Carbon calculation methodology

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Introduction

What does it do?

The Carbon Account stores personal energy use data and calculates how much carbon dioxide is released as a result of your activities. It plots your emissions as you enter information about your home, car, and any flights you take. At present, the Carbon Account does not measure any journeys you make using public transport or any ‘embodied’ carbon, such as the carbon linked to the food you buy.

How does it work?

The Carbon Account makes an initial estimate of your carbon emissions based on the information you enter during registration. As you enter more detailed information such as gas and electricity meter readings it overwrites the estimate with actual data. Energy data and car/flight mileage is stored separately so that if necessary we can change the carbon emissions factors. Below is a full explanation of how the Carbon Account works, and which CO2 emission factors are currently used.

Your estimated footprint

When you first register, the Carbon Account calculates your likely carbon footprint based on your house and car usage. We ask you what type of house you have, how big it is, how many people share it, how well insulated it is and what sources of energy are used for central heating, hot water and cooking. If you have a car, we estimate its emissions based on the efficiency of the model and how many miles you drive.

The calculations for the initial footprint are done in much the same way as existing footprint calculators (except that we find the mpg of your car by asking for your numberplate and querying a DVLA database). The house estimate is based on average energy use data for the information you enter.

To get a figure for you as an individual, the final house total is divided by the number of people who live in your house (children count as half an adult). Your car is considered your own and not divided by how many people you share your house with.

Energy Usage Estimations - Houses

Before we calculate your carbon we need to estimate how much energy you use (when you enter meter readings we stop using the estimations).

For all of the estimates we make based on your registration information, we work in kWh. For heating and hot water we work in gas and calculate an electricity equivalent of 5% less to account for the fact that electricity has a higher energy to heat efficiency factor (gas boilers lose some excess heat; electricity boilers don't).

Heating your house

The first thing the Carbon Account does when estimating how much gas you use to heat your house is look at how many bedrooms you have (it uses this to as the basis for house size):

Number of bedrooms	Estimated annual gas usage for heat (kWh)	Electricity equivalent (X0.95) (kWh)
1	3600	3420
2	7200	6840
3	10800	10260
4	14400	13680
5	22500	21375

>5	5200 * no. bedrooms	Gas figure * 0.95

Once we have this initial figure we adjust it according to the type of house you specified. The default house-type is a mid-terraced house (i.e. terraced house with other houses attached on both sides) or a flat. Other house types are assumed to be larger and/or with increased surface area exposed and liable to heat loss.

House type	Adjustment
Flat	None
Mid-terraced house	None
End-terraced house	+ 5%
Semi-detached house	+ 5%
Detached house	+ 10%
Bungalow	+ 15%

We then continue to adjust the figure based on the level of insulation you specified. Poor insulation is defined as "Houses over 30 years old, where no insulation work has been done since". Average is defined as "Houses over 10 years old (with no insulation work done)". Good insulation is defined as "Houses under 10 years old, and those with cavity wall insulation and loft insulation". The original estimation assumes that you have good insulation.

Insulation Type	Adjustment
Poor	+ 20%
Average	+ 10%
Good	None

If your house is not double-glazed we add 20% to the amount energy we estimate is used to heat your house.

Finally we adjust the figure for the temperature you keep your house at. The initial estimate assumes that your house is kept at 20°C.

Temperature	Adjustment
Less than 20°C	- 10%
20°C	None

More than 20°C	+10%

Heating your water

The Carbon Account asks you whether or not you have heated water (the vast majority of people do!) and how it is heated in order to get an estimated amount of energy used to heat your water. Different values are used for storage and on demand water (including electric showers). Because storage water is kept at a constant temperature and tanks are usually larger we estimate double the energy usage compared to on demand water.

If you use a combination of storage water *and* on demand water, we use the following estimations:

Storage water:

Number of bedrooms	**Estimated annual gas usage for storage water (kWh)**	**Electricity equivalent (X0.95) (kWh)**
1	1200	1140
2	2400	2280
3	3600	3420
4	4800	4560
5	6000	5700
>5	1200 * number of bedrooms	Gas figure X 0.95

On Demand Water:

Number of bedrooms	**Estimated annual gas usage for on demand water (kWh)**	**Electricity equivalent (X0.95) (kWh)**
1	600	570
2	1200	1140
3	1800	1710
4	2400	2280
5	3000	2850
>5	600 * number of bedrooms	Gas figure X 0.95

If you only use storage water and don't have an on demand source, we use the following estimations:

Number of bedrooms	Estimated annual gas usage for water (kWh)	Electricity equivalent (X0.95) (kWh)
1	1550	1472.5
2	3100	2945
3	4650	4417.5
4	6200	5890
5	7750	7362.5
>5	1550 * number of bedrooms	Gas figure X 0.95

If you do not use storage water at all and only have an on demand source, we use the following estimations:

Number of bedrooms	Estimated annual gas usage for water (kWh)	Electricity equivalent (X0.95) (kWh)
1	1000	950
2	2000	1900
3	3000	2850
4	4000	3800
5	5000	4750
>5	1000 * number of bedrooms	Gas figure * 0.95

Cooking

To estimate the energy you use for cooking, we take a basic figure for electricity or gas and then increase it according to the number of bedrooms you have.

The basic figure we use for gas is 500kWh and for electricity 600kWh. We then add an additional 150kWh per bedroom for gas, and an additional 100kWh per bedroom for electricity.

Number of bedrooms	Estimated annual gas usage for cooking (kWh)	Estimated annual electricity usage for cooking (kWh)
1	650	700
2	800	800

3	950	900
4	1100	1000
5	1450	1100
>5	500 + (150 * number of bedrooms)	600 + (100 * number of bedrooms)

Fuel oil, diesel, coal and wood

If you use a fuel other than gas or electricity for cooking or to heat your house or water, we apply a simple conversion factor to get a kWh gas equivalent depending on the efficiency of the fuel in question. All of the fuel options are less efficient than gas at heat conversion, with some less efficient than others.

Type of fuel	Efficiency loss compared to gas	Conversion factor
Fuel oil	3%	1.03
Diesel	5%	1.05
Coal	35%	1.35
Wood	25%	1.25

Electricity usage for appliances

We then estimate how much electricity you use for all other purposes except heating, water and cooking (i.e. appliances).

Number of bedrooms	Estimated annual electricity usage for appliances (kWh)
1	800
2	1200
3	1600
4	2000
5	2400
>5	400 + (500 * number of bedrooms)

Calculating the Carbon Dioxide

Now that we have all the figures relating to your house we convert the kWh energy usage into CO2 equivalents, based on figures from DEFRA.

We total up all the gas, electricity and other fuel usage and then use the following conversion factors.

Note that the figure for electricity is a grid average and doesn't take into account the source of your electricity. Later on when you enter your meter readings you can specify your supplier and we will then take into account how the electricity is generated.

The highlighted emissions factors come from AMEE, which is a database of emissions factors including DEFRA figures. When DEFRA amend a figure, the Carbon Account is automatically updated via AMEE. At the time of writing, these are the emission factors.

Type of fuel	CO2 in kg per kWh
Gas	0.206
Electricity	0.527
Fuel oil	0.215
Diesel	0.25
Coal	0.32
Wood	0.08

Wood is not covered in the DEFRA figures like the rest of the fuels because it is generally considered a carbon neutral, renewable 'biomass' fuel; the tree that grows in the place of the one that is burnt will soak up the CO2. However burning wood will create between 20 and 80 grams CO2 per kWh (source).

Your recorded footprint

Once we have calculated your initial footprint we plot your estimated energy use onto the graph on your Account home. In order to make the graphs reflect your actual energy use rather than an average, you need to enter gas and electricity meter readings and information about how far you have driven in your car.

Domestic consumption

In order to work out how much gas or electricity you have used in a given time period, we need you to enter two meter readings on different dates. When you enter your first gas or electricity reading we store the data but neither your estimated or recorded footprint are affected. It is only when you enter the second reading that the graph begins to plot your actual monthly carbon emissions, and your recorded footprint changes.

The period before the first date you enter meter readings will still be based on our initial estimate and it’s not until you’ve been using the Carbon Account for a year that the whole graph is based on your actual usage. The more often you enter meter readings, the more accurate the graph will become.

Note that the original estimate we make does not account for seasonal changes (energy use is higher in the winter because it is darker and colder) but we hope to make it do so in future.

Example

Estimated annual electricity usage based on registration information: 4500 kWh (this is the average figure for a UK household).

The estimated daily average in kWh can be calculated by diving 4500 by 365 (the number of days in a year).

$$4500 / 365 = 12.33$$

Reading number	Date	Meter reading (kWh)
1	15th April 2007	18542
2	1st May 2007	18780

You can see from this example that the difference between the two meter readings is 238 kWh (18780 - 18542) and so this is the amount of electricity used during the 15 days between April 15th and May 1st 2007. Dividing 238 by 15 (the number of days between readings) gives us an average daily use for that period.

238 / 15 = 15.87

Going back to the original estimate we can see that the real data shows higher energy use and so the graph would go up against the estimate for the period concerned. If the person makes an effort to reduce electricity use before entering another reading then hopefully they would be able to see the graph go down next time.

The method for plotting the energy data on the graph is the same for all types of domestic fuel where consumption can be read from a meter (heating oil and coal are different), but the CO_2 conversion factors change.

Converting gas readings into carbon dioxide equivalents

It is quite straightforward to calculate how much carbon dioxide is released as when natural gas (methane) combusts; we can use a simple ratio based on the chemical reaction that occurs (CH_4 + fire = CO_2 and other stuff).

First we convert the unit that you provide us with (cubic feet or cubic metres) into kWh. We do this so that it is easier to compare gas usage to electricity usage (electricity can only be measured in kWh). The conversion rates we use are:

1 cubic foot of gas = 0.31 kWh
1 cubic meter of gas = 11.06 kWh

At the time of writing the published DEFRA coefficient to convert natural gas to CO_2 is 0.206 kg CO_2/kWh. The 0.206 conversion factor comes from DEFRA via AMEE. The Carbon Account links to the AMEE and API and so if DEFRA change the figure, the Carbon Account gets updated automatically (so the figure may have changed since the time of writing). We plot monthly CO_2 on the graph, but energy usage data is stored separately.

Converting electricity readings into carbon dioxide equivalents

The amount of CO_2 released for each kWh of electricity used depends on how the electricity is generated. We use the following assumptions based on our own research: generating electricity from coal produces 980g CO_2/kWh and generating it from gas produces 360g CO_2/kWh.

If you do not tell us which company supplies your electricity (or select 'other') then we use a single conversion figure provided by DEFRA based on the average electricity that is on the National Grid. Again, we access this via AMEE.The figure at the time of writing is 0.57kg CO_2 per kWh.

To make your Carbon Account more accurately reflect how much CO_2 is released as a result of your activity, we ask you who supplies your electricity. Electricity suppliers are obliged by law to disclose the proportion of electricity generated from each source (known as the 'fuel mix'). The Carbon Account links to a database where this information is stored and then calculates your CO_2 contribution based on which supplier you use.

To view this information visit Electricity Info.

If you select a 100% renewable energy supplier such as Good Energy we do not record any CO_2 emissions related to your electricity use. However because you are still connected to the National Grid it is likely that during 'peak-load' (when demand for electricity is high) you will be using some electricity generated from a dirty source such as coal. Therefore although we don't factor the consumption of green electricity into the carbon footprint figures, we do plot consumption on the graph, using the coefficient for 'average grid electricity' (see above).

Also note that because of other complexities we currently count electricity generated from nuclear sources as zero-carbon like renewables. Nuclear does not produce any carbon at the point of generation but there are some carbon emissions associated with building the plant and obviously there are other non-carbon related environmental issues involved with radioactive waste and its disposal. We hope to include these factors in the future.

Vehicle Readings

How we calculate your emissions from your vehicle depends on how you choose to enter data.

On initial registration we ask you to provide your car registration number and this allows us to pick up information about your vehicle from a separate database. We retrieve an emissions factor (CO2 per km) for your specific make and model of car and then use this to calculate your CO2 based on the average annual mileage you entered.

After registration, we ask you to enter your mileage by reading the digits from your odometer (the thing that measures how many miles your car has done on the dashboard).

When entering your mileage we need you to enter two readings so that we can take the difference between them (in much the same way as we do for gas and electricity readings). Then every time you enter a new mileage and date we take a daily average.

Example entering odometer readings

Ford Focus Five-door: Approx 37 miles per gallon, 184 grams CO2 per km. Note that we can only detect grams of CO2 per km for cars less than six years old.

When first registering lets say you enter an estimated annual mileage of 8000 miles. We first convert miles to km (8000 * 1.6 = 12800).

Then we multiply the annual mileage by the number of grams of CO2 per km: 12800 * 184 = 2,355,200 grams = 2,355.2 kg = 2.36 tonnes CO2 per year.

2,355.2 kg / 365 = 6.45 kg estimated CO2 per day (21.9 miles)

Then you start entering actual readings from your car.

Reading number	Date	Odometer reading (miles)
1	15th April 2007	30,146
2	1st May 2007	30,339

Difference in readings = 193

Daily average: 193 / 15 = 12.87 miles

12.87 miles = 20.59 km

20.59 * 184 = 3788.56 grams / 3.79 kg CO_2 per day

So in this example, your actual emissions are less than your estimate. The more often you enter your reading, the more detailed your graph becomes as it tracks your activity.

For vehicles over six years old where we cannot retrieve a CO_2 per km figure, we use the miles per gallon figure to calculate the CO_2. First of all we convert gallons into litres, and miles into kilometres. Knowing how many kilometres per litre your vehicle does allows us to calculate the fuel consumption over a given distance.

We then simply multiply the number of litres by 2.3 for petrol and 2.63 for diesel to get kg of CO_2. The conversion factors again come from DEFRA via AMEE. Again, we take a daily average distance based on the time between each entry.

Flight Readings

When you enter a flight we ask you to enter your starting and destination airport so that we can calculate the distance. We then decide whether the flight was short-haul, medium-haul, or long-haul and use an emission factor based on this.

Flight distance (miles)	Flight distance (km)	Kg CO2 per km
0 –1500	0-2400	0.15
1500-5000	2400-8000	0.10
>5000	>8000	0.11

In addition to these factors, we also apply a radiative forcing multiplier of 2.7 to all flights to reflect the scientific consensus about the climate effect of emissions released at altitude (see the IPCC report *Aviation and the Global Atmosphere (1999))*.

The reason there are different factors for different distances is because of the altitude at which the emissions are released, and also because of the proportion of the flight spent taking off and landing (when more fuel is used).

Another factor that makes long-haul flights slightly more damaging than medium haul is because of the length of time that the aircraft is heavier due to the amount of fuel it is carrying.

The emissions factors for short-haul and long-haul are from DEFRA, and medium-haul factor is from a report sanctioned by the German government at Atmosfair.

In addition to the distance you travel, we also ask you to which flight class you travel in as this affects your emissions because of how much space taken up in each type of seat.

Flight class	Additional emissions factor
Economy	None
Premium Economy	+ 15%
Business	+ 40%

First Class	+ 60%

Graph information

We have tried to give a thorough overview of how the Carbon Account works in this document, but there is more complexity that we have not been able to cover, and a lot of this relates to the technical documentation accompanying the project code (see below).

In particular the way that we plot the monthly CO2 average on the graph is quite complex, and in order to make the Carbon Account more usable we have made some alterations to avoid drop-offs at the end of the month. If we plotted carbon exactly then we would need to ask for a reading every single day to avoid the graph dropping off. To avoid this we project forward the monthly average CO2 to the end of each month. This means that when users come back to their dashboard it doesn't look like their carbon usage is going down simply because they haven't entered a reading for a few days.

Technical information

The Carbon Account is built in Python/Django, on a PostGreSQL database.

For an overview of the approach taken to development, watch this short presentation by Tom Dyson.

For any further questions, please contact Torchbox.