

# Assumptions Greenhouse Footprint Calculations for the Climate Positive



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## Introduction

The Climate Positive calculation tools and assumptions are reviewed and assessed on an annual basis. The 2008 review is underway during May 2008.

This greenhouse footprint calculation tool derives your footprint in metric tonnes of carbon-dioxide equivalents (t CO<sub>2</sub>-e). The methods and numbers used in these calculations are as accurate as possible and reasonable. This document will give a description of the assumptions the calculations are based on.

Completing the questionnaire in the calculation tool will give you a good estimate for your personal CO<sub>2</sub>-e emissions. This calculation tool is using Australian average numbers and habits if not otherwise specified. Where possible, numbers provided by the Australian Government through the Australian Greenhouse Office (AGO) have been used. The methodology for deriving t CO<sub>2</sub>-e is aligned with that proposed by the International Panel on Climate Change (IPCC). It has to be noted though that differences in everyday behaviour can result in great variations of people's personal emissions, which can only be captured by these calculations to some extent. Results of these calculations depend greatly on the information entered. In addition to that, science and methodologies around climate change are still being developed and refined. For these reasons it can be expected that different calculation tools will differ in their results. It also has to be kept in mind that the measure "t CO<sub>2</sub>-e" is already an estimate with some uncertainties in itself. We encourage people who disagree with some of the assumptions made in our calculator, because they have access to more precise or up to date information, to provide us with this information.

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## How accurate is the tool and what has been neglected?

Your footprint calculation will be most accurate if the consumptions of fuel types you are using in your household and while driving (such as electricity, natural gas, petrol, etc) are entered yearly and in kWh, MJ or litres, rather than monthly and in dollars (or for driving in km). In order to be able to enter your consumptions you will need to look up your bills for electricity, natural gas etc.

It must be noted that even though this questionnaire might reveal a surprisingly large amount of emissions resulting just from every day life, it does not consider every sort of emission that results from our western way of life. Emissions caused for example by the production of all sorts of consumer products (other than cars) and packaging materials have been neglected. Emissions resulting from services you use, such as cinema, pub, restaurant, public transport, street lights, and so on could also be added. What ever emissions are caused resulting from the work you do might also not be insignificant. Unfortunately, a lot of the industrial output of western countries which has created a big part of our current wealth has got massive greenhouse impacts too – this area is probably out of range of influence for most of us though. In this greenhouse footprint calculation, we have decided to focus on emissions resulting from your behaviour of direct energy use and eating. You have an influence to change this, and we hope that our calculation tool will give you guidance in determining if, where, and how to start.

The international (not Australian) emissions are treated differently in the calculator and form an exception to this, please see chapter on International Emissions.

## Resulting greenhouse gas emissions: separation into two types

The resulting emissions are separated into two types:

- Type 1: More certain emissions with a relatively small amount of uncertainty
- Type 2: Emissions which are to be seen as a rougher estimate only with a relatively large amount of uncertainty.

Type 2 emissions (to be seen as rough estimates only) are those resulting from:

- The manufacturing of a car
- Amplification due to release in high altitude while flying
- Food

This has been done to account for the fact that in some areas science hasn't been able to provide accurate estimates yet, or we haven't had access to accurate estimates. We will work on improving the assumptions and calculations as new or more accurate figures and methods become available.

## Transport

### Emissions from driving

The average yearly distance travelled for registered passenger vehicles, according to *Yearbook Australia 2005*, table 22.7 *BUSINESS AND PRIVATE VEHICLE USE — Year ended 31 October 2002*, is 14,700 km. This has been rounded to 15,000 km per year.

Average fuel consumption rates according to the *AGO Factors and Methods Workbook 2005*, Table 4 *Fuel consumption rates by vehicle type* are 10.7 L/100km (petrol cars), 13.9 L/100km (diesel cars), 16.3 L/100km (LPG cars). An average of 12 L/100km has been assumed for petrol and diesel cars. The rates for LPG cars are assumed to be 30% higher in general.

**Table 1 – Fuel consumption rates assumed for the car types**

<b>Car Type / Size</b>	<b>Fuel consumption rate (L/100km)</b>
<i>Motorbike</i>	4
<i>Hybrid</i>	6
<i>Small (4cyl)</i>	6
<i>Efficient (6cyl)</i>	9
<i>Aust ave (6cyl)</i>	12
<i>Large (8cyl+)</i>	15

Energy content and CO<sub>2</sub>-e emission factors of the driving fuels are taken from the *AGO Factors and Methods Workbook 2005*.

For biodiesel and biofuel, a 50% reduction in CO<sub>2</sub>-e emissions has been assumed.

Although these fuels are a source of renewable energy, some CO<sub>2</sub>-e emissions are still created while manufacturing and providing the fuel.

By judging the degree of aggressiveness of your driving habits, the average fuel consumption rates for your car are assumed to raise or decrease by up to 10%. This will have no effect if you have entered your fuel consumption rather than the yearly km travelled.

### Emissions from the manufacturing of your car

The making of an average car has been assumed to create about 7,200 kg CO<sub>2</sub>-e (or 7.2 tonnes) during material mining, material processing and assembling the car. This conservative estimate on the low end of the range has been derived from the following three sources:

1) WEISS ET AL 2000, in *Car Companies and Climate Change: Measuring the Carbon Intensity of Sales and Profits* (published through the World Resource Institute on their website EarthTrends). Result: 6% of life cycle emissions. Assuming a total of 240,000 km in a car's life, this approach will give 5.1 t CO<sub>2</sub>-e.

2) *EIO-LCA model*: Result for 20,000\$ (which is a conservatively estimated value of a new car): 14.5 t CO<sub>2</sub>-e. This homepage models the life-cycle of various products.

3) *Contribution of life cycle phases of a car to the overall GWP*. Result: roughly 14% of the overall global warming potential of a car is caused during its production. This result is more than double than the result from source 1.

This value of 7,200 kg CO<sub>2</sub>-e is distributed over the first ten years of the car's life, weighed in proportion to the average yearly value loss of the car. Because the biggest loss of value appears over the first year, the emissions from car manufacturing will be bigger the newer the car. If the car is older than ten years, no emissions from manufacturing are assumed any more.

Because the emissions for manufacturing of cars depend on many variables, and we haven't had access to any official figures, the resulting emissions are considered to be of the type 2 (see chapter "Resulting greenhouse gas emissions: separation into two types").

### Emissions from flying

The distances are measured as 'great circle distances'. This measure is the distance between two places on the surface of a globe. If possible, the flight altitude should be added to the radius. Most flight information data that is available from airlines or travel agents displays great circle distances. Distances between typical Australian destinations were taken from the Excel spreadsheet *Australian air distances*. Averages have been formed out of this.

Average emissions for Australian domestic air travel (*NGGI 2002*): 158 g CO<sub>2</sub>-e per passenger-km. For international flights this value is lower due to the fact that bigger planes are used that carry more passengers, and the impact of landing and take-off is less compared to the entire trip length. To reflect this, the per-passenger-km emissions for international flights are assumed to be 40% lower.

On average, an Australian travels 2,219 km domestic air kilometres per year. This average has been derived by dividing the total revenue passenger km of all regional and domestic flights of the period July 2004 to June 2005 (as available through the BTRE) by 20,300,000 citizens.

An amplification factor for emissions from flying of 2.5 is applied because emissions in high altitude have a greater global warming impact than on the ground. This factor for high altitude emissions varies roughly between 2.5 and 8, depending on the source. Because the emissions calculated here also include emissions from taxing, landing, takeoff, and climbing (which release emissions close to the earth's surface), a lower factor than in many other sources has been chosen. The factor used here is still a conservative estimate on the low end of the scale. The science behind high altitude emissions is very complex and some research will still have to be done until the amplification effect is known with greater certainty.

Because the underlying science of amplification of emissions in high altitude is still being developed, and we haven't had access to any official figures, the amplified high altitude emissions are considered as being of the type 2 (see chapter "Resulting greenhouse gas emissions: separation into two types").

## Emissions from meat and dairy consumption

How does farming and meat production create greenhouse gas emissions?

Farming creates greenhouse gas emissions in different ways. A relatively small part is caused by use of various farming machines burning fossil fuels. A large part of the emissions is actually caused by ruminant animals' digestion (grazing animals such as cattle, buffalo, sheep) which releases methane as a by-product (so called "enteric fermentation"). The National Greenhouse Gas Inventory 2002 (*NGGI 2002*) estimated that over half of the total anthropogenic methane emissions were directly attributable to livestock. The Inventory estimated that more than 95% of livestock methane emissions are produced from enteric fermentation, of which less than 1% is attributable to non-ruminant animals, such as pigs, poultry and horses.

Climate gases (mainly methane and nitrous oxide) are also released from the manure. This happens especially where animal excrements are concentrated being moist or liquid, which allows anaerobic microsites to occur. Examples for situations where climate gases are likely to be released from manure are poultry housed indoors, and pig excrements channelled into lagoons - to name only a few. Range-kept animals are considered to have no greenhouse gas emissions from their manure. Some nitrous oxide is also released when animal waste is applied to agricultural soils.

As you go down the food chain, it is generally accepted that only roughly 10% of the initial energy will make its way to the next level (referred to later in this document as the "10% rule"). From 100% food-energy in a certain amount of plant product (such as grains or vegetables), you will therefore consume less than 10% of this energy when feeding it to animals and eating the animals' meat.

The numbers used for meat consumption reflect the difference between a meat-based diet and a vegan diet. The remaining agricultural emissions from non-livestock farming are neglected here. These remaining emissions will practically not increase when, with less meat consumption, your intake of other food increases. The reasons for this are: crops previously planted as feedstock for non-grazing animals will simply be replaced by human food crops, and some of the grazing land can also be converted into crop growing land. This will actually easily more than compensate the loss of human food nutrients, keeping in mind the 10% rule mentioned above.

How have emission factors been calculated?

First it has to be emphasised that the factors used in this section are approximations only with a great amount of uncertainty. Please also refer to the chapter "Uncertainty of agricultural greenhouse gas emissions" for further details. However, to obtain the approximate factors used here, the yearly CO<sub>2</sub>-e emissions from the different types of Australian meat farming (as provided by the *NGGI 2004*) have been divided by the produced kg of these meat-types (as per *Yearbook Australia 2005*, for the financial year 2003/2004). The carcass weight was used as the figure for meat production, except for poultry where the dressed weight was used. Emissions resulting from land use change such as land clearing have been neglected.

*Note: Including the emissions from land use change would probably mean a considerable increase of CO<sub>2</sub>-e per kg food. It has been decided to leave them out though as it is difficult and controversial to determine to what extent land would have to be cleared too, in case our diet was more based on grains and vegetables than on meat. Much less land would have to be cleared under a vegetable-and-grain scenario (see the 10% rule, page 6), but some land that can be used for livestock farming could not serve as land for crops.*

The Australian Greenhouse Gas Inventory does not reveal figures about fish. However a study conducted by the University of Chicago in April 2006 (*vegan diets healthier for planet, people than meat diets*) found the following: “Fish can be from one extreme to the other (...): sardines and anchovies flourish near coastal areas and can be harvested with minimal energy expenditure. But swordfish and other large predatory species required energy-intensive long-distance voyages.” The study resumes that a fish diet has an equivalent effect as a red meat diet, both of which have the biggest global warming impact of all possible diets.

For this reason fish has been assumed to have a slightly lower global warming impact than beef, which is still much smaller than the impact of lamb (see Table 3).

The average Australian meat-based diet turns out to have a slightly higher greenhouse impact than that calculated for North America by the University of Chicago. This may have several reasons, as there being variations in diet between the two regions. Also, Australian grazing animals in general are likely to feed on grass with a lower digestibility because of the aridity, which leads to more methane emissions per kg meat.

## Uncertainty of agricultural greenhouse gas emissions

As mentioned before, unfortunately there is a great amount of uncertainty in the emissions from agriculture. In the introduction it was mentioned that greenhouse gas emissions must always be seen as an estimate. However, emissions that are calculated from the burning of fuel are much more robust than the emissions calculated for agriculture. The *NGGI* which is being produced yearly by the Australian Government (through the Australian Greenhouse Office) includes emissions for different types of life stock. The *NGGI* is the official inventory of Australia’s greenhouse gas emissions, but for some sectors has to be regarded as a rough first cut only. The inventory is produced to meet Australia’s commitment to reporting its net greenhouse gas emissions under the United Nations Framework Convention on Climate Change (UNFCCC) and its internationally agreed target of limiting emissions to 108% of 1990 levels over the period 2008–2012.

The emissions resulting from your diet are a first cut and Climate Positive encourages you to include them when determining the amount you want to offset. The agricultural emissions provided by the *NGGI*, and thus the assumptions made by Climate Positive for food emissions, are likely to be up to two times too high or low. For example, emissions for one kg of a certain type of meat may be out by 100%. This is especially the case for different local conditions.

The method of dividing emissions for the different agricultural live stock sectors for 2004 by the amount of meat produced in the financial year 2003/2004 obviously also

incorporates errors. To get a more accurate assumption for the emissions per kg of meat produced, this should also be done for the previous years. The older *NGGI*'s don't specify the emissions for the agricultural sub-sectors though. As time goes on, each year's emission factors will be calculated again to develop a more accurate average.

The emission factors for the different types of food should therefore be seen as rough general guidance only. As the methods for estimating our emissions are being refined in the future, ClimatePositive will update the figures. For this reason it has been decided to treat the emissions from food (together with emissions from the manufacturing of a car, and the flying emissions resulting from amplification due to high altitude) separately to emissions from direct energy use.

### Emission factors and average consumptions of meat in Australia

*Note: The emissions per type of food displayed here are very rough estimates, to be seen as a first cut only, see chapter "Uncertainty of agricultural greenhouse gas emissions".*

**Table 2 – Generic emission factor for meat**

average CO <sub>2</sub> -e emissions per kg of meat (excluding fossil fuel burning)	17.3 kg
Assumed additional emissions for burning of fossil fuel in farming machines and transport directly related to meat production	3%
average CO <sub>2</sub> -e emissions per kg of meat (including assumption for fossil fuel burning)	17.8 kg CO <sub>2</sub>

**Table 3 – Emission factors for different types of meat**

Emissions	Type of meat
23.1 kg CO <sub>2</sub> /kg meat	Beef
17.8 kg CO <sub>2</sub> /kg meat	Fish
51.6 kg CO <sub>2</sub> /kg meat	Lamb
3.6 kg CO <sub>2</sub> /kg meat	Pork
1.8 kg CO <sub>2</sub> /kg meat	Poultry
1.8 kg CO <sub>2</sub> /kg meat	native animals

The next table shows how the figures have been derived. The meat production values have been taken from *Yearbook Australia 2005*, and the CO<sub>2</sub>-e emissions for the different sectors have been taken from *NGGI*.

**Table 4 – Deriving emissions for the different meat types**

Agricultural sector	Meat production 02/03 (1,000 t)	Meat production 03/04 (1,000 t)	emissions 2003 (t CO2-e) (NGGI)	emissions 2004 (t CO2-e) (NGGI)	kg CO2 / kg meat 2003	kg CO2 / kg meat 2004	emissions compared to average	yearly consumptions per person (Australia, 03/04)	CO2-e yearly per person (2004)
Beef (non-dairy cattle)	2,035	1,998	41,195,648	44,668,234	20.2 kg	22.4 kg	130%	36.0 kg	831.9 kg CO2
Fish	n.a.	n.a.	n.a.	n.a.	17.8 kg <sup>2</sup>	17.8 kg <sup>2</sup>	100%	6.0 kg	106.7 kg CO2
Lamb	329	341	17,000,000	17,089,478	51.7 kg	50.1 kg	290%	14.0 kg	721.7 kg CO2
Pork	420	406	below contained in	1,541,032	n.a.	3.8 kg	20%	22.0 kg	78.2 kg CO2
Poultry native animals	726	721	below contained in	848,662	n.a.	1.2 kg	10%	36.0 kg	64.0 kg CO2
other livestock <sup>1</sup>	n.a.	n.a.	n.a.	n.a.	1.8 kg <sup>3</sup>	1.8 kg <sup>3</sup>	10%	0.0 kg	0.0 kg CO2
TOTALS	255		2,082,000						1,802.5 kg CO2
	3,765	3,466	60,277,648	64,147,407	16.0 kg	18.5 kg		114.0 kg	

Key: 1) For "Meat production 02/03 (1,000 t)" this shows 'veal and mutton', for "emissions 2003 (t CO2-e) (NGGI)" this shows 'non beef and lamb livestock.

2) Emissions per kg of fish have been estimated, see also chapter "How have emission factors been calculated?"

3) Emissions per kg of native animal have been estimated, on the basis of 10% of the average emissions per kg meat in Australia

## Emissions and average consumptions of dairy in Australia

The yearly emissions from dairy consumption per person have been estimated by assuming that 53% of milk from Australian production goes into export, thus 47% of the emissions from dairy cattle (as specified by *NGGI*) are considered to be released due to Australian dairy consumption. 56% of dairy value is exported (*Yearbook Australia*), but exported goods are assumed to have some added value. The book states: “In 2000-01 over 50% of the annual milk production was exported, mainly in the form of milk powder and cheese.” This makes 226 kg CO<sub>2</sub>-e per person and year.

You now might ask what happened if you didn't eat meat, but much more dairy instead. Australians currently consume about 100 l of milk, 12 kg of cheese and 4.5 kg of yoghurt per person and year, which as described above creates roughly 226 kg CO<sub>2</sub>-e. If you stopped eating meat but ate three times more dairy products and thus tripled your emissions from dairy products, you would create 678 kg of CO<sub>2</sub>-e emissions instead of 1,803 kg. This still means a reduction of 62% compared to the normal meat diet. Please also refer to chapter “How does farming and meat production create greenhouse gas emissions?” which discusses a scenario where less meat but more plant products are consumed.

## **Household emissions**

### Household emissions through energy bills

Your household emissions are derived from your energy bills. Aligned with Australian Greenhouse Office methodology, different emission factors depending on the Australian State are used for natural gas and electricity. Using 100% Greenpower will reduce your electricity emissions down to zero.

If possible enter yearly consumptions in energy units (such as kWh, MJ, litres) rather than the monthly or quarterly costs. Like this the result will be more accurate since the different energy needs in different seasons won't affect your yearly CO<sub>2</sub>-total.

## **Climate Report Card and Reduction Options**

This section displays a list of the most effective steps you can take to reduce your greenhouse footprint. Depending on your answers, different options will be suggested. The options that will generate most savings are displayed at the top.

At first, three reduction options will be shown for each of the three sections travel, household, and diet.

## **International emissions**

The international per capita emissions are averages according to WRI (World Resources Institute) and IEA (International Energy Agency) data. For non-Australian users of the calculator this means that greenhouse gas emissions from all sectors are considered, rather than just the residential, travel, and diet emissions.

In a few cases, these per capita emissions may differ quite significantly from those reported by individual countries or by the UNFCCC (United Nations Framework Convention on Climate Change). This is because the IPCC (International Panel on Climate Change) allows for different approaches when calculating the emissions, and individual countries may have chosen to use specific values for certain types of activities rather than averages.

## **Abbreviations**

LCA	Life cycle assessment
GWP	Global warming potential (usually expressed in t CO <sub>2</sub> -e)
CO <sub>2</sub>	Carbon dioxide, chemical formula
CO <sub>2</sub> -e	Carbon dioxide equivalent
t CO <sub>2</sub> -e	metric tonne of carbon dioxide equivalent
AGO	Australian Greenhouse Office

## **Terms**

Fuel type	The form in which energy is provided, such as petrol, diesel, natural gas and also electricity
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