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NATIONALE KLIMASCHUTZ INITIATIVE

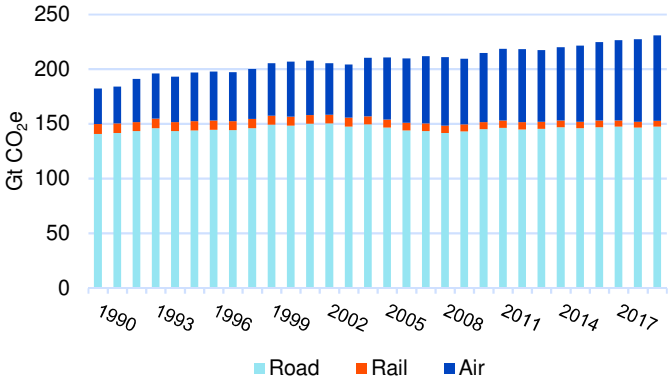
# Factsheet | GHG emissions from aircraft compared with other modes of transport and its role for personal carbon footprint

This factsheet provides an overview of the greenhouse gas emissions of different modes of long-distance passenger transport. First, the transport sectors are classified according to their share of transport volume and their greenhouse gas emissions for Germany as a whole. Then, the average greenhouse gas emissions of different modes of transport are compared and the impact of flight emissions in the personal carbon footprint is highlighted. Finally, an international comparison is made and the role of international air traffic is discussed.

## Overview: Transport sectors by transport volume and GHG emissions in Germany

Despite some efficiency gains in recent years, the transport sector in Germany has seen a steady absolute increase in traffic volume. Air traffic accounts for 19 % of transport volume (263 billion passenger kilometers). For the purpose of territorial delimitation, all flights with departures in Germany are accounted for. Arriving flights are therefore not included in this balance.

Figure 1 shows how greenhouse gas emissions in passenger transport in Germany have risen steadily since 1990. While the "rail" transport sector accounts for only a very small proportion of total emissions, road transport has the largest share. Aviation takes the second largest share with about one third (34 %). Compared with its share of 19 % of transport volume, aviation therefore makes a much greater contribution to greenhouse gas emissions than, for example, passenger rail transport, which is particularly climate-friendly. This is due to the high specific greenhouse gas emissions (emissions per passenger kilometer) of aircraft.




Data: (Allekotte et al. 2020). Pandemic period excluded (2020-2022).

*Figure 1: GHG emissions from passenger transport in Germany according to TREMOD (1990-2019), in gigatons of $CO_2$ equivalents.*

Moreover, over the past decade, aviation has been responsible for almost all of the growth in total greenhouse gas emissions from the transportation sector.

## GHG in direct comparison with other modes of transport

A comparison of the greenhouse gas emissions of the various modes of passenger transport in Germany shows that an aircraft has by far the highest specific greenhouse gas emissions (Table 1).

These are about 40 % higher than those of passenger cars (with an average occupancy of 1.4 persons). Compared to rail and buses, aircraft emissions are even more than 6 times higher. A major factor driving aviation emissions is the additional climate impact from emissions of pollutants and water vapor at high altitudes (non-$CO_2$ effects). These increase the climate impact of flights by a factor of 2 to 5[1].

*Table 1: Specific greenhouse gas emissions of transport modes in Germany (2019).*

| Transport modes | GHG emissions | Occupancy |
|---|---|---|
| aircraft, national | 214 g CO2-eq. / pkm | ca. 70 % |
| aircraft, international | 188 g CO2-eq. /pkm | ca. 80 % |
| car | 154 g CO2-eq. / pkm | 1.4 persons |
| Long-distance passenger rail | 29 g CO2-eq. / pkm | 56 % |
| Touring and long-distance buses | 29 g CO2-eq. / pkm | 54 % |

*Data: TREMOD Version 6.0 (Allekotte et al. 2020). pkm: passenger kilometer.*

[1] Further information on the impact of non-CO2 effects can be found in the documentation of the GHG monitoring tool of FlyingLess (https://flyingless.de/en/ghg-monitoring-tool)

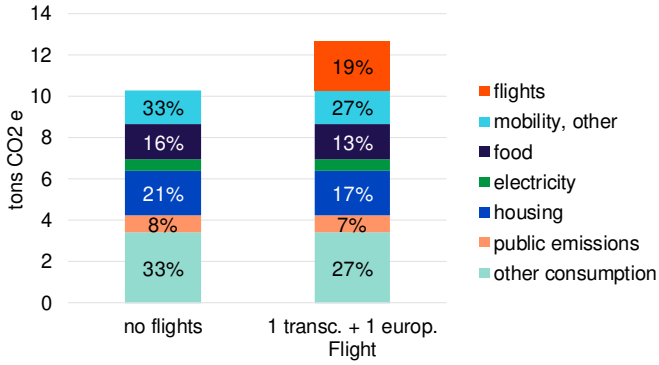
In addition to the high greenhouse gas emissions per passenger kilometre travelled, it should also be noted that aircraft are often used for very long distances. For example, a flight from Stuttgart to Fuerteventura (1,260 km round trip) on the Canary Islands involves 1.4 tons of $CO_2$ per person.

This is roughly equivalent to the amount of greenhouse gas emissions saved by avoiding the car for a year in favor of bicycles and public transportation.

## Role of flight emissions for the personal carbon footprint

Considering the average $CO_2$ balance over one year (Figure 2), the mobility sector takes up about 16 % of the total greenhouse gas emissions, assuming no flight is taken. If, on the other hand, the balance takes into account a transcontinental and an intra-European flight for the same year, 2.4 metric tons of greenhouse gas emissions are added (plus 23 %). The share of the total $CO_2$ footprint for one year accounted for by flights alone is then 19 %.

In this example, the calculation of the personal carbon footprint follows not only the input of individual consumption patterns but also the allocation of overall societal emissions. The category "public emissions" includes, for example, public administration services, water supply, waste disposal and the construction of public infrastructure.



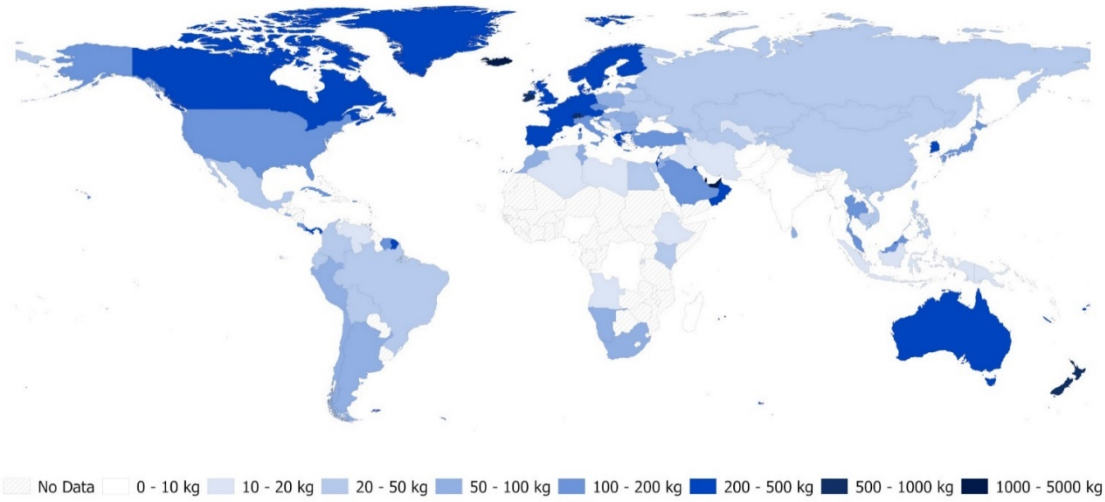

Data: UBA Carbon Calculator (Umweltbundesamt 2022).

*Figure 2: Personal carbon footprint with and without flights.*

## International dimension

National averages of air travel often misrepresent the true extent of personal greenhouse gas emissions. Aviation contributes a few percent of global greenhouse gas emissions each year and is therefore not one of the largest sectors (Ritchie 2020). But for specific social groups (e.g., high-income earners), flying contributes significantly to their personal carbon footprint. Thus, the person does not even have to belong to the "frequent flyer" group.

People who fly are a minority in global terms. Thus, they contribute disproportionately to greenhouse gas emissions. The geographic distribution of average per capita greenhouse gas emissions from international air travel shows strong geographic inequality (Figure 3). The average "rich person" from industrialized countries emits tons of greenhouse gases each year from flying, which in contrast is equivalent to the total carbon footprint of many people in the global South. This is confirmed by a study showing that one percent of the world's population is responsible for 50% of flight emissions (Gössling and Humpe, 2020).




Emissions are assigned to the country of departure of the flights. Data based on (Graver et al. 2019), cartography ifeu.

*Figure 3: Per capita CO2 emissions from international air travel 2018.*

## Outlook

The high greenhouse gas emissions from air traffic can rarely be reduced via efficiency improvements, as aircraft utilization is already relatively high (70 % on domestic flights and around 80 % on international flights). In addition, the number of flights and passenger kilometers has been rising sharply for decades. Alternative propulsion systems such as electric aircraft are not a solution for large passenger aircraft at the moment due to the weight of the batteries. Only the replacement of fossil kerosene with sustainably produced fuels from renewable sources or waste (e.g. plant residues) can help to reduce emissions from air traffic in the future.

According to expert estimates (including O'Malley et al. 2021; Ueckerdt & Odenweller 2023), the available sustainable sources of aviation fuels will not be sufficient in the medium term or will be too energy-intensive to replace today's demand for aviation fuels. Moreover, even with renewable fuels, the effects of additional climate impact due to "non-$CO_2$ effects" persist.

Therefore, the avoidance of air travel or, in the case of short distances, the shift to other means of transport (especially rail) are essential to achieve the climate targets.

### About FlyingLess

With the internationalization of science and research, the air travel of university members has increased – scientists are among the frequent flyers.

The aim of the FlyingLess project is to support universities and research organizations in reducing air travel, which accounts for a significant proportion of their total greenhouse gas emissions.

FlyingLess develops approaches to reduce air travel in the academic sector, which are implemented at different levels (research, teaching and administration).

The project is being conducted in close collaboration with four pilot institutions - the EMBL (European Molecular Biology Laboratory) and the MPI Astronomy in Heidelberg as non-university research institutions, and the Universities of Konstanz and Potsdam as higher education institutions.

The project is led by the ifeu insitute Heidelberg in close cooperation with the TdLab Geography at the Institute of Geography of Heidelberg University.

The project is funded over 3 years within the framework of the National Climate Initiative (NKI) of the Federal Ministry for Economic Affairs and Climate Action.

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