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Environment: treading lightly on the Earth

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Contents

Introduction

This free course, *Environment: treading lightly on the Earth*, focuses on the problem of greenhouse gas emissions, especially carbon dioxide (CO_2), and explores what you can do to lighten those emissions to help reduce the rate of climate change. You will assess your 'carbon footprint' and see what actions you and, if relevant, other household members could take to lighten that footprint. You will also better understand which actions are more and less effective, and the scope and limits of what individuals can do at the personal and household level.

You'll explore the answers to questions such as:

- What is the effect on your carbon footprint of changing your eating habits, compared to driving fewer miles or flying less often?
- What are the limits of what you can do at the individual and household level to reduce carbon footprints?
- What is the individual's role in reducing carbon footprints, or is it mainly a problem for governments and business?

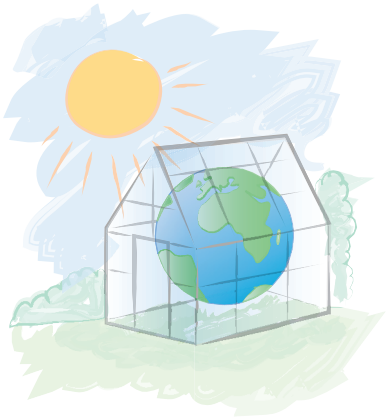


Figure 1 The greenhouse effect due to increasing concentrations of CO_2 and other greenhouse gases in the Earth's atmosphere

This OpenLearn course is an adapted extract from the Open University course U116 *Environment: journeys through a changing world*.

Learning outcomes

After studying this course, you should be able to:

- explain the nature and extent of the carbon footprints of individuals and households within the national and global economy
- understand the main components of the carbon footprint of individuals and households
- assess your individual carbon footprints using a carbon calculator
- understand the main components of the carbon footprint of individuals and households, and the most effective actions for reducing the footprint
- explore options for reducing the your carbon footprint and understand which options are effective.

1 What is a carbon footprint, and why is it important?

A carbon footprint is the annual amount of greenhouse gas emissions, mainly carbon dioxide, that result from the activities of an individual or a group of people, especially from their use of energy and transport and consumption of food, goods and services. It's measured in kilograms or tonnes per year, either of carbon dioxide (CO_2) emissions alone, or of CO_2 plus the mass of other greenhouse gas (GHG) emissions converted into their carbon dioxide equivalent (CO_2e).

GHG emissions associated with human activities are responsible for the enhanced greenhouse effect. More heat is being 'trapped' in the atmosphere than it otherwise would be, known as global warming, which is in turn resulting in our climate changing.

A carbon footprint can also be calculated for an event such as a music festival, or for making and distributing a product such as a car or computer.

The carbon footprint is an environmental indicator – a way of measuring impacts on the environment, in this case mainly climate change. This means that a carbon footprint doesn't measure other impacts, except sometimes indirectly. For example, driving a petrol or diesel car, as well as emitting CO_2, results in local air pollution from nitrogen oxides (NO_X), especially the irritant gas nitrogen dioxide (NO_2) and other engine emissions; so the larger your carbon footprint from driving, the more local air pollution you are creating.

1.1 Carbon dioxide and other greenhouse gases

CO_2 emissions are used as the basis for the carbon footprints because it is by far the main contributor to the enhanced greenhouse effect from human activity (for example burning fossil fuels, clearing forests and making cement). Sometimes only the mass of CO_2 is counted in the carbon footprint. However, as noted earlier, for a complete carbon footprint the other human-generated greenhouse gases are converted into a CO_2*equivalent* (in kilograms or tonnes CO_2e) in terms of their global warming effect compared to $CO_2$and added to the footprint. The complete footprint is then expressed as kilograms or tonnes CO_2e per year.

The two main non-CO_2 greenhouse gases associated with human activities are methane (CH_4), mainly from cattle belching, manure spreading and decomposition, wet rice growing and decomposing waste, and nitrous oxide (N_2O), mainly from nitrogen fertilisers and industrial processes. One tonne of methane has the equivalent global warming potential of 21 tonnes of CO_2, while one tonne of nitrous oxide is equivalent to 310 tonnes of CO_2. But because the amounts of methane and nitrous oxide released are much smaller than CO_2 emissions, their emissions together add about 17% to the UK's contribution, and about 25% globally, to the enhanced greenhouse effect (BEIS, 2023; Ritchie, 2020). This means that other greenhouse gases should not be ignored when measuring a carbon footprint, although to simplify calculations they often are.

In this course, whenever possible the total CO_2 equivalent (CO_2e)will be used.

1.2 The carbon footprint boundary

Setting a 'boundary' determines the scope, or limit, of an issue or system being considered. For example for a carbon footprint the boundary can be set so the footprint is assessed for an individual or household; an organisation, event or product; a city, region or country. In this course you will mainly be considering the footprints of individuals, households and the countries they inhabit.

However, any boundary needs to be defined carefully. Sometimes the carbon footprint is taken to mean an individual's or household's *direct* CO_2 emissions, mainly from burning fossil fuels for home heating and car driving. However, this leaves out their *indirect* CO_2 equivalent emissions arising from the production and distribution of the food, drink and other goods and services they consume, ranging from clothes and electronic products to banking, medical services and Open University modules.

Again depending on the boundary, these indirect emissions often include only those arising from the food, goods and services produced within the country where people live. Although they may also include the emissions associated with imports; for example, the emissions produced by the 'supply chain' of mines, farms, factories, trucks and ships involved in making and transporting the food, cars and computers that the UK imports from the EU and China.

Whichever boundary you choose, the 'footprint' image is used to suggest an individual or group treading on or occupying the Earth (Figure 2). It implies that the Earth can't indefinitely support the lifestyle of that individual or group, and if they are to live sustainably, they'll have to lighten their footprint.

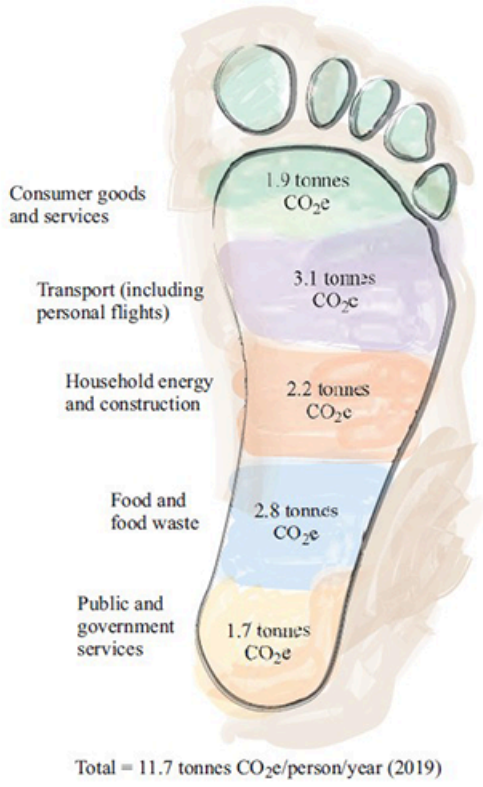


Figure 2 Footprint on the Earth

1.3 Measuring carbon footprints

There are different ways of measuring the carbon footprints. The territorial perspective measures the CO2e emissions produced within a country's borders, excluding emissions from international aviation and shipping. From this perspective, the power stations,

factories, farms, etc. within each country are mainly responsible for that country's emissions, while households are directly responsible for only a relatively small percentage (about a fifth) of the total.

For the UK, the production perspective measures CO2e emissions produced by UK residents and industry whether in the UK or abroad, excluding emissions within the UK by overseas residents and businesses. International aviation and shipping emissions are allocated to countries based on the operator of the vessel.

As the focus of this course is on the carbon footprint of individuals and households, and that's what the carbon calculator, which you'll be using later, measures, we will be looking at the consumption perspective. While individuals and households may be ultimately responsible for triggering most GHG emissions, they don't directly control how much of those emissions are produced and so can't be expected to reduce them unaided. There will be more about this later.

The consumption perspective, on the other hand, refers to CO2e emissions that are associated with the consumption spending of a country's residents on goods and services wherever in the world these emissions arise, and so includes emissions arising from the production and distribution of imports. The focus of this course is on the carbon footprint of individuals and households, so that's what the carbon calculator you'll use later measures, utilising the consumption perspective. It is important to remember that while individuals and households may be ultimately responsible for triggering most GHG emissions, they don't directly control how much of those emissions are produced and so can't be expected to reduce them unaided. There will be more about this later.

Figure 3 is a pie chart that shows the percentage breakdown of an average UK resident's carbon footprint when it was calculated using the 2019 national carbon footprint data. Although this footprint has reduced since 2019, mainly due to the reduction in emissions from electricity generation, its main components remain broadly the same.

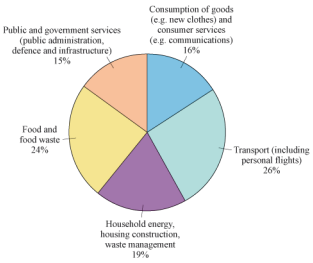


Figure 3 High-level breakdown of the 2019 mean annual UK carbon footprint per person (adapted from Open Access Government, 2023)

The UK government measures consumption emissions, which are based on the country's production emissions plus the emissions associated with imports, minus the emissions associated with exports. The result is the UK's carbon footprint, which has been calculated by the University of Leeds and published by the Department of Environment, Food and Rural Affairs (DEFRA). Figure 4 is a stacked bar chart that shows the UK's declining consumption carbon footprint for selected years from 2000 to 2019. In a stacked bar chart the components that make up the total are 'stacked' in each bar.

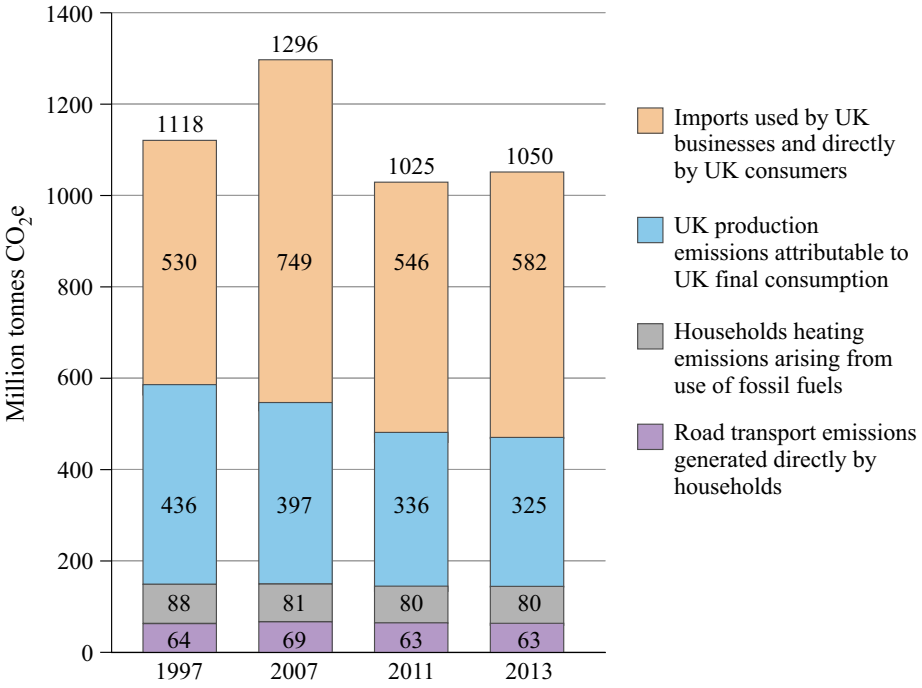


Figure 4 The UK carbon footprint: GHG emissions associated with consumption 2000 to 2019 (total = 774 million tonnes CO_2e in 2019) *(adapted from DEFRA, 2022)*

The carbon footprint updated to 2020 showed a reduction from 2019 (DEFRA, 2023). However, the 2020 footprint coincided with the COVID-19 pandemic when much of the economy was shut down. The official 2019 UK footprint has therefore been used as latest available representative result at the time of writing.

Notice that in Figure 4 the direct carbon footprint of households (the bottom two sections of each bar) from home heating and car driving is relatively small. This is because this breakdown uses the footprint boundaries mentioned earlier, in which household electricity for lighting and appliances, travel by public transport and holiday flights are considered as indirect sources of emissions. The total indirect carbon footprint (the top two sections) includes these emissions plus the emissions arising from the consumption of food, goods and services both produced in the UK and associated with imports.

This and other studies have shown that nearly half the UK carbon footprint is the result of the GHG emissions associated with imports, notably electronic products, clothing and motor vehicles from the EU and Asia. This means that the emissions from an individual's consumption of imported goods and services are generally a major part of their carbon footprint.

Also included in the total carbon footprint in Figure 4 are emissions from government activities, including public administration, health, education, defence and capital investment, for example, in railways. This residue, which arguably can't be allocated directly to households, amounts to 30% of the total UK carbon footprint (DEFRA, 2023).

This means that consumption decisions by individuals and households are responsible for creating or triggering about 70% of the UK's carbon footprint. This proportion is typical for a Global North, country, such as the UK, Germany or USA, where consumption of energy, food, and other goods and services by individuals and households accounts for 60% to 70% of economic output (Ivanova *et al.,* 2016).

Now complete Activity 1 to test your understanding of carbon footprints.

Activity 1 Carbon footprints

Allow about 10 minutes

a. What is a carbon footprint?

Provide your answer...

Answer

A carbon footprint is the total annual mass of 'carbon' emissions which result directly or indirectly from the activities of an individual or a group of people, from an event, or from providing a product or service.

b. Refer back to the pie chart in Figure 3. What does the chart show are the main components of an average UK resident's carbon footprint?

Provide your answer...

Answer

Figure 3 shows that the three main components of an average UK resident's carbon footprint, accounting for about 70% of the total, are:

- •transport (by car, public transport and air)
- domestic energy use, housing construction and household waste
- •food consumption and food waste.

The remainder of the average footprint (about 30%) is roughly equally generated by (i) consumption of goods (such as new clothes) and private (or consumer) services (such as banking and communications),and (ii) use of public and government services.

1.4 Total footprint

The UK Government publishes information on the country's carbon footprint, covering both direct and indirect annual GHG emissions, including the emissions embedded in imports. This provides a comprehensive picture of the UK's total carbon footprint from the consumption perspective (Figure 4).

You'll notice that, where possible, for UK data publications from government departments such as DEFRA (Department for Environment, Food & Rural Affairs) and DECC (Department of Energy & Climate Change) have been used. The names and responsibilities of these departments can change in government reorganisations (e.g. in 2016, DECC became part of the Department for Business, Energy & Industrial Strategy) but remain an invaluable source of information and statistics.

1.4.1 Percentages and parts per million (ppm)

This section explains percentages and percentage change, as well as parts per million (ppm).

Percentages and percentage change

Percentages (%) indicate proportions and show the number of parts out of 100. For example, 30% is 30 out of 100 and 65.2% is 65.2 out of 100.

To find out the percentage of something, first convert the figures into a fraction and then multiply by 100%. For example, if 42 people in a group of 70 vote for a political party, the percentage voting for that party is
42 divided by 70 multiplied by 100%, or

$$\frac{42}{70} \times 100 = 60\%$$

If you already have a fraction and want to change it to a percentage, you multiply by 100%. So three-quarters expressed as a percentage is

$$\frac{3}{4} \times 100\% = 75\%$$

Similarly, to change a decimal to a percentage, you multiply by 100%. For example, the decimal number 0.25 expressed as a percentage is 0.25 × 100% = 25%.

To change a percentage to a fraction, or to a decimal, the percentage is divided by 100. So for example, 30% expressed as a fraction is
30÷100, or 0.30 as a decimal; and 65.2% is 65.2÷100 or 0.652.

In order to find a percentage of a quantity, first convert the percentage to a fraction, or decimal number, and then multiply this by the quantity. For example, to find 20% of 350 people the calculation is:

$$\begin{aligned} 20\% \ \ of\ 350\ people &= \frac{20}{100} \times 350 \ \left(or\ 0.2 \times 350 \right) \\ &= 70\ people \end{aligned}$$

Percentage changes

Repeated measurement of a quantity makes it possible to assess change over time. Change between two given dates is often expressed as *percentage change* in which the change in the measurement between the later and earlier dates is expressed as a percentage of the earlier measurement. This can be written as follows:

$$\text{percentage change} = \frac{\text{value at later date} - \text{ value at earlier date}}{\text{value at earlier date}} \times 100\%$$

You may also come across percentage changes described as percentage increases or decreases.

Calculation of percentage change is best done in stages. For example, if you wish to calculate the percentage increase of atmospheric CO_2 levels from 1995 to 2023, which were 360 parts per million (ppm) in 1995 rising to 420 ppm in 2023, then:

- The change is (420 – 360) ppm = 60 ppm.

- As a fraction of the earlier (or original) value, this is 60 ppm÷360 ppm = 0.1666.
- As a percentage change, this becomes 0.1666 × 100% = 17% (rounded appropriately – you will learn more about rounding later). This is a positive value, so it indicates a percentage increase.

Note that to calculate a percentage change, you always divide by the original (earlier) value regardless of it being numerically larger or smaller than the later one. If it is larger than the later value, then this would be a percentage decrease, which is sometimes written using a minus sign before the number e.g. –11%.

You can also use percentage change the other way round. Suppose you plan to reduce carbon emissions of 350 kg by 20%. What would the new value of emissions be?

There are two ways of tackling this question. Either:

- A 20% reduction leaves 80% of 350 kg of emissions to remain.
- 80% of 350 kg is 80÷100 × 350 kg = 280 kg as the new reduced value.

Or

- 20% of 350 kg is 20÷100 × 350 = 70 kg.
- Subtract 70 from the original 350 to give the new reduced value of 280 kg.

Parts per million

Parts per million (ppm) is an alternative to percentages that can be useful for very small proportions. As the name implies, ppm represent the number of parts out of a million (1 000 000) instead of 100. For even smaller proportions, parts per billion (ppb) may be used.

Like percentages, ppm can be converted into a fraction or a decimal. For example, an atmospheric CO_2 level of 400 ppm can be written as 400/1 000 000. This can also be expressed as a decimal as 0.0004.

Activity 2 Calculating percentages

Allow about 10 minutes

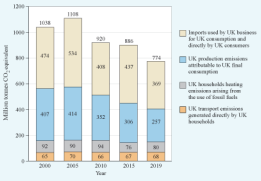


Figure 4 (repeated) The UK carbon footprint: GHG emissions associated with consumption 2000 to 2019 (total = 774 million tonnes CO_2e in 2019) (*adapted from DEFRA, 2022*)

Use Figure 4 to answer the following the questions.

a. What percentage of the total UK carbon footprint of 774 million tonnes CO_2e in 2019 is represented by household heating emissions?

Provide your answer...

Answer

From Figure 4, household heating emissions were 80 million tonnes (Mt) CO2e in 2019. Therefore household heating with fossil fuels as a percentage of the UK total footprint is given by

$$\text{percentage heating} = \frac{80\,\text{Mt CO}_2\text{e}}{774\,\text{Mt CO}_2\text{e}} \times 100$$
$$= 10.33591\%$$

which is 10% to the nearest whole number.

b. What is the percentage change in the total UK carbon footprint between 2000 and 2019? Indicate the direction of change; that is, has the footprint increased or decreased?

Provide your answer...

Answer

The change in emissions between 2000 and 2019 was 774 Mt CO2e – 1038 Mt CO2e = -264 Mt CO2eTherefore, the percentage change in the UK footprint between 2000 and 2019 was

$$\text{percentage change} = \frac{-264\,\text{Mt CO}_2\text{e}}{1038\,\text{Mt CO}_2\text{e}} \times 100\%$$

= -25.43352%

= -25% (to the nearest whole number)

The minus sign indicates that it was a decrease.

c. If the UK managed to reduce its 2019 carbon footprint of 774 Mt CO_2e by 68% by 2030, what would be the resulting footprint?

Provide your answer...

Answer

A reduction of 68% means that 32% of the 2019 footprint remains in 2035 (since 100% − 68% = 32%). The 2035 footprint can therefore be calculated as follows:

$$2035\,\text{footprint} = \frac{32}{100} \times 774\,\text{Mt CO}_2\text{e}$$
$$= 247.68\text{Mt}\text{CO}_2\text{e}$$

which is 248 Mt CO2e to the nearest whole number.

1.5 Summary of Section 1

The main learning points from Section 1 are:

- A carbon footprint is the annual mass of ‘carbon’ emissions that result from the activities of an individual or a group, from an event or providing a product or service. To be complete, a carbon footprint should include the direct and indirect emissions of CO_2 and CO_2 equivalent including other GHGs (mainly methane and nitrous oxide). However, for simplicity, carbon footprints based on CO_2 emissions alone are sometimes used.
- The carbon footprint is an environmental indicator that is concerned mainly with climate change. It measures other environmental impacts, such as local air pollution indirectly.
- Emissions associated with imported food, goods and services are a major part of the carbon footprint of individuals and households in countries of the Global North, such as the UK, Germany and USA.
- From a consumption perspective, individuals and households are directly or indirectly responsible for creating or triggering about 60% to 70% of the total carbon footprint of Global North countries. Hence, reducing the carbon footprint arising from individual and household activities and consumption is very important in addressing climate change.

The next section will consider variations in carbon footprints depending on factors such as where you live, the type of home you live in, income, values and lifestyle.

2 Not all footprints are equally heavy

The carbon footprint of a particular individual or household depends on the amounts and types of energy, food, and other goods and services they consume. This means that their carbon footprint depends on where they live, the type of home they live in, their income, values and lifestyle. Thus, carbon footprints of individuals and households vary widely within a country and also between different countries, but especially between wealthy, Global North countries (e.g. the UK), newly industrialised countries (e.g. China), and less wealthy Global South countries (e.g. Uganda).

For individual or household carbon footprints, the average footprint within a country is usually given. This is more correctly referred to as the mean, which is calculated by dividing the total carbon footprint of a country by its population (see Section 2.1.1: Averages – mean and median). Although these average (mean) values show the variations in carbon footprints between different countries, they conceal the wide variations within each country.

2.1 The carbon footprint of UK individuals and households

The average (mean) carbon footprint of an individual living in the UK can be calculated by dividing total UK annual CO_2 equivalent emissions by the number of people in the country. Using the official government information in Figure 4 this produces a mean footprint of 16.4 tonnes CO_2 equivalent per person per year in 2013.

The average (mean) carbon footprint of an individual living in the UK can be calculated using the official government information in Figure 4. This produces a mean footprint of 11.7 tonnes CO_2 equivalent per person per year in 2019 (for the calculation see section 2.1.1 Averages – mean and median).

This provides a realistic mean footprint of a UK inhabitant on a consumption basis because it includes CO!Warning! inherit not supported2 and other GHG emissions, and takes the data on emissions associated with imports into account. It is about the same as the mean UK footprint used in the carbon calculator that you'll be using later.

Several studies have attempted to provide a more detailed breakdown of this carbon footprint than given in Section 1. They produce different results depending on the data sources, the methods used and how the breakdown is categorised. One detailed breakdown of the average carbon footprint of a UK resident has been produced by Mike Berners-Lee (2020) (Figure 5).

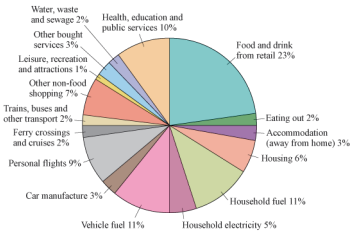


Figure 5 The mean annual UK carbon footprint in CO_2e per person, broken down by consumption category (adapted from Berners-Lee, 2020, p. 196)

Figure 5 indicates that just over a quarter (27%) of the mean UK personal footprint is for transport (car fuel, flights, public transport and the carbon associated with making cars). Household fuel use, mainly electricity and gas, adds a further 16%. This means that

household energy and transport make up almost half (43%) of the total carbon footprint. Another quarter (25%) of the footprint is the carbon associated with food and drink consumed inside and outside the home. The rest of the footprint (32%) arises from housing construction, the consumption of goods and a wide range of services (from hotel accommodation to water supply), and public services such as education and healthcare. This is essentially the same as the high level breakdown in Figure 4.

2.1.1 Averages – mean and median

This section covers two different types of averages – the mean and the median.

An average value is often used to provide a 'typical' value for a set of data. There are several ways of expressing a typical value, but the most common are the mean and the median.

In this study note you will look at two different types of averages – the mean and the median.

Mean values

The *mean* value (commonly called the 'average', although it is just one type of average) is obtained by adding up all the values of a set of data and dividing by the number of items in the set. For example, if three individuals have carbon footprints of 13, 9 and 17 tonnes CO_2e per year, their total footprint is 13 + 9 + 17 = 39 tonnes CO_2e per year. Their *mean* footprint is the total divided by the number of individuals, i.e. 39/3 = 13 tonnes CO_2e per person per year.

To calculate the mean carbon footprint of a UK inhabitant (in 2019) using the information in Figure 4, divide the total UK emissions of 774 million tonnes CO_2e by the 2019 UK population of 66.4 million. The result is 11.67 tonnes CO_2e per person per year rounded to one decimal place. (See Rounding numbers, decimal places and significant figures later in this section.)

Median values

Although the example above gave a value for the amount of CO_2e emissions that could be attributed to each person on an equal basis, this may not represent a 'typical' person. This is because there may be a group of heavy emitters that have a larger effect on the total (and hence the mean) than the majority of more modest emitters. In this case the *median* is a better indication of a typical individual's footprint.

So, if the carbon footprints of a sample of 11 individuals were 21, 6, 15, 16, 10, 9, 13, 25, 12, 11, 27 tonnes CO_2e per year, the mean footprint is 165 tonnes CO_2e per year / 11 = 15 tonnes CO_2e per year.

The median footprint is obtained by arranging the data into numerical order, as follows:

6, 9, 10, 11, 12, **13**, 15, 16, 21, 25, 27 tonnes CO_2e per year the median footprint is the *middle* value in the set = 13 tonnes CO_2e per year, i.e. the sixth value in the set, with five below and five above it.

If there are an even number in the sample, say 10 individuals with footprints of

9, 10, 11, 12, **13, 15**, 16, 21, 25, 27 tonnes CO_2e per year

then the median is halfway between the two middle numbers (13 and 15), i.e. 14 tonnes CO_2e per year, again with five values below and five above.

Consider another example, the UK's income distribution. Some people have very high incomes and some have low incomes, with the majority spread between the extremes. Figure 6 shows the official distribution of the UK population by household incomes (after tax and before deduction of mortgages and rents) in 2021–22. The mean household

income in 2021–22 is £688 per week , calculated by adding up all the incomes and dividing by the number of individuals living in households whose incomes were measured.

The *median* income is the amount which divides the income distribution into two equal groups, half having an income above that amount, and half having an income below that amount. The median household income in 2014–15 is £473 per week (£24 596 per year), which is less than the mean and more representative of an 'average' or 'typical' household.

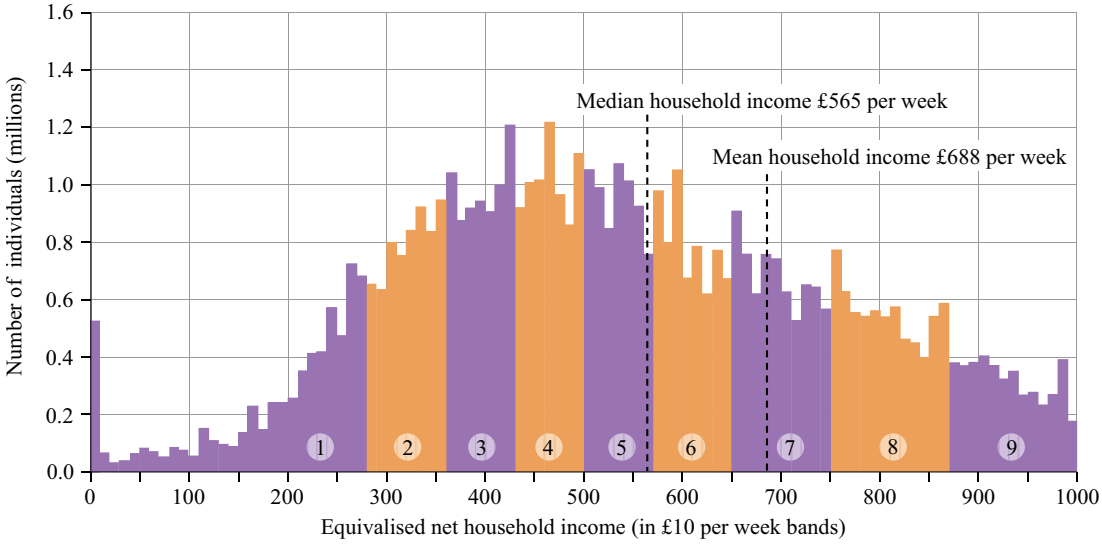


Figure 6 Distribution of the UK population by household incomes in 2021–22. Group 1 is the distribution of household incomes for the 10% of individuals living in the poorest households. Group 9 is the household incomes for the 10% of individuals living in the richest households (excluding 8.8 million individuals with a household income above £1000 per week). Equivalised means the incomes are adjusted to take account of the numbers of adults and children in a household (adapted from DWP, 2023).

2.1.2 The effect of incomes and household types

The carbon footprints given in Section 2.1 are averages (means) for a UK inhabitant. But, as mentioned earlier, footprints differ considerably for different individuals and households.

A factor which generally has a major effect on the footprint is individual or household income (a distribution of which was shown in Figure 6). In general, the higher a person's or household's income is, the higher their carbon footprint will be. This is not just because wealthier people generally consume and travel more, but because, even if they spend little and save a lot, unless they deliberately invest in 'green' carbon saving funds or projects, their money will be invested to make products and in services for consumption, which indirectly adds to their footprint.

An early UK study of income and carbon footprints analysed how the footprint per person differed for ten groups, from households with the lowest 10% to households with the highest 10% of incomes (Gough et al., 2012). The study showed that the carbon footprint per person for households with the highest 10% of incomes was about three times that of people living in households with the lowest 10%.

The carbon footprint per person also varied with household size. One-person households generally had heavier footprints per person than those with two or more occupants. This is

because people living alone usually occupy and heat a bigger space per person and don't share as many goods and services as larger households. So, one of the barriers to reducing carbon footprints is the number of one-person households (nearly a third of all UK households in 2022). Sharing your home, therefore, can be one of the most effective ways of reducing your personal footprint.

A more recent UK study analysed the total energy footprint per person for ten income groups. Similar to the findings of the 2012 carbon footprint study, it showed that the wealthiest 10% used three times as much energy in total as the poorest 10%. The differences were greatest in energy use for transport and recreational activities. The wealthiest 10% used around three times as much energy driving cars and five times as much for recreational activities, including package holidays, when compared to the bottom 10%. Flights taken by people with the highest incomes used around five times more energy than those taken by the poorest, while spending on furniture and clothes by the wealthiest used about four times the energy of such spending by the poorest (Baltruszewicz et al., 2023). Although this study measured energy footprints, these are strongly related to carbon footprints.

Other recent studies have shown an even stronger connection between incomes and carbon footprints, such as the global study whose striking results are shown in Figure 7. It showed that in the European (including the UK) and North American regions, people in the top 10% of incomes on average have around six times the footprints of those with the lowest 50% of incomes. The disparities were even greater in the Asian regions. In China, for example, the top 10% – who have benefited most from the country's industrialisation – produced about 14 times the emissions of the bottom 50% (Chancel, 2022, p. 936).

These studies show clearly that richer people generally have a greater impact on the climate than poorer people and so arguably have a greater responsibility for reducing their footprints. Indeed, Chancel's research shows that to meet global emissions reduction targets, rich people across the world – but especially those in the Global North – must radically reduce their footprints, while to reduce inequality, the half of the population in the poorest parts of the Global South should be allowed to increase theirs.

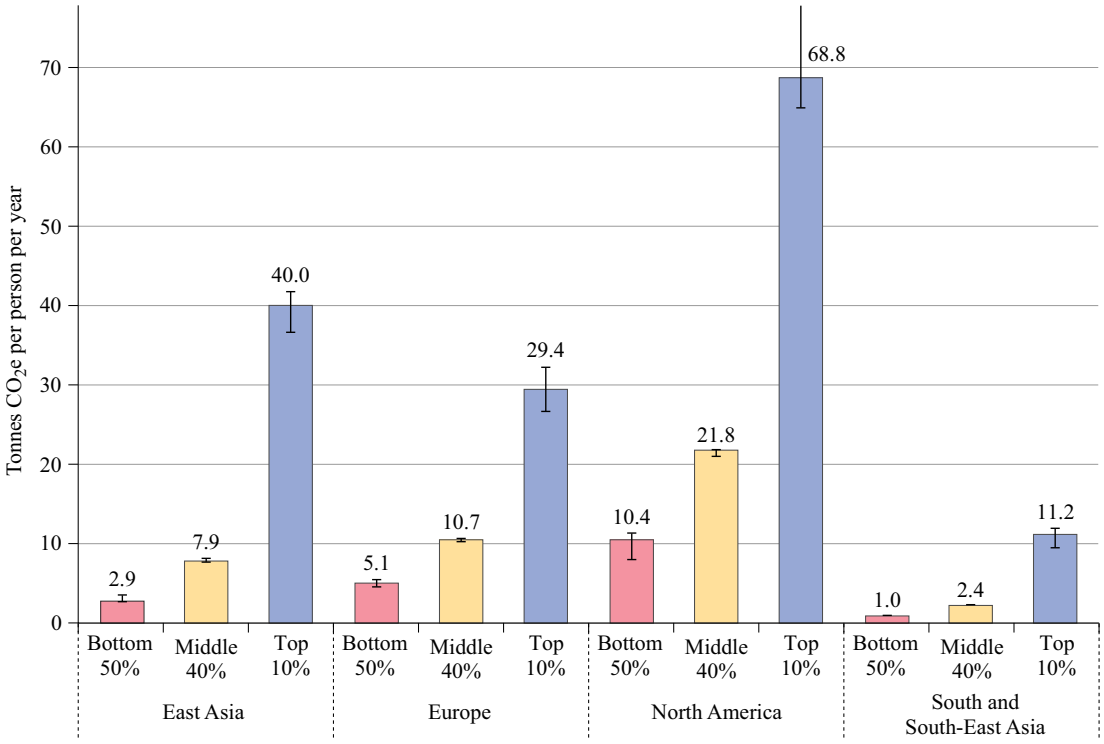


Figure 7 Consumption-based CO_2e emissions per person per year for different income groups in several world regions *(Chancel, 2022, p. 932)*

2.2 Household carbon footprints in other developed countries

Although the mean carbon footprints per person vary in different Global North countries, depending on their energy supply system, climate and economy, their main components are broadly similar to those for the UK. There follows a brief comparison between four European countries and the USA.

A major survey of household consumption in four European countries – France, Germany, Sweden and Norway – was used to calculate their carbon footprints and provide a broad breakdown of those footprints (Dubois et al., 2019). This study showed that the median carbon footprints of the surveyed households in these four countries ranged from 7.3 to 11.3 tonnes CO_2e per year, excluding public and government services. The main components were transport (34%) followed by food consumption, mainly from eating red meat and dairy products (30%); housing and energy use, mainly from home heating (21%); and then other consumption of goods and services (15%).

The components of the mean household footprint for these European countries are similar to the personal footprint pattern for the UK (shown in Figures 3 and 4). As in the UK, the study found that heavier carbon footprints were strongly associated with higher household incomes. Whereas for the USA, on average, residents have one of the largest carbon footprints in the world, at about 16 tonnes CO_2e per person. One study provided a breakdown of American household carbon footprints (Union of Concerned Scientists, 2019). As with the other Global North countries, the main components of American household footprints were home energy use, which included air conditioning as well as heating (hence the high 31% share), transport (28%), food consumption (14%), and goods and services consumption (26%).

2.3 International comparisons of carbon footprints

Carbon footprints are a relatively simple idea, but calculating them can be very complicated. It depends on whether you count only CO_2 or all GHGs and whether you include the emissions associated with imports and exports. It also depends on whether you include the emissions associated with changes in land use and forests, emissions from international aviation and shipping.

This complexity means that international comparisons are usually based on the most widely available data, namely emissions of CO2 alone arising within a country's borders (so-called territorial CO2 emissions, rather than the production- or consumption-based CO2e GHG emissions discussed earlier).

2.3.1 Rounding numbers, decimal places and significant figures

In this section you will look at decimal places, significant figures and rounding numbers, as well as how to choose what precision to give an answer. Start of Case Study

Numbers are often 'rounded up' or 'rounded down' depending on how precise they need to be. Often a good approximation of a number is adequate, and this process is called 'rounding'.

When rounding a number up or down you need to look at the digit immediately to the right of the digit you are rounding to. If this right-hand figure is between 0 and 4 (i.e. less than 5), then the digit you are rounding to stays the same, and if it is between 5 and 9 (i.e. 5 or greater), then it is raised to the next whole number. For example:

62 to the nearest 10 is 60, as the digit to the right of the 6 is 2, which is between 0 and 4, so the 6 remains the same;

2932 to the nearest 1000 is 3000, as the digit to the right of the 2 is 9, which is between 5 and 9, so the 2 is rounded up to a 3.

Decimal places and significant figures are two commonly used ways of rounding.

Decimal places

Decimal numbers (e.g. 65.12) are often rounded to a given number of decimal places. Decimal places are those to the right of the decimal point, e.g. 5.368 has three decimal places. To round this to two decimal places: find the second decimal place (6) and look at the number to its right (8). As that number is between 5 and 9, the second decimal place is rounded up to the next whole number, which is 7. So 5.368 rounded to two decimal places is 5.37.

To round 5.363 to two decimal places: the second decimal place is 6 and the figure to its right (3) is less than 5, so the 6 remains as it is. So, 5.363 rounded to two decimal places is 5.36.

Significant figures

If you are dealing with very large or very small numbers, rounding to a number of decimal places is not convenient. Instead you need a way of rounding numbers that just considers the most important digits in each number. These are called significant figures and tell you roughly how big or how small the number is. The first significant figure in a number is the first *non-zero* digit on, or starting from, the left (ignoring the location of any decimal point).

For example, the first significant figure in 3 246 485 is the 3. It tells you that the number is between 3 and 4 million. The first significant figure in 0.00245 is 2, which tells you that the number is between 2 and 3 thousandths. You can round a value to any number of significant figures in a similar way to decimal places.

Here are two examples:

- Rounding 3174 to 2 significant figures (the abbreviation ‘sig. fig.’ or ‘s.f.’ is often used).

  The first s.f. is 3 and the second is 1. The digit to the right of the 1 is 7; this is between 5 and 9, so the second s.f. is rounded up to 2, giving the answer: 3174 = 3200 (to 2 s.f.).

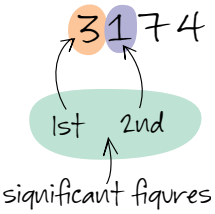


Figure 9

- Rounding 0.0446 to 1 s.f.

  The first s.f. is 4. The digit to the right is 4; this is between 0 and 4, so the first s.f. remains as 4, giving the answer: 0.0446 = 0.04 (to 1 s.f.).

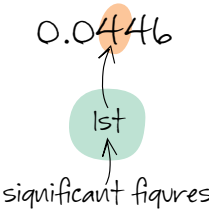


Figure 10

Choosing appropriate precision

When using data or measurements in a calculation, you may need to decide how much to round off the final result, especially if you use a calculator that shows many digits. *The rule is that the final result shouldn’t be more precise than the data used to produce it*, and this should be the number of significant figures in the answer.

For instance, in Table 1 compares UK mean territorial carbon footprints per person with those of other countries. These data cab be used in a calculation to compare them numerically. For Brazil, the calculation for 2022 would be (4.7/2.2) = 2.1363636 on a calculator. The original data were given to 2 s.f., so it is appropriate to round the answer to the same level of rounding. Thus a UK resident’s mean footprint is 2.1 times heavier than a Brazilian’s (to 2 s.f.).

If the original data are not all given to the same number of significant figures, t*hen the least precise item limits the final precision*. For instance, in Table 1, the ratio for UK/ Nigeria emissions is 4.7/0.6 = 7.8333333. The Nigeria value of 0.6 is given to only 1 s.f., so the answer should be that a UK resident’s mean footprint is 8 times heavier than a Nigerian’s (to 1 s.f.).

2.3.2 Carbon footprints per person

The statistics clearly show huge differences between countries in carbon footprints per person. Table 1 shows the mean annual *territorial* footprint per person for selected countries in 2011, when the latest reliable data for all countries were published by the United Nations (UN), plus estimated footprints for 2022 from another source. As these

footprints are for territorial emissions of CO_2 they do not include imports and exports. Hence in Table 1 the mean carbon footprint for a UK inhabitant in 2022 is 4.7 tonnes of CO_2 alone rather than over 11 tonnes of CO_2 equivalent GHG consumption-based emissions discussed in previous sections.

Table 1 Mean annual territorial carbon footprint per person for selected countries (CDIAC, 2015; Global Carbon Atlas, 2023)

Country	CO_2 per person, tonnes per year (for 2011, rounded)	CO_2 per person, tonnes per year (estimates for 2022, rounded)
Saudi Arabia	18.7	18.2
United States	16.8	14.9
Australia	16.2	15
Russian Federation	12.6	11.4
Japan	9.3	8.5
Israel	9.2	6.2
South Africa	9.2	6.7
Germany	8.8	8
Ireland	8.0	7.7
United Kingdom	7.2	4.7
China	6.6	8
Sweden	5.5	3.6
France	5.3	4.6
Thailand	4.6	43.8
Turkey	4.4	5.1
Romania	3.9	3.7
Egypt	2.8	2.3
Brazil	2.2	2.2
India	1.7	2.0
Pakistan	0.9	0.8
Nigeria	0.5	0.6
Uganda	0.1	0.1
World average (mean)	**4.8**	**4.7**

Figure 11 shows estimated footprints for more countries presented in graphical form for the year 2022.

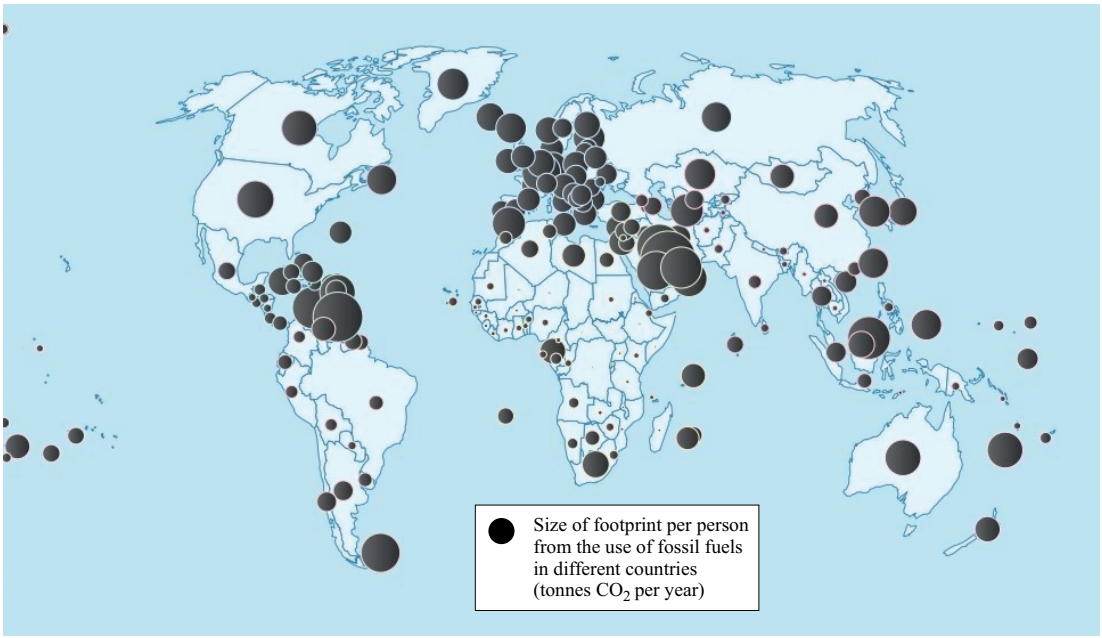


Figure 11 Estimated territorial CO_2 emissions per person in 2022. The bigger the black bubble, the bigger the footprint per person for the country indicated. *(Global Carbon Atlas, 2023)*

Having reviewed Table 1 and Figure 8, now complete Activity 3.

Activity 3International comparisons

Allow about 15 minutes

Use the data for 2022 in Table 1 to answer this question.

How heavy is the mean territorial carbon footprint of a UK resident (in tonnes CO_2 per person per year) compared to the mean footprints of inhabitants of the USA, China, Sweden, India, Uganda and the world mean? Round your answers to the most appropriate number of significant figures (see *Section 2.3.1 : Rounding numbers, decimal places and significant figures*).

Table 2 The carbon footprint of a UK inhabitant in 2022 relative to that of other countries

Country	Mean footprint per person (tonnes CO_2 per year)	UK mean footprint per person relative to other country's mean footprint per person
UK	*Provide your answer...*	*Provide your answer...*
USA	*Provide your answer...*	*Provide your answer...*

China	*Provide your answer...*	*Provide your answer...*
Sweden	*Provide your answer...*	*Provide your answer...*
India	*Provide your answer...*	*Provide your answer...*
Uganda	*Provide your answer...*	*Provide your answer...*
World mean	*Provide your answer...*	*Provide your answer...*

Discussion

The mean carbon footprint of a UK inhabitant in 2022 relative to that of other countries was:

Table 2 The carbon footprint of a UK inhabitant in 2022 relative to that of other countries (completed)

Country	Mean footprint per person (tonnes CO_2 per year) in 2022	UK mean footprint per person relative to other country's mean footprint per person in 2022
UK	4.7	—
USA	14.9	0.32
China	8.0	0.59
Sweden	3.6	1.3
India	2.0	2.4
Uganda	0.1	50
World mean	**4.7**	**1.3**

Note: all values in the final column are given to two significant figures except the value for Uganda. This is shown to one significant figure because the data for Uganda are given to one significant figure.

How realistic are these comparisons? They show clearly that, because people in rich countries generally consume more and have more energy-intensive lifestyles than people in poorer countries, they have heavier mean carbon footprints. But it doesn't mean that the inhabitants of a rich country inevitably have heavy footprints. The inhabitants of Sweden, for example, have only about a quarter of the mean footprint of Americans. This is at least partly because of the low-carbon electricity supplies in Sweden.

But remember that these are figures for *territorial* CO_2 emissions. This is because few countries publish *consumption* emissions that include imports and exports. On a consumption basis, the emissions associated with Chinese exports to the UK, for instance, are counted as belonging to UK *consumers* rather than Chinese *producers*. Nevertheless, by 2019, the mean consumption-based footprint of an average Chinese resident (at 8.0 tonnes CO2e per person) was over two-thirds as heavy as that of an average UK resident (Chancel, 2022).

2.3.3 Total carbon footprints

The picture of carbon footprints changes again when you consider total CO_2 emissions for different countries rather than emissions per person. Table 3 shows that by 2011 China had become by far the greatest total emitter of CO_2, followed by the USA and India.

Table 3 Total territorial carbon dioxide emissions for selected countries (CDIAC, 2015; Global Carbon Atlas, 2023)

Country	Total CO_2 (2011), million tonnes per year (rounded)	Total CO_2 (2023 est.), million tonnes per year (rounded)
China	9020	11397
United States	5306	5057
India	2074	2830
Russian Federation	1808	1652
Japan	1188	1054
Germany	730	666
Saudi Arabia	520	663
South Africa	477	404
United Kingdom	448	319
Brazil	439	483
Australia	369	392
France	339	298
Turkey	321	436
Thailand	303	271
Egypt	221	259
Pakistan	164	200

Nigeria	88.0	129
Romania	84.8	74
Israel	69.5	56
Sweden	52.1	38
Ireland	36.1	39
Uganda	3.8	6.0
World total	**34 437**	**37 150**

Note: the CO_2 emissions shown in Tables 1 and 3 are based on from burning fossil fuels, cement manufacture and gas flaring.

Figure 9 shows more of the same information updated using estimations for 2022, when China, the USA and India combined emitted half of the world's CO_2.

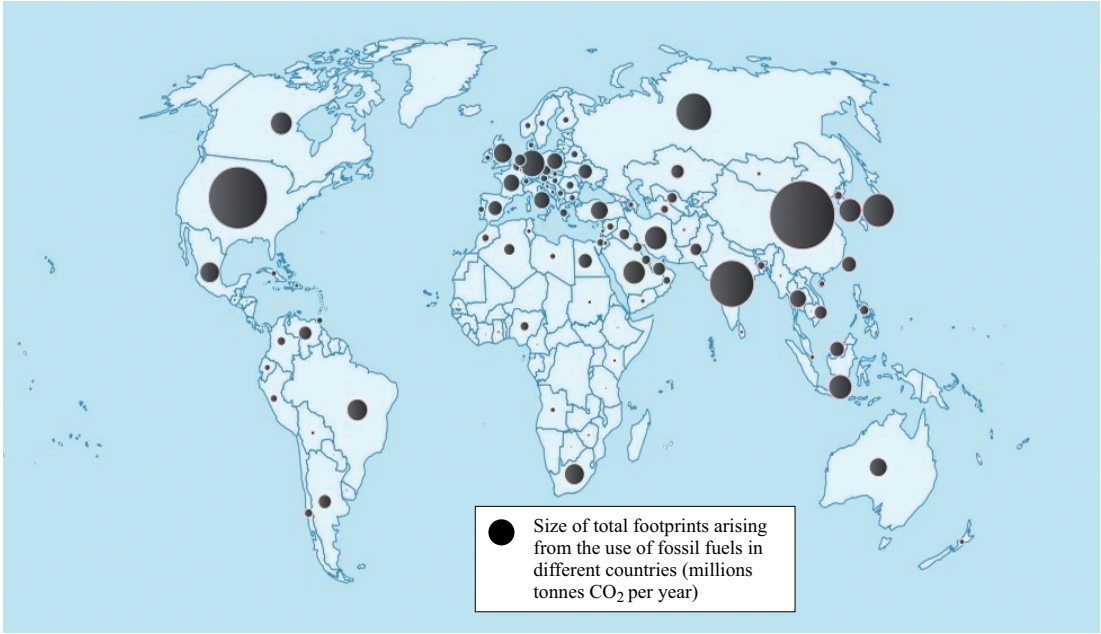


Figure 12 Estimated total territorial CO_2 emissions in 2022*(Global Carbon Atlas, 2023)*

2.3.3 Differences between people and places

Mean individual and household carbon footprints for a country conceal the differences *within* that country. As you saw for the UK, these differences in carbon footprints are strongly related to income and can be very great.

For example, the values given in Table 1 for 2022 hide:

- in India, the 2015 mean carbon footprint of 1.7 tonnes CO_2 per person per year hides the differences between middle-class Indian households living in air-conditioned apartments and owning a television, refrigerator and motor scooter, or perhaps a car (Figure 10(a)), and the household of a subsistence farmer, whose only fuel is dried cow dung for cooking, and perhaps kerosene for a lamp (Figure 10(b))

- in Africa, the contrast between the elite, who may have a private swimming pool, and villagers who have to collect water for cooking and washing (Figures 10(c) and (d)) is not shown
- in China, where the lifestyles of the wealthier members of the very rapidly growing urban population still contrast with those of people living in China's villages and rural areas (Figures 10(e) and (f)).


(a)


(b)


(c)


(d)

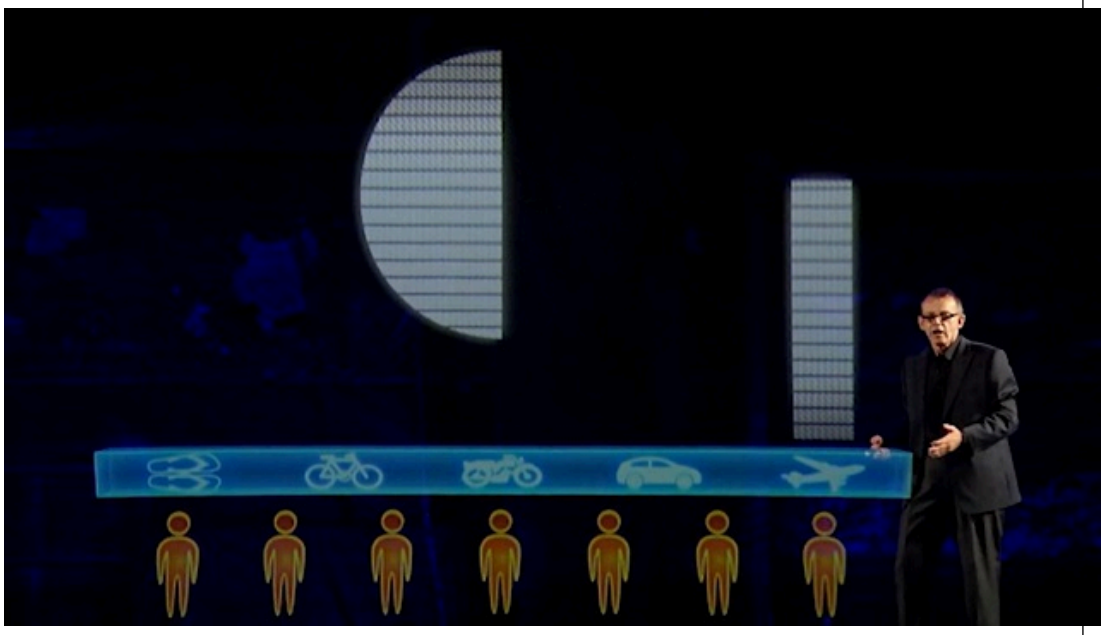

(e)


(f)

Figure 13(a) Apartments, New Town, Kolkata, India, built for India's fast-growing middle class; (b) Indian cattle farmer living on less than £1 per day; (c) government official's house, Libreville, Gabon; (d) villager's house, Jinja, Uganda; (e) typical apartment block, China; (f) village alley, near Yangshuo, China

Now watch the following videos. The first video by the late statistician Professor Hans Rosling graphically demonstrates that the richest billion people in the world emit most of its total carbon dioxide emissions, while the poorest only emit a small proportion. Although this video was made in 2013 and the data have evolved, the basic message still holds. The second video expands on why it is important to compare carbon dioxide emissions *per person* for different countries (as in Table 1 and Figure 8), rather than just total emissions, in order to develop policies for tackling climate change on a fair basis.

Video content is not available in this format.
Video 1 Who is responsible for carbon emissions and climate change?



Video content is not available in this format.
Video 2 Carbon emissions per country and per capita

Activity 4 Income and carbon emissions across the world

Allow about 10 minutes

a. Why is it important for international agreements on reducing carbon dioxide (and other GHG) emissions to compare countries on their emissions per person as well as on their total emissions?

Provide your answer...

Answer

When attempting to negotiate international emissions reduction agreements, comparing mean emissions per person of different countries is fairer and so is more likely to be acceptable to Global South countries wishing to industrialise.

b. Which groups of countries are historically responsible for the main growth in carbon dioxide emissions, and from which groups will the main growth come in the future?

Provide your answer...

Answer

The historical growth in emissions has been from the developed countries during their industrialisation since 1800; some are now stabilising or reducing (though not fast enough). The future growth in emissions is likely to be from newly industrialising countries (e.g. India) and developing countries (e.g. Thailand) whose residents earn between $10 and $100 per day on average.

c. What do the videos suggest that different countries should aim for to reduce their emissions?

Provide your answer...

Answer

Developed countries with very high carbon emissions per person, like the USA, should reduce their emissions to the lower level of other developed countries like France and Sweden. Rapidly developing Global South countries like India and Thailand should try to avoid the path of the Global North by preventing their emissions per person from growing as much.

d. What do the videos leave out of his analysis?

Provide your answer...

Answer

The analysis in the two videos does not include non-CO2 GHG emissions or the emissions associated with imports and exports, but the basic lessons still apply.

2.4 Summary of Section 2

The main learning points from Section 2 are:

- There are different ways of calculating the carbon footprints of individuals and households. Excluding the emissions associated with imports and exports, the mean territorial UK footprint is 4.7 tonnes of CO_2 per person per year. But more realistically, including imports and exports and other GHGs, the mean consumption-based UK footprint of CO_2 equivalent per person per year is more than twice that amount.
- The main components of individual and household carbon footprints in developed countries are private car and air travel, household gas and electricity use, the consumption of food and other goods, and the use of services.
- The carbon footprints of individuals and households vary widely within countries, related especially to people's incomes, household sizes and lifestyles. For example, the carbon footprint per person of people living in Europe and the USA with the highest 10% of incomes is about six times that of those with the lowest 10%.
- The carbon footprint also varies between countries, by amounts depending on how it is calculated. About half of the world's total territorial CO_2 emissions are produced by three countries: China, the USA and India. The average territorial emissions per person in the USA are nearly twice those of people in China and nearly eight times more than people in India.

Territorial emissions are used in international negotiations to limit dangerous increases in global temperatures. To reach international agreements, it is fairer to compare countries on mean carbon footprints per person than on total emissions, although this obscures the differences between the footprints of rich and poor people within each country. Next you will estimate your own carbon footprint.

3 How heavy is your footprint?

In this section you'll be estimating your individual (i.e. personal) carbon footprint using a computer-based calculator.

The carbon calculator was specially developed for The Open University by drawing upon some of the studies and reports discussed in previous sections. The data from these were then updated using the latest available statistics.

The calculator will show you which consumption activities make large and small contributions to your carbon footprint. But because the calculator is a model of reality, that is a simplified representation of the real world, it can give you only an estimate of your carbon footprint and how it is broken down into: emissions arising from the energy you use for room and water heating; your travel by car, public transport and air; your typical diet, usual spending habits, and so on.

The results the calculator produces are only as good as the accuracy of the data, assumptions, equations and options within the model and the information you enter into it. For example, if you drive a medium-sized petrol-engine car, the calculator works out the carbon footprint of your personal car travel by multiplying your approximate annual car mileage (chosen from a drop-down list of options) by the mean CO_2 emissions per kilometre for medium (1.4 to 2 litre) petrol engines from official statistics adjusted for the number of people who typically occupy a household car when in use. The accuracy of the car footprint depends on how close your actual car mileage is to the options offered by the calculator, how close your actual car emissions are to the mean for 1.4 to 2 litre petrol-engine cars, and how typical your car occupancy actually is.

The calculator could, of course, provide a more accurate car travel footprint if you were asked for more detailed information, such as the make and model of your car, how many people usually travel in the car and your typical annual car mileage. But it could be time-consuming and laborious to complete if this amount of detail were required for all the questions in the calculator. Carbon calculators therefore make compromises between the time and effort required to use them and their accuracy. This one tries to make the process fairly quick and easy, and focuses on the information that has the biggest effects, in order to provide an approximate, but realistic, personal carbon footprint.

The carbon calculator also enables you to try out the effects on your footprint of making changes, such as to your home's energy efficiency. Testing different changes without having to make them in reality is a form of computer modelling. In Section 4 you'll be asked to reduce your footprint by modelling the effects of changes allowed by the calculator – such as driving or flying less, or changing your car, diet or spending behaviour. Because it uses the consumption-based perspective, the calculator assumes that most of the nation's footprint arises from consumer demand and behaviour. The emissions generated by public services, business and non-governmental organisations are allowed for to some extent, but the main responsibility for reducing the footprint is given to individuals and households. However, in Section 5 you can try out the effects on your footprint of making changes beyond the household level, such as spending some of your income on 'voluntary carbon offsets' for carbon-saving projects or agreeing to carbon taxes for national investments in low-carbon technologies.

3.1 Calculating your carbon footprint

How big is your carbon footprint? And what are the main contributors to your carbon footprint? You will now use the OU carbon calculator to estimate your personal footprint and identify your actions which contribute to it.

Activity 5 Your carbon footprint

Allow about 1 hour

a. Following the steps below, use the OU carbon calculator to work out your individual carbon footprint.

- Open the carbon calculator, in a new window or tab, by clicking on this link: OU carbon calculator.
- Click on 'Next' on the Welcome screen to start.
- Answer the questions on the calculator's tabs from 'Your Household' to 'Goods' for your existing situation. (There are no questions to answer in the 'Infrastructure' tab). *You'll find that some questions are fairly general and don't exactly fit your personal situation and there are options that require estimates (or even 'guestimates'). So you'll have to choose answers or values that fit your situation as closely as possible.*
- Note that some questions refer to the whole household and some to you personally. If the question asks what do 'you' do (e.g. How many minutes do you spend in the shower?) it means you personally, unless it's clear that all household members are involved (e.g. What main fuel do you use to heat your hot water?).
- For help in using the carbon calculator go to the FAQs page.

- Select 'Next' on the Welcome screen to start.
- Answer the questions on the calculator's tabs from 'Your Household' to 'Goods' for your existing situation. *You'll find that some questions are fairly general and don't exactly fit your personal situation and there are options that require estimates (or even 'guestimates'). So you'll have to choose answers or values that fit your situation as closely as possible.*
- Note that some questions refer to the whole household and some to you personally. If the question asks what do 'you' do (e.g. How many minutes do you spend in the shower?) it generally means you personally, unless it's clear that all household members are involved (e.g. What main fuel do you use to heat your hot water?).
- Additional guidance and FAQs can be found here.

The right-hand panel of the carbon calculator screens includes two bar charts – the 'You' and UK 'Average' carbon footprints. As you answer the carbon calculator questions, the effect on your footprint will be shown on the 'You' bar chart and in the data on Summary screen.

- You can make changes to your answers as many times as you like until you are satisfied you have the best estimate of your footprint. When you are satisfied that you have the best estimate of your existing footprint; go to the Summary tab. Then name (e.g. *ExistingFootprint1*) and save a record of your footprint

Figure 11 below shows the OU carbon calculator 'Summary' footprint screen, with an example existing carbon footprint for a hypothetical student (in the left-hand column of the table and the left-hand bar chart) and the UK average (mean) carbon footprint (in the right-hand column of the table and the right-hand bar chart).

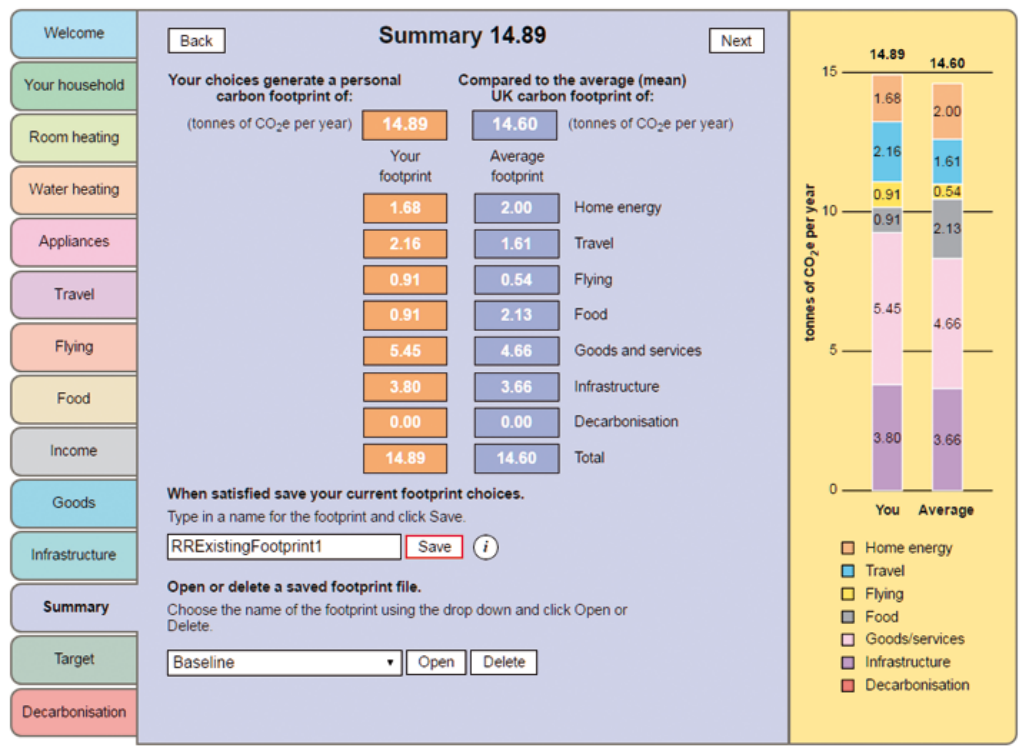


Figure 14 An example of the OU carbon calculator 'Summary' footprint screen. The student's existing footprint is 12.70 tonnes CO_2e per year; this is greater than the UK national average of 11.53 tonnes CO_2e per person per year.

b. The carbon calculator is a simplified computer model of the real world. Why is such a model useful, and what is the implication of it being based on the consumption perspective for measuring carbon footprints?

Provide your answer...

Answer

The carbon calculator is a useful model because it allows individuals to calculate their carbon footprint and explore options for changing it.

Being a consumption-based model, the calculator assumes that individual and household consumption is ultimately responsible for triggering most GHG emissions, so decisions by individuals could significantly reduce the nation's footprint.

3.2 Summary of Section 3

The main learning points from Section 3 are:

- Individual and household carbon calculators are models that use data, mathematical equations and assumptions to convert information that you provide about your home, travel, etc. into an approximate figure for your carbon footprint.

- The results provided by a carbon calculator can only be as good as the accuracy of the data, assumptions, equations and options within the model and the information entered into it. Carbon calculators have to make compromises between usability and accuracy.
- Carbon calculators allow you to model the effects on your carbon footprint of making changes (e.g. to your home's energy efficiency, travel choices or diet), and so explore how best to reduce your footprint.

Now you know the extent of your carbon footprint, next you will look at ways of reducing it.

4 Reducing your carbon footprint

Calculating your individual carbon footprint using the OU carbon calculator gives you a good idea of the contribution to the total footprint made by your choices regarding energy, food, travel, etc. You'll also know how your carbon footprint compares to that of the mean footprint per person for the UK or another country.

Unless you already live a very 'green' lifestyle, it's unlikely that your footprint will be light enough to contribute to limiting global temperature rise and be compatible with long-term environmental sustainability.

This section, therefore, discusses targets for reducing carbon footprints towards an environmentally sustainable level. At the end of the section, you'll then use the carbon calculator again to explore options for reducing your footprint towards such targets.

4.1 Carbon reduction targets

The first international agreement to set carbon reduction targets was the 1997 United Nations Kyoto Protocol. This came into force in 2005 and required developed countries to reduce their human-generated GHG emissions by an average of just over 5% on 1990 levels between 2008 and 2012. The developing countries that signed up, including India and China, were not required to meet any reduction targets, the USA never ratified the treaty, and Canada and Russia withdrew in 2011 before the second reduction period (from 2012 to 2020) began. The Kyoto Protocol was an important, if modest, first step and known to be inadequate to meet the challenges of climate change.

A series of UN climate change conferences (COPs) since Kyoto came into force have attempted to get international agreements on reducing GHG emissions to limit the rise in average global temperatures. The UN climate conference (COP21) was held in Paris in December 2015. It agreed on the need for drastic cuts in total GHG emissions to limit global temperature rise to 2 °C, and preferably to 1.5 °C, above pre-industrial levels. It was signed by most of the world's countries in April 2016. At subsequent COPs it was agreed that limiting the temperature increase to 1.5 °C is needed to avoid the worst effects of climate change. However, in 2023 the World Meteorlogical Organization (WMO, 2023) predicted that a 1.5 °C rise was likely to be reached, at least temporarily, between 2023 and 2027. In fact, 2023 was the hottest year on record (WMO, 2024) but this record was surpassed one year later in 2024 with an annual average temperature increase of about 1.55 °C above pre-industrial levels (WMO, 2025) – a symbolic warning to the world. To limit a long-term rise in the mean global temperature to 1.5 °C, a globally equitable carbon footprint – based on UN estimates – is calculated to be about 2.5 tonnes CO2 equivalent for every person on the planet, reducing to net zero by the end of the century.

The UK Government exceeded its Kyoto targets and in 2008 passed a pioneering Climate Change Act. Under this Act, the Climate Change Committee was set up to advise the government on carbon budgets, a limit on the GHG emissions in a given time period, and associated emission reduction targets, which are legally binding. After the Paris agreement (COP 21), and leading up to the COP26 UN climate conference in Glasgow in 2021, the UK's targets for meeting its Sixth Carbon Budget and its national contribution to limiting global temperature rise to 1.5 °C were strengthened. The current UK targets are a 68% reduction in GHG emissions by 2030 and a 78% reduction by 2035, with a reduction to net zero by 2050 compared to the 1990 level.

'Net zero by 2050' doesn't mean zero carbon (i.e. no emissions); rather, it means that any emissions remaining in 2050 from UK production and consumption plus a share of international aviation and shipping would be balanced by removal of an equivalent

amount of GHGs from the atmosphere, for example by planting trees or developing and using emerging technologies such as carbon capture, utilisation and storage.

By 2024, UK emissions were 50.4% below the 1990 level (CCC, 2025). Although this represents a welcome, as well as considerable fall in emissions, there is still some way to go to meet the targets and the pace of change will need to increase. It is also arguable that now the required emissions reductions are largely in sectors where this is harder to achieve, such as agriculture and aviation.

It is important to understand that, in line with the UN's Climate Convention, these targets are based on territorial GHG emissions and so don't include the UK's carbon footprint associated with imports.

What might these targets mean for your individual carbon footprint?

Activity 6 Carbon footprint targets

Allow about 30 minutes

The mean *territorial* carbon footprint of a UK inhabitant in 1990 was 14.2 tonnes CO_2e per person per year (UNFCCC, 2015).

1. What should be the mean carbon footprint of a UK inhabitant given the following targets?
   a. The UK Government's target of a 68% reduction in territorial GHG emissions on 1990 levels by 2030.
   b. The government's target of a 78% reduction by 2035.
   c. The government's target of reaching net zero by 2050.
2. On a *consumption* basis, including imports and exports, the 1990 UK footprint was approximately 15.7 tonnes CO_2e per person per year (CCC, 2013). What would be the footprints for the above reduction targets?

See Percentages and parts per million (ppm) in Section 1 for how to calculate percentage reductions.

Provide your answer...

Discussion

1. Considering only *territorial* emissions:
   a. By 2030 the mean UK footprint should have fallen to 32% (100% – 68% = 32%) of the 1990 figure of 14.2 tonnes. SO: 2030 footprint = $\frac{32}{100}$14.2 tonnes CO_2e per person = 4.5 tonnes CO_2e per person per year (to one decimal place).
   b. By 2035 the mean UK footprint should have fallen to 22% (100% – 78% = 22%) of the 1990 figure of 14.2 tonnes. 2035 footprint = 22/100 × 14.2 tonnes CO_2e per person = 3.1 tonnes CO_2e per person per year (to 1 decimal place).
2. By 2050 the mean UK footprint should have fallen to net zero. For individuals and households, this means that they should either produce no emissions or offset any remaining emissions by investing in carbon-saving projects within or

beyond their home. Considering *consumption* emissions, including imports and exports:

a. By 2030 the mean UK footprint should have fallen to 32% of the 1990 figure of 15.7 tonnes. 2030 footprint = 32/100 × 15.7 tonnes CO_2e per person = 5.0 tonnes CO_2e per person per year (to one decimal place).
b. By 2035 it should have fallen to 22% of the 1990 figure:2035 footprint = 22/100 × 15.7 tonnes CO_2e per person = 3.5 tonnes CO_2e per person per year (to one decimal place).

For a UK resident, a consumption-based carbon footprint of 5 tonnes CO_2e per person per year by 2030 might be achievable through actions at the individual or household level, such as those that you can explore with the carbon calculator. However, this footprint is twice the globally equitable footprint of 2.5 tonnes CO_2e per person; achieving such light footprints is likely to require policies and actions by others, especially by government and business.

If you live outside the UK, find the mean CO_2 emissions per person for your country using the sources for Table 2 and Figure 9. Then work out your individual target footprint (e.g. using the EU countries' target of 40% reduction by 2030 or by searching for 'emissions reduction pledges, Paris 2015').

4.2 Actions for lighter living

In this section, you will learn about those actions or changes which are likely to have a big effect on your footprint and those with only a small effect. You will also consider some of the complexities in calculating these effects. This should help prepare you for Activity 11 at the end of this section.

Tables 4a–d provide examples of how different actions affect your carbon footprint and so what you could do to reduce it. But be aware that the effects of these actions depend on the assumptions and data sources used. For example, the CO_2 savings from filling cavity walls with insulation depend on: the house type and size (detached, terraced, etc.); its heating system (gas, electric, etc.); and how the house is occupied. You should therefore regard the information in Tables 4a–d as 'ballpark' figures rather than exact numbers. It also means that effects of changes you might make in the calculator may not exactly match those in the tables.

You can view Tables 4a–d in their full size by clicking on 'View larger image' beneath each table.

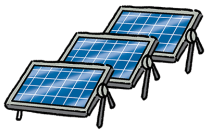
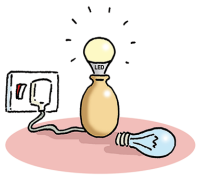
Carbon footprint category	Technical or behavioural actions related to energy	Estimated reduction in carbon footprint (CO_2e)	Source
Energy 	Install solar PV system (average 3.5 kWp) (varies Scotland, NW/Wales to SE England)	660–830 (average 750) kg/year	EST (2023) [Solar panels]
	Replace twenty 50 W halogen lamps/spot lights with 6 W LEDs (used 400 hrs per year)	74 kg/year	Calculated using DESNZ (2023b)
	Replace 70% efficient pre-2005 gas central heating boiler with 90% efficient condensing gas boiler (12 000 kWh/year)	480 kg/year	Estimated using DESNZ (2023b)
	Install 4 m^2 solar water heating: • replacing gas heating (e.g. gas boiler) • replacing electric heating (e.g. immersion heater)	375 kg/year 310 kg/year	EST (2023) [Solar panels: solar water heating]
	Install air source heat pump (in three-bed semi-detached property): • replacing gas central heating (new A-rated condensing boiler/pre-2005 G-rated boiler) • replacing oil-fired central heating (new A-rated/old G-rated boiler)	1900–2900 kg/year (1.9–2.9 tonnes/year) 2900–4400 kg/year (2.9–4.4 tonnes/year)	EST (2023)
	Reduce winter room thermostat temperature from 21 °C to 20 °C (gas-heated properties)	80–140 kg/year	Estimated from national CO_2 savings; Open Access Government (2023)
	Line-dry washing instead of using tumble drier twice per week (100 times per year)	200 kg/year	Adapted from Berners-Lee (2020, p. 90)
	Replace old F-rated (c.2000) fridge, freezer or fridge-freezer with an A or older A+++ rated one	36 kg/year	EST (2023)
	Fix external or internal insulation to solid walls (gas-heated properties)	520 kg/year mid-terrace; 880 kg/year semi-detached	EST (2023)
	Fill cavity walls with insulation (gas-heated properties)	380 kg/year mid-terrace; 650 kg/year semi-detached	EST (2023)
	Fit loft insulation to recommended depth of 270 mm: • from no insulation • from existing 120 mm	550 kg/year mid-terrace; 620 kg/year semi-detached 55 kg/year semi-detached	EST (2023)

Table 4a Estimated effects of individual or household actions on carbon footprint (Energy)

Carbon footprint category	Choices and behavioural actions related to travel	Addition to carbon footprint (CO_2e)	Source
Transport 	Long-haul flight (e.g. London to New York return, 11 000 km)	2874 kg	DESNZ (2023b); note that flight emissions include radiative forcing, explained in the text below
	Medium-haul flight (e.g. Manchester to Barcelona, 2750 km)	511 kg	
	Domestic flight (e.g. London to Glasgow, 1000 km)	273 kg	
	Short-haul flight (e.g. London to Paris return, 700 km)	130 kg	
	Drive 1600 km (1000 miles) with one person in car:		DESNZ (2023b)
	Small petrol car (<1.4 l)	227 kg	
	Medium petrol car (1.4–2 l)	287 kg	
	Large petrol car (>2 l)	438 kg	
	Small diesel car (<1.4 l)	222 kg	
	Medium diesel car (1.4–2 l)	269 kg	
	Large diesel car (>2 l)	336 kg	
	Medium hybrid car (1.4–2 l)	176 kg	
	Medium plug-in hybrid electric car	134 kg (including charging)	
	Medium battery electric car	78 kg (including charging)	
	Drive 8.1 km (5 miles)	Divide above emissions by 200	
	Share car with one or more passengers (average occupancy = 1.6)	Divide by number of people in the car	
 	International rail journey (e.g. Milton Keynes to Paris return, 1000 km or 620 miles)	4.5 kg (due to low-carbon electricity supplies)	DESNZ (2023b)
	UK rail journey of 100 km (62 miles)	3.6 kg	
	Long-distance coach journey of 100 km (62 miles)	2.7 kg	
	Local bus journey of 10 km (6.2 miles)	1.0 kg	

Table 4b Estimated effects of individual or household actions on carbon footprint (Transport)

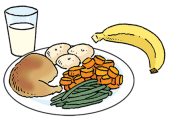
Carbon footprint category	Actions to change consumption of selected foods and drinks or to reduce waste	Estimated effect on carbon footprint (CO_2e) in rank order	Source All from Berners-Lee (2020, pages below), except where stated
Food 	1 kg UK lamb or beef (average consumption per person 20 kg/year)	21–25 kg per kg	p. 224
	1 kg of parmesan	18.6 kg	p. 92
	1 kg of cheddar	11.8 kg	p. 92
	1 kg of pork (average consumption per person 11 kg/year)	7 kg per kg	Poore and Nemecek (2018)
	1 kg goat's cheese	6.4 kg	p. 92
	1 kg eggs	5 kg	p. 85
	1 kg UK cod	4.1 kg	p. 224
	1 kg UK chicken (average consumption per person 30 kg/year)	3.8 kg	p. 224
	1 kg rice	3.0–7.1 kg	p. 95
	1 kg chocolate produced in Europe	2.4 kg	p. 224
	1 litre milk	1.1 kg	p. 86
	1 kg bread produced in the UK	1.1 kg	p. 223
	1 kg bananas shipped from Latin America	0.7 kg	p. 39
	1 kg fresh carrots grown in the UK	0.3 kg	p. 26
	1 kg potatoes grown in the UK	0.3 kg	p. 37
Drink 	750 ml bottle wine (dependent on source)	1.3–1.65 kg	p. 81
	587 ml (1 pint) beer (dependent on source)	0.65–1.0 kg	p. 69
	500 ml plastic bottle of water	0.2 kg	p. 54
Food waste	Minimise waste of edible food (from average 20% thrown away)	370 kg saving/year	Adapted from WRAP (2023)

Table 4c Estimated effects of individual or household actions on carbon footprint (Food)

Carbon footprint category	Actions on goods consumption and waste	Estimated effect on mean carbon footprint (CO_2e)	Source All adapted from Berners-Lee (2020, pages below)
Goods 	A new medium-sized petrol car (e.g. VW Golf, Ford Focus) over a 10-year life	800 kg/year embodied emissions	p. 145
	A new computer kept for 4 years before replacing or scrapping (dependent on make and model)	82–155 kg/year	p. 129
	A new mobile phone, used for 2 years before replacing or scrapping	52.5 kg/year embodied emissions	p. 117
	A new pair of shoes A new pair of trousers	11.5 kg 8 kg	pp. 103, 104
Waste and recycling 	Recycle all household waste rather than about half	130 kg saving	p. 66
	Reusable bags instead of 5 supermarket disposable plastic carrier bags per week	2.5 kg saving	p. 21

Table 4d Estimated effects of individual or household actions on carbon footprint (Goods; waste and recycling)

Activity 7 Lighter carbon living

Allow about 10 minutes

Considering Table 4a–d, what actions do you think are most likely to substantially reduce your carbon footprint? And which seem to make only a relatively small difference?

The actions fall into two broad groups – technical and behavioural (sometimes referred to as lifestyle). For example, installing energy-saving lamps in your home is a ‘technical’ action, while switching lights off is a ‘behavioural’ action. For example, installing energy-saving lights in your home is a ‘technical’ action, while switching lights off is a ‘behavioural’ action. Sort your list of actions into technical (T) and behavioural (B) actions.

Provide your answer...

Discussion

The following actions in Table 4a–d are more likely than others to significantly reduce your carbon footprint. In approximate rank order:

- replace gas or oil central heating with an air source or ground source heat pump (T)
- reduce long journeys by petrol or diesel car as much as possible, especially one-person regular journeys such as commuting (B)

- avoid air travel (especially long- and medium-haul flights) as much as possible; replace domestic and short-haul flights with train or coach travel (B)
- share car journeys with one, two or more passengers (B)
- replace a petrol or diesel car with a plug-in hybrid or battery electric car (T)
- make medium to long journeys by train or coach rather than by petrol or diesel car (B)
- install a solar photovoltaic (PV) system (T)
- install cavity or solid wall insulation (T)
- install or top up loft insulation (T)
- avoid beef and/or lamb consumption (B)
- keep and maintain durable consumer goods such as cars and computers for longer (B)
- replace an old, inefficient gas boiler with an efficient condensing one (but preferable to replace with a heat pump) (T)
- avoid food waste and recycle household waste as much as possible (B)
- line-dry washing instead of using a tumble drier (B).

The following actions are likely to have only a relatively minor effect on your carbon footprint, but may address other important impacts:

- not buying one new pair of shoes or trousers (B)
- avoiding bottled water and disposable plastic carrier bags (B).

These are some of the effective actions that you can take. Remember from Section 2 that household income and size also have a very big effect on personal carbon footprints. There may be little you can, or want to, do about your income, but you may have some control over how you spend it; for example, you could spend spare income on insulating your home, on holiday flights, or on ‘offsetting’ your emissions (see Section 5). The number of people in your household may also not be something you can change, but if you have spare room it is usually carbon efficient for it to have an occupant.

Although having a higher occupancy rate in a house will reduce each occupants footprint, increasing the population of the world, without any other changes, clearly increases total carbon emissions.

4.3 Lighter living costs and constraints

Of course, the costs of ‘light living’ actions also need to be considered. Some actions involve no cost or save money – for example, less flying, shopping or meat eating – or can even make money, such as letting out a spare room. Others are low cost with a rapid payback time. For example, replacing a halogen light bulb with a low-energy compact fluorescent lamp (CFL) or light emitting diode (LED) lamp should pay back the new lamp’s cost in lower electricity bills in a year. Other measures may involve extra cost, for example taking the train instead of driving, or considerable investment, such as installing a rooftop solar photovoltaic (PV) system, which may take ten years or more to pay back. The big carbon-reduction benefits of such actions have to be weighed against affordability, cost and return – although some people may consider that the economics are less important than the carbon reductions.

Apart from cost, there are many other factors that may attract or deter people from acting. Travel behaviour is well known as one of the most difficult things to change. For example,

there may be little choice for some people about using a car for commuting, shopping or ferrying children about. Looking forward to that foreign holiday may be the one thing that keeps someone going.

As noted in Section 2, needs, wants and social values are important too. For example, some people feel that travelling by bicycle or bus is only for people who can't afford a car, and that flying to exotic destinations gives them social status. On the other hand, others get satisfaction in the idea of cutting their travel footprint in half, or making their home really 'green'.

Most people's lifestyles are only partly under their control or are what is considered 'normal' by society. So freedom to change can be constrained by circumstances and the expectations of wider society. Even so, it's important not to fall into the trap of thinking that only making changes with minor environmental benefits is enough. As the former government chief scientific advisor, Professor David McKay, observed, 'If everyone does a little, we'll achieve only a little' (McKay, 2008, p. 3).

4.4 Moving towards a sustainable carbon footprint

In Section 4.1 it was noted that a globally sustainable carbon footprint was about 2.5 tonnes CO_2e per person per year, to be achieved by 2030. That would require the mean footprints per person in the Global North to be reduced by about 80%, while allowing the footprints of poorer countries in the Global South to increase to give their populations a reasonable standard of living.

In Activity 8, you calculated that meeting the UK Government's emission reduction targets on the way to net zero would mean a personal consumption-based carbon footprint of about 5 tonnes CO_2e per person per year by 2030, falling to about 3.5 tonnes by 2035. The discussion noted that such light personal carbon footprints might be achievable by individual and household actions, but are likely to require the making of carbon-saving investments beyond the home and/or actions by government and businesses, such as those discussed in Section 5.

In the next section you will continue to consider your personal carbon footprint.

4.4.2 How can you reduce your carbon footprint?

There are many websites that provide information and inspiration for home eco-refurbishment, lower-carbon transport options, and other green technologies and lifestyle changes. Some give the cost of different actions, available subsidies and the time to pay back any expenditure involved. There are also apps available to download that aim to make it easier and more convenient for users to reduce their impact on the environment – for example, 'Too Good To Go', which aims to reduce food waste.

You will now return to the carbon calculator to explore how you might be able to reduce your carbon footprint to a target level.

Activity 8 Reducing your carbon footprint

Allow about 1 hour 30 minutes

Use the carbon calculator to explore how to reduce your carbon footprint to your chosen target by following the steps below.

- Open the carbon calculator.

- With the calculator running go to the Summary tab and open your ‘existing’ footprint from Activity 7.).
- On the Target screen, select either a Personal OR a Government reduction target.
  - Personal target: first select the ‘Accept footprint’ button to set Your existing footprint value. Your footprint on the bar chart and Summary screen will appear in the box. Then in the box below type in your chosen percentage reduction target.
  - Government targets: select a percentage reduction (50%, 65% or 75%) on the UK Average consumption-based footprint.
- Use the calculator to explore how your existing footprint might be reduced to your chosen target level. Do this by selecting the calculator’s tabs and changing answers to the questions.
- When you are satisfied that you have reached – or done your best to reach – your target, save your reduced footprint using a different name (e.g. ReducedFootprint1)
- FAQs can be found here.

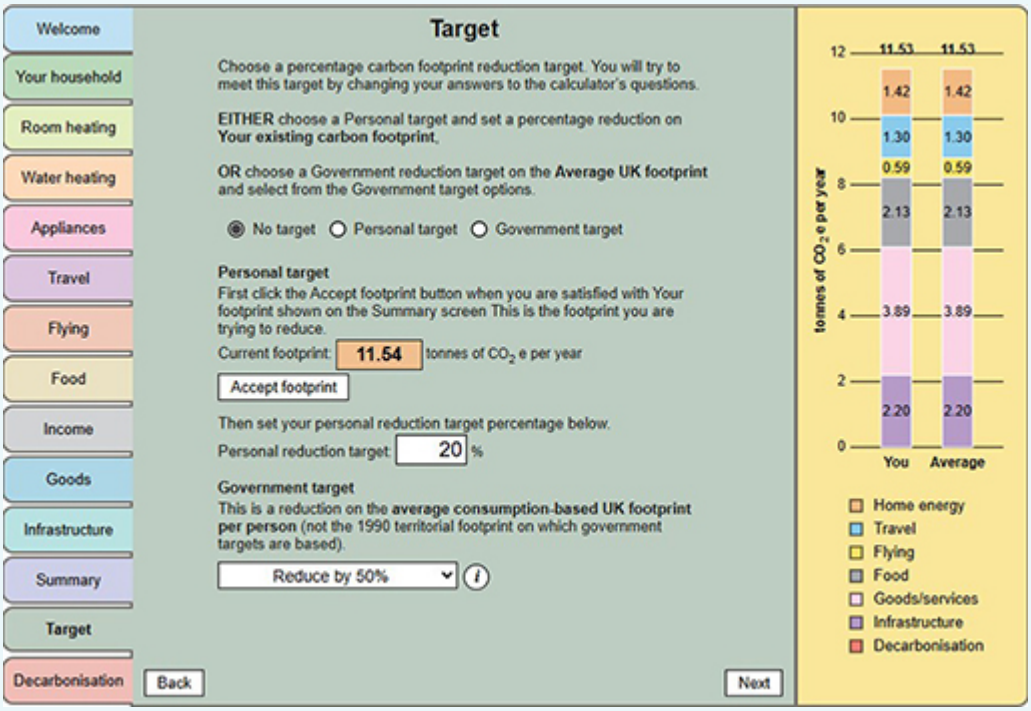


Figure 15 Target screen: My Existing Footprint 1 saved and a Personal target of a 25% reduction on that existing footprint set

If you haven’t managed to reach your target, you have the option of further reducing your footprint via emission reduction measures that could be paid towards by you but are undertaken by government or others in Activity 13 in Section 5.

4.5 Summary of Section 4

The main learning points from Section 4 are:

- There are many national and international targets for reducing GHG emissions, especially CO_2.
- Increasingly, these targets are based on reductions in emissions necessary to give a reasonable chance of preventing the mean global temperature rising by more than 2 °C (and preferably 1.5 °C) compared to pre-industrial levels, in order to avoid dangerous climate change.
- A sustainable carbon footprint is likely to involve an eventual reduction of at least 80% in the mean carbon footprint of people living in rich, Global North countries. Footprint reductions of up to 80% might be possible for some at the individual or household level without losing the benefits of a developed society's lifestyle, but for most people such a reduction will require actions beyond the household and/or by government and business.
- Different technical and behavioural changes have different effects on individual or household carbon footprints. The effects depend on personal circumstances, but the most cost-effective usually include:
    - reducing, or replacing, air and car travel; car sharing
    - upgrading home insulation
    - installing an efficient heating and hot water system
    - fully occupying homes
    - reducing consumption of meat and dairy products
    - spending spare income on low-carbon or carbon-saving goods and services.
- People's ability to radically reduce their footprint is constrained by their circumstances, such as their jobs, family, social pressures and willingness to change.
- A carbon footprint calculator is one way of exploring how to reduce individual or household footprints. However, it can provide only an approximate calculation of the effects of different technical and lifestyle actions.

The final section of this course will look at the role of individuals, households, communities and governments in reducing carbon footprints.

5 Who’s responsible for reducing carbon footprints?

> We must abandon the conceit that individual, isolated, private actions are the answer. They can and do help. But they will not take us far enough without collective action.
>
> (Gore, 2007)

As mentioned earlier, viewed from the consumption perspective, individuals and households directly or indirectly generate the demand for most of the goods and services produced by the economy.

Does this mean that individuals and households are responsible for reducing the CO_2 and other GHG emissions from all their *consumption*? Or are the businesses and industries that *produce* the goods and services at home and abroad mainly responsible? In this section you’ll be considering who is responsible: ‘I’ (as an individual consumer or citizen), ‘we’ (my household, workgroup, community) or ‘they’ (the government, business, other countries, and so on).

5.1 The role of individuals and households

You’ve been considering how to reduce your carbon footprint to help tackle climate change and, to some extent, other environmental changes. ‘I’ as an individual consumer do have a role to play but unless you live alone, you share your household with other people, a group that could be called ‘we’.

The UK Climate Change Committee argues that individuals and households have a major role to play in reducing emissions by making low-carbon choices. The Committee’s Sixth Carbon Budget detailed the actions required by consumers, business and government to meet the UK’s 78% emissions reduction target by 2035 (CCC, 2020). The Committee said that meeting the target requires significant changes in choices by individuals and households to reduce demand and improve efficiency – for example, eating less meat; using electric cars, public transport, cycling and walking; installing a heat pump instead of a gas boiler; reducing growth in aviation demand; and choosing products that last longer. According to the Committee, such changes by consumers will make a major contribution towards meeting the 2035 target on the way to net zero by 2050.

As an individual you may be willing, and able, to make some of these changes, but within a household, there may be different views and priorities about what, if anything, should be done about reducing carbon footprints. Saving energy and other resources can involve some inconvenience or loss of comfort and can involve advance planning or careful thought. It may involve spending money on carbon-saving products or cutting down on some pleasurable activities. There may be social or cultural issues, or deep-rooted beliefs and habits, which differ. Not everyone in the household may agree that the actions are necessary or desirable, or worth even minor inconveniences. Others may be driven by their environmental or other values to live as sustainably as possible.

One member of the household may want to become vegetarian or vegan, while others want to continue to eat meat, fish or eggs; different people in the household may want or need room temperatures to be warmer in winter than others; there may be different views about whether to fly for holidays, on how many new clothes are necessary, and on whether buying second-hand goods or travelling by public transport is acceptable; and so on.

You may be able to think of similar issues in your household, and using the carbon calculator may have highlighted some of them. Does this mean that each member of the household has to be responsible for their own carbon footprint? Or are there shared activities about which compromises must be made in order to reduce the household's total footprint?

Of course, you may not be just part of a shared household: you are also a member of society. Even if you agree within your household about what to do, many others in society are less concerned about reducing carbon footprints or don't have the required knowledge to take action. Is there any point in trying to reduce your footprint when others aren't interested or willing to change? I think there is. Making changes not only reduce your footprint but also act as a positive example for others, who might then be encouraged to take action.

5.2 The role of active citizens and communities

Although the UK Climate Change Committee argues that individuals and households have a major role in reducing emissions, governments have been reluctant to try to change the lifestyles and consumption habits of millions of individuals, focusing instead on working with business and other major decision makers – for example, to decarbonise the electricity supply system.

As George Marshall (2014) has argued, from a psychological viewpoint, asking people to reduce their carbon footprint to help tackle climate change is a very difficult message to get across, as it may require immediate sacrifices in order to address an invisible long-term problem. This is despite storms, floods, heatwaves and other damaging weather events now becoming increasingly frequent and obvious. As these impacts of climate change become more obvious, 'ecoanxiety' is also becoming more prevalent, particularly among young people; although this can spur action, it can have the opposite effect and lead to paralysis in taking action. Also, individuals don't control many of the decisions that affect their carbon footprint, such as national energy and transport policies, town planning, food processing and retailing practices, overseas farming and manufacturing, and so on. Purchasing decisions made by individuals are also influenced by increasingly sophisticated, personalised marketing messages. In other words, while individuals and households are directly or indirectly responsible for most of the consumption of goods and services, they do not control their production, distribution and marketing.

So it is now recognised that while individuals and households can do much to reduce their carbon footprints, they alone can't make the rapid and radical reductions needed to reach a globally sustainable footprint. That requires actions by communities, businesses, and local and national governments.

However, even if individuals don't directly control many economic activities and policy decisions, in a democracy at least, active citizens can exert influence by voting in elections and through political involvement. So, another way 'we' can help reduce carbon footprints is by joining with others in an environmental pressure, protest or action group such as the WWF (previously the World Wide Fund for Nature), Extinction Rebellion, Friends of the Earth or Greenpeace. Many now argue that it is as important, or even more important, for individuals to pressure governments to pursue urgent action on climate change as it is for them to reduce their personal carbon footprints.

A less 'political' approach is to join one of the voluntary groups that get together to help themselves and others to reduce their individual and household impacts. Such voluntary groups include local groups in the Transition Network, as well as the approximately 500 UK community energy groups with nearly 60 000 members that were operating in 2021,

which were formed to install renewable energy technologies, improve home energy efficiency and develop low-carbon transport (Community Energy England, 2023).

In the workplace, individuals can switch off lights and computers, recycle waste paper, and so on. But surveys show that individuals are less likely to save energy at work than at home, as they don't have to pay the bills. However, by working with their colleagues, they can help each other to adopt green practices and encourage their employer to adopt environmental policies – for example, switching to a green electricity supplier, setting up recycling facilities, and establishing staff travel plans. Larger organisations may also have the resources to provide opportunities for employees to take actions aimed at reducing environmental impacts. For example, as part of its sustainability strategy, The Open University has the 'Go Green' initiative that facilitates staff to take action on saving energy, waste, water and travel.

5.2.1 Voluntary carbon offsets

One of the ways that individuals can shift the responsibility for emission reductions from 'I' and 'we' to 'they' is by paying for voluntary carbon offsets. A carbon offset is a reduction in emissions resulting from a carbon-saving project undertaken elsewhere – often in a Global South country – voluntarily paid for by individuals to compensate for (offset) the carbon footprint arising from their activities. (Organisations, such as businesses, can also buy offsets.) For example, many airlines and other companies offer carbon offsets to compensate for the emissions from personal or business flights.

Figure 16 The carbon emissions from air travel are often offset by airlines

However, the benefits of carbon offset schemes have been questioned. The small amount charged by airlines for offsetting the emissions of a flight, for example, bears little relationship to the actual cost of totally eliminating that amount of GHGs from the atmosphere. Tree planting schemes have also been criticised, not least because it takes years for the trees to absorb the CO_2 emissions from, say, a flight made today. However,

there are now projects, such as those accredited by the Gold Standard Foundation, that promise more worthwhile carbon offsets that fund renewable energy and energy efficiency projects and promote sustainable development for the local community where they take place. But whatever the type of project, a carbon offset is a payment to transfer the responsibility for reducing emissions from the person or organisation creating the emissions to someone else.

Despite such reservations, the carbon calculator allows you to offset some of your emissions, especially if you can’t reduce your footprint by individual or household actions. The amount you (theoretically) have to pay for this is based on a realistic price for eliminating each tonne of carbon emissions, not the unrealistically low offset prices charged by airlines, etc.

5.3 The role of governments and business

Despite all the possibilities for individual and group action to reduce carbon footprints, there will still be people, groups and organisations who won’t, or can’t, do much. Many individuals limit themselves to ‘every little bit helps’, with small effects on their carbon footprint, such as reusing plastic bags or recycling paper. This avoids having to consider more significant changes in car and air travel, home energy use, diet or shopping. Others will simply carry on producing and consuming to maximise their own personal or organisational benefit, even if they know this is to the detriment of everyone else and future generations.

This behaviour is what has been called the tragedy of the commons, a term popularised by an American ecologist Garrett Hardin (1968). The ‘tragedy’ is that for a time, each person, organisation or nation can gain an additional benefit by using or consuming a bit more of the commons (the Earth) until a resource is used up, or an irreversible environmental change has occurred. Then everyone suffers.

That’s where government support, taxation and regulation, business initiatives and international agreements to tackle climate change and other environmental problems come in. It’s what ‘I’ and ‘we’ can’t achieve unaided and only ‘they’ have the power to do.

5.3.1 Government taxation and subsidies

One of the things that governments can do is to tax fossil fuels and goods and services that create GHG emissions to encourage households or businesses to reduce those emissions. Or governments can provide grants and subsidies to encourage industry to develop low-carbon products and consumers to adopt them.

An example is transport taxation, in which new cars registered after 2017 with higher CO_2 emissions per kilometre are charged a higher vehicle tax for their first year than those with lower emissions and a standard rate thereafter, with electric vehicles taxed for the first time from 2025. Another is the tax on petrol or diesel fuel intended at least partly to encourage people to change their travel behaviour.

Examples of grants and subsidies for emissions reduction include grants to low-income householders for home insulation and subsidies for installing heat pumps.

Figure 17 Low-carbon products, such as electric cars, have been incentivised through government grants and subsidies.

Taxes on emissions, such as a carbon tax on fossil fuels, are often not popular and they can hit poorer members of society harder than better-off ones. But by careful design to reduce undesirable consequences, such taxes and subsidies can be a very effective way of encouraging businesses, individuals and households to reduce their carbon footprint through financial penalties and incentives (Feng et al., 2010).

The carbon calculator allows you to decide whether to support an increase in taxes to fund national investments in decarbonising the economy and so reduce everyone’s personal footprint.

5.3.2 Government, business and international actions

Other government, business and international actions to address climate change include, in no particular order:

- international agreements on reducing greenhouse gas emissions country by country, such as those negotiated at COP21 in Paris and COP26 in Glasgow national and international policies on increasing renewable energy supply
- regulations on energy labelling of refrigerators, washing machines, etc.
- regulations on the energy performance of buildings
- local and regional planning polices to encourage people to use public transport
- low-emissions zones to discourage use of older, more polluting vehicles
- local authority home insulation and heating improvement schemes
- company programmes to save energy, avoid waste and reduce car commuting
- environmental education and information programmes.

Having now considered what the individual, household, community and government can do to help reduce the carbon footprint complete Activity 11 as a summary exercise.

Activity 9 I, we or they?

Allow about 15 minutes

a. List five activities that 'I' could do as an active citizen, and what 'we' could do as a household, workgroup or community, to reduce your own and others' carbon footprints.

What 'I' as an active citizen could do, or what 'we' as a household, community or workgroup could do to reduce our own and others' carbon footprints:
1.
2.
3.
4.
5.

Answer

You may have suggested some of the following:

What 'I' as an active citizen could do to reduce others' carbon footprints:

1. try to educate or persuade other household members, including children, to adopt more environmentally responsible behaviour
2. join an environmental pressure or support group, or community energy group
3. lobby local or national politicians on environmental issues
4. vote for a political party with the best environmental policies.

What 'we' as a community or workgroup could do to reduce our and others' carbon footprints:

1. try to save energy and resources at work
2. avoid unnecessary commuting and business travel (e.g. by telephone or online communications)
3. work with local schools etc. to adopt environmental teaching and policies
4. work with our employer to adopt environmental policies.

b. List five activities that are beyond the control of individual consumers, citizens, community and social groups.

What 'they' as governments, etc. can do to reduce carbon footprints of the nation, region or world:
1.
2.
3.
4.
5.

Answer

You may have suggested some of the following:

What 'they' as governments, etc. can do to reduce carbon footprints of the nation, region or world:

1. adopt policies to increase supplies of renewable and/or nuclear energy
2. implement national, regional and international agreements and targets to reduce GHG emissions
3. develop and implement plans to reduce a business organisation's carbon footprint
4. adopt and implement regulations to improve the energy performance of buildings and the fuel economy of vehicles
5. introduce or increase carbon taxes, and/or grants and subsidies to individuals, communities and businesses, to help reduce emissions.

5.3.3 Further reducing your carbon footprint

You have now assessed your existing individual carbon footprint and considered how changing your actions, such as changing eating habits, driving fewer miles or flying less, can reduce your footprint. You are almost at the end of this course and the final activity asks you to return to the carbon calculator to see what can be done to further reduce your footprint with some actions beyond the household.

Activity 10 Decarbonising your footprint

Allow about 15 minutes

This activity assumes that you have completed Activity 11 and have tried to reach a Government and/or Personal footprint reduction target.

If you haven't managed to reach your target through individual or household ('I' or 'we') actions, there are some non-household ('they') actions by government or others on the carbon calculator's 'Decarbonisation' screen for reducing emissions.

Even if you've reached your target, you can set a more challenging target to explore the effect of these actions, such as supporting taxes to fund investments in decarbonising the economy or paying for voluntary carbon offsets.

First open the Carbon calculator.

If you've reached your target in Activity 11:

- On the Target screen, starting from your reduced footprint file, set a more challenging target (as in Activity 11 above).
- Select the Decarbonisation tab. Try out the tax and offset options, which will produce emission reductions that subtract from your reduced footprint lowering it further. When you enter one or more decarbonisation option to reach a target already set, the red target line splits to show the target compared to the 'You' result, while the 'Average' bar shows the target line and its value in its pre-Decarbonisation position.
- You'll find that, depending on your income, increased income tax or regular voluntary carbon offset payments, can produce quite large emission reductions.

If you haven't reached your target in Activity 11:

- Starting from the footprint file which hasn't reached your target, use the Decarbonisation tab (as above) to reach it.

In either case:

- When you have reached your target, save the new reduced footprint file using a different name (e.g. *DecarbonisationFootprint1*).
- Additional guidance and FAQs can be found here.

This final activity has helped you explore the impact on your carbon footprint of carbon dioxide emission reduction measures paid for through your taxes or voluntary carbon offset payments, but undertaken by government or others. Such measures can be difficult to implement in practice and are often politically sensitive.

5.4 Summary of Section 5

The main learning points from Section 5 are:

- There are limits to the ability of individuals and households to reduce their carbon footprints, because they don’t directly control decisions about the production and distribution of the goods they consume and services they use.
- Even so, individuals can take actions to help reduce emissions as citizens and/or as active members of community organisations, pressure groups or workgroups.
- There are still many actions concerning the environment and climate change beyond the control of individuals, households and communities (‘I’ and ‘we’). These require action by governments and business at local, national and international levels (‘they’).

Conclusion

This free course, *Environment: treading lightly on the Earth*, has highlighted that much of the carbon footprint of an economy is due to use of energy and transport, and consumption of food, goods and services by individuals and households. Hence, what you can do as an individual consumer, citizen and/or household member to reduce your carbon footprint can be significant. But communities, business and governments also have a crucial role in tackling GHG emissions and climate change.

This OpenLearn course is an adapted extract from the Open University course U116 *Environment: journeys through a changing world*.

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