Documentation for the ISCFC and I2SEA International Student Carbon Footprint Calculator

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University of Washington, Stanford University & University of Gothenburg. Updated Aug 23, 2016.

Below you will find details on how we calculated the data and the sources that we consulted for each question in the calculator. Use the links in the index at the top to skip to any question.

TRANSPORT SECTION

********************** **Q1: Out with friends** **********************

Our updated statistics (Apr 2015) now take into account the full "life cycle" emissions inherent in different forms of transportation, including the production shipment, use and disposal of different kinds of vehicles. We did this on a "per gallon" basis regardless of who owns the vehicle. For this, we consulted mainly the following two sources:

- Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada.
- Carbon Independent. http://www.carbonindependent.org/

Based on these sources, we have used the following life cycle emission values per passenger:

- passenger car: 14.3 kg CO_2e/gallon
- city bus & intercity train: 2.6 kg CO_2e/gallon
- local train: 3 kg CO_2e/hgallon
- transit minivan (e.g., as used in many underdevloped countries): 0.34 kg CO_2e/gallon

Biodiesel use results, on average, in a 55% reduction in CO_2 emissions, per:

- Schubert C. (2006) Can biofuels finally take center stage? *Nature Biotech*. 24: 777-784.

Note that the CO_2 savings of biofuel use varies substantially, depending on the source of the biofuel, from biodiesel made from waste vegetable oil or sugarcane ethanol (90% CO_2 reduction) to corn based ethanol (12% CO_2 reduction).

We have not included here any national or state information about the differing efficiencies of different local transit systems (e.g., efficiency of different types of buses, average passenger load, etc.).

Such information could greatly impact the calculation of CO_2 emissions for public transit use in different locales.

*********************** **Q2: After school** ***********************

Our updated statistics (Apr 2015) now take into account the full "life cycle" emissions inherent in different forms of transportation, including the production shipment, use and disposal of different kinds of vehicles. We did this on a "per gallon" basis regardless of who owns the vehicle. For this, we consulted mainly the following two sources:

- Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada.
- Carbon Independent. http://www.carbonindependent.org/

Based on these sources, we have used the following life cycle emission values per passenger:

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Biodiesel use results, on average, in a 55% reduction in CO_2 emissions, per:

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Note that the CO_2 savings of biofuel use varies substantially, depending on the source of the biofuel, from biodiesel made from waste vegetable oil or sugarcane ethanol (90% CO_2 reduction) to corn based ethanol (12% CO_2 reduction).

We have not included here any national or state information about the differing efficiencies of different local transit systems (e.g., efficiency of different types of buses, average passenger load, etc.).

Such information could greatly impact the calculation of CO_2 emissions for public transit use in different locales.

*********************** **Q3: Getting to school** ***********************

Our updated statistics (Apr 2015) now take into account the full "life cycle" emissions inherent in different forms of transportation, including the production shipment, use and disposal of different kinds of vehicles, as described for Q1, above.

For school bus CO_2 emissions, we used our city bus values (see Q1, above) with the following adjustments (per the American School Bus Council):

- average number of passengers = 54;
- taken 2x per day;
- 7 mpg (=33.6 l/100) for the average school bus.
- average number of school days in a year: 180
- average total distance bus travels per day: 107 km (=66.7 miles)

Carpooling means that the total emissions per gallon are divided by the number of students carpooling.

*********************** **Q4: Air travel** ***********************

Airline CO_2 emissions based on:

- 21.095 pounds CO_2 per gallon (2.425 kg/L) jet fuel (US Energy Information Association; EIA)
- We then doubled that value to account for non-CO_2 greenhouse gases released as airlines emissions (Kollmuss & Crimmins, 2009. *Carbon Offsetting & Air Travel.* Stockholm Environment Institute)
- Extra 8% emissions associated with jet fuel refining (*UN Climate Neutral Network*)
- 80% airlines occupancy (i.e., 20% seats empty; *US Bureau Transportation Stats* 2009)
- Pounds/kg CO_2 per mile at cruising altitude differs for short haul (less than 1800 km) & long haul (more than 1800km) flights due mainly to weight of aircraft. Here we assumed Boeing 747 for long haul flights and Boeing 727 for short haul flights. Other aircraft (e.g., Airbus) fuel use for long & short haul flight are comparable to these Boeing aircraft.
- Take-offs and landings accounts for a substantial proportion of fuel used on most flights; thus numbers of stops during a flight makes a significant difference in your overall emissions (and can increase total flying distance).
- Emissions per mile for Boeing 747 and 727 from *United Nations Economic Commission for Europe* 'Emission Inventory Guidebook,' December 2001.

*********************** **Q5: Other travel** ***********************
Our updates statistics (Apr 2015) now take into account the full "life cycle" emissions inherent in different forms of transportation, including the production shipment, use and disposal of different kinds of vehicles, as described in detail for Q1, above.

Personal accounting for CO_2 emissions per km (or gallon) on public transit will vary substantially depending on many factors, including: the size of the bus, the type of fuel & engine, how many passengers and luggage is on board, and, for train travel, the type of fuel used (and if electricity, the source of that electricity).

With those caveats in mind, please note that the values here are our best estimations.

HOME SECTION

*********************** **Q6: Family (household) size** ***********************
The values you enter here will be used throughout the activity to calculate your personal CO_2 contributions (i.e., by dividing household & room CO_2 emissions by the number of occupants).

If you leave the first box on this page blank, we will automatically enter the average family size for your country or state, per:

- UN compendium of Housing Statistics 2011
- US States, 2013 census data
- Stats Canada

If you leave the second box blank, we will assume that you have your own room.

*********************** **Q7: Home type** ***********************
The answer for this question is used to calculate square meters of heated and cooled space, for which we assume that 90% of the square meters of a housing unit are heated or cooled (per US census).

For residents of the USA, this data (average square meters of different types of housing units) comes from data gathered in the 2009 census.

For residents of Canada, this data comes from the Canada Home Builders Association and macleans.ca (average size of new single family home; other dwellings proportionately figured based on USA data).

For comparisons in Europe (and some data from outside):

- Malcolm Morgan & Heather Cruickshank. 2014. Quantifying the extent of space shortages:

English dwellings. *Building Research & Information*: 42, 710-724.

- *Bulletin of Housing and Building Statistics 2002*, UN Economic Commission for Europe
- *Research Symposium 2008: Space at Home*.

For residents of other countries, we could not find reliable data for average house/apartment/etc sizes in square meters, so we arbitrarily used the house size data from Greece, which was on the small end of the spectrum of house sizes for Europe.

*********************** **Q8: Heating months** ***********************

If you leave the box on this page blank, we will use the average number of 'heating degree days' (HDD) in your country/state/province per:

- *International HDD Data: World Resources Institute* (WRI) 2003

USA States HDD Data:

- *Climate Prediction Center (NCEP/NWS/NOAA) monthly summary*, 2002

Canadian Provincial HDD Data: We could not locate specific provincial averages weighted by population, so we calculated this ourselves, using the available HDD data for Canadian cities (first two sites below), weighted by the populations of those cities relative to the province as a whole (per the third site below):

- Natural Resources Canada
- Canadian Climate Normals
- Canada: Major Urban Areas

Heating Degree Days (HDD) HDD are defined relative to an outside temperature above which a building does not need to use heating. For the purposes of this calculator, we defined this outside temperature to be 12°C (=66.2°F).

Data last updated April 2015.

*********************** **Q9: Home heating method** ***********************

Lbs or kg CO_2 per KWh for different fuels per: 'Carbon Dioxide Emissions from the Generation of Electric Power in the United States' July 2000, Department of Energy (DOE).

This information is saved for use in multiple subsequent questions, as referenced below.

Electric and non-electric home energy profiles for countries/states/provinces per:

- International Energy Agency (IEA) data for OECD and non-OECD countries
- IEA. 2014. World energy balances. *IEA World Energy Statistics and Balances* (database). DOI: http://dx.doi.org/10.1787/data-00512-en. (Accessed on 24 March 2015).

- USA states info from the Department of Energy (2013 data).

Electricity lbs or kg per CO_2 based on electricity profile (i.e., sources of residential electricity) for the country per:

- *World DataBank World Development Indicators*, World Bank, 2011 or 2012 data (depending on country) sourced from:
  - IEA Statistics (OECD/IEA) http://www.iea.org/stats/index.asp
  - *Energy Statistics and Balances of Non-OECD Countries*
  - *Energy Statistics of OECD Countries*; and
  - *Energy Balances of OECD Countries*
- USA states info from the Deaprtment of Energy (2013 data).
- Canada provincial data from Stats Canada [Table 127-0007 Electric power generation, by class of electricity producer, annual (megawatt hour), 2013.].

If you answer 'I don't know' here, we base the calculation on your country's mean use of fuels for heating, per IEA Energy Balances of OECD & Non-OECD countries, as cited above.

Home Heating data from DOE, Table CE2-4c. 'Space-Heating Energy Consumption in U.S. Households by Type of Housing Unit,' 2001. We then calculate KWH/dd/sqm for different kinds of houses & fuel used.

Your average temperature impacts your CO_2 emissions as follows:

- $((20 - degC) / 0.56)^{0.97}$

This formula is based upon heating costs/savings of 3% for every 1°F above/below 70°F, per the U.S. EPA Greenhouse Gas Reporting Program.

*********************** **Q10: How much room heat?** ***********************

For this question, we assumed that 1/2 of the heat used by each individual in a typical home is used to heat their bedroom. This assumption is based upon the fact that the coldest part of the day is during typical sleeping hours.

From your answer in the previous question, we calculated a 'total home heating' value. Your answer to the present question is, thus, an adjustment to this 'home heating' value, which we call a 'blanket savings factor'.

Therefore, if you answered that you use mainly blankets to keep warm at night, we calculated a “blanket savings factor” of 1/4 your total heating use (1/2 the amount of typical bedroom heat – which accounts for 1/2 of a typical individual's heat use:

- $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$

Likewise, if you answered that you use some heat in your room, we gave you a 'blanket savings factor' of 1/8. If you answered that you use as lot of heat in your room, you did not get a 'blanket savings'.

Your 'blanket savings factor' is saved for use in the next question.

*********************** **Q11: Room heating method** ***********************

The information you provide in this question and the previous one is used to calculate an adjustment to your 'total home heating' value (from Q9, above).

If you answered 'a' for this question (that you use a space heater), we first calculated a 'room electricity heating factor' based upon your location's electricity profile as follows:

- *X * 30.5 * heat-months*

...where X=the average lbs/kwh or kg/kwh of the energy source(s) for electricity in your country, state or province; 30.5 is the approximate number of days per month; and 'heat-months' is from your answer to Q8, above.

Multiplying this 'room electricity heating factor' by the kwh/day in space heating a typical room (at 1.5 kw/hr) then gives you the extra emissions accounted for by your space heater usage, based upon your relative use of blankets for heat (see Q10, above).

So if you said you keep your room very warm at night, we assume 8 hrs of full space heater power (8 * 1.5 = 12 kwh/day), if you use mostly blankets, we arbitrarily chose a value of 2 kwh/day, and if you use some blankets for warmth we averaged these two values:

- *(12 + 2)/2 = 7 kwh/day*

If you use your home heating system for your room ('b'), we adjust your 'total home heating' down using your 'blanket savings factor' as described in this info box in the previous question. If you use no heat at all in your room at night ('c'), then we deduct 50% from your total home heating' value (see Q10, above).

*********************** **Q12: Cooling months** ***********************

If you leave the box on this page blank, we will use the average number of 'cooling degree days' (CDD) in your country/state/province as follows.

International CDD Data:

- World Resources Institute (WRI) 2003

USA States CDD Data:

- Climate Prediction Center (NCEP/NWS/NOAA) monthly summary, 2002

For Canadian Provincial CDD Data, we could not locate specific provincial averages weighted by population, so we calculated this ourselves, using the available CDD data for Canadian cities (first two sites below), weighted by the populations of those cities relative to the province as a whole (per the third site below):

- Natural Resources Canada
- Canadian Climate Normals
- Canada: Major Urban Areas

Cooling Degree Days (CDD) CDD are defined relative to an outside temperature below which a building does not need to use cooling. For the purposes of this calculator, we defined this outside temperature to be 19°C (=66.2°F).

CDD data last updated April 2015.

*********************** **Q13: Home cooling method** ***********************
Using the CDD data for your location (see Q12, above), we calculated a mean number of months cooling for your location. We then used this value to calculate electricity used to cool your home based on the size of your home (see Q7, above) and kWh needed to cool a home per square meter using central or window unit air conditioning (US Department of Energy residential home survey, 2005), divided by the number of residents in your home (Q6, above).

For fans, kWh/yr follows this formula:

- *95 watts per hr * number hrs used per day * (number fans in home/number of residents) * 30.5 * number months cooling*

We then convert these values (whether for fans or air conditioning) to pounds or kg CO_2 per kWh based on your electricity source (see Q9, above). This intermediate value, then, is how much CO_2 an average resident in your location in your sized home would emit in order to cool their home.
If you use air conditioning, we then adjust this intermediate value based upon how many months per year you said that you cool your home (see previous question), and the average temperature that you keep your house in the warm (summer) months, compared to our default value of 24°C (=75°F), according to the following equation:

- $((degC - 24) / 0.56)^{0.94}$

This formula is based upon cooling savings/costs of 6% for every 1°F above/below 75°F, per the U.S. EPA Greenhouse Gas Reporting Program

Update April 2015: we now have included a more complete 'life cycle' emissions addition to account for the production, shipment and end-of-life disposal of fans and air conditioning units. Without specific information on these particular items, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q14: Room fans** ***********************

For fans, our calculations of kWh/yr follow this formula:

- *95 watts per hr * number hrs used per day * (number fans in home/number of residents) * 30.5 * number months cooling*

We then convert this value to pounds CO_2 per kWh based on your electricity source (see Q9, above).

Update April 2015: we now have included a more complete 'life cycle' emissions addition to account for the production, shipment and end-of-life disposal of fans. Without specific information on fans in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q15: Light bulbs** ***********************

If you filled in all of the boxes, our calculation assumes:

- for the USA, 100W bulbs and their equivalent in lumens for fluorescent (23W) & LED (15W) bulbs (this is the average wattage for these lights in the USA, according to the US Energy Information Agency, Office of Markets and End Use).
- for Europe, we assumed that the average bulb wattage is 60W or equivalent (data from Germany).
- elsewhere, we had no data, so used a mean of these two values - or 80W or equivalent.

We use these numbers and your reported numbers and hours of use of these bulbs per day at 365 days per year to get the total kWh used for lighting in your house per year. We then convert to CO_2 emissions using your location's electricity profile (see Q9) and divide by the number of residents in your home (see Question 6) to get your individual home lighting footprint.

If you checked 'I don't know' in this question, we calculated default values based on the following USA information:

According to the US Department of Energy (DOE), approximately 70% of residential sockets are incandescent. As above, we assume 100W for incandescent and 23W for fluorescent. An average home has 40 sockets (EnergyStar.gov), but we assume 1/3 of these bulbs are rarely used (closets, basements, attics, etc.). Therefore, 40 * 2/3 = 26 bulbs / 2.6 average number of residents in a US household (see Q6, above) = 10 bulbs per person (so, on average: 3 fluorescent bulbs, 7 incandescent bulbs.

With the recent advent of LED (but their slow adoption at least in the USA) we have adjusted these defaults to 2 CFL, 7 incandescent, 1 LED bulb per person.

According to the 1996 DOE residential energy use survey, bulbs are each used on average of about 3 hours per day. The default calculation, then, is:

- *lbs/kWh*((23 Watts * 2 fluor * 3 hrs) + (100W * 7 incand * 3 hrs) + (15W * 1 LED * 3 hrs))*365*

...where lbs/kWh (or kg/kWh) is CO_2 emissions according to your electricity profile (see Q9, above).

Of course, you will get the most accurate footprint if you know and enter your bulb count, for which we will use the default wattage described above.

Update April 2015: we have now included a small addition to the lighting footprint to account for the production, shipment and 'end of life' disposal of different kinds of bulbs (Ramroth, L. 2008. *Comparison of life-cycle analyses of compact fluorescent and incandescent lamps based on rated life of compact fluorescent lamp*. Rocky Mountain Institute.). We assumed that the corresponding 'life cycle' emissions values for LED bulbs is similar but a bit higher than for incandescent bulbs, due to the extra packaging and weight of LED bulbs of a comparable intensity.

*********************** **Q16: Turning off lights** ***********************

Without asking more specific questions, which we felt that most people would be unable to answer accurately, we needed to guess at some reasonable values here.

We assumed that most students have the opportunity to turn off the lights from approximately 8 rooms during weekdays (at home and at school, including bathrooms) and 5 rooms on the weekends (mainly at home), thus:

- *8*5 + 5*2 = 60 rooms/week or 60/7 rooms/day = 8.6 rooms/day*

We further assumed the average wattage per room at 150 watts (=0.15 kW; much more for large rooms, less for small rooms), and the average time that the lights would then be off after the lights were turned off as 3 hours (could be minutes, could be overnight or over the whole weekend).

Multiplying:

- *0.15 kW/room * 3 hr * 8.6 rooms/day * 365 days/yr = 1412.6 KWh per year*

This value is then multiplied by lbs (or kg) CO_2/kWh for your home/region (see Q9, above) and a savings factor according to your answer to this question as follows:

- *a. Always (0), b. Usually (0.33), c. Rarely (0.67), d. Never (1)*

********************** **Q17: Brushing teeth** **********************
We used TerraPass stats on water wasted if you leave the water running while brushing your teeth: TerraPass estimates this amount to be 6 gallons (22.7 L) per day, or:

- *6 *365 = 2190 gallons (=8285.5 L) per year*

Then, we need to estimate the energy use inherent in water use in the house. This energy use comes mainly from pumping and treating water; according to the study from *The River Network* entitled 'The Carbon Footprint of Water':

"...the energy intensity of municipal water supplies on a whole system basis...typical[ly] range[s] between 1,250 kWh/MG and 6,500 kWh/MG."

...where 'MG' means millions of gallons (approx 3.79 million liters). We decided to take the middle value in this range, or 3875 kWh/MG or 3.875 kWh per thousand gallons (approx 3790 liters) of (unheated) water used.

Therefore, the electricity use involved in leaving the faucet running while brushing your teeth is:

- *3.875 kWh/1000 gallons * 2190 gallons/year = 8.49 kWh/year*

We then multiply this value by your region's electricity lbs (or kg) CO_2/kWh profile (see Q9) to get your footprint if you leave the water running while you brush.

********************** **Q18: Water heating method** **********************
To calculate the footprint of water heating, we first have to know how much energy is required to heat one gallon (approx 3.79 L) from 15.6°C (60°F) to 50.6°C (123°F), a typical water heater temperature. This value is 525 Btu's (British thermal units).

We then can use the known Btu's of different fuels, including electricity (US Energy Information Agency, EIA). Then, we need to know how efficient different water heaters are. We used average values from 'Mr. Electricity' (michaelbluejay.com), namely 59% efficiency for gas and 92.7% for electric water heater tanks.

- For electric heaters we then use standard values to translate Btu's to kWh's, and then use your electricity profile (see Q9, above) to calculate the carbon footprint.
- We use pounds or kg CO_2/Btu of gas (EIA) to calculate the footprint of gas.
- On demand water heaters operate at approximately 52 watts per gallon (=13.7 watts/L; getwithgreen.com), approximately 70% more efficient than a typical electric water heater.
- Shower head water heaters use approximately 46 kWh/gallons (=12.1 kWh/L).
- If you Answer 'I don't know' we assume you have a gas water heater.
- Note that we do not ask about water heater efficiency in this question, though this is an important issue, as 'gas water heaters,' for example, can vary in efficiency from 50% to over 80%. Also relevant are the size of the water heater tank, how well insulated it is and the temperature at which it is set.

- We also add the footprint of cold water here (see previous question).
- Lastly, we have now (April 2015) updated this calculation to include an estimate of the full 'life cycle' emissions to account for the production, shipment and end-of-life disposal of different types of water heaters. Without specific information on water heaters in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

Your value for footprint per gallon (or liter) hot water is saved for subsequent questions.

*********************** **Q19: Showers (baths)** ***********************

We use 2 gallons (=7.6 liters) per minute (gpm) for the average water use of showers (*Consumer Reports*). Different shower heads and settings would change this value. For example, older shower heads in the US (pre 1992) averaged over 5 gpm (=18.9 liters per minute; lpm); newer models can even be below 1.5 gpm (=5.7 lpm).

The average bath uses 50 gallons (=189 liters; watersystemscouncil.org); while a shallow or Japanese style bath uses about 2/3 that much water (thewhirlpoolbathshop.com).

We used the above values -and your answer to Q18 and Q19 [your lbs/kWh (or kg/kWh) footprint for hot water & cold water]- to calculate your yearly bath/shower footprint.

*********************** **Q20: Toilet use** ***********************

For this question, our team estimated that the average person uses the toilet three times per day, two of which are urination.

The value we used for low water volume toilets is 1.28 gallons (=4.85 liters) per flush, whereas standard toilets use 3.40 gallons (=12.87 liters) per flush (http://www.deltafaucet.com). Therefore, low flush toilets use 1.28/3.40 = 38% of the water of a standard toilet.

Our calculation of footprint of using standard toilets is as follows:

- *3 flushes/day * 365 days/yr * 3.4 gallons/flush * 3.875 kWh/1000 gallons (see Q17, above) = 14.45 kWh/yr*

For low flush toilets, the total is:

- *14.45 kWh/yr * 0.38 = 5.43 kWh/yr*

If you answered 'I don't know' (choice 'c'), we used the mean value between the two toilet types:

- *(14.45 + 5.43) / 2 = 9.94 kWh*
  [this is a guess]

If you said you don't flush when you only urinate, then we divide the appropriate number above (for low flush or standard toilet) by 3.

We then use your home electricity profile (see Q9, above) to calculate your toilet use footprint in CO_2 equivalents.

*********************** **Q21: Washing dishes** ***********************

To answer this question, our team consulted published research [Stamminger (2004) 'Is a machine more efficient than the hand?' *Home Energy*, May-June issue, pp 18-22] and ran experiments of our own.

Your answer here is converted to volume of water used per dish load (equivalent to average dishwasher) as follows: Dishwasher ('a'&'b'), 15 liters (l); constant water running ('c'&'e'), 100 l; turning off water between dishes ('d'&'f'), 30 l; basin washing ('c'&'d') saves 5 l;

If you use a dishwasher, we use a value of 1.58 kWh per load (per siliconvalleypower.com). If you answered 'a', then we assumed you use the dishwasher 320 days a year. Based on average use in 2004 in the US (ftc.gov), we guessed that a full size family (we correct for family size below) would completely fill up their dishwasher ('b') 120 days per year. For 'I don't know' ('g'), we assumed you wash your dishes under the faucet with constant running water ('e').

We then used your hot water footprint (Q18, above) and your locale's electricity footprint (Q9, above) to calculate your household's dishwashing footprint; we divide by your number of household members (Q6, above) to get your personal contribution.

If you use room temperature water for washing, then we assumed this was 25% hot water (per Q18, above), 75% cold water (per Q17, above).

Update April 2015: we now also consider the carbon footprint of the manufacture, shipment and disposal of dishwashers, by including a full 'life cycle' estimate of emissions for dishwashers. However, without specific information on dishwashers in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q22: Washing clothes** ***********************

The carbon footprint of washing clothes comes from the use of water, the heating of that water and the electricity used in running a washing machine. We now (as of April 2015) also consider the carbon footprint of the shipment, manufacture and disposal of washing machines, as described under *Life cycle emissions* below.

We used 40 liters (l) for the total volume of water in a top load washing machine, and 20 l for a front loading machine (energystar.gov). We assumed that a hot water wash at 50°C ('a') uses 100% hot water (including ll rinses), a warm water wash ('b') uses 50% hot/50% cold throughout, and a cold water wash ('c') uses 100% cold water. Footprints of hot & cold water from Q18 & Q17, respectively (see above).

For washing machines, we use a value of 0.256 kWh per load, converted to CO_2 via your home electricity profile (see Q11, above).

For machine washing (water volumes & energy use) we consulted the following sites:

- Carbonrally - energy star washing machines
- California Consumer Energy Center
- "Ask Mr. Electricity"

For hand washing, we are currently using an estimate of water use per load from several unverified internet sources; we are seeking more trustworthy information. If you wash your clothes in unheated river or well water, your actual carbon footprint value would be essentially zero.

Life cycle emissions. Without specific information on washing machines in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

Other factors that we do not include here that would (in some cases substantially) impact your clothes washing footprint: the recent availability of high efficiency washing machines that spend more time in soak mode; settings for large, medium and small loads on some machines; washing machines that are more than 10 years old and that use a lot more water per load; and how often you wash your clothes & linens.

********************** **Q23: Drying clothes** **********************

We consulted the excellent research at "Ask Mr. Electricity" for this question as follows:

We then multiply this value by pounds (or kg) CO_2/kWh value from Q9 (see above).

Finally, this value is then multiplied by a 'clothes hanging factor' ('chf') as follows:

- *3.3 KwH per load * 52 loads per year = 171.6 kWh per year*

If you answered 'a' (always hang your clothes) your chf = 0 ; for 'b' (most of the time) your chf = 0.25 ; for 'c' (half of the time) your chf = 0.5 ; for 'd' (some of the time) your chf = 0.75 ; for 'e' (none of the time) your chf = 1 .

There are other relevant factors we don't include here. For example, the 'permanent press' setting on many driers results in approximately double the electricity use (and hence double your footprint).

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of clothes driers. However, without specific information on clothes driers in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q24: Cutting grass** ***********************

For amount of time spent mowing, we used data from Oregon State University and the US EPA (document 420-P-02-014) as follows: push mower- 45 hours per year; tractor mower- twice as fast as a push mower, so 22.5 hours per year.

Electric mowers operate at approximately 1.75 Hp or 1.3055 kW. kWh converted to lbs or kg CO_2 per Q9, above.

For gasoline consumption, we use the following values (per b-e-f.org): 5-8 Hp gasoline push mower: 0.7 gallons per hour (=2.65 l/hr)...20 Hp tractor mower: 2.12 gallons per hour (=8 l/hr)

One gallon of gas releases 19.6 lbs CO_2 equivalents (or 1 liter releases 33.6 kg CO_2 equivalents), per US EPA data.

Per Q7 (above), if you live in a shared house, we multiply your value by 0.5 (half the size of 'your' lawn vs a single family house). If you live in a townhouse, apartment or mobile home, we multiply your value by 0.3 (30% the size of 'your' lawn vs. a single family house).

Finally, we divide your lawn mowing footprint by the number of residents in your home (see Q6, above). For 'I don't know' ('f'), we use the gasoline push mower data.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of lawn mowers. However, without specific information on lawn mowers in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q25: Weed whacking** ***********************

For amount of time spent using a weed whacker, we used US EPA data (document 420-P-02-014): 9 hours per year.

Electric weed whackers operate at approximately 0.72 kW (based on Craftsman 6 amp model electric weed whacker), thus 0.72 * 9 = 6.48 kWh per year; kWh converted to lbs or kg CO_2 per Q9.

For gasoline consumption, we use 0.18 gallons (=0.68 l) per hour (based on Ryobi PLT3043S model gas weed whacker); 0.18 * 9 = 1.64 gallons (=6.2 l) per year. One gallon of gas releases 19.6 lbs CO_2 equivalents (or 1 liter releases 33.6 kg CO_2 equivalents), per US EPA data.

Per Q7 (above), if you live in a shared house, we multiply your value by 0.5 (half the size of 'your' yard vs a single family house). If you live in a townhouse, apartment or mobile home, we multiply your value by 0.3 (30% the size of 'your' yard vs a single family house).

Finally, we divide your weed whacking footprint by the number of residents in your home (see Q6, above). For 'I don't know' ('e'), we use the gasoline weed whacker data.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of wee whackers. However, without specific information on weed whackers in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q26: Cleaning leaves** ***********************

For amount of time spent using a leaf blower, we used US EPA data (document 420-P-02-014): 10 hours per year.

Electric leaf blowers operate at approximately 1.1 kW (based on Stihl BGE 61 model electric leaf blowers), thus 1.1 * 10 = 11.1 kWh per year; kWh converted to lbs or kg CO_2 per Q9.

For gasoline consumption, we use 0.7 gallons (=2.8 l) per hour (per b-e-f.org); 0.7 * 10 = 7 gallons (=28 l) per year. One gallon of gas releases 19.6 lbs CO_2 equivalents (or 1 liter releases 33.6 kg CO_2 equivalents), per US EPA data.

Per Q7 (above), if you live in a shared house, we multiply your value by 0.5 (half the size of 'your' yard vs a single family house). If you live in a townhouse, apartment or mobile home, we multiply your value by 0.3 (30% the size of 'your' yard vs a single family house).

Finally, we divide your leaf blowing footprint by the number of residents in your home (see Q6, above). For 'I don't know' ('e'), we assume that you don't use gas or electric leaf blowers to collect your leaves.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of leaf blowers. However, without specific information on leaf blowers in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada).

*********************** **Q27: Yard waste** ***********************

According to the EPA, the total yard waste generated in the US annually is 35 million tons. With 105.5 million households in the USA (2000 census), that's approximately 636.36 pounds (=288.65 kg) yard waste per household per year.

Here are the US EPA estimates for pounds or kg's CO_2 per pound or kg of yard waste:

- landfill: 0.2 (high due to methane release from anaerobic breakdown within a landfill)
- compost: -0.05 (negative due to recovery of carbon in the soil)
- burning: 0.01 (essentially zero; it is considered photosynthetic 'return to atmosphere')
- energy generation from burning: -0.05
- mean value for USA: 0.12 (we use this value if you answered 'f': 'I don't know')

We multiply these values by the 636.36 pounds per household as calculated above (we could not find comparable values from enough other countries to make good international estimates), and then divide that value by the number of residents in your household (per Q6, above). And per Q7 (above), if you live in a shared house, we multiply your value by 0.5 (half the size of 'your' yard vs a single family house). If you live in a townhouse, apartment or mobile home, we multiply your value by 0.3 (30% the size of 'your' yard vs a single family house).

If your yard waste is trucked to a central facility for composting, we use the following data from the publication 'Fuel consumption estimation for kerbside [sic] municipal solid waste (MSW) collection activities' by Thuy T.T. Nguyen & Bruce G. Wilson: 0.0295 pounds (or kg) CO_2 emissions from trucking per pound (or kg) medium density waste, or 19.59 pounds (=8.9 kg) CO_2 per household.

*********************** **Q28: Garbage** ***********************

After consulting data from various municipal solid waste documents (Novogorod Russia, Vancouver Canada & Charlottesville USA), we assume that home garbage weighs, on average, about 1 pound per gallon (=0.12 kg/l), though this is highly dependent on the nature of the items disposed, and how 'packed down' (i.e., dense) your garbage is.

We then used the US EPA value of 0.94 pounds (or kg) CO_2 per pound (or kg) of average municipal solid waste disposed in a landfill to calculate your household garbage footprint based on your answer here. For your personal footprint we divide by the number of residents in your household (per Q6, above). We calculate your 'outside the house' garbage footprint the same way, but we don't divide by the number of residents in your house (since this latter value is for you personally). We also include the footprint of transport of your waste to a disposal facility as described in this box in the previous question.

If you answer 'I don't know' ('h'), we use the average amount of garbage generated per person for your location from the latest year available (for most countries, 2011), per:

- http://unstats.un.org/unsd/environment/wastetreatment.htm

...and for US states from:

- Dolly Shin. 2014. *Generation and disposition of Municipal Solid Waste (MSW) in the United States –A national survey*. M.Sc. Thesis, Columbia University, Dept. of Earth and Environmental Engineering (Prof. Nickolas J. Themelis, Advisor).

Some municipalities incinerate mixed waste rather than burying it; this produces, on average, 17% the CO_2 emissions when compared to burying waste (because buried waste releases more methane due to the anaerobic breakdown per US EPA). We include this factor automatically with respect to your location per the same two documents listed above (UNstats & Shin 2014).

********************** **Q29: Paper** **********************

We could not find reliable statistics on the average number of sheets of paper used per student per week (including notebook paper, printed assignments, homework, etc.); we guessed that approximately 50 sheets per week is close to typical, while giving you the opportunity to make that estimate yourself.

We used the US average of 30 weeks in school per year, thus 50 * 30 = 1500 sheets of paper per school year. 100 sheets of paper is approximately 1 pound, so 1500/100 = 15 pounds (or 6.8 kg) paper per year.

Environmental impact estimates were made using the Environmental Defense Fund Paper Calculator (for more information visit http://www.papercalculator.org) as follows:

- *The production of 1 pound (or kg) of paper produces 3 pounds (or kg) of net CO_2 emissions.*
- *The production of 1 pound (or kg) of recycled paper produces 2 pounds (or kg) of net CO_2 emissions.*

If you reuse paper already printed on one side, your footprint is zero. If you use both sides of the paper, your footprint is half of what it would be if you only used one side.

We don't consider recycling versus landfill disposal of paper here; we ask about that in a subsequent question.

********************** **Q 30: Phone charging** **********************

According to the Lawrence Berkeley Lab (http://standby.lbl.gov/summary-table.html), the average cell phone draws about 3.68 watts while charging and 2.24 watts when fully charged but still plugged in (this latter is called 'vampire power'). We assume that one hour of charging per day is all that is required to keep your phone fully charged. So if you charge your cel phone for 1 hour per day, your cel phone use footprint is:

- *0.00368 kW * 1 hour/day * 365 days/yr = 1.34 kWh per year*

…for every additional hour, your footprint is:

- *0.00224 kW * 1 hour/day * 365 days/yr = 0.82 kWh per year*

If you charge for >1 hour per day, we add 1.34 to the following value: We take the number that you enter into the box, subtract 1, and multiply by 0.82 above to calculate your kWh cel phone use per year.

Another factor that needs to be considered is the energy associated with the cell phone networks:

cell towers, servers, etc. If you only use your phone for calling ∧ texting, then we use an estimate of 3x the footprint for cell network usage over and above your battery-use calculation (see above). In addition, if you use your phone for internet access, then we include a footprint of 10KWh/gb. Both of these estimates come from our examination of variety of sources including:

- http://science.time.com/2013/08/14/power-drain-the-digital-cloud-is-using-more-energy-than-you-think
- http://www.ericsson.com/res/docs/2013/the-global-footprint-of-mobile-communications-the-Ecological-and-economic-perspectiv.pdf

We then use your electricity profile (see Q9, above) to convert kWh to pounds (or kg) CO_2 per year for cell phone use.

Note that we do not consider here other ways in which cell phone use increases atmospheric CO_2, such as the manufacture, transport or 'end-of-life' disposal of cell phones -- these factors will be included for any new electronics purchases that you report in Q47 (below).

*********************** **Q31: Watching TV***********************

Different television (TV) models draw differing amounts of power (http://reviews.cnet.com/green-tech/tv-power-efficiency/). Based on recent increase in energy efficiency of televisions, we have now (Apr 2015) chosen an average value of about 175 watts when a TV is in active use and 5 watts when left on stand by (this latter is called 'vampire power'). So for every hour that you watch TV per day your total electricity used for the year would be:

...and for every hour on standby, your yearly total would be:

- *0.005 kW * 1 hour/day * 365 days/yr = 1.825 kWh per year*

We then use your answers to this question and your electricity profile (see Q9, above) to convert kWh to pounds (or kg) CO_2 per year for your TV use.

Also, note that your TV model could have lower (e.g., older & smaller models) or higher (e.g., plasma) power use than the values used here (though we do ask about new electronics purchases in Q47, below).

One way to decrease your power use while watching TV is to turn down the light output on your TV. This is generally done by adjusting the 'contrast' and/or the 'backlight' settings. Strangely, the 'brightness' control does not really impact the total light output to a significant degree (see aforementioned cnet review). Some TVs also have 'energy saver' modes.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of televisions. However, without specific information on televisions in particular, we used the suggested value of 0.293 kg CO_2 per US dollar in cost for appliances as an estimate for these additional life cycle emissions over the average 'lifetime' of the appliance (Mike Berners-Lee. 2011. *How Bad Are Bananas? The Carbon Footprint of Everything*. Greystone Books: Vancouver, Canada). This of course, will vary based on model, and indicates that if your family purchases a used TV, you could be saving substantial additional emissions in these ways.

********************** **Q32: Home computer** **********************
Different computer models draw differing amounts of power, from 60-250 watts in active use (http://michaelbluejay.com/electricity/computers.html). Here we have chosen an average value of 105 watts when either in active use or with a screen saver running, and 3.5 watts when allowed to go to sleep with no screen saver (these answers are approximately those for a Macintosh G5 desktop). So for every hour per day that you use a computer OR have the screen saver running, your total electricity used for the year would be:

- *0.105 kW * 1 hour/day * 365 days/yr = 38.325 kWh per year*

…and for every hour asleep, your yearly total would be:

- *0.0035 kW * 1 hour/day * 365 days/yr = 0.2775 kWh per year*

We then use your answers here and your electricity profile (see Q9, above) to convert kWh to pounds (or kg) CO_2 per year for computer use. If you answered 'I don't know' ('e'), we assume that you leave the computer on all the time, but allow it to sleep while not in use.

To reduce your energy use, never just leave your computer screen (desktop view) on or even use a screen saver- this saves no energy. Instead, either let your computer go to sleep (black screen) or turn it off when not in use. Also, you can save 15% or more energy if you turn down the screen brightness.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of computers per:

- Lisa Hopkinson and Peter James. 2011. *Life Cycle Energy and Environmental Impacts of Computing Equipment- A June 2011 Update to a 2009 SusteIT Report*. Higher Education Environmental Performance Improvement Project, University of Bradford and goodcampus.org.

We attribute a year's worth of this life-cycle calculation in this question, although if you share this computer, then this is an over-estimation for you. Furthermore, if you buy a used or factory refurbished computer, then you are extending the life of the item, and can consider that a savings in terms of life cycle emissions.

********************** **Q33: Laptop computer** **********************
Different laptop models draw differing amounts of power, from 15-85 watts in active use (http://michaelbluejay.com/electricity/computers.html, apple.com). Here we have chosen an average value of 45 watts when either in active use or with a screen saver running, and 2 watts when allowed to go to sleep with no screen saver or turned off and charging the battery. So for

every hour per day that you use a computer OR have the screen saver running, your total electricity used for the year would be:

- *0.045 kW * 1 hour/day * 365 days/yr = 16.4 kWh per year*

…and for every hour asleep, your yearly total would be:

- *0.002 kW * 1 hour/day * 365 days/yr = 0.73 kWh per year*

We then use your answers here and your electricity profile (see Q9) to convert kWh to pounds (or kg) CO_2 per year for computer use. If you answered 'I don't know' ('f'), we assume that you leave the computer on all the time, but allow it to sleep while not in use.

To reduce your energy use, never just leave your computer screen (desktop view) on or even use a screen saver- this saves no energy. Instead, either let your computer go to sleep (black screen) or turn it off when not in use. Also, you can save 15% or more energy if you turn down the screen brightness.

Update April 2015: We now include the 'life cycle' carbon footprint inherent in the manufacture, shipping and 'end of life' disposal of laptop computers per:

- Lisa Hopkinson and Peter James. 2011. *Life Cycle Energy and Environmental Impacts of Computing Equipment- A June 2011 Update to a 2009 SusteIT Report*. Higher Education Environmental Performance Improvement Project, University of Bradford and goodcampus.org.

We attribute a year's worth of this life-cycle calculation in this question, although if you share this computer, then this is an over-estimation for you. Furthermore, if you buy a used or factory refurbished laptop, then you are extending the life of the item, and can consider that a savings in terms of life cycle emissions.

*********************** **Q34: Other electronics** ***********************

Different types of home electronics can be different in how much power they draw. For this question we use a stereo system (CD player and amplifier powering speakers) as an example (per My Opera). Here we have chosen an average value of 50 watts when in active use, and 7 watts with both components in sleep mode (so called 'vampire power'). So, for every hour per day that you use this type of stereo system, your yearly total electricity use would be:

- *0.05 kW * 1 hour/day * 365 days/yr = 18.25 kWh per year*

…and for every hour asleep, your yearly total would be:

- *0.007 kW * 1 hour/day * 365 days/yr = 2.55 kWh per year*

We then use your answers to this question and your electricity profile (see Q9, above) to convert kWh to pounds (or kg) CO_2 per year for your electronics use. If you answered 'b' (turn off some of the time), we assumed that you have your electronics on half of the time (i.e., hours per day) that you're not using it.

Note that we do not include here other ways in which electronics use increases atmospheric CO_2, such as the manufacture, transport or 'end-of-life' disposal of electronics, all of which are substantial greenhouse gas contributors (though we do ask about new electronics purchases in Q47, below). Note, also, that if you use more that one kind of electronics equipment (e.g., stereo, xbox, guitar + amp), and you answered 'b' or (especially) 'a' here, then our calculations for your 'vampire power' footprint here are underestimations.

FOOD SECTION

*********************** **Q35: Calories per day** ***********************

We use kcal/day to help give a more accurate average footprint for a given diet in different countries, but also to help correct for your diet versus the average resident of your country.

For country average kcal/day, we used Food and Agricultural Organization (FAO) data from 2007. This data is the average for all residents (i.e., it doesn't distinguish between males and females). We were able to find data from two studies (citations below) which gave reference caloric intake for males and females: one from England and one from Bangladesh. In both cases, women consumed approximately 86-87% of the calories of men. In the British study, this 86-87% value held across all diets examined (meat-eaters, fish-eaters, vegetarians and vegans), despite large differences in total caloric intake among these diets.

Thus, for mean male and female kcal/day intake for different countries, we adjusted the FAO data as follows:

- *male average = average * (2/1.865)*
- *female average = average * (1.73/1.865)*

These adjustments yield a mean female caloric value that is 86.5% of the male value.

These values, as well as the country mean, are saved for use in subsequent questions.

The two studies on caloric intake that we used are:

- Spencer, Appleby, Davey & Key. 2003. Diet and body mass index in 38000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians and vegans. *Int J Obesity* 27: 728-734.
- Haseen F. 2007. Change in food and energy consumption among the ultra poor: is the poverty reduction programme making a difference? *Asia Pac J Clin Nutr* 16(Sup1): 58-64.

********************** **Q36: Diet************************

Using your reported calories (or your country & gender mean; see Q35 above) we calculated a 'calories factor' as your kcal/day value divided by your country's mean caloric intake (average of M+F). This factor is needed to personalize the statistics that we use here and in subsequent questions.

The average footprint from your country (which we multiply here by the 'calories factor' to derive your initial footprint) is based upon:

- The average diet in your country from 2007, as seen in Food and Agricultural Organization (FAO) statistics;
- The footprint in food production based on that in the USA (from Weber CL & Matthews HS. 2008. Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environ. Sci. Technol.* 42, 3508–3513.)
- 'Internationalization' of the values from the Weber & Mathews study using mean global (for imports) and domestic per capita values for fertilizer (FAO) & fuel use (International Energy Agency) in agriculture, two of the main contributors to food footprint in production.
- Due to insufficient data, we had to guess at average vegetarian diet makeups in different countries. To do so, we used the data in Spencer et al. (2003; see this box in the previous question) of a reduction in caloric intake of 5% in vegetarians and 15% in vegans compared to omnivores. In countries in which the mean caloric intake approaches malnourishment, we used less or no adjustment in caloric intake for vegetarians and vegans.
- For vegetarians, we assumed a replacement of meat calories with fruits/veges, carbs/cereals, eggs & dairy in the same proportion as found in mean diets for your country. For vegans, we used this same logic for replacement of dairy & egg calories.

**********************Q37: What do I eat?**********************

Average diet makeup for each country from Food and Agricultural Organization 2007 stats.

We calculated the footprint (in CO_2 equivalents, taking into account all major greenhouse gases) associated with a specific quantity of consumed foodstuffs per Weber & Matthews (2008). We adjusted these values based upon the details described in Q37 above (i.e., your location's average use of fertilizers and fuel in production).

Your footprint is, thus, based on your reported diet, and adjusted based upon your reported calories/day when compared to an average person in your location (see first food question).

For this question, we assume a conventional (non-organic, non-local) diet, and make any adjustment for organics & local consumption based on subsequent questions.

Note that the Weber & Matthews study that we used calculated a full (life-cycle) footprint associated with different foodstuffs based on typical food consumed in the US. Although we attempted to correct for different agricultural practices around the world, there is really no reliable data on comparisons of footprints in food production around the world. Furthermore, no data exists, for example, for the footprint of wild hunted mammals (e.g., deer, caribou); we assume that the footprint from wild-caught mammals is quite small compared to the footprint of farmed meat. If much of your mammal consumption is wild-caught, we suggest that you leave that out of the mammal category. Our calculator will thus assume that these are vegetable calories in your diet, perhaps a better estimate of the true food footprint of wild-caught meat.

(Note: The larger portion of your footprint related to hunting is likely due to transport for hunting excursions and the refrigeration/freezing of the prepared meat.)

*********************** **Q38: Eating organic*************************
The data we use for organic versus non-organic footprints for different foodstuffs come from two sources:

- Foodwatch report 'Organic: A Climate Saviour? The foodwatch report on the greenhouse effect of conventional and organic farming in Germany.' August 2008.
- DEFRA (Department for Environment, Food and Rural Affairs) UK.

For 'most of the time' we used a value of 90%, for 'some of the time' 50%, and for 'rarely or never' 10%. If you answered 'I don't know', we used the 10% value.

You may notice that some animal organic farming methods are actually MORE carbon intensive than non-organic methods. This is mainly due to increased demands on grazing land in most organic methodologies.

Note that these data are likely most relevant for farming methods in Europe, North America and other heavily industrialized ('Western') societies. Most cultivation methods in underdeveloped countries are, by default, 'organic.' In practice, though, such organic farming methods presumably involve much less land and energy use than Western organic farming methods.

*********************** **Q39: Eating local** ***********************
In contrast to what you may have heard or imagined, the footprint of shipping foods over long distances has a relatively small impact on total food footprints when compared to food choices in general. In other words, food production is the source of most greenhouse gases associated with food, not transport and other so-called 'food miles.'

The relative impact of food miles is greater for vegetarian and vegan diets, as the total footprint in production is much smaller for these diets versus omnivorous diets (see previous questions).

The data that we use for food miles derives from the excellent study by Weber & Matthews (2008) 'Food-Miles and the Relative Climate Impacts of Food Choices in the United States' (*Environ. Sci. Technol.* 42, 3508–3513).

Note that, again, these food miles values were calculated based on food consumed in the US. Different countries (with different modes of food transport, for example) may differ somewhat from the values we use here.

*********************** **Q40: Composting** ***********************
We use US Environmental Protection Agency (EPA) statistics that suggest that composting of food scraps at home actually reduces greenhouse gases through microbial action. We only give you composting 'credit' for the vegan portion of your diet.

Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. 3rd Edition, September 2006. EPA.

*********************** **Q41: Take away containers** ***********************
For the footprint of take-away containers, we consulted the following study:

Madival S, Auras R, Singh SP and R Narayan. 2009. Assessment of the environmental profile of PLA, PET and PS clamshell containers using LCA methodology. *Journal of Cleaner Production* 17: 1183–1194.

*********************** **Q42: Burning wood** ***********************
When wood burns on a pile, approximately 11% of the carbon is released as impartially burned particulate matter in the form of CO and CH_4 (Susott et al 2002, Smith et al 1993), which are more potent greenhouse gases than CO_2.

According to Smith et al (1993), burning one kg of wood in an open pile results in approximately 900 grams of CO_2 emissions equivalents. Susott et al (2002) showed that efficient stoves can reduce these emissions by up to half by more completely incinerating the wood.

We base our calculations here on those two studies, assuming that an efficient indoor stove produces 59% of the CO_2 emissions as an open fire.

There is some question about how to count total wood burning emissions, as trees are a renewable resource. But since forests are being cut 70% faster than they are currently being planted (Brown 2011), we decided to consider all wood burning emissions to be a net production of CO_2.

Sources:

- Brown LR. 2011. *World on the Edge: How to Prevent Environmental and Economic Collapse.* Norton: New York.
- Smith KR et al. 1993. Greenhouse gases from biomass and fossil fuel stoves in developing countries: A Manila pilot study. *Chemosphere* 26, 479-505.
- Susott RA et al. 2002. *Reducing PM2.5 Emissions Through Technology*. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT.

PURCHASES SECTION

*********************** **Q43: Clothing** ***********************
For clothing footprints, we based our analysis on USA data and then internationalized the statistics, as described below.

For US data we used:

- The US Bureau of Statistics 2007 Personal Expenditure Survey to arrive at a % of income spent on new clothing.
- We then multiplied this value by the mean income in the US in that year (27907) to arrive at an amount spent per person under 25 years old per year on new clothing ($1283.72)
- With an average piece of new clothing costing $25 (per the same Personal Expenditure Survey), that works out to 51.35 items of clothing per person under 25 per year
- We then used statistics from American Apparel and Footwear Association (AAFA) – Annual 2007 Trends report (An Annual Statistical Analysis of the U.S. Apparel and Footwear Industries) for total numbers of shoes and other clothing purchased per year in the US, divided by the 2007 population to arrive at a per capita average number of pieces of clothing purchased
- We used the Stromberg report ('Carbon Footprint Analysis with Action Plan Summary report April 2008') for carbon footprint per piece of clothing: 0.45 kg CO_2e (= 1 lb) per piece.
- Then we multiply 0.45 kg CO_2e/piece by 51.35 pieces/year to get a clothing footprint for under 25 years old US residents of 134.45 kg (=296 lb) per person per year.

For international data, we adjusted this value using UN Development statistics on % of yearly mean income spent on clothing in different countries, and then adjusting the USA data accordingly.

Based on your input in the box (if any) we then further adjust your footprint versus that of the average resident of your country as described above.

Exchange rate information is from April 2015 at xe.com and similar sites.

*********************** **Q44: Packaging choices** ***********************
For international data on Packaging, we use OECD data on the composition of packaging in municipal solid waste (1980-2005 dataset) in 20 countries from Europe plus the USA. For countries for which we have no data, we arbitrarily use the data from the Czech Republic, which is at the low end of packaging use & disposal for these 21 countries.

We then use US EPA statistics for the emissions associated with glass, plastic, metal and paper packaging when landfilled versus recycled.

For thinking about packaging: 'often' assumes an 80% reduction in waste generation (recycled or landfilled); 'sometimes' assumes a 40% reduction; 'never' uses the national average packaging waste generation.

For recycling: 'always' assumes 100% of packaging is recycled, 'sometimes' 50% & 'never' 0%.

Exchange rate information is from April 2015 at xe.com and similar sites.

********************** **Q45: Drinking water** **********************

Even if the bottles are recycled (which they often are not), the production and shipment of plastic water bottles results in far more CO_2 emissions than municipal water sources.

Although many parts of the world still do not have reliable sources of clean water, this is not true in industrialized countries, where clean, tested municipal water is readily available. There seems little justification in many cases for the widespread purchasing of water from plastic bottles.

In situations where good sources of water are not available, buying water in larger containers results in less plastic waste, and reusable large containers even less.

********************** **Q46: Shopping bags** **********************

For average bags used per person per year, we consulted the study: Kahn BE and Schmittlein DC (1989) 'Shopping trip behavior: An empirical investigation' *Marketing Letters*, vol 1.

For the CO_2 emissions associated with paper & plastic bags, we consulted the study: Lilienfeld R (2008) 'Review of Plastic vs. Paper bag LCA Studies' *ULS Report*, Rochester MI.

We validated these numbers by consulting the excellent book: *How Bad Are Bananas, The Carbon Footprint of Everything* by Mike Berners-Lee (2010, Greystone Books).

According to these studies, the differences in CO_2 emissions between the two kinds of bags are minimal.

Berners-Lee points out that not all reusable bags are equal. For example, if that bag itself is only usable for 6 months, it might actually be better (in terms of CO_2 emissions) to use disposable bags.

On the other hand, a very sturdy, long lasting bag (like a hefty cloth bag or a backpack) are far better in terms of lifetime emissions than disposable bags.

********************** **Q47: Electronics** **********************

We based our values on life cycle (production, recycling, transport) emissions reported by " Apple:

- iPod Nano – 9.15 kg CO_2
- iPhone 3g – 27.5 kg
- MacBook – 220.5 kg

and Sony Trinitron 32' TV – 185.5 kg.

We used an low-average value here of 74 kg per item – assuming that most young people are typically buying smaller rather than larger electronics.

*********************** **Q48: Recycling at home** ***********************
For international data on plastic, glass, metal and paper waste, we use OECD (2004 & 2008 datasets) and World Resources Institute (WRI 1998, extrapolated to 2008) data on municipal solid waste in 43 countries worldwide.

We then use US EPA statistics for the emissions associated with glass, plastic, metal and paper packaging when landfilled versus recycled.

We assumed that half of a students' waste is at home, half at school.

For recycling: 'always' assumes 100% of such waste is recycled, 'sometimes' 50% & 'never' 0%.

*********************** **Q49: Recycling at school** ***********************
For international data on plastic, glass, metal and paper waste, we use OECD (2004 & 2008 datasets) and World Resources Institute (WRI 1998, extrapolated to 2008) data on municipal solid waste in 43 countries worldwide.

We then use US EPA statistics for the emissions associated with glass, plastic, metal and paper packaging when landfilled versus recycled.

We assumed that half of a students' waste is at home, half at school.

For recycling: 'always' assumes 100% of such waste is recycled, 'sometimes' 50% & 'never' 0%.

*********************** **Q50: Reusing** ***********************
Recycling is wonderful, but we should remember the 3Rs: Reduce, Reuse, Recycle -- in that order! Reducing what you buy, reusing what you do buy (and buying things second hand) are the most environmentally sound choices - and they save money!

Once these reused items are no longer useful, THEN it's the time to recycle them!

For this question, if you answered that you reuse items 'whenever I can', we assume that you use it 3 times before recycling; if you answered 'sometimes,' we assume 1.5 times reuse on average, and 'never' assumes zero times reuse for each of the materials.

We do include a small correction for plastic water bottles, since we already asked about that in Q45 (above).