Climate calculator - duckumentation

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1 Introducktion

1.1 Our Aim

The main aim of the Ducky calculator is to enable you to understand the impact that a more sustainable lifestyle can make on your climate footprint. We use a **consumption-based accounting** approach to track the global impact of carbon emissions and help you track your activities over time. Our goal is to visibly demonstrate the reduction in climate emissions that sustainable behaviour generates.

We update our calculations both when you make lifestyle adjustments, and when industries switch to more sustainable options. This means you're able to get up-to-date calculations when you adopt new habits, as well as check the impact of a change you're thinking about making.

What is Consumption Based Accounting?

Many approaches to tackling carbon footprint employ a **production-based approach**, which only calculates carbon footprint based on products manufactured inside a country's borders. While this may seem practical, it means that an individual's actions are often dwarfed by local industry, and can make a more sustainable lifestyle seem ineffective.

At Ducky we advocate a **consumption-based accounting** view of carbon emissions, where all global emissions can be allocated to individual consumption of products and services. This is opposed to production-based accounting, where the producer is penalized for their direct emissions. It's an approach that places power back into your hands.

1.2 Functionality

The Ducky calculator works in such a way that after entering the most basic household data, all other data are estimated based on the average values for a Norwegian household. This means that for an average household, the climate calculator can give you a reasonable indication of your climate footprint with little input (though naturally the result will always improve as more input is given).

This means you can immediately calculate how much a change in your lifestyle will reduce your climate footprint, and can make plans for a more sustainable future.

1.3 Personal vs. household footprint

The Ducky calculator estimates personal climate footprint. But wait, didn't we *just* say we use household data? This is true, but because we want to show the effect of an individual's actions, we divide emissions related to the entire household (like heating) between you and the rest of your household. All other emissions are based on your personal habits, which you can enter into the calculator.

We're working on integrating household footprint into the calculator, but in the meantime there are a couple of ways to get your entire household's footprint. Each member of the household can take the test, or you can get your own precise footprint and then take average values for the rest of your household.

1.4 API sharing

The Ducky calculator is easily accessible via API to integrate in your website. We can easily adapt the calculator for the desired input and deliver the results for either personal or household footprints. Check out our ***API landing page*** for more information.

1.5 Calculator accuracy

We're always updating our calculator based on new research and changes in industrial and government policy. This means that the numbers generated are the most accurate based on the research available today. However there are of course large variations in climate emissions within any population. You might undertake a sustainable activity that we simply haven't accounted for, or a major supermarket might have recently changed to a more ethical supplier.

Furthermore, there's always a chance that two reports on the exact same topic may come up with different results. There's always a bit of error in any research, so what the Ducky calculator provides is really the most likely footprint given your input.

Lastly, calculations are made based on average data for Norwegian households. If you're based outside of Norway you can still use the calculator, however there are likely to be some local factors which may affect its accuracy.

1.6 How to contribute?

We’re constantly improving the calculator. To make this happen, we ‘re always on the lookout for more partners and collaborators. If you have feedback or ideas, get in touch by:

- **Sending us feedback** if you see some possibilities for improvements.

- **Sending us suggestions** for updated research or data that could improve the calculator.

- **Sending us ideas** for joint projects that could improve our calculator or study user behavior.

- And lastly, **sending us your CV**! If you are passionate about our calculator and want to make it your job to improve it, let us know! We’re a growing company and are always looking for new minds to help us move forward.

2 Meet the Calculator

Before we go any further, let's make a quick disclaimer. We have strived to make the Ducky calculator as transparent as possible. We're trying to help you live a more sustainable life, so you need to know that you can trust our numbers. The remainder of this document presents an overview of how our calculations are made, and what sources we have used.

Still, the calculations made are sometimes quite complex, and it is challenging to describe it all in detail. If you're really keen on diving into the nitty-gritty of our calculator, get in touch and we'll happily guide you through it.

2.1 Why CO_2-equivalents?

At the moment the Ducky calculator divides your personal climate emissions into five categories, listed in section 3. Each of these categories use different calculation methods and calculate different values, but ultimately they are all converted to **CO_2-equivalents**. This converts all the greenhouse gases involved in your emissions to the amount of carbon dioxide (CO_2) which would have the same effect on the climate over a 100-year time period. This is the most common unit to measure climate change impact, as used by the Intergovernmental Panel on Climate Change.

When you save CO_2-equivalents, you also reduce your impact on land use, which in turn improves ecosystem functioning and increases biodiversity. These are not represented numerically in the calculator, however you can read about some of the ways that ecosystems benefit from more sustainable actions ***at these links***.

2.2 Calculation methodology

Calculations for household consumption are based on macro-economic input-output data, which report emissions per NOK spent on a service or a product. These emissions are calculated on a national level, and we estimate them at a household level using the amount which your household spends on this service or product.

This method of calculating consumption (adjusting national data down to a household level) is a **top-down approach**. For the remaining categories, we apply a **bottom-up approach**, which means that we calculate all contributions with specific calculations on a per-product level. A relevant example is all the emissions that occur in the production and distribution of 1 kg of beef, or all emissions associated with driving 1 km with a car. We take these values and work upwards, multiplying them by the total amount of beef eaten in a month, or kilometres driven in a week.

Top-down calculations	Bottom-up calculations
Gives an overview of greenhouse gas emissions based on socio-economic data like income and household type. The data are connected to the survey of consumer expenditure (Statistics Norway), and are compared to global emission models.	Calculates emissions to climate change based on specific activities like transport, food and energy consumption, which are then summed.

3 Category calculations

The Ducky calculator divides carbon emissions up into five different categories: food, energy, consumption, transport, and public consumption. Each of these use a different metric to calculate emissions energy use, which is then converted to carbon emissions.

3.1 Food

Our food calculator uses the amount of calories consumed by a person to calculate their carbon emissions. The calculator works with the average daily consumption by Norwegians (around 2700 calories), but if you eat a little more or less than average it's easy to adjust your values.

There are two important steps to this category.

1. **Calculating how much of each food group is consumed**

We've used ***Aurelie Stamm's study on the average carbon footprint*** of a Norwegian diet to estimate the amount of each food group that makes up a person's diet. This can of course be adjusted, for instance if you're a vegetarian, we take the calories that would usually be allocated to consumption of meat products and place them in other categories, like vegetables, beans and dairy products.

2. **Calculating how many carbon emissions each group generates**

Once we've figured out the carbon emissions generated per calorie of food (again using Aurelie Stamm's work), we can calculate the average carbon emissions generated by a person's diet. It's a pretty extensive set of figures, but you can see a summarised version of the values ***at this link***.

We use six main food categories: grains, fruit & vegetables, meat, fish, eggs & dairy and beverages. This in turn are then broken up into a range of different subcategories. Let's have a look at some of the categories in more detail.

Meat

As you might already know, meat consumption has the highest impact per calorie of all the food groups. On average, meat production emits three times as much CO_2 emissions per calorie than the production of the average vegetable. This is partially just because meat and other animal-based products are higher up in the food chain, meaning that area that could be spent growing plants is instead spent growing food for animals. As a rule of thumb, it takes about 10 kg of plant-based food inputs to create 1 kg of meat.

Additionally, ruminant animals like cows and sheep have digestive systems that produce methane as they break down grass, which they fart and burp out. Methane is a powerful greenhouse gas, although it disappears more quickly from the atmosphere than CO2. It is counted in the overall footprint in CO2 equivalents, where it's given a factor reflecting both its greenhouse effect and lifetime.

Note that the environmental impact will vary based on what kind of meat you consume, although an average value for meat is chosen in the calculations.

Dairy products

Since dairy products are associated with animal husbandry, they are also associated with high environmental impacts for the reasons described above. Specifically, milk, yoghurt and cheese have high emissions per calorie content, comparable to the average emissions of plant-based products. If you're a vegan (or lactose intolerant), you can also input this, and the calculator will attribute those calories to other categories.

Food waste

Food waste represents an efficiency loss, and thus is associated with an environmental impact. If we reduce food waste at the consumption stage, this food will not have to be produced, and thus we get an emission reduction. ***Hamilton et al.*** found that the average Norwegian wastes 10% of the food they buy. If you make an effort on a regular basis to minimize food waste, you can of course input this and it will be reflected in your carbon emissions.

3.2 Energy

Energy sources

To calculate emissions from energy use in a household, we use average emissions from European electricity production. For the electricity consumed in the households, a factor of 439 gCO_2 eq/kWh is currently used. This is the average value including both direct and indirect emissions contributions for ***Europe in 2019***.

Hang on. Isn't my electricity renewable?

The majority of Norwegian electricity is produced by hydropower, which is a renewable energy source. However, Norway is connected to the Nordic electricity grid, and we transmit electricity to other Nordic countries, which in turn trade with other European countries. These countries' electricity production is not based solely on renewables, instead largely on fossil fuels like coal and gas power plants as well as nuclear energy. So when you use less electricity, more renewable electricity is transferred to these countries, and you enable other users to switch over to more renewable sources, thus lowering your overall footprint!

Heating Your Home

The basis for calculating the amount of energy you use to heat your household is the size of your house average. Using ***Statistics Norway's energy consumption per m***^{2} for different dwelling types, we calculate an estimate of your household's energy use.

This does vary of course, based on the type of house you live in, the number of people living there, and the year the house was built and last renovated. A rekkehus built in 2012 with two people living inside it is likely to use much less energy than a family of six living in a large standalone house built in 1917.

Statistics Norway gives energy use per area for different house types and number of persons in the household. This is used to adjust the total energy use for the household with the number of people living in the household. Additionally, ***Sandberg et al. (2016)*** give energy use per dwelling type, renovation standard and construction year. So the more information you give about your house, the more accurate the estimate becomes.

Heating your water follows a similar set of rules. The average Norwegian household uses 2659 kWh per year to heat their water[1]. This will of course vary based on the number of people in a household, and this number is also adjusted based on your

[1] Average water use is given as 9,5 liters per minute and it takes 0,041 kWh of energy to heat one liter of water from 10-38 °C. With a water use length of 8,5 minutes per day for 2,2 persons, this gives an average energy consumption of 2659 kWh per year, which coincides with the statistical yearly use.

shower and other hot water use habits. The real kicker for most calculations though, is the simple question: *where is your heating coming from?*

Heating Sources

Norwegians, more than many other European countries, get their heating from a range of different sources, including gas, electricity, wood fires, heat pumps and heat from waste incineration. At Ducky we use a national average heating mix to estimate the energy cost of heating, which can be found on www.fjernkontrollen.no.

We also consider emissions of biogenic CO_2, which is carbon produced from burning material which is part of the natural carbon cycle (ie. NOT fossil fuels). While burning trees that have absorbed carbon over their lifetime does remain within that carbon cycle, it still increases CO2 concentrations in the atmosphere and therefore contributes to global warming in the short term, so those emissions do have to be taken into consideration. Based on a ***Norwegian study on the efficiency of burning spruce***, we consider that that using biogenic fuel only emits 60% as much carbon as fossil fuel use, so regions which use more biogenic energy will have a lower climate footprint[2].

But I heat my home by burning wood!

You can also calculate the emissions produced by burning wood to heat your home. It is worth noting that on top of the direct emissions from wood combustions, we also include felling, cutting and transportation of logs as an environmental impact. The factor we used is from a paper by ***Arvesen et al***.

I also have heat pumps.

Using heat pumps also reduces your emissions, because you reduce the amount of electricity needed to heat your home. We use estimates from ***Enova*** to calculate the yearly energy savings that can be achieved using different types of heat pumps. Depending on which type of heat pump you're using, you can reduce the amount of energy it takes to heat your house by between 35% and 60%, and to heat your water by between 60% and 85%.

Lighting and Electronics

The energy used for lighting and electronic appliances also makes up a large chunk of this category. According to ***Statistics Norway***, the average energy use for lighting

[2] Note, however, that emission factors for biogenic CO2 emissions can vary significantly based on factors such as crop rotation time, albedo effects, utilization of logging residues for bioenergy, and whether the wood or biomass is used for bioenergy or other short-lived products or for e.g. construction purposes.

in Norwegian homes is 1000 kWh per year. If you turn off unnecessary lights or use LED lights in your home, this value goes down.

Energy consumption for electronics will vary but an average value of 2850 kWh per year is given. Dishwashers and tumble dryers use large amounts of energy, so if you use a clothes horse or use less dishes than average, you can input this information into the calculations.

3.3 Consumption

Our consumption section calculates the climate emissions produced by goods and services unrelated to food, energy and transport. We calculate the average household's consumption based on the household's income, the idea being that the more you earn, the more income you have available to spend on goods and services. Again, this number changes based on the composition of your household. For instance, if there are three children in your household, the money it takes to feed them will mean that less money is allocated to consumption.

We use Statistics Norway's ***Survey of Consumer Expenditure*** to determine the average proportion that a household spends in 46 different consumption categories. These categories include everything from hospital expenses to sporting equipment, and like the total consumption footprint, these vary based on the composition of your household. If you have no kids, you're unlikely to spend money on primary school fees, so that gets allocated elsewhere.

These amounts are calibrated with household income, and average amounts for money spent on energy, transport and food are removed as these categories are considered from a **bottom-up perspective**. Tax has been removed from the income based on general tax tables, as emissions from tax money are covered by the public emissions. Any donations you make during the year are also removed from your consumption footprint. It's true that those donations might be used for emissions-intensive activities elsewhere, however those emissions are allocated to the organisation or individual you're donating to.

We make the assumption that all money you earn is spent in some way. You might put a lot into savings, but our calculator assumes that money will still be spent somewhere down the line on housing, tuition fees, or a different long-term savings goal. We're currently working on improving our model for calculating the footprint of long term investments like housing.

Input-Out Calculations

We mentioned earlier in this document that household consumption is calculated using a top-down approach, as opposed to the bottom-up approach which is used for food, energy and transport. The top-down approach we use is better known as an **Input-Output modelling.** You can read more details about how these calculations are made in ***Steen-Olsen et al. (2016)***.

This approach doesn't add up all your spending and decide what your climate emissions are based on the combined emissions of that spending. Instead it takes the total emissions associated with all activity in the Norwegian economy, and then decides what your share of those emissions is based on your income. For example, in

Norway the average emissions for clothing are 44g CO2e per NOK spent, so your emissions for clothing are multiplied by the amount your household would normally spend on clothing.

On top of these consumption calculations, there are several personal habits which can affect the footprint of your consumer.

Quality- and repair consumer The main assumption here is that by repairing a product or purchasing a more durable product, you replace the need to buy a similar product in a relevant time frame. As an example, if you use an object 20% longer than its expected lifetime, you save climate change emissions equal to 20% of production emissions of that object.	**Ethical consumer** For this habit it is estimated both that the user not only spends more money on ethical consumption, but also on more ethical forms of transport, food and energy. As such, emissions are reduced, as more money is spent on fewer products and services.
Service consumer If more money is spent on services, such as renting a movie online or using a subscription service as opposed to buying DVDs, the emissions related to manufacturing of goods decreases, and overall consumption emissions decrease. Likewise, using a repair service for a pair of jeans produces significantly less emissions than repairing an old pair.	**Recycling** Emission reductions for paper and plastic are compared to waste incineration, by comparing current recycling rates with an optimal recycling rate which is deemed realistic we see the potential emission reduction from increasing our recycling. Especially plastic, paper and metal have a potential for increased recycling rates[3].

[3] Emission savings from recycling are based on the average waste and recycling rate of Norwegian households for paper, glass, plastic and metal waste. The amount of waste per household is taken from statistics Norway, while the current recycling rates are taken from syklus.no and grontpunkt.no. CO_2e reductions per kg recycled for the different materials is taken from loop.no.

3.4 Transport

At its core, our calculations for transport are pretty simple. The unit we convert to carbon equivalents for travel are kilometres, so it's simply a calculation of how far you travel with which forms of transport, and then calculating your footprint based on each of their emissions. Types of travel are divided into three broad categories (listed below), with most of our average values coming from the ***2013 Norway Travel Survey***.

Throughout the three categories, we do make several assumptions. For instance if you live in a two-car household, we assume you drive to work more often. The good news is that you can adjust our assumed values by giving more precise data.

There are a few potential sources of error here. We assume that cars are bought and used for an average lifetime, and incorporate the costs of car production into our calculations. If you have a collection of American muscle cars that you never use, or only have one car but sell it and buy a new one every year, our figures may be a little low. Our factors for the emissions of owning and driving a car are largely based on ***this EU report***.

Work

The first category is work. We assume that five days a week you engage in some form of travel to a workplace, though this can of course be adjusted if you walk, bike or ski to your workplace. And yes, if you work from home, throwing on slippers and stumbling to your laptop counts as walking to work.

If you use public transport or drive (or a combination of all three) to work, then we start to take into account the distance to your workplace. The Norwegian average is 10km, but you can of course adjust this.

Public transport forms and availabilities vary from place to place, so we've split the difference between train and bus for the kilometres travelled by public transport to work.

Carpooling is a system that is starting to become more and more common, so we've incorporated this into the calculator as well, splitting emissions from carpool travel between the driver and the passengers.

Short journeys (weekly)

This category takes into account travel unrelated to work that you might engage in on a weekly basis. You might be taking the bus to the shops, driving to drop kids off at school, or carpooling to a friend's house out of town. You can input a rough

estimate of how far you usually travel on a weekly basis with different forms of transport, or go with Norwegian averages.

It's worth noting that for the above two categories, if you own more than one car, the calculator makes an assumption that the car is used more often, so if you have one car that you barely ever use, you'll want to make sure you manually adjust the kilometres you drive.

Long journeys (yearly)

Long journeys account for the emissions of more sporadic travel, like holidays or other long-distance journeys. These can take the form of long-distance car, train, bus or plane travel.

This section can have quite an impact on the overall calculation if you're a frequent traveller, so we advise giving as much information as possible. We use different length categories based on the form of travel. For example, you can choose the number of flights you take within Scandinavia, within Europe, or to other continents. For car trips, we generally assume you're not going to drive to another continent, so we instead use trips to your surrounding region, to further away in the country, or to other countries entirely.

The carbon intensity of travel can often vary based on its length, which is why we've categorised trips in this way. For instance, the most carbon intense part of a flight is often the take-off and landing, which means that while a longer flight will release more emissions than a shorter flight, it will release fewer emissions per kilometre travelled. So for a 12 hour intercontinental flight, we'll calculate your emissions using · 105,6 g CO_2 per km, whereas we'd use 158g CO per person for a domestic flight.

Our carbon intensity factors for flying come ***DEFRA's factors for direct emissions***, combining with a height factor describing the increase radiative forcing at altitude, and an indirect factor the accounts for emission associated with producing airplane fuel.

I travel frequently to London for work. Does that count?

Actually, in our calculations it doesn't. While we always recommend finding more sustainable travel means where possible, we still attribute work-mandated travel to a company's footprint, not the individual's.

What if I use Nabobil a lot?

For cars that are primarily used for carsharing, we make the assumption that there are 10 users per car, and that the car production and maintenance make up 16% of

the car’s emissions. So if you use a shared car you’ll be allocated the kilometres you drive, as well as 1.6% of that car’s production and maintenance costs.

3.5 Public Emissions

Calculations of emissions from the public sector are based on economic data (similar to the calculations of household consumption emissions). These include the emissions produced by road construction, hospital upkeep and other publically available services provided through our taxes.

The yearly spending in the public sector is documented in KOSTRA (Local Governments-State- Reporting). This way, all direct and indirect emissions are accounted for. Currently, these emissions are equally divided to all inhabitants in Norway as we all benefit from our public sector. The emissions are divided into municipalities, counties, and national levels.

There is a possibility to expand emission data to reflect the climate footprint of your local municipality based on where you live.

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