion of what either the Ps or school could to do to help. |

| *Activity* | | *Notes* |
|---|---|---|
| **2** | **Travel: reducing carbon emissions** | Again, ensure that all Ps contribute to the discussion. |
| | T: What form of transport is the most economical in terms of minimizing carbon emissions? *(Walking, cycling)* | |
| | T: Which is the most economic of car, bus, train and plane? *(Bus should be the most economic, in general terms)* | As far as transport is concerned, we don't need to force people to live in a different way, but to encourage them to be aware of the effects of their choices. In some cases there are no choices, i.e. people living in isolated villages with no public transport have no choice but to use cars. |
| | T: Is the bus always the most economic? *(It might depend on the number of passengers)* | |
| | T: Yes; a very full train will be more environmentally friendly than a bus with only a few passengers. | |
| | T: Are there disadvantages with trains? *(Stations not always where you need to travel; inconvenient times)* | Similarly, some people need to travel by plane to do their work effectively and efficiently. |
| | T: What forms of transport should we avoid, if possible, to keep carbon emissions to a minimum? *(Car and plane)* | These are all discussion points. |
| | T: Here is the Data Sheet for travel in the UK. | Hand a copy of Data Sheet 2 to each pair of Ps. T should explain what is required and then monitor Ps' progress as they work. |
| | T: Calculate the carbon emissions for a journey of 200 km. | |
| | T: Why are these values not exact values but only estimates? *(Car engine sizes vary; number of passengers is an important factor)* | Review answers with the class. |
| | T: *Data Sheets 3* and *4* give you more precise figures for carbon emissions. These are useful if you want to calculate your (or your family's) carbon footprint. | Discussion points: there might be a local car-sharing scheme or a 'park and ride' facility just out of town: these are both helpful in reducing carbon emissions and provide efficient ways to reduce the numbers of cars (and hence carbon emissions and traffic congestion) in towns and cities. |
| | *30 mins* | |

| Activity | | Notes |
|---|---|---|
| **3** | **Reducing your carbon footprint** | This is also a discussion activity but here there are precise tasks to complete. |
| | T: At the moment, in the UK, the average person has a carbon footprint of about 10 000kg (or 10 tonnes) per year. | |
| | The recommended sustainable footprint is actually only 2500 kg (2.5 tonnes). | |
| | What can we do to reduce our own carbon footprint? *(Ps should suggest lots of ideas for discussion)* | Make sure that all Ps contribute to the discussion. |
| | T: What about non-essential plane travel? Should we restrict our freedom to fly? | Some people would regard flying to Spain for a holiday as essential! Again, this is for discussion – there are alternative ways to travel! |
| | T: Suppose the government decided that each person would be given the freedom to use up to 500 kg of carbon emissions per year on flying to holiday destinations. | |
| | Using *Data Sheet 3* and the data on distances between places on *Data Sheet 4* (or estimating from a map or using information from the internet), plan how you would use your carbon emissions air travel quota for one year. | Each pair of Ps will need a copy of Data Sheets 3 and 4, and, if necessary, access to world map. |
| | T: Who would like to tell us their choices of destinations for the year? | T monitors and helps where necessary. |
| | | Allow Ps 5 minutes for deciding their strategy and another few minutes for the calculations. |
| | *45 mins* | |
| **4** | **Homework** | |
| | Use the carbon footprint computer package at | |
| | http://actonco2.direct.gov.uk/index.html | |
| | to calculate the yearly total for your household. | |