

Annual Carbon Footprint of an Average Swiss Resident and of his/her Key Actions

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The scientific consensus is unequivocal: Global warming is mainly caused by greenhouse gas emissions from anthropological activities. This leads to changes in the climate system yielding many effects, such as the loss of biodiversity, more severe droughts, and more powerful storms. Consequently, human, environmental and financial costs are drastically increasing [1]. To quantify the impact of an action on the climate, the carbon footprint unit (expressed in kg CO₂-equivalent) is commonly used by life-cycle analysts.

Even though Switzerland's climate strategy aims at reaching carbon neutrality by 2050 [2], the country is already witnessing the effects of climate change. While Swiss residents are sensitive to this issue [3], it is unclear whether they have the knowledge to understand their carbon footprint and the appropriate tools to limit their emissions. The carbon footprint of people is influenced by their actions and is closely related to their lifestyle: The top 1% richest persons in the world emit approximately 50% of all carbon emissions [4]. Our project aims to provide knowledge and to identify useful actionable levers for citizens in order to help them reduce their carbon footprint. Working towards this goal, we asked ourselves: **What are the main actions and sectors of living that influence the yearly carbon footprint of a Swiss resident?**

The carbon footprint of Swiss residents

We start by modeling the yearly carbon footprint of an average Swiss resident using a life cycle analysis (LCA) methodology. We collect and compile data from various sources, using official datasets from the Swiss Confederation as often as possible. To understand in details the *net carbon emissions* of consumers, we focus on the final demand of a Swiss resident. Hence, we take into account the imported emissions (also known as grey emissions) as well as the emissions linked to the country's production without the emissions of the exports (resulting in an abroad final demand). This methodology, schematized in Figure 1, will be used to estimate the carbon footprint of an average Swiss resident.

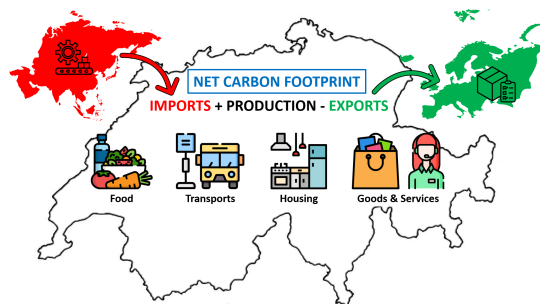


Figure 1: Methodology of calculation of the net carbon footprint of a Swiss resident.

Following approaches from previous research [5] on the subject, we decompose the carbon footprint of a Swiss resident into four *sectors*: **Food, transport, housing, goods & services**. We choose these four sectors because they capture well most aspects of the life of residents (and the reader!). Each of these four sectors is divided into

categories, and the categories are further subdivided, when relevant, into *subcategories*. For example, "beef meat" is a subcategory of the category "animal foodstuffs" belonging to the "food" sector. Hence, we obtain three different levels of decomposition, offering a detailed overview of each sector contributing to the annual carbon footprint of a Swiss resident. We show this decomposition in Figure 2.

Our key result is that the **carbon footprint of an average Swiss resident is 11.6 tonnes of CO₂-eq. per year**. The goods & services sector and the transport sector (almost exclusively from aviation and cars) contribute each to 30% of the total emissions. The goods & services sector contains categories whose emissions are difficult to reduce, such as in health. On the contrary, some categories can be reduced by a change in lifestyle, such as in clothing and with the internet consumption. Notably, heating houses produces alone 12.5% of the carbon footprint of a Swiss resident.

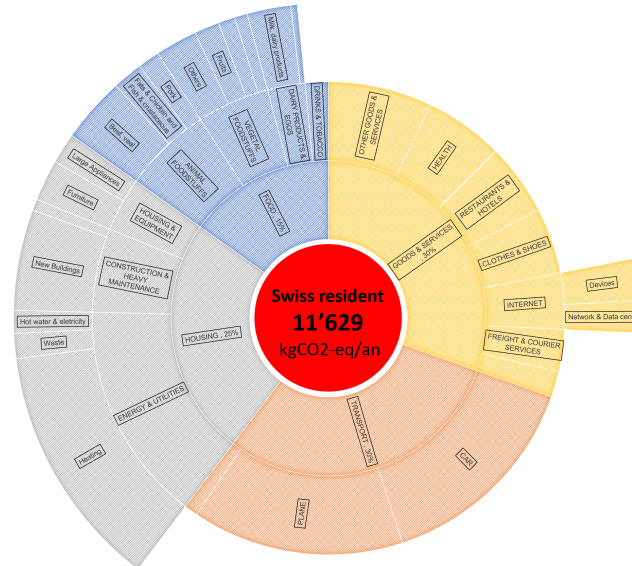


Figure 2: Annual average carbon footprint of a Swiss resident.

Evaluation and validation of our results

To validate our results, we compare our methodology and results with the methodology and data obtained by a study conducted at the Swiss Federal Institute of Technology in Zurich (ETHZ) in 2018 [6], in which the authors computed the carbon footprint as a function of the socio-economic class of the Swiss residents. To compare our results with theirs, we first normalize their computations to obtain an annual value for an average Swiss resident. We obtain then that our calculation for the annual carbon footprint is 2.6 [tons of CO₂-eq/pers.year] higher than that obtained by the ETHZ study (total of 9.01 [tons of CO₂-eq/pers.year]). One key difference is that the ETHZ study doesn't take into account the carbon footprint of services (representing 2.5 [tons of CO₂-eq/pers.year]), and the data used for the transport category are more recent for our study, leading to a higher impact of aviation. Another difference lies in the data acquisition, treatment, and conversion to carbon footprint from both studies, as the ETHZ study mainly used monetary data while we use data in various units. After correcting these differences, we were able to compute an annual carbon footprint that is very close to ours. All in all, this comparison helped us to confirm our main results, as well as our methodology.

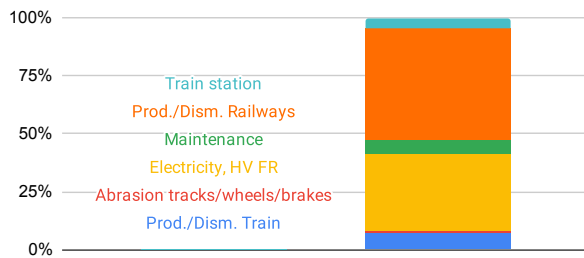
Does flying emit more than lighting your house?

This semester project finds its root in an interdisciplinary project, called Climpact [7], in collaboration with computer scientists from EPFL. The team of machine-learning researchers is interested in surveying people to understand their **perception** of their carbon footprint. They developed a statistical model and a machine-learning algorithm to compute the perception of people from *pairwise comparisons*: Instead of asking people "how much does flying emit?", a difficult question for the non-experts, the approach is to ask people to compare actions, such as "does flying emit more than lighting your house?". This requires to define a list of actions, representative of people's daily life, that will be used in the survey.

Our detailed computation of a Swiss resident's carbon footprint enables us to easily derive this list of actions. We model the carbon footprint of each action according to our LCA methodology normalized over an entire year. We thus obtain a list of 56 actions covering people's daily life in terms of food (e.g., eating a vegetarian diet, meat, and seasonal fruit and vegetables), transport (e.g., travelling by plane, commuting by train or bus, and biking to work), housing (e.g., heating a house, lighting it, and taking showers) and goods & services (e.g., possessing a bank account, reading, going to the restaurants). An example of an action is displayed in Figure 3 and shows the processes responsible of the

carbon footprint of this action. In this way, the survey participants can establish orders of magnitude between actions that are part of their lifestyle, and they can identify the levers of action to pursue a more sustainable life.

Round trip in train from Geneva to Barcelona



(a) Graphical Representation

Results of Action T.10		
Process	%	kg CO ₂ -eq/p
Prod./Dism. Train	7.2	1.45
Abrasion tracks/wheels/brakes	0.9	0.19
Electricity, HV FR	33.5	6.76
Maintenance	5.6	1.12
Prod./Dism. Railways	48.5	9.78
Train station	4.3	0.86
Total	100.0	20.17

(b) Results Table

Figure 3: Example of Action T.10 "Taking a round-trip in train from Geneva to Barcelona".

As a result, actions can be compared together: For example, 20'000 CHF put in a conventional bank account will release as much CO₂-eq as a Swiss resident over one year. This amount represents the equivalent of 8.3 round trips by plane from Geneva to New-York, heating an entire home for one family over 1 year and 8 months, drinking water from plastic bottles for 40 years, or doing a one-week ski-trip by car 111 times. Each individual action has an influence on the carbon footprint of our own life, and changing to low-carbon habits is one of the keys to limiting global emissions, and thus climate change.

The methodology developed in this work enables improving datasets for carbon footprint studies and identifying the main axes requiring improvement to reduce our carbon footprint. These are crucial steps to reach carbon neutrality by 2050. To limit global warming below 2°C, the carbon footprint of a typical Swiss resident should be reduced in average by 390 kg of CO₂-eq per year until 2050. Our carbon footprint can be improved by changing our habits and by adopting technologies that have less impact on the climate. For educational purposes, the 56 actions and their detailed computations will be published on the Climpact website [7] with a simple objective: share this knowledge with the Swiss population and study the individual perception of the carbon footprint by comparing multiple pairs of actions. This could help climate scientists, sociologists, communicators, politicians, and the general public to raise awareness about climate change and take the necessary steps to reduce our carbon footprint.

Finally, it is important to note that this research gives insights into the carbon footprint of Swiss residents. However, the carbon footprint is only one indicator of the life cycle analysis that focuses on climate change. Other factors, such as ocean acidification, impact on soils, freshwater use, and loss of biodiversity must not be neglected, because they are also crucial to the habitability of the planet. The whole methodology developed in our work can be easily adapted to other indicators, so that one could obtain a more comprehensive analysis of what is the general impact the human beings on the planet and how we could live in a truly sustainable way.

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