'Terrific! I can't remember the last time I read a book that was more fascinating and useful and enjoyable all at the same time.'
Bill Bryson

HOW BAD ARE BANANAS?

THE CARBON FOOTPRINT OF EVERYTHING

MIKE BERNERS-LEE

CO_2e

Throughout this book carbon footprints are measured in CO2 e, short for carbon dioxide equivalent. This is simply a way of describing an object or action's overall contribution to global warming, taking into account CO_2 as well as other greenhouse gases such as methane and nitrous oxide.

The 10-tonne lifestyle

The text refers to the 10-tonne lifestyle. Readers are encouraged to attain a total carbon footprint of ten tonnes per year – around a third lower than that of the typical UK citizen. Together, we can make a difference ...

'If we're serious about really addressing climate change, we need to become energy and carbon literate, and get to grips with the implications not only of our choices but also the bigger infrastructures which underpin the things we consume. How can we educate our desires unless we know what we're choosing between? Mike Berners Lee, to my complete delight, has provided just the wonderful foundation we need – a book that somehow made me laugh while telling me deeply serious things.'

Peter Lipman, Director of SUSTRANS

'Enjoyable, fun to read and scientifically robust. A triumph of popular science writing.'

Chris Goodall, author,
Ten Technologies to Fix Energy and Climate

'Curiously fascinating to both climate geeks and well-rounded human beings alike.'

Franny Armstrong, Director of *The Age of Stupid*
and founder of 10:10

MIKE BERNERS-LEE is the founding director of Small World Consulting, an associate company of Lancaster University, which specialises in organisational responses to climate change.

The carbon footprint of everything

Mike Berners-Lee

PROFILE BOOKS

I'm grateful to many of Small World's clients for providing material, but especially to Booths supermarkets, Lancaster University, the Crichton Carbon Centre, Historic Scotland and the Keswick Brewing Company.

Finally, thanks to everyone who said 'Oh, you're writing a book … how interesting!' and to those who, just to keep my morale up, pre-ordered copies long before I'd even finished the first draft.

Introduction

A few years ago I agreed to go round a supermarket with a journalist who wanted to write an article on low-carbon food. We trailed up and down the aisles with the dictaphone running and she plied me with questions, most of which I was pitifully unable to answer.

'What about these bananas? … How about this cheese? … It's organic. That must be better … isn't it? … Or is it? … Lettuce must be harmless, right? … Should we have come here by bus? … At least we didn't fly! How big a deal is food anyway?'

It was not at all clear what the carbon-conscious shopper should do. There was clearly a huge gap in the available consumer knowledge and on that day we couldn't fill it. The article never happened, and it's probably just as well. Since then, I have looked long and hard into all kinds of carbon footprints, and carried out numerous studies, including one for a supermarket chain.

This book is here to answer the journalist's questions, and many more besides. It's not just a book about food and travel. I want to give you a sense of the carbon impact – that is, the climate change impact – of everything you do and think about. I want to give you a **carbon instinct**. Although I have discussed the footprint of just under one hundred items, I hope by the time you have read about these you will have gained such a sense of where carbon impacts come from that you will be able to make a reasonable guesstimate of the footprint of more or less anything and everything that you come across. It won't be exact, but I hope you'll at least be able to get the number of zeros right most of the time. There are messages here for personal lives, for businesses and a few sprinkled in for policy makers too.

Some basic assumptions

I'm hoping I can take three things for granted:

- climate change is a big deal;
- it's man-made
- and we can do something about it.

However, out of respect for the still widespread confusion over these assumptions, I have put more about them in an appendix in case you want to check them out before moving on.

Perspective

A friend recently asked me how he should best dry his hands to reduce his carbon footprint; with a paper towel or with an electric hand drier. The same person flies across the Atlantic literally dozens of times a year. A sense of scale is required here. The flying is tens of thousands of times more important than the hand drying. So my friend was simply distracting himself from the issue. I want to help you get a feel for roughly how *much* carbon is at stake when you make simple choices – where you travel to, how you get there, whether to buy something, whether to leave the TV on standby and so on.

Picking battles

I'm not trying to give you a list of 500 things you can do to help save the planet.[1] You could probably already write that list yourself. You will find at least 500 possibilities in here, but this is a book about helping you work out where you can get the best return for your effort. This book is here to help you **pick your battles**. If you enjoy the read and by the end of it have thought of a few things that can improve your life while cutting a decent chunk out of your carbon, then I'll be happy. The book isn't here to tell you what to do or how radical to be. Those are personal decisions.

Is carbon like money?

In one sense, yes it is.

Carbon is just like money in that you can't manage it unless you understand it, at least in broad terms. Most of the time we know how much things cost without looking at the price tag. I don't mean that we have an exact picture, but we know that a bottle of champagne is more expensive than a cup of tea but a lot cheaper than a house. So most of us don't buy houses on a whim. Our financial sense of proportion allows us to make good choices. If I really want champagne I know I can have it, provided that somewhere along the line I cut out something just as expensive that is less important to me. Our carbon instinct needs to be just like the one we have for managing our money.

That's where the similarity ends. Unlike with money, we are not used to thinking about carbon costs. It's also much harder to tell how much we are spending because we can't see it and it's not written down. Furthermore, unlike what happens when we spend a lot of money, we don't personally experience the consequences of our carbon impact because it's spread across nearly seven billion people and many years.

Enjoy the read

These pages are written for people who want to love their lives and for whom that now entails having some carbon awareness alongside everything else that matters to them.

Dip in. Keep it by the loo. Read it from cover to cover or flit around. Use it as a reference if you like. Talk about it. Take issue with it. Let me know how it could be improved (**info@howbadarebananas.com**). Think of it like an early map, full of inaccuracies but better, I hope, than what you had before.

If there's a fourth premise behind the book, it is that nearly all of us, including me, have plenty of junk in our lives that contributes nothing at all to the quality of our existence. It's deep in our culture. Cutting that out makes everyone's life better, especially our own. I got a big win by swapping my solo car commutes for bike rides and lift shares. That works for me, but I'm not prescribing that particular solution for you because we are all different. I hope you enjoy the read and that while you are at it you bump into at least something you can use.

So how bad are bananas?

As it happens, they turn out to be a fine low-carbon food though not totally free from sustainability issues to keep an eye on: see page 27.

A quick gu… carbon and ca… footp…

Carbon footprint is a lovely phrase that is horribly abused.[1] I want to make my definition clear at the outset.

Throughout this book, I'm using the word **footprint** as a metaphor for the total impact that something has.

And I'm using the word **carbon** as shorthand for all the different global-warming greenhouse gases.

So, I'm using the term **carbon footprint** as shorthand to mean the *best estimate* that we can get of the *full climate change impact* of something. That something could be anything – an activity, an item, a lifestyle, a company, a country or even the whole world.

CO_2e? What's that?

Man-made climate change, also known as global warming, is caused by the release of certain types of gas into the atmosphere. The dominant man-made greenhouse gas is carbon dioxide (CO_2), which is emitted whenever we burn fossil fuels in homes, factories or power stations. But other greenhouse gases are also important. Methane (CH_4), for example, which is emitted mainly by agriculture and landfill sites, is 25 times more potent per kilogram than carbon dioxide. Even more potent but emitted in smaller quantities are nitrous oxide (N_2O), which is about 300 times more potent than carbon dioxide and released mainly from industrial processes and farming, and refrigerant gases, which are typically several thousand times more potent than carbon dioxide.

In the UK, the total impact on the climate breaks down like this: carbon dioxide (86 per cent), methane (7 per cent), nitrous oxide (6 per cent) and refrigerant gases (1 per cent).

Given that a single item or activity can cause multiple different greenhouse gases to be emitted, each in different quantities, a carbon footprint if written out in full could get pretty confusing. To avoid this, the convention is to express a carbon footprint in terms of **carbon dioxide equivalent (CO_2e)**. This means the total climate change impact of all the greenhouse gases caused by an item or activity rolled into one and expressed in terms of the amount of carbon dioxide that would have the same impact.[2]

Beware carbon toe-prints

The most common abuse of the phrase carbon footprint is to miss out some or even most of the emissions caused, whatever activity or item is being discussed. For example, many online carbon calculator websites will tell you that your carbon footprint is a certain size based purely on your home energy and personal travel habits, while ignoring all of the goods and services you purchase. Similarly, a magazine publisher might claim to have measured its carbon footprint but in doing so looked only at its office and cars while ignoring the much greater emissions caused by the printing house that produces the magazines themselves. These kinds of carbon footprint are actually more like carbon 'toe-prints' – they don't give the full picture.

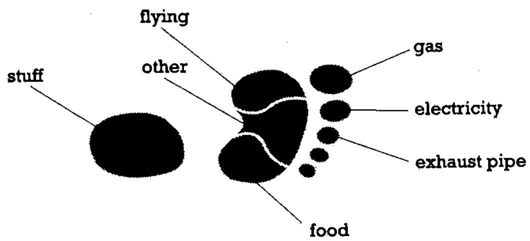

Figure 1.1 The footprint of a lifestyle is bigger than its toe-print.

Direct and indirect emissions

Much of the confusion around footprints comes down to the distinction between 'direct' and 'indirect' emissions. The true carbon footprint of a plastic toy, for example, includes not only direct emissions resulting from the manufacturing process and the transportation of the toy to the shop: it also includes a whole host of indirect emissions, such as those caused by the extraction and processing of the oil used to make the plastic in the first place. These are just a few of the processes involved. If you think about it, tracing back all the things that have to happen to make that toy leads to an infinite number of pathways, most of which are infinitesimally small. To make the point clearly, let's try following just one of those pathways. The staff in the offices of the plastic factory used paper clips made of steel. Within the footprint of that steel is a small allocation to take account of the maintenance of a digger in the iron mine that the steel originally came from … and so on for ever. The carbon footprint of the plastic toy includes the lot, so working it out accurately is clearly no easy task!

To give another example, the true carbon footprint of driving a car includes not only the emissions that come out of the exhaust pipe, but also all the emissions that take place when oil is extracted, shipped, refined into fuel and transported to the petrol station, not to mention the substantial emissions caused by producing and maintaining the car.

A note about high-altitude emissions

Emissions from planes in the sky are known to have a greater impact than those that would arise from burning the same amount of fuel at ground level. The science of this is still poorly understood. Nevertheless, because our measure is setting out to be a guide to climate change impact it is essential to try to take this into account. That is why in this book I have multiplied all aviation emissions by 1.9.[3] (Some experts believe the true impact of plane emissions could be even higher, and suggest a multiplier of up to 4.)

In the Some more information section you'll find a slightly more technical discussion of the methodologies I have used to get the numbers (page 187).

The essential but impossible measure

The carbon footprint, as I have defined it, is *the* climate change metric that we need to be looking at. The dilemma is that it is also impossible to measure. We don't stand a hope of being able to understand how the impact of our bananas compares with the impact of all the other things we might buy instead unless we have some way of taking into account the farming, the transport, the storage and the processes that feed into those stages. A key question, then, is this: 'How should we deal with a situation in which the thing we need to understand is impossibly complex?'

One common response is to give up and measure something easier, even if that means losing most of what you are interested in off the radar. The illusionist Derren Brown refers to one of his core techniques as the *misdirection of attention*: by focusing his audience on something irrelevant he can make them miss the bit that matters. Examples include an airport waxing lyrical about the energy efficiency of its buildings without mentioning the flights themselves. The same thing can happen by accident. If you settle for a toe-print, there is a very good chance it will *misdirect* your attention away from the big deals.

An alternative response to the dilemma, and the approach that this book is all about, is to do the best job you can, despite the difficulties, of understanding the whole picture. This book is about making the most realistic estimates that are possible and practical, and being honest about the uncertainty.

Blurry numbers ...

First and foremost, I am trying to get the orders of magnitude clear.

In my work I put a lot of effort into developing a realistic picture of different carbon footprints using a variety of methods. This book draws upon a lot of that, as well as the most credible secondary sources that I have been able to find. However, huge uncertainty remains. So when you see a number like '2.5 kg CO_2e' on an item such as a burger, bear in mind that it is a best estimate. What it really means is something like 'best estimate of 2.5 kg CO_2e, probably between 1.5 and 4 kg CO_2e and almost certainly between 1 and 10 kg'. That is the nature of all carbon footprints. Don't let anyone tell you otherwise.

Some of the numbers you'll see are even flakier still. This generally happens when I'm trying to bring the beginnings of a sense of scale to important questions that are almost impossible to quantify. Sometimes my calculations and assumptions are highly debatable but I've included them because I think that just going through the thought process can be a useful reflection on something that matters. Examples include the footprint of having a child, a nuclear war or a text message.

If you think you can offer an improvement on any of the numbers in this book, I'll be very happy to hear from you.

... but they will do ...

Let me be emphatic that the uncertainty does not negate the exercise. Real footprints are *the essential measure* and nothing short of them will do. The level of accuracy that I have described is good enough to separate out the flying from the hand drying. And even if you use the numbers here to make finely balanced decisions, most of the time those choices will be better informed than if you had no guidelines at all.

... for now

That we find footprinting tricky is a problem for us all. The situation we are in is like sailing round the world with a map from the 1700s. How should we respond? Throw that map away and have nothing? Definitely not! Use a high-quality map of just a small part of the ocean and ignore the rest? No way. Use the maps we have but treat them with caution? Absolutely. Try to make better maps? Of course – and the work is ongoing. This book is just an early map. Better ones will follow. And this book is trying to help you improve the carbon map that you carry around in your own head.

Making sense of the numbers

So far we've established what we need to try and measure, but a tonne of carbon is still a highly abstract concept. I'm now going to try to give it a bit more real-life meaning.

What does a tonne of CO_2e look like?

If you filled a couple of standard-sized garden water butts to the brim with petrol and set fire to them, about a tonne of carbon would be directly released into the atmosphere. (The carbon footprint of burning that petrol by driving is a bit more than that, for reasons explained later.) If you did the same with a pint milk bottle, that would release just over a kilogram of carbon dioxide, and if you burned a blob about the size of a chickpea, that would release about a gram.

1000 grams (g) = 1 kilogram (kg)
1000 kilograms = 1 tonne

How many tonnes do we each cause?

To give a quick sense of scale, the average UK person currently has an annual carbon footprint of around 15 tonnes. The Chinese and Malawians emit less but the Americans and Australians more. There is more detail on this later on. You get smaller numbers if you only include the obvious bits of your footprint such as household energy and travel or you miss out emissions on goods you buy that are manufactured overseas.

The 10-tonne lifestyle

I'm not here to set you a particular target or to make you feel guilty. How you decide to live is a personal choice that only you can make. I just want to help you understand carbon so that you can do whatever you decide to do with more knowledge.

However, to help get a sense of perspective I have adopted a 10-tonne lifestyle as another unit of measure for this book. I am going to refer to it from time to time, because it gives an alternative and sometimes clearer way of conceiving of those abstract kilograms and tonnes of CO_2e.

Apart from being a round number, there is not much that is particularly magic about a 10-tonne lifestyle – that is, a lifestyle causing 10 tonnes of CO_2e per year. It's certainly not a long-term sustainable target for everyone in the world: if everyone went in for 10-tonne living all over the globe, emissions would skyrocket by 40 per cent.

On the other hand, truly sustainable long-term targets aren't practical or helpful in the short term. For example, the UK has a target to cut carbon emissions by 80 per cent by 2050. If you apply this to the stuff we import as well as to the emissions within the country itself, that would take us down to around 3 tonnes per person per year. Some commentators think we'll need to go even lower. Ultimately, though, it's virtually impossible for an individual in the developed world to get down to a 3-tonne lifestyle any time soon. That kind of cut requires the whole economy to be made greener.

Ten tonnes, by contrast, is a modest aspiration target that most people could meet with enough effort. In the UK and many other European countries, adopting a 10-tonne lifestyle would mean reducing your emissions to about one-third below average. In Australia and the US, it would mean a reduction of closer to two-thirds below average.

One way of thinking about the footprint of an object or activity is to put it in the context of a year's worth of 10-tonne living. For example, a large cheeseburger, with a footprint of 2.5 kg CO_2e, represents about 2 hours' worth of a 10-tonne year. If you drive a fairly thirsty car for 1000 miles, that is 800 kg CO_2e, or a month's ration. If you leave a couple of the (now old-fashioned) 100-watt incandescent light bulbs on for a year, that would be another month used up. One typical return flight from London to Hong Kong burns up around 4.6 tonnes CO_2e. That is just under 6 months' ration in the 10-tonne lifestyle.

A short car commute, a daily cheeseburger, and some wasteful lighting habits could easily use up a quarter of the 10-tonne budget. Then if you also take the flight to Hong Kong, that would leave just 3 months' ration left in the 10-tonne budget for *everything* else that year: other food, heat, buying stuff, health care, use of other public services, your contribution to the maintenance of roads, any wars around the world that your government is involved in (like it or not) – *the lot*.

You might be wondering whether there are any better ways of spending this or any other sized budget than blowing most of it on burgers, commuting and flying. If that question is of interest, this book has been written for you.

How many tonnes for a life or a death?

I hope the comparisons so far have helped to make a tonne of carbon seem a bit more tangible. But let's see whether it's possible to get a handle on how much it might actually *matter*. Our species is good at understanding the direct, immediate and visible consequences of our actions. We are a lot less smart at grasping the consequences when they are dispersed across billions of people whom we will never meet. This might not have mattered when we lived in caves but it won't let us live well in a global society. Our impacts used to be local and visible. Today they are not. Perhaps we need to find it as shocking when we see dispersed suffering inflicted through needless carbon emissions as it would be to see the same suffering inflicted all in one place in front of our eyes by, let's say, a street stabbing.

I did some 'back of the envelope' sums and arrived at a figure of 150 tonnes CO_2e per climate change-related death. I've spelled out my calculations in the endnote that follows this sentence.[4] If you look it up and follow my sums, you'll see that I don't have even the beginnings of a rigorous argument to justify my figure. But it was an interesting thought process and one that, if you do decide to follow it, you might even find faintly plausible. Or you may think my line of thought is hopelessly unrealistic. And maybe you would be right. I was just playing with ideas. It is up to you to decide what meaning to take from them. For me, even a possibility of any realism in this line of thought throws up a challenge.

The 150 tonnes per life figure would mean that if your lifestyle had the footprint of the average UK citizen, one person would have to die from climate change somewhere in the world every 10 years. If you were to fly to Hong Kong and back 11 times first class – that would be another death.

How much would it be worth paying to save a tonne of carbon?

This is not going to be an easy question to answer. An unknown number of lives depends on our response to climate change, and even if we did know how many, it is not as if our society has a consistent approach, even in the very broadest of terms, to determining the kind of value that each one of those lives might have. So, putting a financial value on the saving of a tonne of carbon is going to be tough, to put it mildly. Nevertheless, it's a question worth pondering because unless we understand there to be real and tangible value in cutting emissions, we will simply never bother and, for better or worse, money has become our language for understanding value.

As I write, £12 per tonne is the maximum price of CO_2 that companies in the UK could have to pay.[5] Let's see what happens if we work on that £12 figure. With global emissions at 50 billion tonnes, does that mean that the world might be prepared to pay just 600 billion pounds to eradicate our emissions completely? Is that really all it's worth to us? That's about three-quarters of a per cent of global output in economic terms to have a miracle cure for climate change? Surely on this basis carbon is worth a lot more than £12 per tonne.

Let's see what £12 per tonne implies if you link it in to my estimate of 150 tonnes per death. That would put the value of a life at just £1800. The value of the world's population under this analysis is a mere £12 trillion, or about six times the Gross Domestic Product of the UK. My home town of Kendal has about 24,000 people. Would it really be a good deal to blow up everyone in it if it would liberate £43 million? This analysis places the value of the UK population at just £108 billion. In other words, the people living in the UK are valued at about 5 per cent of their GDP.

So how much should it be worth in financial terms to save a tonne of carbon? A great deal more than the £12, clearly!

Under 10 grams

A text message

0.014 g CO_2e one message
32,000 tonnes CO_2e all world's texts for a year

The biggest part of a text message's footprint is the power used by your phone while you type – and of course by your friend's phone while they read what you've written. If the two of you take a minute between you to type and read the message, and you each have phones that consume 1 watt of power when in use, the message's footprint will be about a hundredth of a gram. This figure takes into account the transmission of a 140-character message across the network.[1]

Around the world, about 2.5 trillion texts are sent every year.[2] Don't be fooled into thinking that the 32,000 tonnes footprint for this total is a big number. It isn't. 32,000 tonnes is about one ten-thousandth of a per cent of the world's carbon footprint. In other words, texting is not a big deal. It wouldn't even be a big deal if my numbers were out by a factor of a hundred.

Incidentally, as of 2008, nearly a quarter of all text messages were sent in China, and about a fifth in the Philippines, where they average an impressive 15 messages per day for each phone. The average North American phone sent just a couple of messages a day, whereas British phones manage six texts per handset.

In summary, we can relax about sending texts (but no spam, please).

A pint of tap water

0.14 g CO_2e one pint
14 kg CO_2e a year's tap water for a typical UK citizen

A year's supply for one person is the same as a 20-mile drive in an average car.[3] That includes drinking, washing, cleaning – the lot.

Unlike the bottled alternative, which has around 1000 times the impact (see page 43), cold tap water is not a major carbon concern for most people. Indeed, the provision and disposal of household water accounts for less than half a per cent of the UK's carbon footprint.[4] Climate change looks set to cause serious water stress in some places. In the UK as a whole it looks as though we are going to have plenty, even though some redistribution might be called for.

Interestingly, if our pint of tap water is poured down the drain, its footprint leaps almost fourfold to just over half a gram because it is more carbon intensive to treat waste water than to supply the water in the first place.[5] If the eventual fate of the drink is to be flushed down the loo along with another 6 litres, that takes the total to 4 g CO_2e.

Tap water itself is one thing. Heating it up is another matter, accounting for a decent chunk of the typical person's emissions (see page 24). See also Swimming pool, page 152, and Desalination, page 91.

A web search

0.2 g CO_2e Google's estimate for the energy used at their end
0.7 g CO_2e from an efficient laptop – a lower estimate
4.5 g CO_2e from a power hungry machine and making higher estimates of power used in the network

So that is between 2 and 14 seconds' worth of ten tonne living for a 30-second single search.

At the low end of the scale, I've started off with Google's estimate of 0.2 g CO_2e for the electricity they use at their end when you put in a single search enquiry.[6] Add to it just 30 seconds of machine time at your end on an efficient 20-watt laptop while you tap in the search, wait for the result and scan it for what you want. That's another 0.1 g, bringing the total so far to 0.3 g. Your local network and the servers that actually host the information you are digging for probably come to at least 50 per cent of the amount of power used by your machine, even if they are super-efficient, like your laptop,[7] so that takes us to 0.35 g. Wear and tear and depreciation of hardware throughout the whole system probably doubles this because of the emissions that are required in the manufacture of all that kit. That takes us to 0.7 g CO_2e for a single enquiry that might let you, say, find the location of the restaurant you're heading to.

On a more power-hungry desktop computer that uses 150 watts of power, your web search might burn through about 0.75 g CO_2e. If you apply the same mark-ups for networks and hardware, we get to a grand total of 4.5 g, with Google accounting for just 0.2 g of that.

One can search for information about the footprint of web searches. You'd find blogs and articles all coming up with different figures based on different assumptions and all including different things. Some look at multiple searches and therefore produce much higher headline figures.[8]

At the high end of my estimate, the activity of surfing clocks up a carbon footprint at about half the rate of the 10-tonne life. In other words, if you spent a whole year browsing the web non-stop you'd trigger about 5 tonnes of emissions. That sounds good until you remember that at the same time you might also be wearing clothes, keeping warm, burning calories, getting closer to your next need for medical attention, living in a building that needs periodic maintenance and so on. Even while you are sat at the machine, your browsing is just one part of your footprint.

Google is estimated to deal with 200–500 million enquiries per day. If we go with the top estimate, and the high-end figure for the footprint of a single search, Google searching accounts for 1.3 million tonnes CO_2e per year. That is a big number, but it is only about one forty-thousandth of our global footprint. We can probably relax about it. Reading the stuff we find is an altogether more carbon-hungry activity – see page 15.

Walking through a door

Zero CO_2e a normal household door on a summer's day
3 g CO_2e getting in through your front door on a cold winter's day
84 g CO_2e big electric doors opening into a large stairwell on a cold windy day

At the high end, that's a banana's worth of greenhouse gas every time you enter the building.

The entrance door of the building where I work has no manual option.[9] To get in you have to press a button and wait while two electric motors whir and double doors swing slowly open, creating a space 2 m wide by 2.5 m high. You enter a spacious stairwell with two large radiators. The only decoration is a certificate proclaiming the 'D'-rated energy performance of the building. It takes 18 seconds for the doors to finish closing. This three-year-old building was amazingly rated environmentally 'Excellent' in its BREEAM assessment.[10]

The power used by the electric motors themselves isn't the problem. They account for just 1 g CO_2e. The problem is the size of the space you have to open, the time it has to stay open for and the vast heated space that the doors open onto.

For this building there must have been lots of other options, such as manual doors that swing shut and can be opened singly, with an override button for disabled access. Rotating doors attached to turbines that generate electricity as you pass through have been trialled in Holland but sound like the kind of gimmick that can tarnish the reputation of the renewables industry.

In a typical home on a cold, blustery day, the numbers are more likely to come out at about 3 g, based on opening it by hand and closing it straight away.

An email

0.3 g CO_2e a spam email
4 g CO_2e a proper email
50 g CO_2e an email with long and tiresome attachment that you have to read

A typical year of incoming mail adds up to 135 kg CO_2e: over 1 per cent of the 10-tonne lifestyle and equivalent to driving 200 miles in an average car.

The annual figure provided here is for the typical business user and includes the sending, filtering and reading of every incoming message. According to research by McAfee, a remarkable 78 per cent of those incoming emails are spam. Around 62 trillion spam messages are sent every year, requiring the use of 33 billion units of electricity and causing around 20 million tonnes of CO_2e per year. McAfee estimated that around 80 per cent of this electricity is consumed by the reading and deleting of spam and the searching through spam folders to dig out genuine emails that ended up there by accident. Spam filters account for 16 per cent. The actual generation and sending of the spam is a very small proportion of the footprint.

Although 78 per cent of incoming emails sent are spam, these messages account for just 22 per cent of the total footprint of your email account because, although they are a pain, you deal with them quickly. Most of them you never even see. A genuine email has a bigger carbon footprint, simply because it takes time to deal with. So if you are someone who needlessly copies people in on messages just to cover your own back, so you can claim they should have known about it, the carbon footprint gives you one more good reason for changing your ways. You may find that after a while everyone at work starts to like you more, too.

The average email has just one-sixtieth the footprint of a letter (see page 44). That looks like a carbon saving unless you end up sending 60 times more emails than the number of letters you would have posted in days gone by. Lots of people do. This is a good example of the *rebound effect* – a low-carbon technology resulting in higher-carbon living simply because we use it more.

If the great quest is for ways in which we can improve our lives while cutting carbon, surely spam and unnecessary email have to be very high on the hit list along with old-fashioned junk paper post.

If only email were taxed. Just a penny per message would surely kill all spam instantly. The funds could go to tackling world poverty, say. The world's carbon footprint would go down by 20 million tonnes even if genuine users didn't change their habits at all. The average user would be saved a couple of minutes of their time every day and there would be a £170 billion annual fund made available. If 1p turned out to be enough to push us into a more disciplined email culture – with perhaps half the emails sent – the anti-poverty fund would be cut in half but a good few minutes per day would be liberated in many people's lives and the carbon saving would be around 70 million tonnes CO_2e – that's nearly as much as all UK household electricity.

Drying your hands

Zero CO_2e letting them drip
3 g CO_2e Dyson Airblade
10 g CO_2e one paper towel
20 g CO_2e standard electric drier

On average, if you used public toilets six times per day, your hand drying would produce around 15 kg per year; equivalent to 1 kg of beef.

'What's the greenest way to dry my hands?' is a frequently asked question, so I'll answer it even though I have already made the point that if you really want a lower-carbon lifestyle you should be asking about something more important.

Close to the low end of the scale is drying your hands with a Dyson Airblade. This dryer does the job in about 10 seconds with 1.6 kilowatts of power. Its secret is that it doesn't heat the air. It just blows it hard. This makes it far more efficient than conventional hand driers.

In the middle of the spectrum I have put paper towels, based on 10 g of low-quality recycled paper per sheet, and only one towel used each time.[11] (Of course, if you use two or three towels the footprint doubles or triples.)

At the high end are conventional heated hand driers. These take a shade longer than the Dyson and use around 6 kilowatts of power. The big difference is explained by the fact that it always takes a lot of energy to create heat.

Right at the bottom of the scale comes not drying your hands at all – or indeed using a small hand towel that is reused many times in between low-temperature washes. I am not a hygiene expert but I'm told that neither option is good from that point of view: they may even end up adding to the already substantial footprint of the health service (see page 13).

100 grams to 1 kilo

A mug of tea or coffee

21 g CO_2e black tea or coffee, boiling only what you need
53 g CO_2e with milk, boiling only what you need
71 g CO_2e average, with milk, boiling double the water you need
235 g CO_2e a large cappuccino
340 g CO_2e a large latte

So if you drink four mugs of tea with milk per day, boiling just what you need, that's the same as a 60-mile drive per year in an average car. A single latte every day would be nearly 1 per cent of the 10-tonne lifestyle.

The shock here is the milk. If you take tea or coffee the British way, with milk, and you boil only the water you need, then the milk accounts for two-thirds of the total footprint (see Milk, page 71). The obvious way to slash the footprint of your tea is reduce the amount of milk, or simply to take it black (herbal tea, anyone?) (Figure 4.1). Although this will reduce your nutritional intake, you could easily replace the lost calories with something more carbon-friendly such as a biscuit.

I have based my cappuccino and latte sums on the large kind that some of the coffee-house chains encourage you to quaff. These come

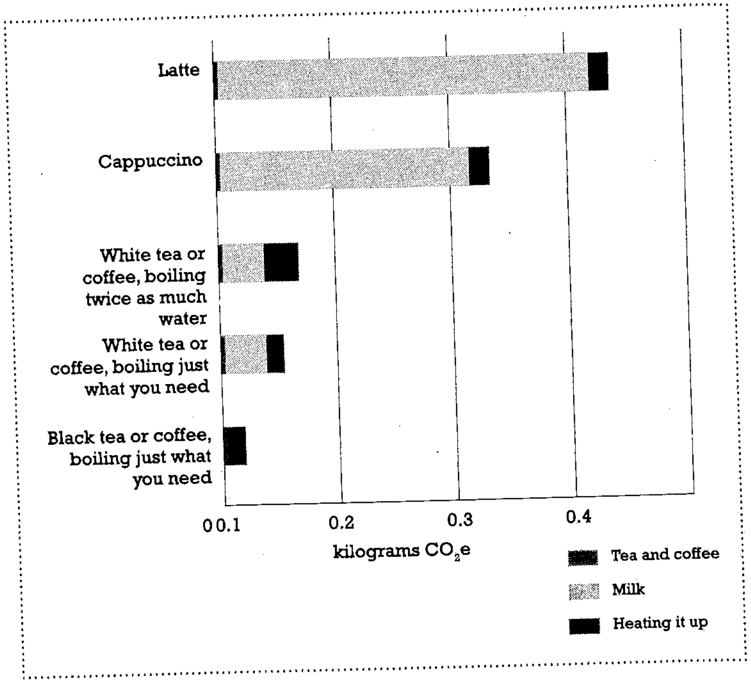

Figure 4.1. The footprint of a 250 ml mug of tea or coffee with no sugar.

in with a higher impact than four or five carefully made Americanos, filter coffees or teas. They also mean you are drinking an extra half a pint of milk, perhaps without realising it.

At my work we've suddenly decided that next week we're all going to do without milk in our drinks. At worst it will taste horrible. At best we'll change habits of a lifetime, resulting in decades of reduced hassle, lower carbon, slight cost savings and possibly even fractionally improved health. It has to be worth trying.*

If you boil more water than you need (as most people do), you could easily add 20 g CO_2e to your drink. Boiling more than you need wastes time, money and carbon; if you haven't yet developed perfect judgement, to avoid this you can simply measure the water into the kettle by using a mug.

Finally, think about your mugs. Buy sturdy ones; look after them and save hot water by only washing them up at the end of the day, rather than using a fresh mug for every cup.

A mile by bus

15 g CO_2e one of 20 passengers squeezed into a minibus in the suburbs of La Paz
150 g CO_2e typical London bus passenger
1.4 kg CO_2e per mile Lake District resident sharing a double-decker bus with just the driver

The efficiency of a bus is just about proportional to people it is carrying. It also depends on the amount of stopping and starting.

A double-decker bus can do between 7 and 14 miles to the gallon. A couple of years ago I took one of these through the Lake District from Windermere to Keswick. It was just me and the driver for the whole ride. At, say, 10 passenger miles per gallon it worked out far worse than leaving the bus in the garage and me taking the car. Another way to look at it is that the bus was going anyway, and my getting on it was just about carbon free. It's a Catch-22. No one wants to take the bus, because it is just as cheap and quicker to take the car (if you've got one), and so far people who care about the carbon arguments are still in a pitiful minority. On the other hand, if the bus were three times as frequent and one-third of the price it would probably be very popular. Everyone apart from the car manufacturers would be better off.

La Paz, Bolivia, is the place I think of where this principle is practised to perfection provided you are prepared to set aside a bit of safety and comfort. Twelve-seater minibuses charge around town with 20 or more people crammed inside. You can get just about anywhere for

* Stop Press. Update: we survived. It was horrible. I'm going to pick different battles. A little bit more herbal tea is drunk in the office these days, possibly as a result of the

one Boliviano – a few pence – and you are unlucky if you have to wait more than 5 minutes. Most people in the developed world would choose a luxury version of this for perhaps five times the price, but the principle is sound and in Bolivia 10 years ago the 'value proposition' met the market need perfectly.

All my numbers have factored in the fuel supply chains as well as the exhaust pipe emissions. I also include a component for the emissions entailed in manufacturing the vehicle, although for the bus this is a small consideration because they do so many miles before needing replacement.[1]

A nappy

89 g CO_2e reusable, line-dried, washed at 60°C in a large load, passed on to a second child
145 g CO_2e disposable
280 g CO_2e reusable, tumble-dried and washed at 90°C

So that's 550 kg per child for two and a half years in disposables; the equivalent of nearly two and a half thousand large cappuccinos.

Most parents will be relieved to hear that there is usually no carbon advantage to be had from reusable nappies. On average they come out slightly worse, at 570 kg per child compared with 550 kg for disposables. And if you wash them very hot and tumble-dry them, reusables can be the worst option of all. However, if you put your mind to it you can make reusables the lowest-carbon option. To do this, pass them on from child to child (so that the emissions embedded in the cotton are spread out more), wash them at a lower temperature (60°C), hang them out to dry on the line, and wash them in large loads.

For a disposable nappy, most of the footprint comes from its production. But about 15 per cent arises from the methane emitted as its [illegible] that if you wrap them up in a plastic bag they will never rot at all).

The study I'm basing my figures on assumed that the average child stays in nappies for about two and a half years, and is changed just over four times a day.[2] On this basis, in the UK, nappies account for something like one two-thousandth of total greenhouse gas emissions – or more like half a per cent for homes with babies.

What does all this mean for the carbon-conscious family? If you have two children and stick to non-tumble-dried reusables throughout, you might be able to save nearly half a tonne CO_2e. You will also cut out landfill. It's a significant efficiency, but (here's the catch) you need to know your own minds before you start out because if you give up, revert to disposables and bin the reusables, it could be the option with the highest footprint of all. But try to keep all of this in perspective: if you take just one family holiday by plane you will undo the carbon savings of perfect nappy practice many times over.

UK climate change secretary Ed Miliband recently drew on the same nappy study to defend his announcement that his own children wear disposables. He was roasted – somewhat unfairly I thought – by blogging eco-mums who claimed that the study was fatally flawed. Poor chap. At least he'd thought about it. The debate illustrates, yet again, that this kind of analysis is more murky and subjective than we might think.

A punnet of strawberries

150 g CO_2e (or 600 g per kilo) grown in season in your own country
1.8 kg CO_2e (or 7.2 kg per kilo) grown out of season and flown in, or grown locally in a hothouse

How have we got into the habit of buying tasteless out-of-season strawberries, which have a footprint more than 10 times the tastier seasonal version?

Although I've given just one number for local, seasonal strawberries, the precise footprint depends on such things as the soil, the use of fertiliser and the use of polytunnels.[3] Some of these variables increase both the yield and the emissions per hectare, so whether they result in more or less carbon per strawberry is not so simple to work out. Luckily, they are all so much better than the out-of-season version that a good enough rule of thumb is just to stick to those grown in your own country – unless your government subsidises the heating of greenhouses (as is the case, for example, in The Netherlands). This kind of hot-housing is, broadly speaking, just as bad as air-freighting the fruit from hotter countries (see Flying, page 135, and Asparagus, page 83).

In short, then, the best advice is to wait until they are in season, then enjoy them twice as much. Or if you really can't wait, buy frozen or tinned: these lie somewhere in the middle of the range, in carbon terms, along with those travelling 'middle distances' by road and boat from warmer climes.

All the figures here have taken account of the 23 per cent average wastage between the field and the checkout. A small amount of the footprint is the packaging and this is actually in a good cause if it enables more of the strawberries to find their way into our mouths. The footprint of the plastic will typically be lower than that of the wasted fruit.

A mile by train

0.15 kg CO_2e Intercity standard class
0.16 kg CO_2e London Underground
0.19 kg CO_2e light rail or tram
0.30 kg CO_2e Intercity first class
An 18-mile intercity rail journey has the same footprint as a cheeseburger, whereas a 5-mile journey on the Tube is equivalent to a pint of milk

Although trains can be a relatively green way to get around, the figures above show that the emissions of rail journeys are higher than you might think. All the numbers provided include the direct emissions and electricity consumption of the moving train itself but also attempt to take account of the embodied emissions from train manufacture, the upkeep of the rail network and the running of all the infrastructure.[4]

The amount of energy required to propel a train down a track depends mainly on just a few simple things:[5]

- How fast the train goes. The air resistance goes up with the square of the speed.
- How many stops there are. Each stop wastes energy – the exact amount being proportional to the square of the speed and the weight of the train. Some newer trains reduce this stoppage waste through 'regenerative braking', a similar technology to the one used in hybrid cars.
- Rolling resistance of the wheels on the track. This is lower for trains than for cars because metal wheels on metal tracks are more efficient than rubber tyres on asphalt. The rolling resistance goes up proportionally with the weight of the train.
- The type of fuel used. Electricity beats diesel because although there are inefficiencies in generating it from fossil fuels in the first place, once this has been done the train engine can turn almost all of the power into movement. A diesel engine is much less efficient.

Long-distance Intercity trains go fast (that's bad) but stop infrequently (that's good). In the UK, they're often electric (that's good), but they're also extremely heavy (that's bad). The weight of the train per passenger seat, amazingly, is around twice that of an average car. Just to be clear, what I am saying is that the weight of a full train is twice that of all the cars that would be needed if each passenger drove instead. Professor Roger Kemp,[6] who has looked at this astonishing fact in detail, explains it in terms of overengineered safety: trains weigh at least twice what they need to because we have become obsessed with safety and have forgotten that rail travel is already over

100 times safer than driving. A couple of miles from my house an Intercity train derailed and rolled down a high embankment. Incredibly, only one person was killed. The event was still splashed across the national news, raising public fears, even though so many more people die on the roads every single day. One price of this excessive focus on safety may well be that twice as much energy is required to get our trains moving every time they leave a station.

First-class travel deserves a mention because the number of seats you can squeeze into a first-class carriage is around half the number in a standard-class carriage. This means that the weight being moved per person is doubled again; we're now up to the weight of four cars per seat. I sometimes board trains where half the length is nearly empty first class and the rest is crowded standard class, suggesting that the real weight being hauled per first-class passenger may be even higher.

Things are a bit more complex when it comes to the Eurostar, because when it's in France it runs on electricity that comes predominantly from nuclear power. This is low-carbon energy, whether or not you think nuclear power is worth it in other ways. However, I don't think it is useful to think of trains in nuclear-friendly France as having a smaller footprint than those elsewhere – which is how they are sometimes portrayed. That's because all the nuclear electricity that French power stations can produce would get used up regardless of whether any trains were running. In that sense, the trains are effectively powered by the fossil fuel plants that provide the extra electricity over and above the nuclear 'baseload' (see A unit of electricity, page 55, for more on this somewhat confusing concept of marginal depend).

Interestingly, the London Underground is almost as low-carbon, per passenger mile, as Intercity trains, despite stopping much more often. This is mainly because people are packed in so tightly – almost tessellating, nose to armpit. Other reasons are that the Tube travels relatively slowly, is all-electric, and has lighter trains.

Overall, trains are generally a lot greener than cars but not as good as walking, cycling or staying at home. A sensibly designed car can win, provided you fill it with people. Even two people travelling together are better off driving an efficient car than travelling first class.

See also London to Glasgow return, page 117.

A 500 ml bottle of water

110 g CO_2e locally sourced and using local distribution
160 g CO_2e average
215 g CO_2e travelling 600 miles by road

A bottle a day would add up to 0.6 per cent of the 10-tonne lifestyle.

At more than 1000 times more carbon intensive than its tap alternative, knocking bottled water out of our lives has got to be a simple win. It doesn't even taste better.

Processing the water is the easy part: the bulk of the emissions come from packaging and transport. There is 80 g CO_2e per litre just for the plastic. On top of that is the energy required to melt the PET (polyethylene terephthalate) balls down and mould them into bottles. Transport is significant because water is so heavy. If it has gone 600 miles by road, that could add a further 115 g CO_2e per bottle.[7]

As I write this, London has announced plans to start reintroducing public drinking fountains. This is an encouraging step forward. If everyone switches away from bottles it will be great for the environment and still just as healthy, refreshing and convenient. Interestingly, even though people will be financially better off, the economy may look as though it has slowed down a fraction. This is a nice illustration of how inadequate it is to measure how we are doing by our economic growth. When we are all using the fountains, we might collectively look a shade poorer on paper because the few people who make their living persuading us to buy the bottled stuff will need new jobs. But that will be more than compensated for by the extra cash that the average person will save. So the economy will recede as we all get better off. Let's not cry for the peddlers of bottled water either. Even if you don't believe that they had it coming to them, they are clearly talented and persuasive people who are also more than capable of being successful in constructive careers.

If the world consumes 200 billion litres of this bottled water per year,[8] that's 80 million tonnes of greenhouse gases, or one-sixth of a per cent of global emissions. This is a win worth having!

A letter

140 g CO_2e a 10 g letter made from recycled paper and recycled by you
200 g CO_2e a typical 25 g letter printed on virgin paper and sent to landfill
1600 g CO_2e a small catalogue sent to landfill

If you have five letters delivered per day plus two catalogues per week, that's a massive 480 kg CO_2e per year, nearly 5 per cent of the 10-tonne lifestyle.

Mail clocks up a carbon footprint in four basic ways (Figure 4.2):

- Paper production. The carbon footprint of paper manufacture depends on the recycled content, the quality of the paper and the efficiency of the mill. The junk mail coming through our door generally uses high-quality stuff and doesn't tend to boast any recycled credentials. My estimates are based on paper that has a typical UK mix, with less than one-fifth recycled content. That gives it a footprint of 2.35 kg CO_2e per kilo. The best estimate for pure virgin paper comes in at 2.59 kg per kilo, and 100 per cent recycled paper at about half of that; it takes about half as much energy to create new paper from old paper as it does to create paper from trees.[9]

For the footprint of printing on the paper to turn it

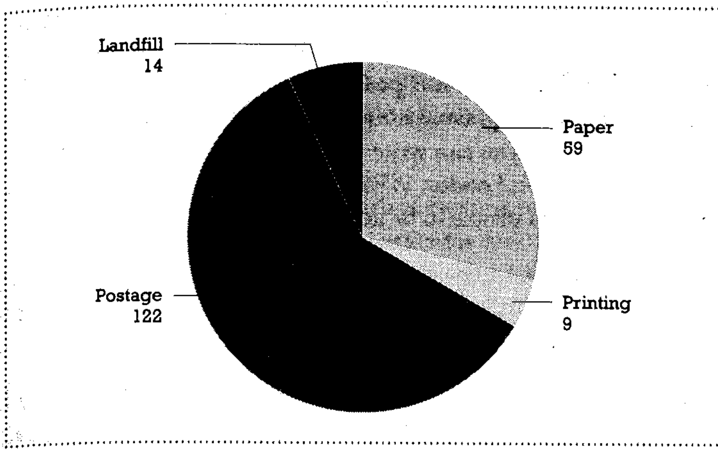

Figure 4.2. The carbon footprint of a 25 g letter, printed on virgin paper, posted by second-class mail and thrown into landfill (grams CO_2e).

into glossy and enticing sales literature, I estimate an additional 350 g CO_2e per kilo.

- Postage. For a standard letter, this accounts for most of the footprint. It's impossibly difficult to trace the carbon footprint of posting a letter by direct means. However, if you take the footprint of the postal services sector as a whole and divide it by the turnover of that sector you can get a broad idea of the carbon footprint per unit of cost. In the UK it comes out at about 380 g CO_2e per £1 spent. A 25 g second-class letter would have cost 32p in the UK, and we can associate a carbon footprint of about 120 g CO_2e with that. So most of the impact of a junk letter comes from the burden that it places on the whole infrastructure of our postal system: vans, trains and sorting offices.
- Decomposition. A good deal of junk mail ends up in landfill, where it decomposes anaerobically and produces methane. For this I have allowed 550 g CO_2e per kilo of paper.[10] You can avoid this, of course, by recycling as much mail as possible. This is OK to do even if the letter has a plastic window. But do remove any other plastic – such as film wrap.

Eliminating junk mail will declutter your life as well as saving carbon. The purpose of most of it is to persuade you to buy stuff you don't need, so brain purification is probably the biggest reason of all for putting an end to it. To avoid junk mail, use a free junk-mail opt-out service. In the UK you can write to the Mailing Preference Service, Freepost Lon20771, London WE1 0ZT. Give your address and a list of all the names of people to be taken off all possible mailing lists.

The service can take a few months to kick in, but it should work. At the back of this book, just to make things easy for you, there is a page ready for you to cut out and send.

To deal with the ones that still get through, keep a stack of printed labels by your door saying 'Return to sender. Please strike us off your database.'

In the UK, there's a Royal Mail service for avoiding unaddressed junk mail that is delivered to everyone on postal rounds. If you wish to opt out of receiving Door to Door mail items, email your name and address to **optout@royalmail.com**. Note that there are caveats on the Royal Mail website about the other unaddressed mail that this will stop.

Finally, a message to the instigators of junk mail: more and more people will think badly of you for using high-carbon marketing techniques. If you must use mailshots, at least keep your databases clean, use recycled paper and keep your messages short.

Sending an email beats sending a letter hands down (see page 15).

1 kg of carrots

0.25 kg CO_2e local, in season
0.3 kg CO_2e average
1 kg CO_2e shipped baby carrots

So a bag of carrots is like a 2-mile train ride.

At around 2 g CO_2e per calorie, these and other root vegetables are some of the most climate-friendly foods available – and healthy too. If you ate only these foods and others that have similar carbon intensity you could feed yourself for just over 1 kg CO_2e per day, or less than 500 kg CO_2e per year.

Seasonal vegetables have small carbon footprints because they avoid all of the main greenhouse gas sources for food: they are grown in natural conditions without artificial heat, they don't go on aeroplanes, and they don't incur the inefficiencies inherent in the production of food from animals.

If you go on to boil your carrots for 10 minutes, you will add a few more grams CO_2e per kilo to the footprint. (For more on cooking, see boiled potatoes, page 69.) My children will only eat their carrots raw. That suits me fine. It's better from every angle – there's less carbon emission, it saves time, and the nutritional value is better.

Note that some baby varieties have a much lower yield per acre of land, resulting in higher emissions per kilogram. So it usually makes sense to buy full-sized, classic varieties. And, as with other vegetables, favouring misshapen specimens may help avoid wastage in the supply chain (see page 183).

A newspaper

0.3 kg CO_2e the *Guardian Weekly*, recycled
0.39 kg CO_2e the *Sun*, recycled
0.48 kg CO_2e the *Daily Mail*, recycled
0.82 kg CO_2e the *Guardian*, recycled
1.8 kg CO_2e a weekend 'quality' paper, recycled
4.1 kg CO_2e a weekend 'quality' paper, sent to landfill

A quality paper every day of the week adds up to 270 kg CO_2e per year, even if you recycle them all. That's equivalent to flying from London to Madrid one way.

1 kg of cement

100 g CO_2e Eco-Cement
710 g CO_2e standard cement, efficient production
910 g CO_2e global average
1 kg CO_2e inefficient production

The world produces around 2.2 billion tonnes of cement per year – or around 300 kg per person. Nearly half of this (47 per cent) is produced in China. Making this basic building material results in a staggering amount of CO_2e: around 4 per cent of the world's total greenhouse gas footprint.[33] This figure is so high because the chemical process that turns limestone into cement gives off large volumes of CO_2 directly *and* takes a huge amount of energy.

Around half the footprint is down to the chemical reaction. There is not much you can do to reduce this without changing the product itself. About 40 per cent comes from the burning of fuel to drive the reaction, leaving 10 per cent for other bits and bobs in the cement industry and its supply chains.

Because of the basic chemical reaction required to make the stuff, it is hard to see how conventional Portland cement could be made into a low-carbon product. One alternative is Eco-Cement, a product invented by John Harrisson in Tasmania. Eco-Cement's advocates claim not only that this product requires half the energy input of conventional cement, but also that it reabsorbs CO_2 from the air as it hardens (around 400 g CO_2e per kilo). There are also claims that it is easier to incorporate waste materials into the mix than with normal cement and that it is easier to recycle. The product is based on magnesite, which is not as abundant as limestone, and perhaps that's why not everyone is using it yet. Or perhaps it is no good at sticking things together. I haven't tried it.

Cement makes up about 12 per cent of the footprint of the UK construction industry, so other potential ways of reducing its impact are to use different materials, to build to last and build less, and to refurbish in preference to knocking down and building anew (see House, page 149).

1 kilo to 10 kilos

A paperback book

400 g CO_2e recycled paper, with every copy printed getting sold
1 kg CO_2e average
2 kg CO_2e the same book on thick virgin paper, with half the copies getting pulped

The carbon footprint of a typical paperback is about the same as watching 12 hours of programmes on an average TV.

Overall, reading is a low-carbon activity and there is plenty of room for it in the sustainable lifestyle.* Why? It's hard to drive or shop while you read. For a short while, a gripping novel halts the consumerist lifestyle in its tracks.

My average figure is based on a 250 g book printed on paper from a UK-typical mix of virgin and recycled pulp.[1] I've assumed that 60 per cent of all copies made are actually sold, even though I've heard more pessimistic estimates than this. The economies of scale in printing

* 'Sustainable lifestyle': this is a tricky expression. It doesn't bear much scrutiny and we could get hopelessly bogged down defining it. However, I strongly suspect that whatever your definition I would still stand by my assertion that it leaves plenty of scope for reading.

are such that it pays to print too many.

At the high end, the same book is printed on heavyweight high-gloss virgin paper and weighs 350 g. Half of the print run is pulped without ever hitting the shops.

At the low end, the book still weighs 250 g but is printed entirely on recycled paper. Roughly speaking, it takes about twice as much energy to make paper from trees as it does from recycled pulp – though the actual value varies enormously depending on the efficiency of the paper mill and the quality of the paper.

What you are reading right now doesn't yet exist as I write, but I'm guessing that, in carbon terms at least, you are holding a better-than-average paperback because my publisher thinks about these things. However, once you stop to think about it there are all sorts of difficult questions about what to include in the sums. I haven't included the electricity burned by my computer as I'm typing right now, or any part of the footprint of my publisher's offices at Profile, or a host of other possible elements.

Nonetheless, I hope this book pays for itself in carbon terms fairly easily. You only have to cut out about three car miles to cancel out its production.

All carbon footprints need to be thought of in terms of 'bang for buck': do the benefits outweigh the impact? To maximise the 'bang' side of the equation you simply have to read this book, talk about it and pass it around.

Electronic book readers deserve a mention. I guesstimate that an e-reader has a footprint of around 50 kg.[2] If I'm right you'd have to get through at least a hundred paperbacks (bought new and then sent to recycling) before the paper saving outweighed the embodied emissions of the reader itself. This is before electricity consumption of the reader and in IT networks has been taken into account. E-readers may be wonderful devices but I can't see a carbon argument for getting one, unless it gets you reading more. And you can't yet take them in the bath, either.

A loaf of bread

1 kg CO_2e an 800 g loaf

Bread is good stuff: a year's calorific intake can be had for around half a tonne CO_2e. That's only 5 per cent of the 10-tonne lifestyle and one-sixth of the current UK diet.

As Figure 5.1 shows, just over half the emissions of a loaf of bread come from the actual growing of the ingredients. About one-sixth is the baking. Transport is typically one-seventh, and the supermarket itself adds about one-ninth. The bag is a very small consideration – and if it helps to keep the bread fresh for longer, it is probably well worth it.

Bread is a great low-carbon food provided we actually eat it. There's the catch. It gets thrown away because we are fussy eaters and because it doesn't keep well. Tristan Stuart's eye-opening book *Waste* has a picture of a Marks & Spencer sandwich factory systematically dis-

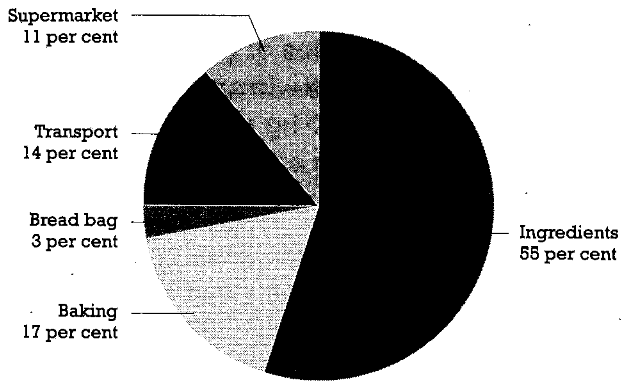

Figure 5.1. The footprint of bread at the supermarket checkout.

carding four slices from every loaf: the crust and the next slice from each end.[3] The remaining slices get made into fresh sandwiches and are still at risk of being binned before they are sold. Only once safely through the checkout do the odds of a sandwich being eaten start looking good, but there are still such hurdles as children who won't eat crusts and over-catered corporate lunches.

Loaves sold straight to consumers are no better, because the shelf life is so low. Plenty is binned by the supermarkets and plenty more goes stale in bread bins, or ends up in a half-eaten sandwich. To keep the carbon cost of your bread to a minimum, buy only what you need, enjoy the crusts and get your children to do the same. Find uses for stale bread: toast, dunked in soup and so on. Remember that bread mould doesn't kill you. And buy smaller loaves if you are not getting through them – the introduction of the 600 g loaf will help with this.

A bottle of wine

400 g CO_2e from a carton, with few road miles
1040 g CO_2e average
1500 g CO_2e over-elaborate bottles, transported for thousands of miles by road

So if you drink three bottles of typical wine per week, which is pushing the limits of a healthy lifestyle, that is about 150 kg per year, equivalent to driving 210 miles in an average car.

My estimates here are based on a study I did for Booths supermarkets (Figure 5.2). For a typical bottle, just over one-third of the footprint comes from the production of the wine itself. Whether or not it is possible to reduce this by buying organic wine is not clear, although there may be other environmental benefits of the organic option. It is difficult to know from the label what the carbon intensity of a particular vineyard is, so I have just given all wine a typical value, based on various studies.

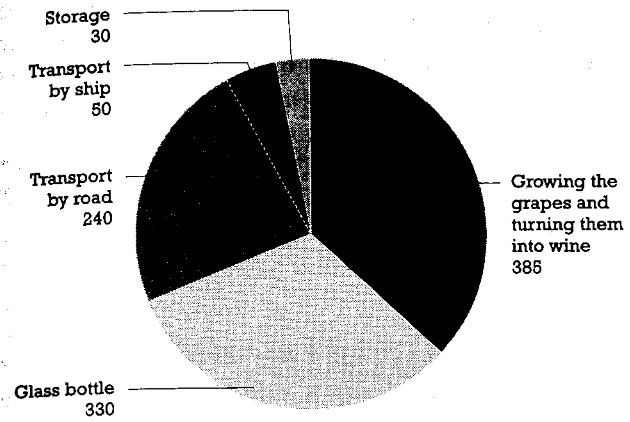

Figure 5.2. The carbon footprint of a bottle of wine (in grams CO_2e).

The glass bottle accounts for a similar amount of carbon to that of the wine it contains. There is a simple saving to be made here: by buying wine boxes or cartons you can reduce the footprint of the packaging by a factor of about five. In doing so you will also reduce the weight, so transport emissions can also be slashed by one-third. There will be absolutely no loss of quality, even though you might lose some choice. If the carton offends you, you can always decant the wine into a jug.

There is a lot that can be done without getting rid of the glass altogether. Organico is a wine distributor near where I live that has started importing some of its wine unbottled. This cuts the transport weight. It does its own corking and puts a £2 deposit on the bottles, which are themselves 15 per cent lighter than normal and are made from clear glass because this is better for eventual recycling. One further nice touch is that they have done away with the concave bit under the bottle that has always struck me as fundamentally dishonest.

Note that shipping is only a small component, so it doesn't matter all that much what continent your wine comes from. Far more important are the road miles – both in your country and in the country of origin. For this reason, locally produced wine could cut the footprint by 25 per cent, provided that your neighbourhood has the right kind of climate.

Because it is less dilute, wine often turns out to be a slightly less carbon-intensive way of taking alcohol on board than beer (see page 49).

All these calculations assume that you recycle any packaging.

1 kg of plastic

0.75 kg CO_2e EcoSheet
1.7 kg CO_2e PET for plastic bottles, from recycled materials
3.4 kg CO_2e polystyrene from virgin materials
3.5 kg CO_2e average
4.4 kg CO_2e polypropylene for injection moulding, made from virgin materials
9.1 kg CO_2e some types of nylon[4]

Plastic is such useful stuff: it's tough, durable and waterproof. No wonder we use so much of it. Unfortunately, plastic tends to be so durable that it hangs around in landfill sites for centuries, clutters up the stomachs of animals and fish, transforms remote Scottish beaches into junkyards and has ended up in almost every ecosystem you can think of. But from a purely carbon perspective, its inability to rot is good news in as much as it won't add to methane emissions from landfill: if we assume that the plastic is put in the bin rather than tossed into a street or field, those hydrocarbons are going back underground where they came from.

As the figures above show, the footprint of making plastic from virgin material is about double what it would be if recycled products were being used. The challenge for recycling plastics is that it's difficult but necessary to separate the various types and process them separately. This isn't true for EcoSheet, however. This brand-new construction material can be made from the full range of different plastics, so almost nothing goes to landfill. Once you have finished with it, the sheeting can even be reworked into new boards. The makers, 2K Manufacturing, told me that they don't even need to heat up waste plastic to the usual recycling temperatures to create their boards. As I type, only a few sample boards per day are being produced, but by the time you read this, full production is expected to have been underway[5] and there is every likelihood that the Science Museum in London will have used the stuff to build its new exhibition on climate change.

Biodegradable plastic packaging is worth a mention because it can be a well-intentioned disaster area. It sounds great, but if you send it to landfill it rots down and emits methane and if you throw it into the recycling bin it can ruin the entire batch. It should be compostable instead, but I have also heard that it releases chemicals that slow down the degrading process for the rest of the bin or heap.

Taking a bath

Zero CO_2e heated by solar energy
0.5 kg CO_2e modestly filled, efficient gas boiler
1.1 kg CO_2e generously filled, efficient gas boiler[6]
2.6 kg CO_2e generously filled, electric water heating

A daily bath adds up to between 180 and 950 kg CO_2e per year – that's between 2 and 10 per cent of the 10-tonne lifestyle.

In our family at least three of us often end up using the same water, even if not all at the same time. (Anyone who's been running through mud has to go last.) Since we top up with hot, the bath is always full to the overflow by the end. That is about 120 litres, giving a footprint per person of around 400 g.

10 kilos *to* 100 kilos

A pair of shoes

1.5 kg CO_2e Crocs
8 kg CO_2e synthetic
11.5 kg CO_2e average
15 kg CO_2e all leather

Imelda Marcos's collection of 2700[1] pairs of shoes would have had a carbon footprint of around 30 tonnes, or 3 years' worth of 10-tonne living – assuming, of course, that they had all been typical shoes.

As the numbers here show, shoes vary enormously in their carbon footprint (no pun intended). Just as important is their longevity.

At the low end of the carbon scale are Crocs, the simple and surprisingly durable shoe consisting of just 250 g of expanded EVA and sold without packaging. For these shoes, the raw material comes in at just over 1 kg. The rest is a guesstimate.

The 8 kg synthetic pair is based on a study of synthetic fell-running shoes, made in China but travelling to market by boat. My average figure, meanwhile, is based on the input-output model (see page 195) and a price of £50 per pair. The model tells us that in the typical shoe about half of the carbon footprint is down to materials, around one-quarter is down to energy used in shoe manufacture, 15 per cent is transport, 5 per cent the shoe box and 5 per cent other bits and bobs.[2]

I have estimated the higher figure for all-leather shoes on the basis of the carbon intensity of cattle farming.

Most of our footwear comes from the Far East, although specialist leather might also have had to travel a long way to get there. Shipping is fairly efficient. The big inefficiency in transport comes if a product is air-freighted for speed. This is most likely in high-end fashion, though unfortunately there's no way to be sure as a consumer what has and hasn't been delivered from the country of origin by plane.

1 kg of cheese

12 kg CO_2e hard cheese

That's about 3 kg CO_2e for a big 250 g block from the shop – equivalent to a 4-mile drive or a massive 12 kg of carrots.

It takes about 10 litres of milk to make 1 kg of hard cheese, adding up to a considerable carbon footprint that's higher than that of many meats. The message is clear, then: going veggie doesn't reduce your impact if you simply swap meat for cheese. Neither will it save you money or make you healthier. Perhaps the best advice if you're keen to reduce the climate impact of your diet is to think of cheese as a meat and therefore a treat. Many people will also improve their life expectancy by cutting back somewhat.

However much cheese you eat, there's an easy carbon win by keeping waste to a minimum. That means buying only what you think you'll actually get through and also avoiding binning hard cheese just because it's showing a tiny sign of mould. This is perfectly safe according the US Food Safety and Inspection Service, which must surely be among the most cautious groups around:

> *Cheddar, cut off at least 1-inch around and below the mould spot (keep the knife out of the mould itself). After trimming off the mould, the remaining cheese should be safe to eat. Re-cover the cheese in fresh wrap and keep refrigerated.*[3]

As for which hard cheese to buy, the most sustainable types probably come from cows that have grazed almost exclusively on rough pasture that couldn't have been used for crops – though of course that information isn't generally available in the shops.

Note that which country or area the cheese has come from doesn't matter much when set against the impact of the milk production (see page 71). Hence the easiest way to reduce the carbon footprint of your cheese is to opt for soft cheeses, because these require less milk to produce.

A congested commute by car

22 kg CO_2e five miles of crawling each way in an average car
Every working day for a year would be 4.8 tonnes CO_2e more than flying from London to Hong Kong and back

A congested drive can cause three times the emissions of the same drive on a clear road.[4]

Driving in queues very roughly doubles your fuel consumption per mile. However, that's only half of the story. By adding your car to the mass of ugly, belching motors, you also make a lot of other people queue just a little bit longer. It turns out, via a bit of simple queuing theory,[5] that the extra emissions you force everyone else to produce (when you add them all together) is about equal to the extra emissions that you produce yourself as a result of having to queue instead of being able to drive straight through. In other words, if your journey is congested, by choosing to do it you cause about three

The queuing theory logic also works for the time that gets wasted. If you make the assumption that the journey is many times longer than it would be if there were no traffic, then the time you waste in the queue is about equal to the sum of the extra time you make everyone else waste. In other words, the hassle and anguish that you experience is equal to the hassle and anguish that you inflict. So when deciding whether to drive through a busy area at rush hour, picture your own pain and double it.

All of this adds to the case for travelling by bike, bus, train, foot or lift-share wherever possible. It's also a useful reminder that all motorists should treat cyclists with the respect they deserve for helping to cut everybody else's journey time.

Where you must drive in busy conditions, do your best to minimise stops and starts – both your own and everyone else's. A steady slow stream of traffic is more efficient than a faster but less steady one unless the stops are so long that everyone can turn their engines off. One good tip is to think about what to do when two lanes merge: to reduce emissions, ease your speed down, merge gently and in good time, and allow others to do likewise. In theory at least, two lanes travelling at 50 mph can carry about the same traffic as 3 lanes travelling at 70 mph, assuming that everyone leaves a safe stopping distance between them and the next vehicle. This is because slower cars need less distance between them.[6] Jeremy Clarkson and I don't agree too much of the time, but one point of common ground is that it's good to minimise the use of brakes on the motorway if you can. And when you overtake, put your indicator on in good time too, so no one else has to brake either.

A night in a hotel

3 kg CO_2e low-carbon scenario
25 kg CO_2e £70 spent on dinner, drinks, bed and breakfast in a hotel with average eco-credentials
60 kg CO_2e high-carbon scenario

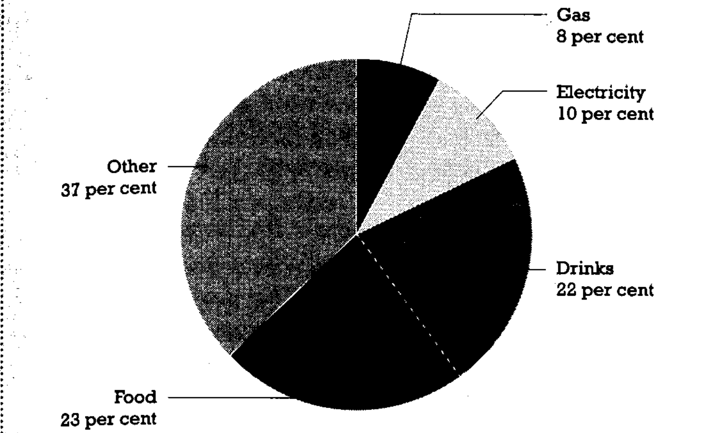

Figure 6.1. The 42 million tonne carbon footprint of the UK's hotels, pubs and catering industry.

For my high-carbon scenario I have chosen one of those hotels where the TV and six lights are already on when you walk into your room. The room itself is too hot and you cool it by opening the window even though the radiator is on. There is a swimming pool, with air-conditioning. You order beef or lamb for dinner and it arrives with baby vegetables air-freighted from Peru. There is too much for you to eat. For pudding you have strawberries even though it is winter. In the kitchens, half of the food cooked is thrown out at the end of the night. You stay one night, finding your way through three towels as well as your sheets. You have a full English breakfast in the morning, giving the paper you ordered a quick glance before leaving it on the table (from where, surely, even in this hotel, it goes for recycling).

The low end of the scale could be a large, very well run hotel or, more likely, a simple bed and breakfast with thoughtful owners. If you stay a few nights your sheets and towel aren't changed unless you ask. The room is comfortable and you can adjust your own heating. You opt for a low-meat-and-dairy meal with seasonal vegetables and you get to choose how much goes onto your plate. Leftovers end up in the next day's soup. You have something like cereal or muesli, fresh fruit and toast for breakfast. There is a selection of papers shared between guests (with the added advantage that you get to browse several if you have time). What you are paying for is a more personalised service in which you can have what you require without it being thrown at you just in case. The difference in carbon footprint between these two scenarios might be as high as a factor of 20.

The British clock up 42 million tonnes of emissions through their use of hotels, pubs, cafes and restaurants (Figure 6.1). That's nearly 5 per cent of the national carbon footprint. What the British drink when they are out has almost as much impact as what they eat, and both of these have a bigger footprint than the energy used by the establishments where the eating and drinking happens.

As a rule of thumb, the hotels, pubs and catering industry in the UK has a footprint of about 400 g CO_2e for every pound you spend. Roughly speaking, this seems to be true whether is it food, drink or accommodation that you are buying. However, this is just a general figure and the footprint certainly doesn't have to go up or down with the price. Indeed, there is a lot that the carbon-conscious consumer can do to keep emissions down, simply by spending money in establishments that think about the issues.

When eating out, look for seasonal fruit and vegetables, and choose places where the lower-meat and lower-dairy options are cooked with at least as much passion as anything else. The restaurant should be taking steps to minimise food waste both on your plate and behind the scenes. In a hotel, look for good energy management, minimisation of laundry and a general sense of care with resources. In a pub, look for local cask beer.

For any hotels, pubs or restaurants seeking to understand their carbon footprint, a colleague and I have built and tested a carbon calculator especially for tourism businesses and have made it freely available online.[7]

A leg of lamb

38 kg CO_2e a 2 kg joint at the checkout

For the same carbon footprint, you could have a bowl of porridge (made with half milk, half water) every day for 4 months.

Lamb comes in with a carbon footprint of about 17 kg for each kilo produced at the slaughterhouse. Transport, basic processing, refrigeration and a little bit of packaging each add a little bit, so that by the time the meat reaches the checkout the footprint has increased by about 10 per cent. You will add a similar amount again by the time you have picked it up from the shop, put it in the fridge and cooked it, taking the overall carbon impact to more than 20 kg per kilo.

The issues surrounding sheep are very similar to those relating to cows (see Steak, page 95, and Milk, page 71). Like cows, sheep ruminate, releasing large quantities of methane. And just as with beef farming, the exact impact of different types of sheep farming is complex and only partly understood. Hill farmers can claim that they are putting otherwise unproductive land to use. Some also claim that putting sheep on the hills helps the soil to absorb carbon from the air. Counterarguments are that hill-farmed sheep are inefficient, that they spend too much energy wandering around, eating low-energy food and keeping warm and that therefore they burp more methane per joint of meat than their lowland counterparts.

It seems probable that, from a broad sustainability point of view, hills are the best places to have sheep. But ultimately only one thing is clear: a low-carbon world is going to have to involve less lamb. The typical footprint of this meat is even higher than that of beef. The low-carbon choice is to think of lamb as a treat and to eat less of it.

If what you most want to do is send a final eco-message to the world, the best answer I know of is to be dressed in easy-to-rot clothing and put in a wicker coffin. It is possible to be buried in woodland with the idea that your remains will become trees – a lovely idea, though if everyone tried this we might run out of room.

100 kilos to 1 tonne

London to Glasgow and back

53 kg CO_2e banana-powered bike
66 kg CO_2e coach
120 kg CO_2e train
330 kg CO_2e small efficient car
500 kg CO_2e plane
1100 kg CO_2e large four-wheel drive

All these scenarios are based on one person travelling the 405 miles each way on their own. I've based the figures for the small efficient car on my own Citroen C1 travelling at a steady 70 miles per hour and getting 55 miles per gallon, which I know is realistic. The four-wheel drive, meanwhile, is based on a Land Rover Discovery doing 19 miles to the gallon. If it goes above 70 miles per hour or puts the air-conditioning on, its impact will be higher still.

For all the road vehicles, the exhaust-pipe emissions make up about half of the footprint. About one-third lies in the manufacture and maintenance of the vehicle itself, and the remaining one-sixth is down to the supply chain of the fuel (see Petrol, page 87). I've assumed that you keep to the speed limit and look after your car with about average care.

The bike is the outright winner if you can afford the time, you are careful about what you eat (see Cycling, page 23) and you don't have a headwind. Of the more practical options, the coach comes top, with a footprint more than 15 times smaller than the gas guzzler. One reason that the coach beats the train is that they travel more slowly, which is significant because the energy needed to overcome air resistance goes with the square of the speed. Another reason is that although a coach is heavy, the weight per passenger is much less than it is for a train (see page 40).

Some analyses that I've seen put a train ticket and a solo drive closer together in carbon terms. But I'm suspicious of these claims because the embodied emissions of the car per passenger mile are often ignored or underestimated. Whatever the precise difference (and it will of course vary widely depending on the particular vehicles), the train also lets you get some work done, read a book or sleep instead of arriving at the other end stressed and frazzled.

The plane could actually be better than driving if you have the wrong kind of car. (My sums are based on flying economy class.) But please don't take this as an advert for flying: it's just a reminder of quite how carbon-profligate some road vehicles are.

As soon as there are more people on the trip, of course, cars become a lot more efficient. If we load the whole family into my C1, along with everything for a week's holiday and put bikes on the back (it is possible, but only just), the fuel consumption goes down by at least 10 per cent. But the emissions per passenger fall so low that we'd be better going that way – in carbon terms, at least – than all travelling by train.

When it comes to both speed and safety, trains and planes win. When you are calculating how much of your life will be taken up by the journey, my back-of-the-envelope calculations tell me that a driver with a fairly typical life expectancy should add about 2 hours each way to the car journey time to take account of the 1 in 200,000 chance that they will lose the rest of their life in a crash.[1] If you are in your twenties and in good health you might want to call it 3 hours. This is a very significant chunk to add on to the expected journey time of 7 hours.[2] For trains and planes the average loss of life expectancy through injury or death is vanishingly small, despite the lavish media coverage that any crash does get. I'm sad to have to report, for the sake of even-handedness, that the bike will lose hands down on safety grounds unless you are careful with your route choice.

A common myth is that huge four-wheel-drive guzzlers are safer for their occupants. This is generally not true. They are, however, more dangerous for everyone else on the road.

Christmas excess

4 kg CO_2e per adult low-carbon scenario
280 kg CO_2e per adult UK average
1,500 kg CO_2e per adult high-carbon scenario

A full-on Christmas could cost you a couple of months' worth of 10-tonne living.

I said at the beginning that this book was about picking your battles. Christmas has got to be a good place to go looking, even if it might entail breaking a few habits and engaging in some delicate family negotiations. For most of us there is a golden opportunity here to escape some mindless consumerism, stress and perhaps even debt.

In my numbers I have only included unwanted presents, wasted food, avoidable travel, fairy lights and cards. Clearly it's not a complete list, but enough to give a flavour. The numbers are per adult and are based on three scenarios, none of which is intended to be ridiculous.

The average adult spends a massive £440 on presents, of which 20 per cent will be totally unwanted.[3] There will also be a lot of 'partly wanted' middle ground, so I've assumed an average 'wantedness factor' of 50 per cent for all presents. In the festive season we spend about £150 more than usual on food, and I've allowed one-third for waste, thinking that this will be slightly higher than it is in the rest of

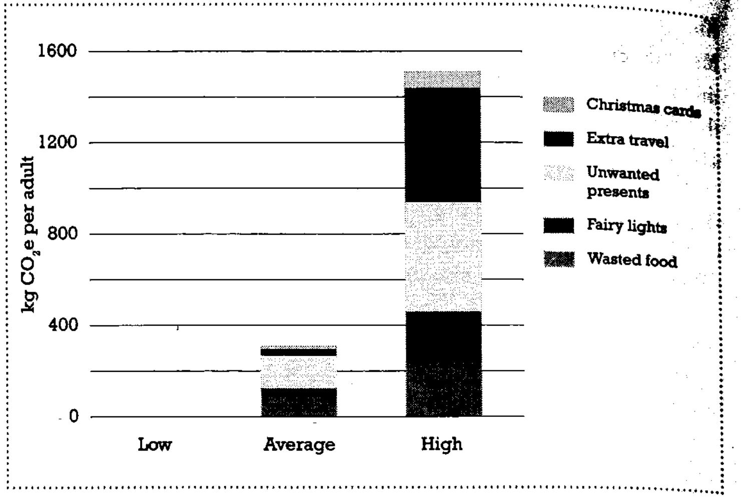

Figure 7.1. The footprint of Christmas waste in the three scenarios.

the year because of the 'Oh-no-not-turkey-again' effect and the fact that the big meals tend to keep coming over the whole period long after most of us have reached our 'wafer-thin mint' threshold.[4] The fairy lights burn through about 45 kilowatt-hours. The average adult posts about 20 cards, with most of the footprint coming from the delivery not the paper. We typically travel 50 miles each above what we would do anyway, and it is generally by car.

In the high-carbon scenario, you spend £1000 on presents (yes, that feels extreme to me, too, but it's only a little over double the average). Sadly, in this scenario the 'wantedness factor' turns out to be just 30 per cent because you are even worse than me at choosing presents. People are too embarrassed to tell you or to sell them, so they gather dust or even get sneaked into landfill. You decorate your house with a wild lighting display that doesn't use LED bulbs. You post 200 rather large cards. You also clock up 500 miles on a tour of relatives in a thirsty car.

I think the low-carbon scenario could be at least as festive and a lot less hassle. The food is great but none gets wasted. You might eat a bit too much, but you make up for that over the coming months, so it's not additional. Your presents are thoughtful but not necessarily expensive. You encourage people to be honest in their reaction and you've kept all the receipts. You have LED fairy lights. You stay at home and you send cards only to a few people that you haven't seen for ages and with whom you really don't want to lose touch. You video-Skype your distant relatives and make plans to see them properly another time.

Some friends of ours spread the word that only children were going to get presents worth more than a strict limit of £1. They asked everyone to reciprocate, packing any cash saved off to the charity of their choice. Both giving and receiving became an exchange of gestures and altogether more fun.

Insulating a loft

350 kg CO_2e outlay for a three-bedroom house
35 tonnes CO_2e payback over 40 years

The payback of insulating a loft can be a remarkable three and a half years' worth of 10-tonne living.

My calculations are based mainly on figures produced by the Energy Saving Trust[5] and assume you are adding 270 mm of rockwool insulation to the previously uninsulated loft of a three-bedroom house. According to the EST's figures you save 800 kg CO_2e per year, but I've rounded this up to 880 kg to take account of fuel supply chains that I know they don't include.

The embodied energy of the insulation material pays back in less than six months and is good for at least 40 years. You will therefore save about 35 tonnes of greenhouse gas.

In terms of money, even without a government grant, you'll get payback on your £500 investment in 4 years, even when a 10 per cent discount rate is applied. In other words, the decision to insulate your loft tomorrow will save you £900 on top of paying back your outlay compared with investing the money in a bank account with a 10 per cent interest rate. (See page 134 for more on discount rates.) In other words, it's a no-brainer. In the UK, the EST may well offer you a 50 per cent grant, too, which makes it a no-brainer even if you are suspicious that they may have been optimistic with their numbers.

Table 7.1 gives a detailed breakdown for the scenario discussed so far and also for someone increasing their insulation from 50 mm to 270 mm. This is a good move, too, but only if you care about the carbon savings or can get a grant. If you are just in it for the money, and you apply a discount rate, then I don't think you ever quite get it back again. However, at just £5 per tonne, the CO_2e saved improving your existing insulation is still a hugely cost-effective way of investing in a lower-carbon world.

The EST's calculations that I've used here are based on the assump-

	From no insulation to 270 mm	From 50 mm insulation to 270 mm
Cost without a grant	£500	£500
Annual payback	£150	£150
Embodied emissions in the material[6]	380 kg	380 kg
Annual carbon saving (including fuel supply chains)	880 kg	880 kg
Financial payback period (with 10 per cent discount rate applied)	4 years	Never quite makes it
Payback over 40 years (with 10 per cent discount rate applied)	£900	–£50
40-year carbon saving	35 tonnes	10 tonnes
Profit or cost per tonne of carbon saved	**Net profit of £70!**	**Net cost of £5**

Table 7.1. Insulating the loft in a three-bedroom house without a government grant: the money and the carbon

tion that rather than cashing in on all the financial and carbon savings that would be possible if you kept your home at the same temperature that it used to be, you will in fact allow your home to be warmer once it is insulated. In other words the sums here assume that you will lose some of the available savings in exchange for a warmer and perhaps more comfortable home.

Various types of loft insulation are available: you can get the standard synthetic kinds as well as varieties from sheep's wool, paper and a range of other options. Some of these sound good, but you should only choose them if you are 100 per cent convinced that there is no compromise on performance or the longevity. Those are the priorities.

A necklace

Zero CO_2e handed down or made from driftwood and seashells
200 kg CO_2e £500 worth of new Welsh gold
400 kg CO_2e £500 worth of gold and diamonds sweated out of mines in developing countries

Who would have thought that something so small could have such an impact! But think about it for a moment and it makes sense: gold and diamonds are precious precisely because it takes effort and sweat to extract them.

At the bottom of my scale are items for which the value is in the art and not the materials. Also at the low end of our scale is a piece of jewellery that has been passed on or reforged from an existing item. The carbon impact here is simply from the energy required to melt it down.[7]

To arrive at my ballpark figure for the carbon footprint of jewellery – 400 g CO_2e per pound spent – I have once again used the technique of working out the carbon footprint of an industry and dividing it by that industry's total output. The same model that we used to get the overall figure can give us an idea of where that footprint comes from.

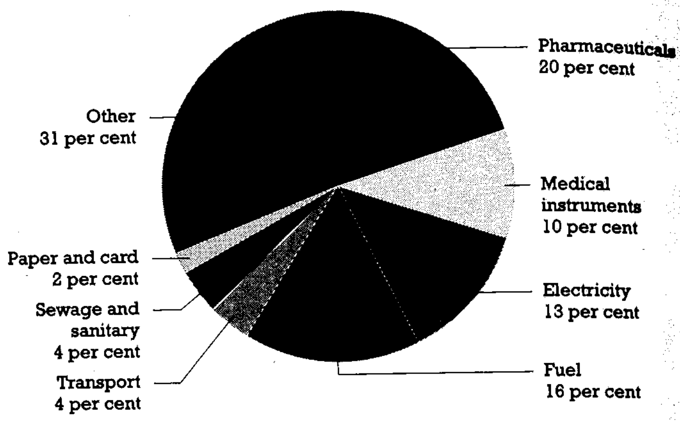

Figure 8.1. The footprint of healthcare in the UK: 27 million tonnes.

surprised me at a massive 2 per cent of the footprint of all healthcare. I'd like to think this is not the stuff that clogs up the filing cabinets of one of the world's biggest bureaucracies but rather the consumables used to keep things clean. So what can we do to reduce the emissions of our healthcare? The best option is to stay healthy, of course. This might involve cycling (safely) or walking more, and thinking about the amount of meat and dairy produce in your diet – all things that will reduce your direct footprint, too, and which are discussed elsewhere in this book. When you do actually need healthcare, be as careful with NHS resources as you would be if you were paying for it directly yourself. But relax in the knowledge that at around 170 g CO_2e per pound it is one of the lower carbon ways for you or your government to spend money.

Photovoltaic panels

3.5 tonnes CO_2e producing a solar roof capable of generating 1800 units (kilowatt-hours) of electricity per year
50 tonnes CO_2e lifetime saving; that's 5 years' worth of 10-tonne living

Warning: This section contains myth-busting payback calculations that will interest some more than others.

I'm going to do the financial sums and the carbon sums and then put these both together to see how electricity-producing photovoltaic solar panels rate as a cost-effective way of saving carbon.

First, the financial bit. Many governments offer a 'feed-in tariff' to reward individuals who install solar panels on their roofs. In the UK, householders are offered a massive 36.5p per unit generated.[2] This handout is guaranteed for the next 20 years. On top of the feed-in tariff you can still use what you generate yourself (thus cutting the amount you have to buy) or sell it back to the grid to get even more revenue. It's an incredibly generous government handout (especially given the UK's financial situation) and if currently available micro-photovoltaic panels are a viable source of electricity, surely we should all be diving in?

Analyst and author Chris Goodall[3] has done sums on the financial payback from micro-renewables. He estimates that it will cost you £10,000 to get a set of panels installed that is capable of providing you with £1800 kilowatt-hours per year. Once you have taken account of income from the tariff, your sales to the grid and reductions in your grid electricity bill as well as annual maintenance costs, Chris thinks you can make a return of £730 per year. This figure suggests a financial breakeven after 14 years. That sounds fine, but what this is really saying is that provided everything goes to plan you will be exactly as well off as you would have been if you had kept the £10,000 *in a box under your mattress*. Such a simple 'payback period' calculation would be fatally flawed because it would ignore both the fact that you could have done something else with the money, where at the very least you would have got a bit of interest to offset inflation, and the fact that even the surest-looking projects, backed up by manufacturers' guarantees, carry a degree of risk.

More realistic payback sums need to have a way of taking into account the fact that money in your hand right now is worth more to you than the promise of the same amount of money to be paid to you in the future provided that things go well. This can be done by applying a so-called discount rate to the future payback. Applying a 10 per cent discount rate (a fairly sensible figure) is equivalent to saying that you'd be just as happy to have £900 in your pocket now as you would be to have £1000 promised to you in a year's time on the condition that your photovoltaic panel project is still going to plan. Following the same logic, a promise of £1000 in two years' time is worth just £810 to you today and the financial return that you hope to get in your 14th year is worth less than one-fifth of the same money in your hand right now. So, what happens to your solar payback period once a 10 per cent discount rate has been applied? It turns out that you would never get more than two-thirds of your money back, even if your panels lasted forever. (Which they won't. After 20 years they can be expected to be functioning at less than 80 per cent efficiency and after 40 years they will probably have had it.) In other words, don't buy a solar roof purely as a profit-making venture, even with the government's wildly generous feed-in tariff.

But what about the carbon sums? I'll guesstimate that the £10,000 you spend is half on the kit and half on the installation. To give the carbon sums their very best possible chance I'll generously overlook the footprint of installation and use the lowest plausible figure I can take from my input–output model for the manufacture of the panels: 0.7 kg CO_2e per pound spent. That gives the panels a footprint of 3.5 tonnes. If we assume that the electricity generated all replaces output from coal-fired power stations rather than the UK grid average, then the carbon saving per year is about 1.8 tonnes and you'd pay back the carbon in about 2 years. So where does that leave us? After 40 years your net cost (your initial investment minus the paybacks each year with discount rate applied) is still over £3000. The government will have invested £13,000 over the 20 years of the feed-in tariff and (I'm assuming) nothing from then on. Something like 50 tonnes CO_2e will have been saved.[4] That's a cost of £330 per tonne, even worse than a micro wind turbine and dramatically worse than offshore wind.

Are there any reasons to get a solar photovoltaic roof? Perhaps. You might want to invest in a developing technology. Or you might simply want one for fun. If you need to buy things to prove your status in society, solar panels are one of your most carbon-friendly options. We spend billions on mindless junk and flights around the world for that very reason: status. With the panels you can show everyone that you have spare cash but that you also think about the world. Photovoltaic panels can replace the SUV, and you might still be in the vanguard of this trend if you are very quick.

Flying from London to Hong Kong return

3.4 tonnes CO_2e economy class
4.6 tonnes CO_2e average
13.5 tonnes CO_2e first class[5]

Three economy trips are a whole year's worth of 10-tonne living. One trip is equivalent to 340,000 disposable carrier bags.

In other words, for your carrier bags to have the same footprint as just one trip to Hong Kong you would have to go to the supermarket every single day for 10 years and return each time with 93 disposable bags.

A Boeing 747 carrying 416 passengers burns through 116 tonnes of fuel on the 9700 km flight each way. Almost one-third of the total weight on take-off is fuel. As the fuel burns it creates three times its weight in CO_2. But the impact is worse still because high-altitude emissions are known to have a considerably greater impact than their low-altitude equivalents. The science of this is hideously complex and poorly understood,* but there is still a clear case for applying a multiplier to aviation emissions to take account of their extra impact. I have used a factor of 1.9.[6] Aviation is sometimes said to account for between 1 and 2 per cent of global emissions. These statistics ignore the effect of altitude. The proportion is also higher in the developed world, especially in those bits of it, like the UK, that are surrounded by sea. Here, personal flights account for a huge 8 per cent of the carbon footprint of all consumption. That rises to nearly 12 per cent once business flights and air-freight are added on.

In terms of your own lifestyle it might be much less than this. Many British people never fly at all. On the other hand, for some people, flying accounts for the overwhelming majority of their total footprint, and trying to cut carbon in other areas might simply be a misdirection of attention, distracting them from what matters. First-class and business-class tickets are particularly high in impact simply because your seat uses up more of the plane and because by paying more money you provide a greater proportion of the commercial incentive for the flight. It's hard to imagine a low-carbon flying technology coming to the rescue. The physics of flight simply does not allow us to reduce the energy it takes to keep us in the air by more than a few per cent,[7] and for the foreseeable future that energy has to come from fossil fuels. Nevertheless, there are still some efficiencies to be had. One of these is the automation of air-traffic control to replace the current archaic manual system. Humans are woefully unable to calculate optimum flight paths in real time with hundreds of planes in the air at once, all competing for space and time slots. One estimate is that upwards of 9 per cent efficiency improvements are possible.[8]

Ultimately, then, it's hard to avoid the conclusion that most of us need to fly less. But that needn't make our lives any worse. Make your flights count: go for longer but less often, and do things you really couldn't do at home. For the rest, try local trips, which involve less travel time and therefore more holiday. After all, the experience of getting to an airport, hanging around in a departure lounge and then sitting cooped up for hours are intrinsically rubbish ways of spending time. Also think about *where* you fly to: the closer the destination, the fewer the emissions. One myth is that long-haul flights are automatically more efficient per mile than short-haul because they involve proportionally less time taxiing, queuing, taking off and landing. This isn't necessarily true, because the long-haul flight has to lift more fuel. The truth is that the most carbon-efficient way of getting across the world is in several hops – but not too many.[9] But none of this changes the fact that the further you fly, the larger the footprint.

Of course, the flying conundrum affects companies as well as individuals. I work with a few businesses for whom flying is a key issue. They know it's high in carbon, costly and time consuming. They also know they have always had strong business reasons for doing it. New thinking is required to break out of old habits. Video conferencing may never fully replace human contact, but on the other hand it is a lot cheaper and easier once you are fully conversant with the technology. What is worth more, one face-to-face visit or ten video link-ups?

It is difficult to see a place in the low-carbon world for much air-freighted food (see Asparagus, page 83), let alone durable goods such as clothing. Some garments are air-freighted simply to reduce lead times and cut the cost of stock that is tied up in transit at sea. Air-freight labels are one piece of consumer information that would surely be simple and helpful. Currently these are found on some supermarket fresh produce but nowhere else.

I'm sometimes asked about air freight from developing countries: 'Surely it's good to keep supporting that country by carrying on the trade!' In broad terms, I don't think so. The argument is a bit like saying you should keep the arms trade booming so that people can keep their jobs. Economies need to be powered by people doing things that are useful. Anything else is an unsustainable nonsense.

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* Here is a glimpse of the main issues: The amount of nitrous oxide that a jet engine produces varies with altitude. Its effect on ozone levels also depends on attitude. *And* furthermore the effect of that ozone on climate is altitude dependent. Planes also cause contrails under certain atmospheric conditions, and these are known to make a short-lived but large contribution to the greenhouse effect. The contrails themselves depend on temperature, weather conditions, time of day and, you've guessed it, altitude.

cauliflower, celeriac, celery, chicory, corn salad, Japanese mustard spinach (komatsuna), Japanese turnip, Jerusalem artichoke, kale, leeks, onion, parsnip, potatoes, spinach, spring greens, squash, swede, turnips.

Fruit

All year round: Apples, pears, oranges, citrus fruit and, of course, bananas, pineapples and mangoes can be low carbon even if they have come by boat from the other side of the world or stored. The following are also likely to be in season.

January: All-year-round fruit – as above.

February: early rhubarb.

March: rhubarb (forced).

April: rhubarb.

May: gooseberries, rhubarb, strawberries.

June: cherries, gooseberries, raspberries, redcurrants, strawberries, rhubarb.

July: blackcurrant, blueberries, cherries, gooseberries, loganberries, peaches, raspberries, redcurrants, rhubarb, strawberries.

August: blackberries, blueberries, cherries, gooseberries, greengages, nectarines, peaches, loganberries, raspberries, strawberries.

September: apples, blackberries, blueberries, damsons, grapes, melons, nectarines, pears, peaches, plums, raspberries, strawberries.

October: apples, elderberries, grapes, pears.

November: apples, cranberries, pears.

December: apples, pears.

Some more information

Some assumptions revisited

I started out with three assumptions:

- Climate change is a big deal.
- It is man made.
- We can do something about it.

This book isn't really about those assumptions, but this section is for anyone who is still unsure. The human capacity for collective denial is an amazing phenomenon to watch. If that is where you are right now, I'm not too hopeful that I can shift you.

Is climate change a man-made big deal?

At the end of the day we all have to make up our own minds. I can't go over the scientific arguments in detail here, and even if I did I'd just be one more voice for you to sift through. But I will briefly go through how I came to make up my mind.

None of us really knows for sure what climate change is going to mean for us in the coming decades. The science is hideously complex and uncertain. The media still report a full spectrum of arguments. It's a confusing picture for the layman. What basis can we have for knowing whether a news article, a TV programme or a book is credible?

A key question in this context is *how can we work out whom to trust?* I meet plenty of people who have understandably given up trusting anyone over climate change. But it is possible to do a lot better than that. This is how I make up my own mind about a report or a piece of research:

1. I look at the argument itself and see if the logic makes sense at face value.
2. I look at the competence of the source.
3. I look at the resources and information that it had at its disposal.
4. Critically, I try to understand the motivations – political, financial and psychological. How strong was the dedication to truth? Who funded it and what did those funders want? Who wanted what from their careers, and what influence might this have had? What was the psychological readiness of the source to accept and report on different findings that might emerge?

These are the questions I have been asking about sceptics' arguments. They can sometimes pass the first test but every single one of them fails at least one of the final three.

A few years back, just before I reoriented my working life towards addressing climate change, I thought I'd better double check that the whole thing wasn't a storm in a teacup. I didn't want to go to a whole lot of trouble for nothing. I knew my family was going to have to put up with my hardly earning anything for a year or two while I learned a new trade.

A good friend of mine had raved about Bjørn Lomborg's book, *The Skeptical Environmentalist*. 'Mike,' he said, 'I've read this book and it's rearranged my thinking.' It's a thick and persuasively written tome with some 2000 academic references. It makes the claim that we can all afford to chill out about climate change and we would do better to invest the money elsewhere. Lomborg further asserts that the climate-change worriers are psychologically wedded to a doom-and-gloom position on life. To me, that last point hit a nerve. It was an important challenge to address. I thought, 'Perhaps he's right! Maybe I should ask myself if this applies to me?' I didn't want the experience of realising in years to come that the only reason I've done all this stuff about climate change is because of some unhealthy personal hang-up. At the very least I felt that the mainstream scientific community should have a blisteringly clear response to Lomborg, and it was disquieting that I couldn't readily find one.

I sat down to spend about a week with Lomborg's work. I picked into some of his arguments in detail and before long found that even from my distant position I could see several clear misrepresentations of science. Then I found that his book had never been peer-reviewed. Then I started uncovering websites that detailed his errors literally in their hundreds, along with roasting dismissals of his arguments from scientists, statisticians and economists alike. After that I started to read about Lomborg's close shaves with the Danish Commission for Scientific Dishonesty. In the end it was abundantly clear to me that the whole thing was a sham. I came to a clear view, but it took detailed consideration of his work; far more than can be expected of the average man on the street. Lomborg passed the first and third of my tests but failed the second and fourth. To this day Lomborg carries on, and has a following. It is incredibly unhelpful for the world. I don't know any scientists who have any time for his position at all, although some commentators treat his work with unwarranted respect in the misguided name of 'balance' or perhaps just to be polite.

In the name of open-mindedness I've looked in detail at several other 'sceptics' and had a similar experience.[1]

So much for the sceptics. Let's look at the mainstream scientific community. The UN's Intergovernmental Panel on Climate Change consists of around 2500 scientists. The sceptics point out that there may be potential for group-think and mass hysteria. These are warnings that should be taken seriously. Furthermore, there have been occasional errors in the IPCC's work, and even the hint of the odd deliberate misrepresentation. However, the standard of integrity that is demanded of the climate-change believers is on a different plane altogether from that demanded of the sceptics. As I write, some scientists at the University of East Anglia are in headline-hitting trouble for 'sexing up' their work in a way that the some of the sceptics would consider quite normal.

It's worth bearing in mind that it would also be possible to criticise the IPCC for its caution. Does it offer a sufficient platform for the airing of discomfort about poorly understood scientific risks? Does the level of deliberation and the need for consensus among such a wide community, some members of which have clearly been under political pressure to play things down, result in an undercooked estimation of the risks? We can't know for sure. We do know that the extent of scientific consensus is almost unanimous in affirming the first two of my assumptions.

Finally I want to note a trend that I have also picked up on among the people I know. The more scientifically minded they are and the more they have thought about the issues, the more worried they tend to be that even though we *might* almost all be fine, it is also just as likely that we'll end up frying in our billions. I talk to a lot of academics, mainly physical scientists and social scientists. In the last few weeks I've started conducting my own informal opinion poll by asking any senior academic that I meet to estimate the percentage of people in their department who think that 'climate change is a big deal and is man made'. So far I have yet to have anyone give me a figure under 99%. It is an amazing phenomenon that the academic community, those with the most realistic and mature understanding of how the academic process works and of how scientific knowledge evolves, are so clear about my first two assumptions whilst the wider public remains so obstinately doubtful.

Can we do something about it?

People ask me sometimes why they should bother when, even if everyone in their country cut the carbon, it would make such a small impact on world emissions. Sometimes I hear businesspeople trying out the argument that their hands are tied until governments act or until their end consumers care more. Governments say they can't move ahead of popular opinion. I hear Chinese people saying that the developed world started it and is more carbon hungry so they should start the cuts, whereas in the UK I hear people saying we're just a pinprick in comparison with the US or the emerging Chinese middle classes.

The UN climate negotiations in Copenhagen and elsewhere have surely taught us that it isn't enough to hope that world leaders will sort things out on their own. So the question is: Where does leadership come from? My answer is that it can come from anywhere and we need it to come from everywhere at once. If the Chinese middle class wants a Western lifestyle, then Western lifestyles had better become lower carbon. Who can start that off? Anyone can. Anyone who finds a way of enjoying life more for less carbon is setting a standard for others. Anyone who chooses a lower-carbon food is helping the supermarkets to emphasise that product. Any supermarket that improves and promotes its lower-carbon range is helping its customers to enjoy low-carbon food. All of this helps the political parties to move into a low-carbon position.

If you can find a way of being happier but with a smaller footprint, you are a leader.

The cost efficiency of selected carbon-saving options

The list I give below isn't complete but I have included it to illustrate that it is essential to pick our battles. Some of the least cost-effective options on this list are receiving major UK government funding while some of the best-looking options haven't had serious attention. There could be other well-founded reasons for this, but they aren't yet obvious to me.

It can be frustrating to see public money wasted on red herrings, apparently because the analysis simply hasn't been done. Quantified carbon and cost analysis may not be the whole story, but it is an essential part of it.

All the figures below are net costs or profits over the lifetime of the measure. They are based on a financial discount rate of 10% (see Photovoltaic panels, page 133). In other words, if you are promised a saving of £1000 but have to wait a year for it, I've only called it £900. If you have to wait 2 years, I've called it £810, and so on.

- **Putting 270 mm loft insulation in homes that haven't got any**
  £70 net profit per tonne saved. £2.80 for every £1 invested.
- **Investing in offshore and onshore wind farms**
  Just above zero. Payback in 15 years (would be 8 years if we ignore discount rates). Lifetimes of the farms vary.
- **Slowing down from 70 miles per hour to 60 miles per hour on the motorway**
  Variable, but typically cost neutral even when the value of the driver's time is included. No investment costs (see page 67).
- **Pay farmers to keep their forests via the Amazon Fund or similar**
  £3 per tonne, plus biodiversity benefits (see Deforestation, page 154).
- **Funding family planning in the developing world**
  £4 per tonne according to the Optimum Population Trust. See Having a child, page 151.
- **Upgrading loft insulation to 270 mm where 50 mm currently exists**
  £5 per tonne. This figure is the total cost, which is shared between government and homeowner.
- **Government investing 24p per unit to a feed-in tariff for micro wind turbines**
  £250 per tonne saved, assuming that this replaces electricity from coal, and ignoring the embodied energy in the panels themselves (see Wind turbine, page 146).
- **Government investing 36.5p per unit to a feed-in tariff for micro-photovoltaic panels**
  £360 per tonne saved, assuming that this replaces electricity from coal, and ignoring the embodied energy in the panels themselves (see Solar panel, page 133).
- **Building to code for sustainable homes level 6 (carbon neutral) instead of to current building regulations**
  Almost certainly very expensive (see A house, page 149).

Where the numbers come from

I hope I have already made the point clearly enough that carbon footprinting is a long way from being an exact process, whatever anyone ever tells you or whatever numbers you might see written on the side of products in some shops. All my numbers are best estimates and nothing more, even though I have reached them as carefully as I can.

I have tried to be as transparent as I can within the practical constraints of the book and my resources. Occasionally the sources are confidential to clients of mine, but more often it is simply too laborious to document every last detail. Nevertheless, there is a reasonable degree of transparency most of the time, and here is a summary of my approach.

I have used a variety of different methods and sources. I have drawn on a range of publicly available data sets and models, from life cycle studies and reports, and from studies I have carried out myself for businesses across different industries. I have used models that we are developing all the time in my company, Small World Consulting.

Often I've arrived at numbers from a couple of different routes to check that the results agree with each other. I've tried to put notes and references in the text wherever possible. Occasionally, frankly, it has been more a case of putting my finger in the air and guessing, but when that has been the case I've tried to make it clear.

Here are some of the main sources I have used.

Publicly available data sets drawn from process life cycle analyses

Process based life cycle analysis is the most common approach to carbon footprinting. It is often referred to as 'bottom-up' because you start off down on your hands and knees, identifying one by one all the processes that have had to happen in order for, say, a product to be created. Then you add up the emissions from each process and that's the footprint of the product. Simple! Except that it isn't. Not at all. It's back-breaking work and since the number of processes you really need to count up is always infinite, the job is never quite complete, so you end up with an underestimate. In fact the leaks are often shocking, 50% or more. To make matters worse, these problems are popularly overlooked, even in the development of government-backed and funded guidelines, such as the PAS 2050 standard (which was published despite a government-commissioned study that concluded that the draft methodology wasn't fit for some of its key intended purposes[2]).

For all the problems, and despite being hard work, process life cycle analysis is still an essential source of detailed information that can't be gathered any other way. Here are some of the key sources of this type that I've used, each of which is referenced in the main text:

- Defra publishes emissions factors for a range of fuels, electricity sources, transport modes, utilities and waste. These are mostly UK specific and don't take account of full supply chains. I use them where I can but supplement with additions for the missing supply chains.
- The University of Bath produces the Inventory of Carbon and Energy, a publicly available data set of carbon emissions factors for hundreds of materials, mainly relating to the construction industry, up to the factory gate.
- The Association of European Plastics Manufacturers (APME) publishes data sets of emissions factors for a wide range of plastics based, not surprisingly, on European manufacture.
- The UK's Market Transformation Programme has a wide range of data on the carbon intensity of common appliances.
- I have drawn on a further wide range of life cycle analysis studies from all kinds of sources. This is tricky because they all draw their boundaries in slightly different ways and use slightly different assumptions. At its best this has involved me in picking through high-quality academic studies. At its worst it has degenerated into 'Google footprinting': scrounging around the web, digging for numbers. When I've sunk to these depths, I've let you know.

Environmental input–output analysis

This is a neat alternative and complement to process life cycle analysis. It's not as popular, perhaps because it's a bit harder to get your head around, but it's at least as robust as anything else in the murky world of carbon footprinting. It is sometimes called a 'top-down' approach because it starts by looking at the whole economy from a height. It uses macroeconomic modelling to understand the way in which the activities of one industry trigger activities and emissions in every other industry. Input–output's key 'trick' is a piece of funky maths (for which a man called Wassily Leontief got a Nobel Prize) that succeeds in the capturing the endless ripple effects in a way that is 100 per cent complete. It has the further advantage that if you know how much you spend on something you can get an instant crude estimate of its carbon footprint. It's like a magic trick. And just like all the best magic it is also a bit too good to be true: the downside of input–output analysis is that the results can be ridiculously generic.

Input–output analysis is powerful tool both because it doesn't 'leak' and because once the model has been built it is often easy to use. The basic technique is well established. The specific model I've used is one we developed at Small World Consulting with Lancaster University. It draws mainly on data from the UK's Office of National Statistics. Our model is based on a 2007 picture of the UK economy; it deals with all the greenhouse gases and employs an emissions weighting factor for high-altitude emissions. A key weakness, which I refer to from time to time and sometimes adjust for, is that it treats imports as though they had the same carbon intensity as domestic production, whereas in reality they are usually more carbon intensive.

Most of the time I have used a combination of process-based and input–output approaches to get my numbers. At their best, process-based methods can be more precise, but input–output analysis is often able to get at places that process life cycle analysis is unable to reach. Putting the two methods together is sometimes called a hybrid approach, and the result is a bit like looking through both a microscope and a telescope at the same time. They each show you different things and between them, if the lenses are clean, you might end up with a passable understanding of whatever it is you are looking at.

Booths supermarkets' greenhouse gas footprint model

Over the last three years my company has been mapping out the carbon footprint of the Booths group of supermarkets and its supply chains. The model we now have draws on a great many life cycle studies of foods up to the farm gate, often using those funded by Defra. Reports and agricultural models from Cranfield University deserve a mention because I've used them extensively even though they are not uncontentious. Also well worth a mention are five reports produced by the Food Climate Research Network. The Booths model includes transport, processing, packaging refrigeration and the supermarket chain's other operations. All of these components are attributed to products, broken down into 75 categories. The model goes into a lot of detail, but that doesn't make it accurate. Human understanding of emissions from agriculture is still poor. The model is simply the best picture we have managed to achieve so far. Its purpose is purely practical and we think it is now good enough to work from, enabling actions to be reasonably well targeted on the hotspots. It is, I think, the most comprehensive model of the climate impacts of supermarket food in the public domain.

Direct greenhouse gas (GHG) emissions per GDP and per person for 60 countries

Note that these figures do not take account of embodied emissions of imported or exported products, or of international transport. They are simply estimates of the emissions that actually arise from each country.

Country	Population (millions)	GDP (billions of $)	GHG (million tonnes CO_2e)	GHG per person	GHG/ GDP$	GHG/ GDP as a percentage of UK figure	Electricity emissions intensity (kg CO_2e per kilowatt-hour)
Argentina	38,730	469	316	0.0082	0.6738	174	0.2750
Australia	221,210	561	529	0.0024	0.9430	244	0.8680
Austria	8180	242	91	0.0111	0.3760	97	0.2240
Belarus	9820	63	74	0.0075	1.1746	304	0.2940
Belgium	10,420	298	140	0.0134	0.4698	121	0.2740
Brazil	183,910	1385	983	0.0053	0.7097	183	0.0780
Bulgaria	7760	58	68	0.0088	1.1724	303	0.4720
Canada	31,950	919	758	0.0237	0.8248	213	0.2240
China	1,303,040	7219	6467	0.0050	0.8958	232	0.7710
Columbia	44,920	300	160	0.0036	0.5333	138	0.1530
Croatia	4440	50	29	0.0065	0.5800	150	0.3790
Cyprus	830	17	8	0.0096	0.4706	122	0.8430

Country	Population (millions)	GDP (billions of $)	GHG (million tonnes CO_2e)	GHG per person	GHG/ GDP$	GHG/ GDP as a percentage of UK figure	Electricity emissions intensity (kg CO_2e per kilowatt-hour)
Czech Republic	10,210	182	147	0.0144	0.8077	209	0.5020
Denmark	5400	159	68	0.0126	0.4277	111	0.3560
Estonia	1350	18	21	0.0156	1.1667	302	0.7220
Finland	5230	144	81	0.0155	0.5625	145	0.2970
France	62,180	1626	563	0.0091	0.3462	90	0.0820
Germany	82,500	2146	1015	0.0123	0.4730	122	0.4999
Greece	11,060	226	138	0.0125	0.6106	158	0.7770
Hungary	10,110	156	83	0.0082	0.5321	138	0.4210
Iceland	290	9	3	0.0103	0.3333	86	0.0010
India	1,079,720	3115	1744	0.0016	0.5599	145	0.9120
Indonesia	217,590	722	470	0.0022	0.6510	168	0.7720
Iran	67,010	463	583	0.0087	1.2592	326	0.5230
Ireland	4060	145	68	0.0167	0.4690	121	0.5920
Italy	58,130	1491	583	0.0100	0.3910	101	0.5240
Japan	127,690	3435	1355	0.0106	0.3945	102	0.4410
Kazakhstan	14,990	103	211	0.0141	2.0485	530	1.1160
Korea (South)	48,080	906	527	0.0110	0.5817	150	0.4370
Latvia	2310	25	11	0.0048	0.4400	114	0.1810
Liechtenstein	33	2		–	–	0	
Lithuania	3440	41	20	0.0058	0.4878	126	0.1210
Luxembourg	450	29	11	0.0244	0.3793	98	0.3250
Malaysia	24,890	235	154	0.0062	0.6553	169	0.4920
Malta	400	7	3	0.0075	0.4286	111	0.8140
Mexico	104,000	935	520	0.0050	0.5561	144	0.5760
Netherlands	16,490	476	218	0.0132	0.4580	118	0.440
New Zealand	4080	87	75	0.0184	0.8621	223	0.1780
Nigeria	128,710	137	232	0.0018	1.6934	438	0.4460
Norway	4590	162	55	0.0120	0.3395	88	0.0090
[illegible]	[illegible]	311	230	0.0015	0.7395	191	0.370
Papua New Guinea	4809	13	7	0.0015	0.5385	139	
Poland	38,180	455	388	0.0102	0.8527	220	0.6620
Portugal	10,520	189	85	0.0081	0.4497	116	0.4140
Romania	21,690	169	155	0.0071	0.9172	237	0.4510
Russian Federation	143,850	1309	1938	0.0135	1.4805	383	0.3290
Saudi Arabia	23,950	304	371	0.0155	1.2204	316	0.7490
Slovakia	5380	72	51	0.0095	0.7083	183	0.2550
Slovenia	2000	38	20	0.0100	0.5263	136	0.3630
South Africa	45,150	468	505	0.0112	1.0791	279	0.8530
Spain	42,690	983	428	0.0100	0.4354	113	0.3810
Sweden	8990	244	70	0.0078	0.2869	74	0.0590
Switzerland	480	224	53	0.1104	0.2366	61	0.030
Thailand	63,690	474	320	0.0050	0.6751	175	0.5280
Turkey	71,790	511	304	0.0042	0.5949	154	0.4960
UK	59,840	1696	656	0.0110	0.3868	100	0.4730
Ukraine	47,450	279	414	0.0087	1.4839	384	0.3410
US	293,950	10,708	7065	0.0240	0.6598	171	0.5750
Venezuela	26,130	145	237	0.0091	1.6345	423	0.2450
EU (except UK) average					0.47053	122	
Non-EU average					0.72497	187	

Source: derived from factsheets within Höhne, N., Phylipsen, D. & Moltmann, S. (2007) *Factors Underpinning Future Action: 2007 Update*. A report by Ecofys for the Department for Environment, Food and Rural Affairs. Ecofys GmbH, Cologne. Available at <http://www.fiacc.net/data/fufa2.pdf>.