DESIGNING A PERSONAL CARBON CALCULATOR

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It is not straightforward. You have to get through a lot of ‘philosophy’ first. After that it gets easier. A bit easier.

First, who’s it for? There are many kinds of carbon calculators, but let’s assume it’s a personal one aimed at answering the perennial question ‘What’s my carbon footprint?’.

Let’s take for granted that this refers to emissions of the ‘Kyoto basket’ of greenhouse gases, even though not all have carbon in them, measured in CO2 equivalents or CO2e.

Next, what do we include, and what do we leave out? There are divergent views about which emissions an individual could be considered responsible for. Some would say none at all, because it’s not an individual’s problem. At the opposite extreme you could say all humanity is jointly responsible for the whole lot, so divide 52 billion tonnes of CO2e by 7.6 billion people and the answer is about 7 tonnes a year.

It is a genuine world problem, so getting that 52 billion a year down is the ultimate task. But there is no World Government able to do it. Only sovereign nations have the levers. The question is whether the responsibility lies with the governments, or with the citizens: or perhaps a bit of each.

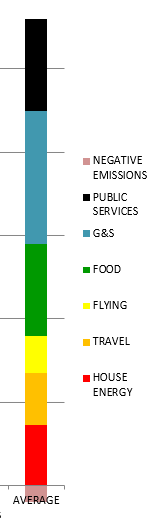
This is where our calculators start. Most people accept that individual citizens have *some* responsibility, and we are all urged to live greener. Some calculators work on direct emissions, that is, emissions from energy used in homes, and emissions from transport. These are very easy to measure and give an accurate answer provided users can find their fuel bills and MOT certificates. They amount to about a quarter of the total, and the rest is considered to be outside the power of individuals – so up to the government and ‘industry’.

Other calculators spread their scope wider, to include ‘indirect’ emissions as well, that is, those ‘embodied’ in the goods and services we consume. They assume that ultimately, consumers are responsible for all they consume. You can see this makes some sense. But…in the UK it turns out that most of the goods are imported, so the emissions do not arise in the UK itself, but somewhere else. Should we count them? This is an important decision, because emissions embodied in imports add around 35% to the total. While this is a large proportion, it’s quite possible to say, well that’s China’s problem, and just ignore it. The UK government does exactly this in reporting the country’s emissions under the Kyoto Protocol, so who are we to argue?

And there’s another matter to decide. Quite a big chunk (about 21%) of the country’s emissions arises from the government itself, or its many functions in providing public services. Usually we don’t buy these: they are paid for through taxes and various other revenue sources. Should we count *them*?

To cut a long story short, the calculators we developed for the Open University took the widest possible view, embracing everything that UK citizens could be considered as ‘consuming’. This had the advantage of presenting the user with a full picture, so they could get an idea of where their emissions were coming from, and they could make their own choices about which they felt most responsible for.

An implication here is that the average individual’s footprint is 1/67 millionth of the whole UK footprint, including net imports and other ‘extra-territorial’ emissions such as international aviation and shipping. In numbers that’s about 730/67 = 10.8 tonnes CO2e per year. As a statistic, GHGE per capita is a bit like more familiar ones such as the ‘GDP per capita’.[[1]](#footnote-1)

The notion of GHGE per capita can be taken further. National statistics usually break down GHGE into emitting categories such as transport, electricity and industry, but a consumer calculator needs categories that make sense to consumers, categories that match our patterns of expenditure. Fortunately, most of these are available too, at a national level, and once again they can all be mapped onto the individual at a 1/67 millionth scale.

This gives us what we sometimes call a ‘fingerprint’: a pattern of different categories that is exactly the same for the nation as for the average individual. You can use coarse, aggregated categories, or fine, differentiated categories. We have usually compromised with just seven categories, and we have given them colour-codes to help identify them, in roughly rainbow-order, shown in the stacked-bar figure on the right.[[2]](#footnote-2)

The ‘direct’ emissions (House Energy, Travel and Flying) are given ‘red-end’ colours, while indirect emissions (Food and Goods & Services) are given ‘blue end’ colours. Public services are coloured black, to indicate they are beyond the control of consumers, but subject to political control by citizens and paid for through taxes. ‘Negative emissions’ are in pink/purple, below the zero line. Currently the UK reports about -0.4 tonnes per head of negative emissions.

This averaging process, using national-level data, is the basis of the calculator. If a user gives no information at all, they are still likely to be close to average. If they are able to give a small amount of information, again we can use statistical processes to infer their likely footprint. With more and more data we can start to modify the fingerprint, the relative proportions of the different categories, and work out a more detailed and accurate carbon footprint.

It might be thought this process is a bit crude. Can’t we find better ways of measuring at least some components? Yes, in some cases we can, and we sometimes do, but most users prefer to just get on with it.

It must be constantly borne in mind that for most users, the calculator is not fun: it is a chore, to be got over as soon as possible. Too many questions, too many instructions, too much information, all tend to make users give up before the end. So, despite deficiencies in accuracy or ‘truthfulness’, there is a strong presumption on making the calculator as short as possible. And of course, visually appealing and easy to use.

In any case, strict accuracy is very difficult to achieve, and we should not expect too much. In the cheery words of a veteran carbon expert ‘If you’re within 50% of the true value, you’re doing pretty well’.[[3]](#footnote-3)

Bearing this in mind, and the need for concision, all calculators make considerable use of short-cuts and ‘proxies’: measurable factors that stand in for factors that are not directly measurable. But in this calculator, we also try to get real data if possible.

Calculators that are suitable for students and die-hard greenies are not usually suitable for ordinary members of the public, for whom we need much quicker, easier and simpler versions. The result has been ‘horses for courses’, several versions of the basic calculator for different purposes or different user-groups.

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HOUSEHOLDS AND INDIVIDUALS

Quite a lot of ‘consumption’ takes place ‘at home’ in a ‘household’ – that is a with a number of others, usually related to us: the family. This means that a lot of emissions are actually shared, so to get the individual emissions, we need to divide by the number of people. So we need to know the number of people. In fact the basic statistics about the household (that are hard to change) are established right at the beginning. These are:

* Size of the house, usually measured estate-agent-style as number of bedrooms
* Size of the household, number of people in residence
* Disposable household income, selected from one of seven crypto-numerical categories. Of this, more later

Here is a short summary of the main sections:

HOUSE ENERGY (Red).

Average household expenditure 7%, considerably higher than the standard value of around 4% before the recent price rises. Very accurate emissions estimates come from **electricity and gas bills** and their kWh figures. A very few households use other heating fuels, but there are so few they are ignored, although there is often a note to tell users how to account for fuel oil.

If users are unable to access the bills, it is much harder to estimate emissions, and at least a dozen more questions are required about house size, occupancy, heating, hot water and appliance use. Nightmare!

Recently the carbon intensity of energy – and particularly electricity – has declined dramatically. This means that, oddly perhaps, domestic energy has become a rather small part of the carbon footprint, and is declining all the time.

TRANSPORT (Orange)

Average household expenditure 16%. For **family vehicles**, accurate emissions can be calculated from mileages, given on **MOT certificates**. If no MOT certificates, rough estimates are demanded in 5 categories relative to the average.

Sometimes people ask, surely it makes a difference how many people travel in the car? Yes, it does make a difference, but it is virtually impossible to determine the ‘typical’ occupancy and whether the trip is genuinely multiple or (for example) ‘chauffeuring’. So the calculator simply divides the total mileage by the number of people in the household.

When it comes to **public transport** it is much more difficult for users. Usually this is a small term, so there is little point in cluttering up the calculator for the sake of very few users. We make do with just a few questions and tolerate crude estimates of distances travelled.

Public transport is added to private transport and together they make up the Orange bar in the chart.

FLYING (Yellow)

Average household expenditure 1%. This is easy to calculate, because nearly everybody can remember where they went by plane, how many times. It is striking that in any one year most British people do not fly at all, but others fly a great deal, and this can easily dominate their carbon footprint.

The climatic effects of flying arise not just from burned fuel, but from upper-atmosphere effects of condensation trails. These are considered to add another 90% to the basic emissions effects, so the government recommends a ‘multiplier’ of 1.9 for air emissions. The calculator follows this recommendation.

FOOD (Green)

Average household expenditure 16%. Academic research on food shows that the largest component of food emissions arises from the production of livestock. The calculator questions are in two parts. The first asks users to select the closest diet to their own, reflecting the livestock content. The second part asks about food-related behaviours, and adjusts the emission score accordingly.

Most ordinary consumers have close-to-average results, but there is a range of about 4:1 between the highest and lowest possible scores. This is realistic.

GOODS AND SERVICES (Blue)

Average household expenditure 60%. This is by far the hardest category to calculate, and makes extensive use of proxies. It includes housing costs like rent and mortgages, a large proportion of expenditure for many households.

We know from academic research the amount of the ‘government share’ (black section of the graph). We can also calculate in various ways (either from direct questions or national statistics) the values for house energy, transport, flying, and food, as discussed. That leaves the purchase of ‘goods and services’ which is a complex mixture of products, services and imported goods – and very hard to measure. But it can be calculated as the difference between the known total and the sum of all the other known factors, the answer being about 30% of all emissions, leaving aside the 21% that the government uses to run the public services.

This value of 30% is the national figure, but also that of the average UK citizen. But of course, most citizens are not average, and will have different spending patterns, and therefore different emissions from the goods and services. Fortunately, academic researchers have done enough detailed work on households, income and emissions, for us to derive a formula that predicts overall emissions from expenditure. Expenditure is difficult to measure directly, so we ask users to estimate their ‘disposable income’ – how much they have to spend after deductions and benefits.

Here we run into another problem, one that most calculators simply ignore: that users are often reluctant to ‘declare’, even to themselves, anything about their incomes. We get round this by yet another proxy: we group income classes into slightly facetious categories, and then we find that users are prepared to select one of these categories. This is close enough.

Having arrived at a ‘baseline’ estimate of expenditure on goods and services (and hence, emissions) we then ask a series of questions about consumption behaviour that generate small coefficients that nudge the value of the baseline up or down. The final result is the best estimate of emission from goods and services, which is both the highest-spending and highest-emitting category for the average UK citizen, and for most other people as well.

It is notable that spending on goods and services is ‘elastic’ with respect to income, whereas for most other categories it is less elastic. High income does not make you (for example) heat the house twice as much or eat twice as much. Generally extra income is spent on more **stuff**, and in addition, more travelling – but the calculator already registers travelling.

PUBLIC SERVICES (Black)

This does not cost households anything directly, but is paid for by the approximately 40% of GDP used by the state. It has been estimated at about 21% of emissions, and most versions of the calculator assume it is equally shared at about 2.2 tCO2e per person. This means it is a higher proportion of emissions for low income households and a lower one for higher income households.

This introduces an unavoidable ‘political’ element into the calculator, because these emissions cannot be affected by consumer changes in behaviour. To make any changes, citizens have to act politically.

EXPANDING THE RANGE OF PERSONAL AGENCY

Many people completing one of these consumption-calculators simply note the result and move on. They often assume this is it, set in stone. But of course, the real purpose behind the calculators is to help people *reduce* their personal footprint.

There are several ways in which the calculator can help do this. Just looking at the way the categories break down is already surprising, because for most people the indirect emissions are much greater than the direct emissions. Oh. And because it is compared with the average, it shows which categories are large relative to the more typical case, perhaps therefore deserving further attention.

Then, the calculators can be used to simulate alternative households who do things quite differently. You can play around with each factor separately to ‘model’ say different diets, or household investments, or consumer behaviour. You can pretend to be ultra-green, or ultra-brown, and see what happens. These could be the basis of a carbon-reduction strategy, perhaps carried out over many years.

There are choices within the household, and choices beyond it. The latest calculator we have produced tries to take all this into account, and to generate a result that compares the effects of different choices. This is probably an important innovation, so I shall describe its operation.

The first step is to establish a baseline against which reductions are measured. Most versions use the national average, and this is good enough for most purposes, but academic research has shown that personal footprints correlate very strongly with three factors which are hard to change and which most people feel are ‘baked in’ to their household and established lifestyle. These factors are:

* Rate of expenditure
* Dwelling size relative to household size
* Air miles

The calculator uses these to establish a kind of ‘demographic footprint’ that applies to average citizens with shared values for these factors. So a high-income childless couple in a 7-bedroom house flying to New Zealand every year would have a high ‘baseline’ while (say) a low-income household of four in a 3-bedroom house, who never fly, would have a low baseline. These baselines reflect current realities and give sharper guidance regarding options for reductions.

It then proposes four menus of different kinds of processes that could be undertaken, and the user can select them or enter new values. These are:

* Personal behaviour changes
* Investment in low-carbon household installations or processes
* Investment in remote low-carbon processes
* Government-directed decarbonisation processes

The calculator can be used in various modes, but the principal one is simply to arrive at net-zero emissions, which is the current UK government target for 2050. Once this is achieved, the calculator shows a pie-chart of the relative contribution made by the four categories.

To give an example of the result, I have inserted my own personal data. My baseline is higher than average at 12.9 tCO2e/y. I do the usual greenie things and have solar panels on the roof. I have invested in a remote wind-farm. These get me more than half way to zero, but government and business have to do the rest.

Generally, the results of this exercise show that household-scale choices contribute relatively little, while large-scale process do the lion’s share.

Some find this surprising. Others say ‘well of course’. What do you think?

1. Of course, ‘average’ is merely a mathematical construct, but it is helpful as a yardstick. Perhaps even more helpful would be the statistical ‘median’, more representative of the typical case, but this is mathematically awkward, so generally, we stick with the average or *mean*. [↑](#footnote-ref-1)
2. It should be remarked that some users find the fingerprint chart disconcerting as giving ‘too much information’. It is easy of course to combine everything into one single-coloured bar. [↑](#footnote-ref-2)
3. Pers. com., Mike Berners-Lee, author of *How Bad are Bananas?* and *There is No Planet B*. [↑](#footnote-ref-3)