European Frequent Flying Levy

Impact study

CE Delft

Committed to the Environment

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Disclaimer
The European Union Aviation Safety Agency (EASA) has made available the AERO-MS model for this research on a complimentary basis. The content of this report does not reflect the official opinion of EASA or of the European Union. Responsibility for the information and views expressed lies entirely with the authors.

Delft, CE Delft, may 2024

Publication code: 24.230304.062

Client: Stay Grounded

Publications of CE Delft are available from www.cedelft.eu

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Content

Summary

Stay Grounded has commissioned CE Delft to calculate remaining carbon budgets for European aviation and to estimate the effects of a European Frequent Flying Levy (FFL). The budgets are derived from the latest IPCC budgets and the FFL effects are modelled with the European aviation model AERO-MS. The analysis shows that a substantial reduction of aviation on the short term is necessary to align the sector with the goals of the Paris Agreement. A FFL can contribute significantly to the required reduction of demand by applying the polluters pay principle.

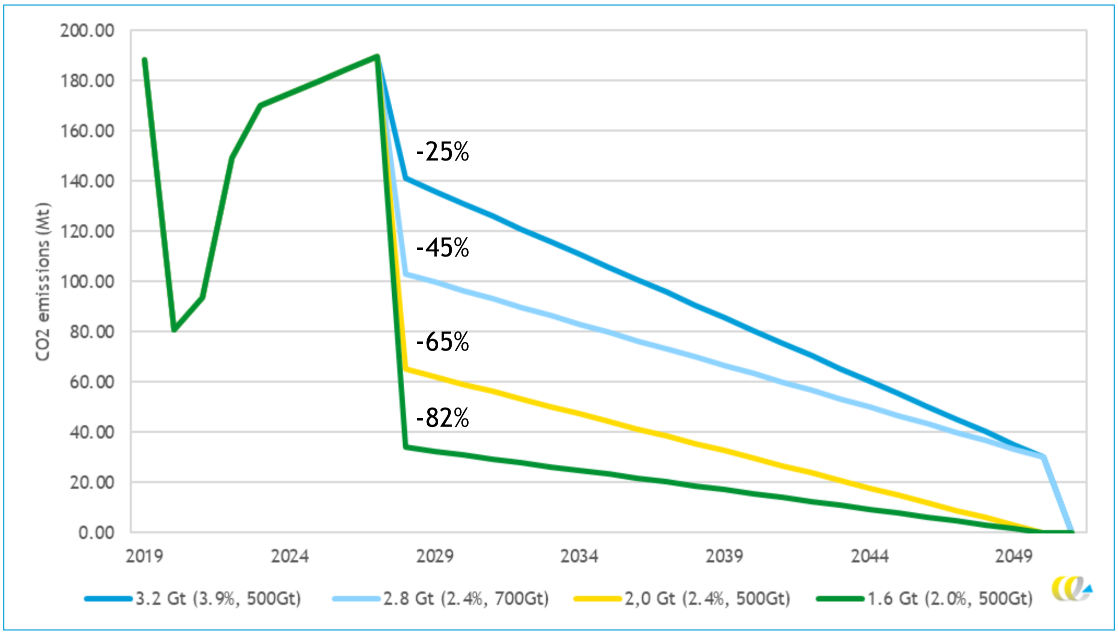
Immediate emission reduction necessary for aviation

The global leaders have agreed in the Paris Agreement to limit global warming to well below 2˚C and to aim for 1.5˚C. CO_2 is the key driver of global warming and it adds up cumulative in the atmosphere. Meaning, the goal of the Paris Agreement can be translated into remaining global carbon budgets. Based on the latest estimates from IPCC for these global budgets and possible ethical principles, we have allocated part of this budget to the European aviation sector, as shown in Table 1.

Table 1 - European Aviation Carbon Budget based on historic emissions and socio-economic forecasts (in Gt CO_2)

Allocation options/Carbon budgets considered	50% 1.5˚C (500 Gt)	66% 1.7˚C (700 Gt)
Hard to abate (IEA NZE) share 3.9%	3.2 Gt	4.5 Gt
Constant aviation market share 2.4%	2.0 Gt	2.8 Gt
Decreasing share 2.0%	1.6 Gt	2.3 Gt

Figure 1 - Potential reduction paths for four remaining European carbon budgets for European aviation. The numbers represent the corresponding 2028 reduction targets compared to 2019 emissions



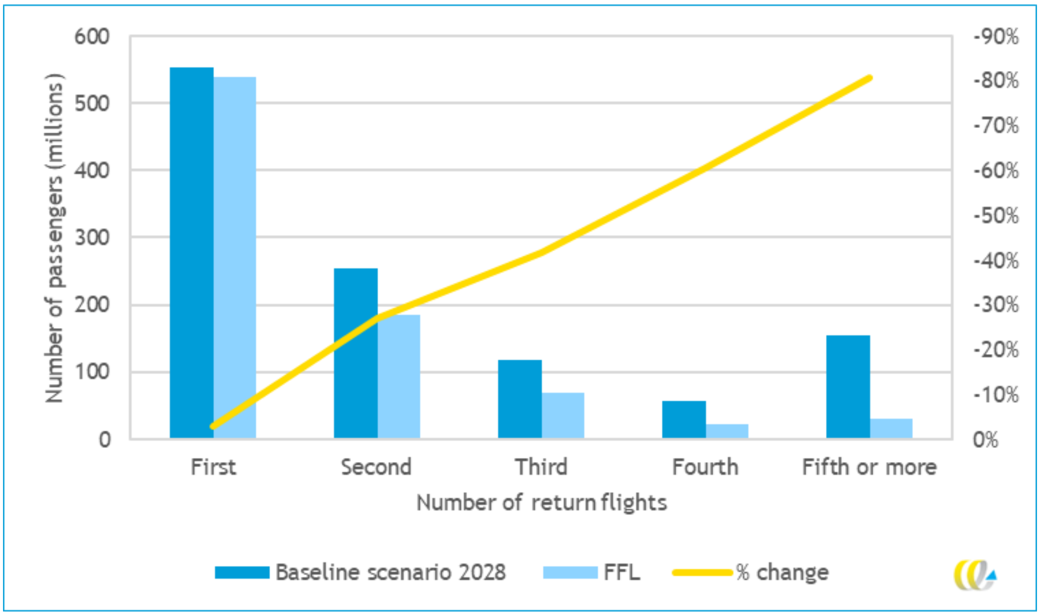
Based on these remaining carbon budgets for European aviation, indicative reduction paths for the CO_2 emissions are constructed, visualised in Figure 1. The paths show that an immediate reduction of carbon emissions is necessary to align with the estimated remaining carbon budgets. Otherwise aviation is likely to contribute to an overshoot of the remaining budgets and in addition requires disproportional amounts of clean energy and land (both are likely to be scarce resources in the next decades) or depends on uncertain technological breakthroughs. The expected technological and operational efficiency improvements and upscaling of SAF production are not sufficient. As a last resort, immediate demand management measures are necessary to align the aviation sector with the goals of the Paris Agreement. We have estimated necessary reductions of 25 to 82% in 2028 compared to 2019 levels.

European Frequent Flying Levy leads to significant demand reduction

Stay Grounded and other NGOs propose an European Frequent Flying Levy to reduce demand for aviation and hence emissions on the short term, without making flying unaffordable for low income groups. The proposed levy is applied for all departing passengers in all 30 countries of the European Economic Area (EEA) and the UK. The levy is charged per individual flight and has a zero rate for the first return flight per year and an incremental increase every second flight (€ 50 for flight 3 and 4, € 100 for flight 5 and 6, € 200 for flight 7 and 8, € 400 for 9 and more flights) in combination with surcharges for first/business class (€ 100), medium-haul (€ 50) and long-haul flights (€ 100) per individual flight. The levy leads to a significant reduction in demand and additional annual tax revenues of € 63 billion, assuming that the FFL replaces national ticket taxes. Due to this policy the number of passengers at European airports is estimated to reduce by 25.8% and CO_2 emissions by 21.1% compared to the baseline. This is comparable to the emission reduction required by an allocation principle which allows the share of aviation to grow to 3.9% of global emissions (hard-to-abate argument), or about 50% of what would be required in case the share of aviation would be kept constant at current levels.

Figure 2 shows the effect of the FFL on the number of passengers in categories of the number of annual return flights. For passengers flying once a slight decrease of 3% is observed, due to the surcharges. The demand of passengers flying more often is significantly more decreased with up to 81% for passengers taking five or more return flights in a year.

Figure 2 - Impacts of FFL on the flying frequency of passengers departing from Europe31



1 Introduction

1.1 Background

Global emissions from aviation have been continuously on the rise, increasing the climate, environmental and air quality impacts of the sector. During the COVID-19 pandemic, there was a drastic decrease of emissions from the sector, however it has been quickly recovering since. The aviation sector is seeing annual growth in demand of 5-8%, a lot faster than the efficiency improvements of aircrafts (Figure 3). This causes a net increase in carbon dioxide (CO_2) emissions (one of the most important Greenhouse Gases (GHGs) contributing to climate change). Next to the emissions of CO_2 aviation impacts climate through indirect effects of emissions and changes to the atmosphere. The best estimate of these combined worldwide non-CO_2 climate impacts of aviation from 1940 to 2018 in terms of the current effective radiative forcing are twice (Lee et al., 2021) as large as the CO_2 impacts.

Figure 3 - Trends in air traffic, fuel efficiency and CO_2 emissions from the aviation sector from 1970-2020

Source: (Lee et al., 2021).

In 2015, the world leaders agreed in the Paris Agreement to limit anthropogenic global warming levels to well below 2˚C, and preferably to 1.5˚C, compared to pre-industrial levels (UN, 2015). This implies that net-zero emissions has to be achieved globally around 2050 with intermediate reduction targets. The smaller the temperature goal, the more the negative effects of global warming can be constricted. An important aspect is to reduce the probability of reaching tipping points in global warming and therefore the contribution to irreversible processes. However, lower temperature targets require faster decarbonisation and more radical measures.

The decarbonisation of the global aviation sector is very challenging. The sector is considered 'hard-to-abate' due to its unique requirements, high costs of decarbonisation solutions and slower pace of implementation of new technologies compared to other sectors. Moreover, the implementation of efficient policies to reduce the sectors' climate impact is hampered by its international character and competition. Important aspects for the decarbonisation of aviation are:

- innovations in aircraft design, materials and engines lead to fuel efficiency improvements per passenger kilometre when the fleet is renewed;
- technological innovations like battery electric or hydrogen-powered aircrafts are expected to be suitable for short/medium-haul flights within the next decades;
- Sustainable Aviation Fuels (SAF)[1] can be blended with fossil kerosene and reduce the climate impact for all types of flights;
- optimisation of air traffic operations can lead to shorter routes;
- restrictions of airport capacity reduces the number of aircraft movements;
- demand management (via national and international ticket price measures).

The passenger demand (and consequently aviation emissions) can be reduced through international ticket price measures such as a Frequent Flying Levy (FFL). Introducing such a measure could be a decarbonisation solution suitable for implementation in the short-term, whilst buying time for the development of other more complex technological decarbonisation solutions (requiring more development, testing and implementation time). In addition, demand reduction decrease the demand for biomass and clean energy, which are likely to be scarce sources in the next decades.

1.2 Purpose of the study

Stay Grounded, New Economics Foundation, Possible and further NGOs proposes a FFL policy (NEF, 2021). Stay Grounded has commissioned CE Delft to estimate the effects. In this study the following research questions are answered:

- What is the resulting CO_2 emission reduction due to the introduction of an FFL? What portion of the remaining carbon budget does the FFL CO_2 emission reduction pathway represent?
- What is the resulting passenger demand reduction due to the introduction of an FFL?
- Who benefits from the FFL the most compared to introduction of non-progressive measures to constrain demand? How are different income groups affected?
- What are the resulting taxation revenues due to the introduction of an FFL?

The goal is to assess the effects of the introduction of a FFL for all 30 countries of the European Economic Area (EEA) and the UK. Before the FFL is introduced, we give a short overview of the current status of taxation.

[1] Sustainable aviation fuels are developed to replace fossil kerosene, as most of them bring a significant emission reduction. The production or SAFs require feedstocks, which are either biomass feedstock or clean energy. There is no consensus in science/literature whether biofuels, and to be more specific biomass, should be defined as carbon neutral Becken, S., Mackey, B., & Lee, D. S. (2023). Implications of preferential access to land and clean energy for Sustainable Aviation Fuels. *Science of the Total Environment*(886). https://www.sciencedirect.com/science/article/pii/S0048969723025044 . In essence, plant material (biomass) is not a clean energy source as it releases CO_2 emissions when burned. However, plant growth is an ongoing process, subjected to the availability of land (or water for algae fuels). The emissions from burning biomass are in the past absorbed from the atmosphere during plant growth. The issue arises from the time lag between the carbon emissions and the equivalent amount being removed from the atmosphere and stored in new plants (biomass).

1.3 Current aviation taxation

The aviation sector in Europe has a unique fiscal regime, specific to each country. Due to international agreements, the aviation sector has a number of tax exemptions on fuel and tickets (VAT). Currently, only Norway and Switzerland apply a kerosene tax (for domestic flights only) (Ricardo et al., 2021). These tax exemptions are not applied to other modes of transport. There is for example a consumption tax on transport fuel and electricity for the rail transportation and rail tickets have a VAT included in the price, in some countries with a reduced rate. For the road transportation sector, fuel is taxed at approximately € 0.62 per litre, and diesel for trains are taxed at € 0.12 per litre in the UK (OECD, 2022).

Some European countries however have national departure ticket taxes, ranging from € 0.40 in Italy to € 205 in the UK. Not only the rate, but also the scheme varies between countries. The Netherlands for instance applies a single rate, whereas others distinguish in flight distance and/or comfort class (for instance UK), as specified in Annex A.6.
Transfer passengers are exempted in all European countries. Due to differences in rates, national taxation leads to evasion of passengers to neighbouring countries, especially if the differences in the rates are large and airports abroad are easy to reach.

Due to the taxation exemptions on fuel and tickets, NGOs state that the aviation sector faces a 'tax gap'. This amount represents the revenue that is lost from the unique taxation scheme of the sector. Transport & Environment (T&E) identifies a tax gap of € 34.2 billion which is set to increase to € 47.1 billion by 2025 (T&E, 2023). The same study identifies that CO_2 emissions could have been reduced by 34.8 million tonnes if the taxation exemptions were ended in 2022.

1.4 Frequent Flying Levy

A Frequent Flying Levy is a progressive taxation scheme that applies an increasing extra charge on the ticket price for every consecutive return flight taken by an individual within a specific time period (for instance a year). The FFL aims to address the unequal distribution of aviation activities, due to the nature of the tax, increasing for each consequent return flight. Next to the increase in the rate per trip, it is possible to include distance dependent or class-dependent sur-charges that incorporate the higher external effects of long-haul and business class travel. An overview of the external effects of aviation is presented in (CE Delft, 2023).

The International Council on Clean Transportation (ICCT) and New Economics Foundation (NEF) consider the FFL a fairer tax than a uniform levy (ICCT, 2022; NEF, 2021). Low income groups have a low propensity to fly and are more price sensitive, whereas high income groups fly more and are less price sensitive. Hence, a uniform tax (not increasing with consecutive flights) affects low income groups more than high income groups.
The environmental effects of a FFL depends on the taxation rates and the geographical scope, the larger the scope the lower the effects of evasion to neighbouring countries.

In this study the effects of a European FFL are estimated. The rates of the surcharges are doubled for consecutive return flights with sur-charges for medium-haul and long-haul flights and premium class (business class and first class).

1.5 Challenges for the Frequent Flying Levy

A Frequent Flying Levy has not been implemented anywhere in the world so far. In contrast to the current national aviation taxes, there are additional challenges. The feasibility and implementation of the FFL are out of the scope of this study, yet need to be mentioned.

The FFL should be implemented on a large scale (preferably global) to have the largest impact. This would limit airport leakages of passengers travelling to neighbouring countries (if the ticket prices do not include the FFL there) and would also ensure a level playing field for all airlines competing for passengers. Looking at the European scale, implementing a FFL could cause political challenges and tensions since in order to introduce an EU regulation of taxes a unanimous decision of the European Council is required.
Moreover, countries bordering with non-EU countries might fear competition from non-EU airports and airlines, and could be more hesitant to implement this levy. However, the increase in tax revenues might be an important argument in favour of the FFL.

There are some challenges with the implementation of the FFL which necessitates a data tracking and acquisition structure of each passenger and flight taken in the EEA + UK in order to keep taxation evasion to a minimum without breaching privacy restrictions.

In addition, the implementation of a FFL will be challenging in reality because people travel for a variety of reasons, for example for business, leisure or family visits abroad. The FFL increases the total ticket price every time a round trip is booked. This means that the order in which the trips are taken matters. An individual travelling for three business trips at the beginning of the year and taking a flight vacation later in the year would have the holiday counting as a fourth return trip. This passenger would have to pay higher taxes for the leisure flight, because of his business trips taken earlier on in the year, without additional measures to prevent it. There are therefore good reasons for processing and levying leisure and business flights differently, but this is out of scope of this study. Another solution could be to require businesses to reimburse employees who are required to fly for work for any higher FFL amounts employees are then charged for their non-business travel.

In parallel to this impact assessment, a legal assessment has been carried out by Adastone Law. The results are described in (Adastone Law, 2024). Although there a challenges, the legal advice supports the conclusion that the implementation of some form of Frequent Flying Levy in Europe is legally achievable.

1.6 Reading guide

In Chapter 2, remaining carbon budgets for European aviation are derived. The IPCC has estimated global remaining carbon budgets. Those are allocated to the European aviation sector based on several ethical considerations, resulting in a number of possible options of the European aviation carbon budget for the years 2020-2050. All options considered require immediate demand reduction. For illustration purposes, we have derived the remaining aviation CO_2 budget for the average European citizen and compared the result to the average global citizen. In Chapter 3, we show the imbalance of the distribution in aviation activities focusing on the passenger demand, travel behaviour and the resulting emissions.

Both, the required demand reduction to align the aviation sector with the goals of the Paris Agreement and the unequal distribution of flying activities between non-flyers, occasional flyers and frequent flyers, are reasons to introduce a FFL. In Chapter 5 the policy is described and the estimation results are discussed in terms of passenger demand, CO_2 emission reductions and taxation revenues. Finally, a discussion of the results is presented in Chapter 5.

2 Remaining carbon budget for global and European aviation

Since 1900, global CO_2 emissions per year have increased from 2 Gt in 1900 to 37 Gt in 2022 (IEA, 2023b), contributing to global warming. In the Paris Agreement the overall objective was set to hold the global average temperature increase to well below 2˚C above pre-industrial levels and to pursue efforts to limit this increase to 1.5˚C (UN, 2015). Greenhouse gases (GHGs) are the primary drivers of global warming, with CO_2 being the key player. The gas stays into the atmosphere for thousands of years and hence adds up cumulatively. This implies that not only the increase in CO_2 emissions has to be stopped, but the trend has to be turned into a fast decrease in global GHG emissions reaching net-zero emissions around 2050. The remaining emissions between today (or another recent reference year) and the net-zero situation is called a remaining carbon budget or short CO_2 budget. This chapter focuses on answering the question:

'Which CO_2 budget, for global and European aviation, is in line with the global warming levels of 1.5˚C and well below 2˚C set by the Paris Agreement?'

In this chapter, a description of the global aviation sector CO_2 emissions and decarbonisation challenges towards 2050 is presented. IPCC has derived remaining global carbon budgets (IPCC, 2022).(IPCC, 2018). In this chapter aviation sector budgets are estimated on global and European scale based on different allocation principles and ethical considerations. Finally, reduction paths that fit within these remaining European aviation budgets are proposed to illustrate the emission limits for specific future years. The methodology of this chapter is based on our study on aviation carbon budgets for Amsterdam airport Schiphol (CE Delft, 2024).challenges towards 2050 is presented. IPCC has derived remaining global carbon budgets (IPCC, 2022).(IPCC, 2018). In this chapter aviation sector budgets are estimated on global and European scale based on different allocation principles and ethical considerations. Finally, reduction paths that fit within these remaining European aviation budgets are proposed to illustrate the emission limits for specific future years. The methodology of this chapter is based on our study on aviation carbon budgets for Amsterdam airport Schiphol (CE Delft, 2024).

2.1 Aviation development towards 2050

To limit global warming well below 2˚C (and aim for 1.5˚C), net zero emissions have to be realised on a global scale around 2050. The 'lower' the temperature goal, the faster the decarbonisation has to happen. Net-zero emissions means that emissions and removal of CO_2 to the atmosphere have to be balanced for the sum of all sectors. Due to the cumulative character of CO_2 in the atmosphere, emission overshoots in specific sectors or periods have to be compensated by negative emissions in other sectors or different periods in time.
To assess what this would mean for the aviation sector, we first give a short description of the current situation. Afterwards, the final state of global net-zero aviation is described, which should be reached around 2050 depending on the exact global reduction path.

Finally, the path towards 2050 is discussed, since this path determines the amount of cumulative emissions and therefore global warming[2].

Aviation current situation

Currently, aviation uses fossil kerosene for almost 100% of its energy demand. Overall aviation contributed to 2.4% Tank-To-Wing (TTW) or 3.7% Well-To-Wing (WTW) of global CO_2 emissions in 2019 (ICCT, 2019). The WTW emissions are higher than TTW since emissions of fuel production and distribution are included. Despite efficiency improvements in aircraft technology and operations, the sector's emissions have increased by 2.3% per year on average between 1990 and 2019, as growth in air travel demand outpaced efficiency improvements in aircraft technology and operations (IEA, 2023a).

The main takeaways from the current situations in the aviation sector are:
- energy demand is almost 100% fossil kerosene;
- aviation contributes to 3.7% of global CO_2 emissions;
- globally demand grows faster than efficiency improvements leading to an annual growth of CO_2 emissions by 2.3% over the last three decades.

Aviation 2050 situation

The aviation sector is relying on innovations in technology to decarbonise the sector. Fuel efficiency improvements are achieved through weight reductions, integration of more efficient engines and improved aircraft aerodynamics. For short-haul and potentially medium-haul flights new options are emerging with electric or hydrogen-powered aircrafts. For long-haul flights these options are probably not feasible within the next decades. For these flights Sustainable Aviation Fuels (SAF)[3] of biologic or synthetic origin are likely the key technology to significantly decrease emissions (taking production and distribution into account) assuming they are produced using green electricity. These technological solutions for aviation require large amounts of clean energy and biomass (Becken et al., 2023). In addition, remaining non-CO_2 emissions have to be compensated by negative emission technologies. Currently, they are untested at scale and probably they will be land and/or energy intensive and will have high costs.

Global demand of aviation is expected to increase significantly due to the expected worldwide economic growth. Aviation demand however is also strongly dependent on ticket prices. The future development of ticket prices is however uncertain due to efficiency improvements, energy and fossil fuel prices, as well as (international) policies such as carbon pricing.

2 In many public discussions the net-zero goal for 2050 seems to be presented as the ultimate goal. It is important to realise that the cumulative CO_2 emissions are the key driver of global warming. Hence, staying within a specific remaining carbon budget is much more important than the moment when net-zero is reached.

3 There is an ongoing debate about greenwashing in aviation and whether the term 'Sustainable Aviation Fuel' is misleading. We are aware of the fact that the production processes of types of SAF does not lead to GHG reductions and that they have additional environmental disadvantages. However, we have chosen to use the term SAF in this report, since this it is currently common practice to call alternatives to fossil kerosene SAF.

The expected trends in the aviation sector in 2050 include:

- emergence of technological solutions accelerating decarbonisation of the sector;
- electric or hydrogen-powered aircrafts usage for short-haul flight;
- reduction in carbon emissions for long-haul flights due to SAF (biofuels and synthetic);
- existing levels and especially the expected growth in worldwide aviation demand leads to large demand for clean energy and biomass;
- remaining non-CO_2 emissions need to be compensated by carbon removal to achieve a net-zero impact.

Aviation emission pathway towards 2050

The remaining carbon budget towards the net-zero goal, has to be shared globally with all sectors, resulting in competition between aviation and other sectors for this carbon budget. This carbon budget is a cumulative budget for all years between 2020 and 2050.
High emissions in the next years automatically result in a lower remaining carbon budget in the years further ahead, which makes it more challenging to stay within a specific budget.

To significantly reduce emissions in the next two decades, the aviation sector relies on SAFs, since the other technological solutions will not be operational on large scale. However, also scaling-up SAF production takes time. Even with historically high year-on year growth rates of renewable electricity and green hydrogen production, and when Direct Air Capture (DAC) will be technically mature and ready to be scaled up, this takes decades (Bauen et al., 2020). Hence, the immediate scaling-up of biofuel production and pre-commercial development of the synthetic fuel production becomes imperative, as solely relying on depleting the remaining carbon budget and immediately switching to SAFs is impossible. Production of SAFs require green energy and biomass, but the aviation sector is not the only sector requiring green energy and biomass for its decarbonisation.
Demand for green energy and biomass will increase in the future, resulting in competition between sectors for these goods not only in 2050 but already in the next years. The analysis in Section 2.7 shows that the aviation sector needs to increase decarbonisation efforts. Demand management measures are necessary to align the aviation sector with the goals of the Paris Agreement.

Conclusion

- Aviation is a hard-to-abate or costly-to-abate sector. Breakthroughs in aircraft technology such as hydrogen or battery electric demand tome to develop and SAF will be costly to scale up to satisfy the necessary demand.
- Immediate scaling-up of biofuel production and pre-commercial development of the synthetic fuel production are essential, bearing in mind the scarcity of these resources and competition with other sectors.

2.2 Global GHG budgets

The IPCC has consolidated the best knowledge of climate science and estimated remaining carbon budgets from the beginning of 2020 onwards. These budgets (Table 2) are available for different temperature limits and probabilities that these budgets will limit global warming to the specific temperature.

Table 2 - Estimated remaining carbon budgets from the beginning of 2020 in Gt CO_2

Temperature increase/probability	50%	67%	83%
1.5˚C	**500**	400	300
1.7˚C	850	**700**	550
2.0˚C	1,350	1,150	900

Source: (IPCC, 2022).

Beginning of 2024, within four years, approximately 147.5 Gt CO_2 of the budget is already emitted to the atmosphere with 36.0 Gt in 2020, 37.9 Gt in 2021, 36.8 Gt in 2022 and 2023 (Crippa et al., 2022; Crippa et al., 2021; IEA, 2023a, 2023b). To illustrate the scale of the current emissions, we have estimated the number of years that remain until particular global budgets are reached (see Table 3).

Table 3 - Remaining carbon budgets from 2024 and remaining number of years until the budgets are exhausted if the current worldwide emissions stay constant

Temperature increase (probability that limit is exceeded)	Remaining carbon budget (Gt CO_2)	Remaining years with current emissions (36.8 Gt per year)
1.5˚C (50%)	352.5	9.6
1.7˚C (67%)	552.5	15.0

The Paris Agreement sets the goal to maintain global warming well below 2˚C and to pursue efforts to limit it to 1.5˚C. Therefore, carbon budgets limiting global warming to 2˚C temperature increase are not considered in the further analysis, since they are not aligned with the Paris Agreement. Moreover, the 400 Gt budget (and lower), seems to be out of reach given the fact that already 147.5 Gt have already been used in the last four years despite a reduction in global economic activities due to the COVID-19 pandemic.

In this study we therefore consider two budgets:
- **500 Gt**: 50% likelihood that global warming is limited to below 1.5˚C.
- **700 Gt**: 67% likelihood that global warming is limited to below 1.7˚C. Note that this budget is not in line with limiting global warming to 1.5˚C, and the extent to which this budget is Paris-aligned is debatable.

These budgets have to be shared with all sectors and countries globally. We want to stress that there is no scientifically correct distribution for this allocation problem. It requires political and societal choices. In the next paragraphs, we first determine a global aviation budget and thereafter a European aviation carbon budget, both based on technological and ethical considerations.

2.3 Global aviation CO_2 budgets

The remaining carbon budgets can be allocated to aviation based on different societal and political choices:
- Increasing the share for aviation since the sector is considered ‘hard-to-abate’. This approach is based on data from the International Energy Agency (IEA) Net-Zero Emissions (NZE) scenario which gives an estimate of 3.9%.

- Maintaining the current market share of aviation in global CO_2 emissions from 2019[4] onwards of 2.4% (ICCT, 2020).
- Decreasing the share of aviation since flying is not a basic human need (like food or housing). Therefore, aviation may be considered as a luxury product (Gallet & Doucouliagos, 2014) used by a small and wealthy part of the world. In 2018 only 11.1% of the world population took a flight (Gossling, 2020). Access to the sector is therefore also unequally distributed between developed and developing countries. This percentage is assumed to equal 2%, which results in a 17% reduction of the remaining carbon budget for aviation compared to the current share.

Table 4 - Remaining carbon budgets from the beginning of 2020 for Global aviation in Gt CO_2

Global aviation carbon budget	500 Gt	700 Gt
IEA NZE carbon budget: 3.9%	19.5	27.3
Current aviation share: 2.4%	12.0	16.8
Decreasing share: 2%	10.0	14.0

Table 4 illustrates the remaining global aviation carbon budgets that follow from the assumption. The budget vary from 10.0 Gt CO_2 to 27.3 Gt CO_2. Consequently, the range of remaining years until the global aviation carbon budget is exhausted can be calculated, based on the current emissions for global aviation. If the current global aviation emissions stay constant (at the 2019 emissions level) then the global carbon budget for aviation will be reached in 6.8 years (for the 500 Gt budget) and 22.5 years (for the 700 Gt budget).

2.4 European aviation CO_2 budgets

The allocation of a share of the global aviation budget to European aviation is an ethical question. A starting point could be the current share of European aviation. In 2019, flights departing from Europe31 countries (considering EU27, EFTA[5] countries and the UK) had a share of 18.2%[6] (EASA, 2022) of global aviation, whereas the share of these countries citizens in the global population was only 6.8%. Applying this share would manifest the disproportional high amount of flights from European citizens compared to population groups elsewhere. On the other hand side a uniform distribution for all citizens would not reflect the economic differences between countries. However, these two options define the upper and lower boundaries for the European share:
Upper boundary: Applying a socio-economic forecast based on current emissions leads to a share for Europe of 16.4%[7]. This is lower than the 2019 share of 18.2% due to the fact that the population growth and economic growth is expected to be larger in other parts of the world than in Europe (see Table 5).
Lower boundary: Based on a uniform distribution for all global citizens, Europe would receive a share of 6.8% (UN DESA) (see Table 6).

[4] 2019 is chosen as reference since this is the last regular year before the COVID-19 pandemic.
[5] Iceland, Liechtenstein, Norway and Switzerland. However, since Liechtenstein has no airport it is not counted in the Europe31 countries.
[6] There are many sources reporting different emissions, mainly due to the differences in geographical scope and considered coverage. Here we use country emissions from EUROCONTROL and global aviation emissions determined by the IEA.
[7] The share in 2019 was 18.2% for the EU27, EFTA countries and the UK.

Table 5 - European Aviation Carbon Budget considering socio-economic development forecast (in Gt CO_2)

Allocation options/Carbon budgets considered	500 Gt	700 Gt
Constant aviation market share: 2.4%	2.0 Gt	2.8 Gt
IEA NZE share: 3.9%	3.2 Gt	4.5 Gt
Decreasing share: 2.0%	1.6 Gt	2.3 Gt

Table 6 - European Aviation Carbon Budget considering uniform distribution per global citizen in 2019 (in Gt CO_2)

Allocation options/Carbon budgets considered	500 Gt	700 Gt
Constant aviation market share: 2.4%	0.8 Gt	1.1 Gt
IEA NZE share: 3.9%	1.3 Gt	1.9 Gt
Decreasing share: 2.0%	0.7 Gt	1.0 Gt

Between 2020 and 2023, commercial aviation in Europe31 countries emitted 0.49 Gt CO_2 (EASA, 2022). The allocation of the remaining carbon budget to European aviation according to a decreasing share for the sector is not a feasible target considering the emissions over the past four years. Similarly, the allocation of the global budget to aviation in Europe considering a uniform distribution for all global citizens is also not a feasible target.

Reflections on the budgets

The process of allocating the share of the remaining carbon budget to a given sector/ region/citizen group has to consider social and political (ethical) choices and not only technical and economic arguments. In this complex process, decisions have to made related to how uniform or heterogeneous the budget should be distributed. This results in a wide range of resulting carbon budgets.

The ambition of the Paris Agreement is to limit global warming to 1.5˚C and to enforce warming well below 2˚C. This fits best with a global budget of 500 Gt. The physical impacts of a global warming of over 1.5˚C may be disproportionally larger than that of 1.5˚C due to tipping points. To not risk overshooting this level of global warming Europe, being one of the wealthiest regions worldwide, could feel responsible to aim for the 1.5˚C. Therefore, for European aviation, only budgets based on the 500 Gt global budget are considered to be fully in line with the Paris Agreement. This sets a maximum budget of 3.2 Gt for European aviation, in case the share of aviation rises to 3.9%.

Aviation is considered a hard-to-abate sector, which is difficult to decarbonise. However, aviation activities can also be considered a luxury product since they are not a basic need. Because of this, one might also argue that aviation has to follow the same or even a more restrictive path than other sectors. This would lead to remaining carbon budgets of 2.0 Gt or 1.6 Gt. People running out of money will probably skip flying for their summer holidays before they make drastic reductions in eating or heating. The same argumentation might be applied to a limited carbon budget.

The emissions between 2020-2024 of the aviation sector in Europe show that immediate action is required to decarbonise the sector to stay under the limit of the ambitious remaining carbon budget estimates by 2050.

2.5 Personal CO_2 budget per average European citizen

To illustrate the magnitude of the remaining carbon budgets we have translated them to a budget for the average European citizen and compared it to the average global citizen. This is a theoretical exercise and we are aware of the fact that different ethical considerations would lead to very different results.

The personal CO_2 budget is estimated from the 2.0 Gt CO_2 budget allocated to European aviation considering a constant market share for aviation and the socio-economic development forecast for European countries. Firstly, the emissions from aviation in Europe for the years 2020-2023 are subtracted, resulting in 1.50 Gt for the remaining carbon budget for aviation in Europe. After that, the remaining budget is distributed between freight (19%) and (81%) passenger transport (ICCT, 2020), resulting in 1.22 Gt for passengers. Dividing this budget by approximately 530 million inhabitants for the Europe31 countries, leads to a personal budget of 2.30 ton CO_2 from aviation for the average European citizen.

Note that the budget of 1.22 Gt covers all departing flights from airports in Europe31 countries. This is a different perspective than a European passenger perspective. Flights departing at European airports also carry non-European passengers (mainly returning to their home countries or transferring to other airports). At the same time European passengers are on board of flights departing from airports outside Europe31 (mainly Europeans on their return flights home or further transfers) and these emissions are not part of the estimated budget. Under the assumption that the segments of European and non-European passengers are of a comparable size, they compensate each other and the European budget can be allocated to the European passengers as well. However, on many airport-pairs between Europe and non-European destinations the share of Europeans higher than the share of visitors. This implies that the aviation emissions that should be allocated to European citizens is larger. If this situation should be manifested by allocating a larger carbon budget to European citizens is a political and ethical question, that is out of scope of this study.

As a comparison, we have estimated the carbon budget for the average global citizen using the same methodology and starting with a global carbon budget for aviation of 12 Gt. Subtracting the global aviation emissions for 2020-2023, taking the share of passenger transportation and dividing the resulting budget by 8.1 billion people leads to a personal budget of 0.91 ton CO_2 from aviation. Therefore, the budget of the average European citizen is approximately 2.5 times larger than the budget of the average citizen according to this theoretical allocation method.

With the current aircrafts and fuels, the budget of an average European citizen of 2.30 ton CO_2 for the years 2024 to 2050 corresponds to approximately:
- 10[8] return flights from Amsterdam to Barcelona (economy class); or
- 4 return flights from Amsterdam to New York (economy class) or 2 (business class); or
- 3 return flights from Amsterdam to Tokyo (economy class) or 3 single flights (business class).

[8] CO_2 emissions per flight are estimated with the ICAO carbon emissions calculator https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx

The budget of an average global citizen of 0.91 ton CO_2 for the years 2024 to 2050 would approximately correspond to the following:

- 4 return flights from Amsterdam to Barcelona (economy class); or
- 1.6 return flights from Amsterdam to New York (economy class) or 0.8 return flights (business class); or
- 1 return flight from Amsterdam to Tokyo (economy class) or 1 single flight (business class).

If we assume ambitious climate policies that lead to zero-emission aviation in 2050 and a linear path for the years in between, the average European inhabitant could fly almost once every two years to Barcelona from Amsterdam or almost once every five years to New York (and back) based on this budget. These numbers could increase with efficiency improvements and SAF blending obligations.

2.6 Non-CO_2 effects

It is important to note that non-CO_2 climate effects of aviation are not considered in these budgets. The main reason is that these emissions do not cumulatively add up, since their lifetime in the atmosphere is much shorter. Hence, they do not fill up the budget. However, non-CO_2 emissions lead to global warming for a short period in time. During this period they increase the probability of reaching tipping points in global warming and to contribute to irreversible processes. Therefore, it is very important to develop efficient non-CO_2 policies and to reduce them as soon and as fast as possible. If this is not possible, the total number of flights or average distance of flights has to be reduced more than will be estimated in the following section.

2.7 Reduction paths for remaining European carbon budgets

Using the remaining European carbon budgets calculated in Section 2.4, indicative reduction paths for the CO_2 emissions can be visualised (see Figure 1). The emissions below the lines correspondent to the estimated European aviation carbon budgets from 2020 onwards. The 2019 pré-COVID-19 emissions are shown as reference, but are not included in the budgets. We want to stress that it is not important at which moment in time the emission reductions are achieved, as long as the cumulative emissions are identical. Hence, if the reduction is not achieved in the earlier years, more drastic measures will be needed at a later stage to prevent an overshoot of emissions.

Figure 4 - Potential reduction paths for four remaining European carbon budgets for European aviation

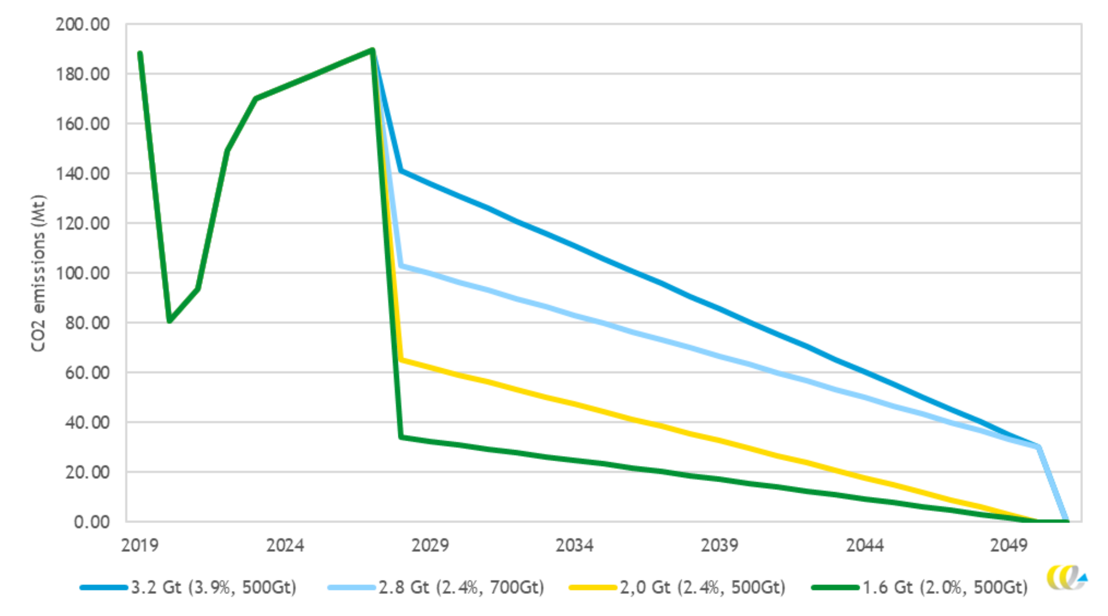


Figure 4 shows four indicative reduction paths corresponding to four remaining European aviation carbon budgets, three for the 500 Gt global budget and one for a global budget of 700 Gt. Also the exact choice of the paths is rather arbitrary, it is obvious that immediate action is necessary, since higher reduction rates per year based on technological and operational efficiency improvements are not realistic.

For all paths the realised emissions for European aviation between 2020 and 2023 are plotted. For the period 2024 to 2027 a slight increase in emissions is assumed, with 2027 approximately on the level of 2019[9]. For the carbon budgets of 2.8 Gt and 3.2 Gt, it has been assumed that there are still CO_2 emissions in 2050, since the ReFuelEU aviation assumes SAF[10] blending of 70% for this year, still requiring 30% fossil fuel. It is further assumed that all remaining emissions after 2050 are compensated through carbon removal from the atmosphere, resulting in a sharp decrease between 2050 and 2051. Without this assumption even stronger decreases in 2028 would be necessary. Between 2028 and 2050, a linear reduction path is drawn, requiring very significant efficiency improvements and probably additional demand measures. For the 2.0 Gt and 1.6 Gt budgets, a linear path reaching zero emission in 2050 is illustrated, since these budgets leave no room for remaining emissions in 2050.

9 This development is based on the Mid growth ICAO traffic forecast for Europe.

10 It is important to realize that the entire cycle from fuel production, transportation and combustion (Well-To-Wing emissions) has to become carbon neutral for SAFs, otherwise remaining emissions from the chain also have to be compensated by negative emission technologies or permanent carbon storage.

Since immediate action is needed, reduction targets for 2028 are set, with respect to the 2019 carbon emission values to construct reduction paths that align with the remaining carbon budgets. CO_2 reduction targets compared to 2019 that corresponds to the paths for 2028 and other future years are summarised in Table 7. For a more detailed discussion on carbon budgets see a specific study on this topic for Amsterdam Airport Schiphol (CE Delft, 2024).

Table 7 - Indicative reduction targets for 2028 and 2040 compared to 2019 emissions for the four remaining carbon budgets

Remaining European aviation carbon budgets	2028	2030	2040
3.2 Gt (3.9%, 500 Gt)	25%	31%	57%
2.8 Gt (2.4%, 700 Gt)	45%	49%	66%
2.0 Gt (2.4%, 500 Gt)	65%	69%	84%
1.6 Gt (2.0%, 500 Gt)	82%	84%	92%

For the two lowest carbon budget of 2.0 Gt and 1.6 Gt in the figure, the reduction targets are very difficult to achieve. Both require an immediate drastic decrease in carbon emissions, with 2028 carbon emissions much below the 2020 values, which was the peak of the COVID-19 pandemic. The budgets that result from allocating the same budget to all global citizens (see Table 4) set maximum limits to European aviation emissions of 1.9 Gt (for the 700 Gt global budget) and 1.3 Gt (for the 500 Gt global budget). Both seem to be out of reach.

Overall, the reduction paths show that in order to stay within the limits of the remaining carbon budgets, the aviation sector needs to increase decarbonisation efforts.
The development of the aviation sector without additional decarbonisation policies is not in line with the Paris Agreement. The expected technological and operational efficiency improvements and upscaling of SAF production is not sufficient. As a last resort, immediate demand management measures are necessary to align the aviation sector with the goals of the Paris Agreement. This would also decrease the risk of overshoots and prevent the introduction of more extreme measures in the future.

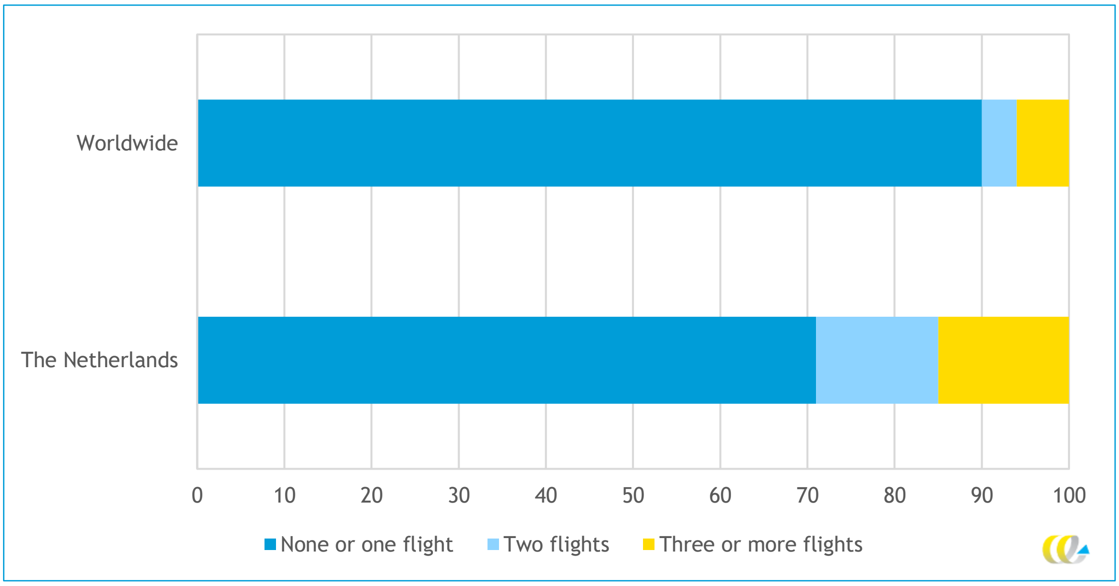
3 Distribution of aviation activities

A Frequent Flying Levy addresses the overall climate impact of aviation by reducing the demand through ticket price increases. Since the levy increases with the number of flights per passenger, it also addresses the heterogeneous distribution of flying between individual people. This chapter describes the current distribution of aviation activities which is a necessary input for modelling of the effects of a FFL. We discuss the distribution of aviation activities (flying frequency and emissions) and their relation to wealth distributions globally and for citizens in European countries.

3.1 Imbalance of flying frequency distribution and related CO_2 emissions

Currently, the aviation sector shows large imbalances of flying frequency and CO_2 emissions on a global level. Approximately 90% of the global population doesn't fly or buys one return ticket a year (this is called flying once in this section), while approximately 6% of the global population flies more than twice a year. 1% flies more than five times a year (IEA, 2022b). In developed countries, like the Netherlands, almost 30% of the population flies more than twice. Figure 5 shows the comparison of the Netherlands with the world average.

Figure 5 - Flying frequency distribution globally and in the Netherlands



In emissions the imbalance is even bigger than in the number of flights. For example approximately 1% of the global population accounted for over half of all emissions from commercial aviation in 2018 (Gossling, 2020). These imbalances in emissions are amplified since frequent flyers more often fly long-haul and premium class (business class or first class). The longer flight distances and space requirements of higher comfort classes in aircrafts lead to more emissions than short-haul economy class trips. Flying business class results in two to three times more CO_2 than passengers in economy class due to the larger space requirements. To illustrate this further, on a global level, in 2019, long-distance flights (above 4,000 km) represented approximately 6% of flight departures and half of all CO_2 emissions.

On the European level, a survey of the travel frequency and destinations showed that approximately 17% of the EU28 population take 77% of the trips within the EU, and 4% of the EU28 population take 52% of the trips outside the EU (Gossling, 2020). The choice of destination (and therefore flight distances) and seating class depends on the travel purpose, described hereafter.

3.2 Relation to wealth distribution

Flight frequency is strongly related to income since passengers with high incomes fly disproportionally more than low income passengers (Banister, 2019; Cass, 2022; Fouquet & O'Garra, 2022; Gossling, 2020; Otto et al., 2019). Table 8 shows the proportion of non-flyers and frequent flyers for countries for different wealth categories. In the lowest income category countries 98% of the population does not fly, whereas this number drops to 51% for the high income countries. For those with more than six return-flights per year, the trend is opposite, making up 0.02% of the population of the low income countries and 10% in the high income countries.

In 2019, 80% of the flights were taken by the wealthiest 20% of the world population and 40% of the total passenger traffic was attributed to 2% of the world population who took more than six return flights.

Table 8 - Estimated non-flyers and frequent flyers (selected here by 6 and more return flights per year) by country income groups globally for 2019 (World Inequality Lab, ongoing)

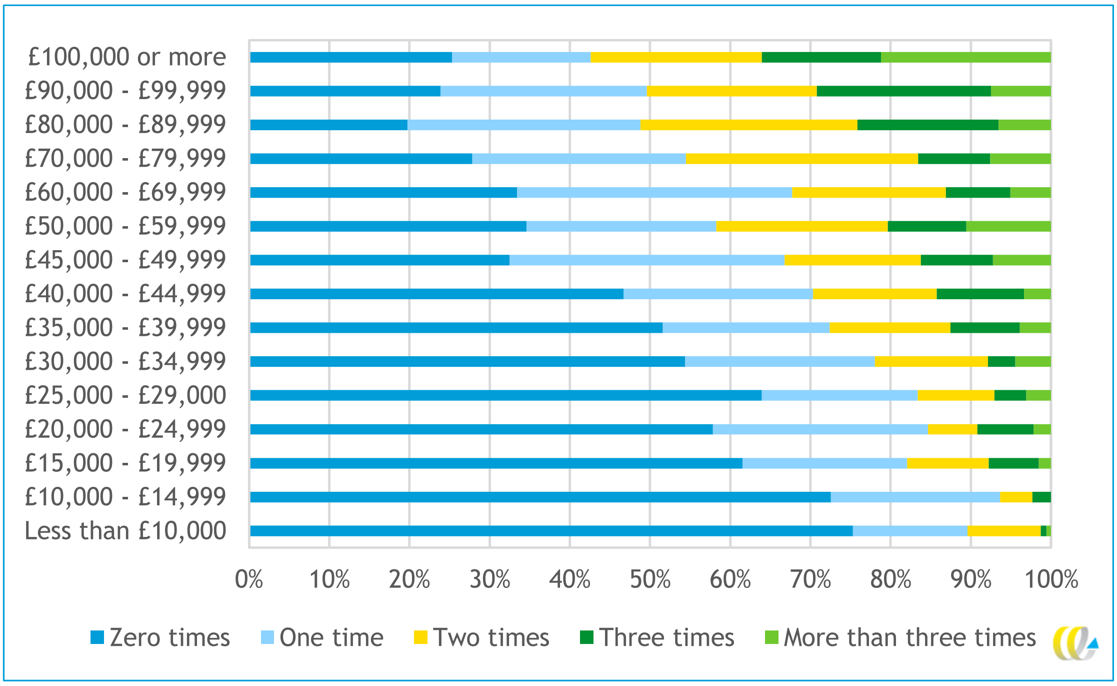
Country classification	Total population (millions)	Non-flyers		Flying 6+ return flights/year	
		Count (millions)	Percentage of population	Count (millions)	Percentage of population
High income	1,210	614	51%	121	10%
Upper middle income	2,679	1,848	69%	46	2%
Lower middle income	3,058	2,695	88%	16	1%
Low income	724	710	98%	0.2	0.02%
Total	**7,670**	**5,868**	**76%**	**182**	**2%**

Within a country, the number of flights for an individual is also strongly correlated with income. Using ECF data a case study is made for the United Kingdom (More in Common, 2024). Figure 6 shows the proportion of the UK population flying zero, one, two, three or more than three times a year for a holiday abroad per household income group[11]. In a wealthy country like the UK, 75% of the lowest income group does not fly compared to 25% for the highest income group. There are almost no frequent flyers with more than three flights a year in the lowest income groups (< 1%) while in the highest income group 21% is a frequent flyer.

[11] Counting people going on holiday abroad who 'always fly' or 'tend to travel by plane' from the ECF survey.

Using this data[12] the relation between the average number of holiday flights versus household income is plotted in **Figure 4**. The dotted line represents a linear fit of the data showing a strong linear relation between the number of flights and household income.

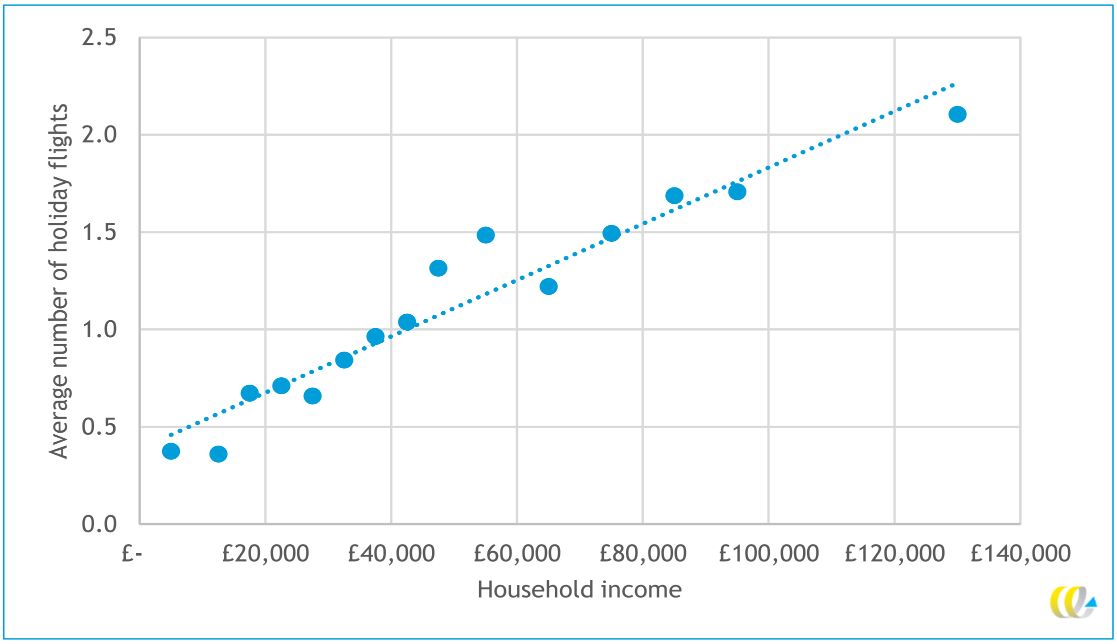
Figure 6 – Number of holiday return flights per year for household income groups in the UK



Source: CE Delft analysis based on ECF data (More in Common, 2024).

[12] Assuming 'more than three times' is on average five flights per year and '£ 100,000 or more' is on average £ 130,000.

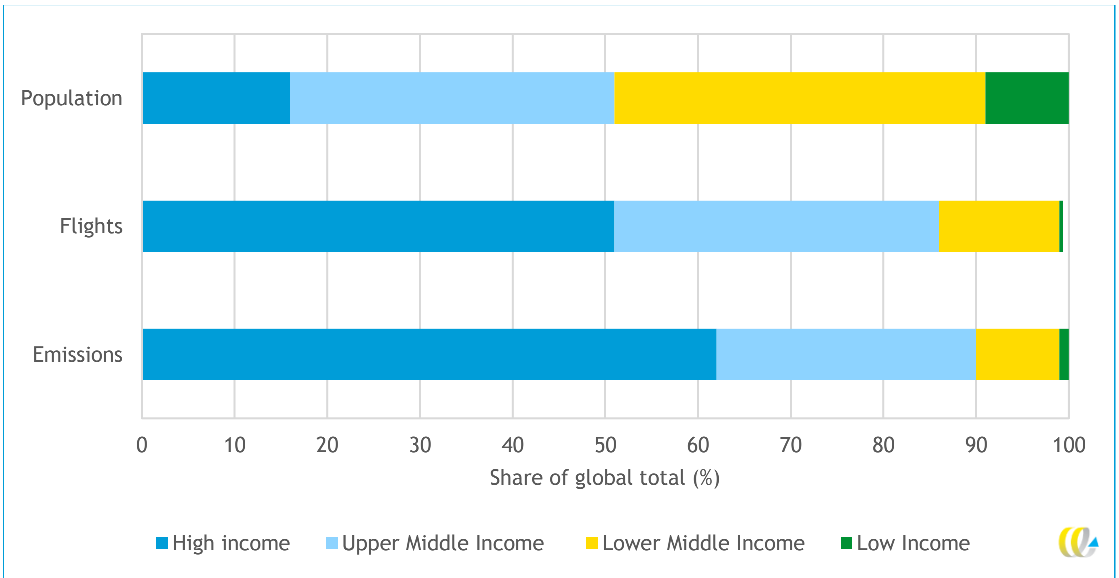
Figure 7 - Average number of holiday flights (return flights) per person versus household income in the UK



Source: CE Delft analysis based on ECF data (More in Common, 2024).

Similarly to the flying frequency, carbon emissions are also highly correlated to income (documented in (Chancel, 2022)). A study by ICCT estimated that 62% of the passenger CO_2 emissions originate from high income countries, while 1% of CO_2 emissions come from the low income countries. This shows the disparity between countries belonging to the high income and low income brackets (apportioned by World Bank, 2019 data) and the clear correlation between emissions and income. Figure 8 summarises the imbalance in the number of flights and emissions for different citizens from poor and rich countries.

Figure 8 - Population, flights and CO_2 emissions from passenger aviation operations distributed by country income bracket

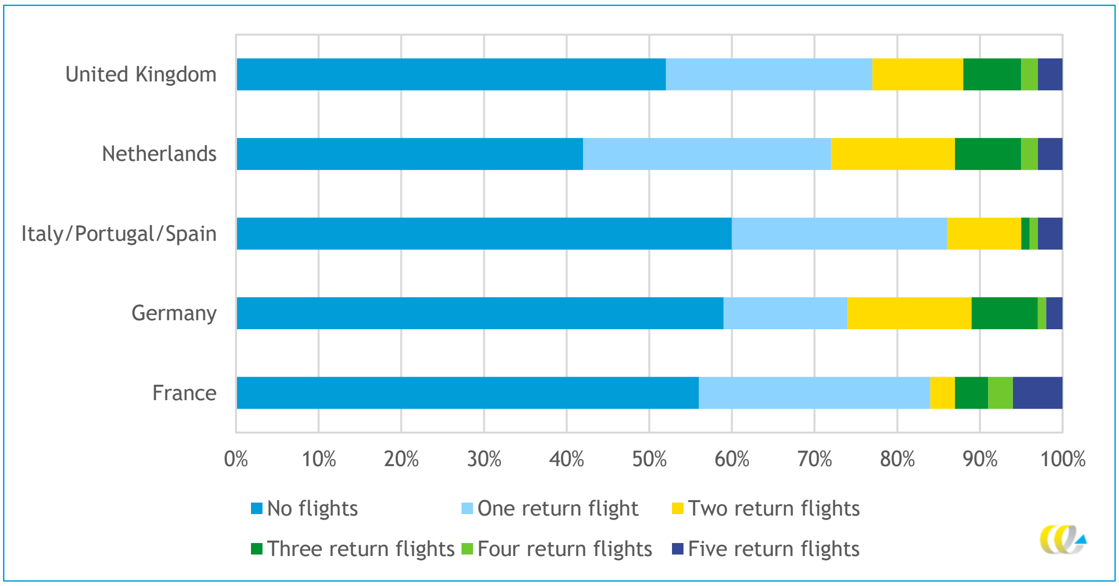


Source: (United Nations, ongoing; World Bank, ongoing).

3.3 Differences between European countries

In the previous section the dependence of the propensity to fly has been discussed on the global scale. Also within Europe, there are notable differences in the flying frequency between individual countries. In Figure 9 the distributions are shown for a selection of Western European countries. It shows that the percentage of the population that does not fly varies between approximately 40-60%. Passengers flying more than five times represent approximately 3-6% of the country's population. Factors influencing the propensity to fly are the income, the geographic location of a country and on passenger level the travel purpose, which will be discussed in the following section. Similar data was not available for Eastern European countries which have a lower GDP and less passengers per capita. This dependence is discussed further in Annex A.3.

Figure 9 - Distribution of (return-)flight frequency for select representative countries from EFTA + UK



Source: (ICCT, 2022).

3.4 Travel purpose

In this study we distinguish three main travel purposes of air passenger travel. They are:

- Business passengers: Passengers travelling for business purposes, for a meeting with clients, conference, etc. The flight tickets of these passengers are usually paid by the company/organization resulting in a low price sensitivity. The passengers have little flexibility to postpone trips, and are constrained to certain travel locations.
  In developed countries approximately 20% of air travel is for business purposes (IEA, 2022a). The COVID-19 pandemic however, has increased remote meetings and business interactions, leading to a decrease in business passenger travel (IEA, 2022b). It rose again, but not (yet) to previous levels.
- Visiting friends and relatives: In a globalised world many people in all income categories live separated from their families and friends. When visiting them the location is constrained (like for business passengers). In general, these passengers are more flexible in the travel time and more price sensitive, since they have to pay the tickets by themselves.
- Leisure: Passengers travelling for vacation purposes have the highest flexibility.
  They can make choices regarding the destination (include a flight or not), duration and

have some flexibility with regards to the timeframe of the trip. On average, these passengers are the most sensitive to ticket price changes.

For distances up to 1,000 km, there is regular competition between air and ground transport. For distances between 1,000 and 2,000 km ground transport is often significantly slower, more expensive and less convenient (during the booking process and the journey). For most distances above 2,000 km and all intercontinental destinations, taking a flight is usually the only feasible option.

When ticket prices increase many passengers will accept the higher costs and not change the travel behaviour. The share depends strongly on the changes in price levels. For those who change the travel behaviour the chosen options depend manly on the travel distance and the travel purpose. Passengers with a fixed destination (business and visiting family and friends) will travel less. For trips below 2,000 km they will also partly change the transport mode and travel by car or train instead by plane. Leisure passengers will in addition change their destination choice and chose destinations closer by, which do not require flying.

Conclusion
- for the business segment the price is on average less important than in the other segments;
- passengers of all travel purposes choose between air and ground transport for short flights;
- leisure passengers are most flexible and sensitive to ticket price changes.

Conclusion

- There is a high imbalance of aviation activities (in terms of flying frequency and carbon emissions) on a global, European and country level. The imbalance is highly related to the wealth distribution.
- Higher carbon emissions are reported for long-haul flights and passengers purchasing business class seats (factor 2 to 3 compared to economy).
- Passengers have different travel purposes (business, visiting family and friends, leisure) and therefore fly more or less and are more or less flexible.
- The number of flights correlates strongly with income. For the UK a linear correlation between the income and the number of flights has been observed.
- The current situation of aviation activities in Europe highlights the imbalance of flight frequency and emissions. A possible solution to reduce emissions from aviation is via demand management in the form of international price measures described in the following chapter.

4 Effects of introducing a Frequent Flying Levy

In this chapter we present the effects of introducing a Frequent Flying Levy. Firstly, in Section 4.1 we define the taxation policy. In Section 4.2 the rates are described, followed by a short description of the estimation method in Section 4.3. In Section 4.4 the main results on passenger demand, CO_2 emissions and taxation revenues are described. This is followed by a more detailed discussion of the effect for households in different income categories (Section 4.5), on the travel distance (Section 4.6), per seating class (Section 4.7), the effect of surcharges (Section 4.8), and the effect of replacing national ticket taxes (Section 4.9).

4.1 Description of Frequent Flying Levy

A Frequent Flying Levy (FFL) is a taxation policy aiming to reduce carbon emissions from the aviation sector through passenger demand management. The FFL is applied onto the ticket price, increasing the added charge for every return flight[13] taken by an individual within a year. Next to the increase in the rate per consequent flight, it is possible to include distance dependent or class dependent surcharges that incorporate the higher environmental impacts of medium/long-haul and business class/first class travel (CE Delft, 2023). This is especially recommended as a tax on kerosene (which is distance-based) is still lacking for international flights (and also in most cases for national flights). In addition to the possibility of surcharges, the FFL can replace current national taxation or can be added on top and it has to be decided how to deal with transfer passengers.

To summarise, in this study we distinguish the following dimensions in the taxation policy:
- Transfer passengers: included or excluded, which implies the question whether the transfer at an European hub is counted as an additional flight or not.
- National ticket taxes: replaced or an add-on.
- Surcharges for medium-haul, long-haul[14] and business/first class: included or excluded.

In this study the effects of a European FFL are estimated for passenger transport in EU27, the UK and EFTA countries (Iceland, Liechtenstein, Norway, Switzerland) for the year 2028. Due to this geographical scope the levy leads to a level playing field for aviation within Europe and for flights to and from Europe. Global transfer passengers with a transfer in Europe are only affected in case of an inclusion of transfer passengers. Evasion of passengers may play a role in the South-East European region and additional measures might be helpful to prevent unintended effects of the levy. However, since evasion is a feasible option for a relatively small number of passengers, this has a minor effect on the overall results for passenger demand, global CO_2 emissions and tax revenues. Hence, it is out of scope of this study.

[13] In this study a maximum rate is charged for five and more return flights.

[14] Medium-haul represent flight distances between 1,500 km and 4,000 km. Long-haul represent flight distances above 4,000 km.

Based on the findings of Section 2.7, the policy should be implemented as soon as possible. This is because the carbon budget is made up of cumulative CO_2 contributions and the sooner demand reductions/decarbonisation efforts are implemented, the lower the risk of overshoots and more extreme measures in the future.

4.2 FFL tariffs

The Frequent Flying Levy considered in this study consists of a general levy, which increases with the number of flights and surcharges for medium/long-haul and business/first class, which do not vary with the flight frequency. The levy is applied to all passengers departing from European airports, where an additional charge is added to the ticket prices and replaces current national departure taxes.

The general levy starts with zero for the first two flights (first return flight), and the rate increases after each second flight (each return flight) within the year[15]. To account for the distance and the comfort class people are travelling, different levels of surcharges are introduced for medium-haul, long-haul, and business/first class passengers. Transfer passengers pay the same rates as direct passengers for a return-trip to the final destination. Hence, what is called a flight within this study, might also describe a combination of multiple flights for a trip from the origin to the final destination.

In this study we have considered the following FFL ticket rates and surcharges for distance and seating classes (see Table 9). The rates are proposed by the client of this study. It is assumed that the levy is applied for passengers buying a flight, no matter whether it is a single flight, a return flight, or a multi-stop flight.

Table 9 - FFL tariffs and corresponding surcharges per individual flight implemented in this study (in €$_{2023}$)

Number of return flights	Individual flights	General levy per flight	Surcharge medium-haul	Surcharge long-haul	Surcharge business/first class
1	1 and 2	0	50	100	100
2	3 and 4	50	50	100	100
3	5 and 6	100	50	100	100
4	7 and 8	200	50	100	100
5	9 or more	400	50	100	100

The tariffs presented in Table 9 are defined for passengers departing from European airports. However, trips between European and non-European airports are charged twice the rate, since the return trip is not part of the policy. With this implementation a stimulation of long-haul flights is prevented, since without this factor two long intercontinental flights would be charged lower than short flights within Europe.

The rates of this approach lead to significant increases in ticket prices for passengers flying multiple times in a year. A ticket of a fifth return flight in a year would increase at least by € 800, without surcharges. The modelling in this study stops with five return flights, however, when putting the levy into practice, it could also be considered that the levy

15 In order for the FFL to work well, a European registration system is required, which registers the flight activities of all passengers at European airports. The implementation of such a registration system and the alignment of European privacy standards is a challenge, which requires special attention, but which is not investigated as part of this report.

continues rising for each additional (return) flight. Many return flights within Europe can currently be booked for prices below € 200. The prices of these tickets would increase to € 1,000[16], if this is the fifth return flight. This is a price increase of 400%.

4.3 Estimation method

The estimation of the effects of a FFL is very complex since the response of travel demand on ticket price changes is only known to a limited degree. Most studies refer to price elasticities that have been estimated more than 15 years ago which do not distinguish between income and flight frequency (InterVISTAS, 2007), important categories for estimating the response of introducing a FFL. A literature review did not provide new insights on price elasticities. In addition, the reported elasticities are only valid in the price regime of current ticket prices. Large ticket price changes, which can occur as a consequence of the FFL, may lead to other behavioural changes, which are not incorporated in the reported elasticities.

To estimate the impact of the FFL, we make use of the European aviation model AERO-MS[17]. The model is used to quantify economic and environmental impacts of policy measures related to the emission reduction in the air transport system. The baseline scenario for the estimations is the Mid growth ICAO traffic forecast[18] for 2028 which takes into account the impacts of the outbreak of COVID-19. AERO-MS does not incorporate information of the flight frequency of individual passengers. Therefore, a pragmatic approach has been chosen to take into account country-specific flight frequency distributions and variations in the price elasticities per flight frequency for economy and business class passengers.

The model calculates the passenger demand, CO_2 emissions as a function of the flight distances, seating classes (economy vs business/first class) and destination region, as well as the taxation revenues for all Europe 31 countries separately. It provides the outputs for the baseline in 2028 and for possible implementations of the FFL in the same year. A more detailed description of the method and the assumptions can be found in Annex A.

4.4 Main results of a FFL

In the baseline scenario, 1.138 million passengers depart from European airports in 2028. This is 15% more than the pre-COVID-19 level of 994 million passengers in 2019.
The expected CO_2 emissions of all departing flights from these airports is expected to be around 188 Mt (being similar to 188 Mt in 2019[19]) and national ticket taxes lead to tax revenues of € 10.5 billion. The general results of the passenger demand, CO_2 emissions and taxation revenues are presented in Table 10.

Replacing the national taxation by the FFL as presented in Table 9 results in a significant reduction of passenger demand (-26%), which translates to a 21% reduction in CO_2 emissions

16 In this example the fact is neglected that current national taxation is subtracted.

17 AERO-MS is a validated European aviation model that has been used in many official impact assessments for the European Commission: https://trimis.ec.europa.eu/sites/default/files/project/documents/20130218_181700_44187_TeamPlay_ToolDescriptionAEROMS.pdf

18 https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2022/ENVReport2022_Art7.pdf

19 In this period of nine years the growth in demand and the efficiency improvements of the aviation sector compensate each other leading to the same emission levels in the two years.

from flights departing in Europe. The taxation revenues would rise to € 74 billion, corresponding to approximately 600% increase of the baseline taxation rates of 2028.

Table 10 - Overall results of effects of the FFL in terms of passenger loads, CO_2 emissions and tax revenues

	Baseline scenario 2028	FFL	% change
Passengers (millions)	1,138	844	-25.8%
CO_2 emissions (Mt)	188.5	148.6	-21.1%
Taxation revenues (billion €2023)	10.5	74.1	607%

Figure 10 - Impacts of FFL on the flying frequency of passengers departing from Europe31

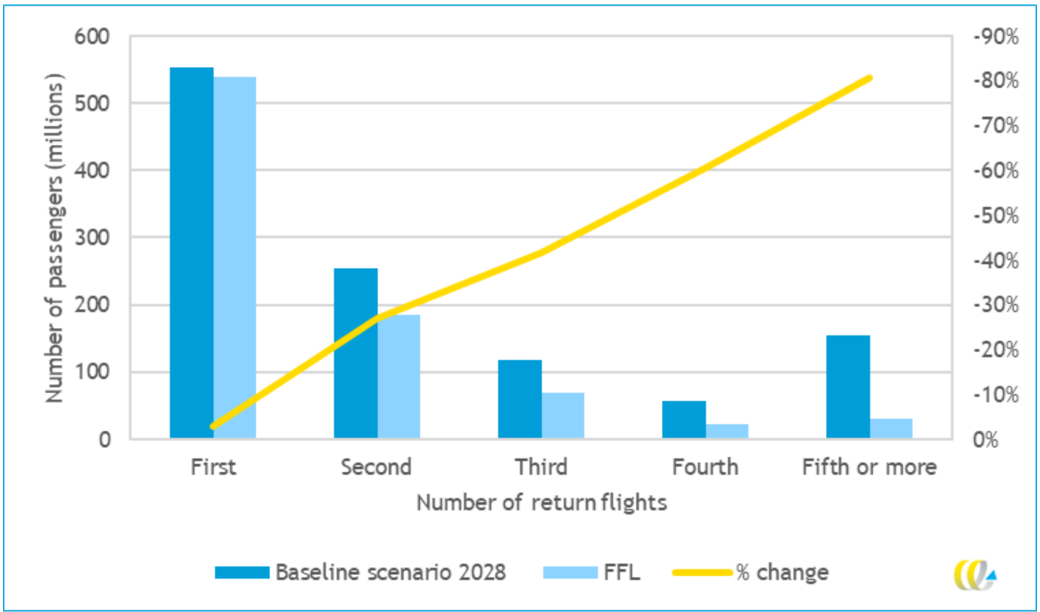


Figure 10 shows the effect of the FFL on the number of passengers in categories of the number of annual return flights. For passengers flying once a slight decrease of 3% is observed. This is due to the fact that the surcharges for medium and long-haul flights and for business and first class are higher than the current national departure ticket taxes. The demand of passengers flying more often is significantly more decreased with up to 81% for passengers taking five or more return flights in a year. This significant reduction is caused by price increases for return tickets of approximately € 800. This highlights the effectiveness of the FFL taxation policy for passenger demand management, and therefore CO_2 emission reduction.

4.5 Impacts of a FFL per household income group

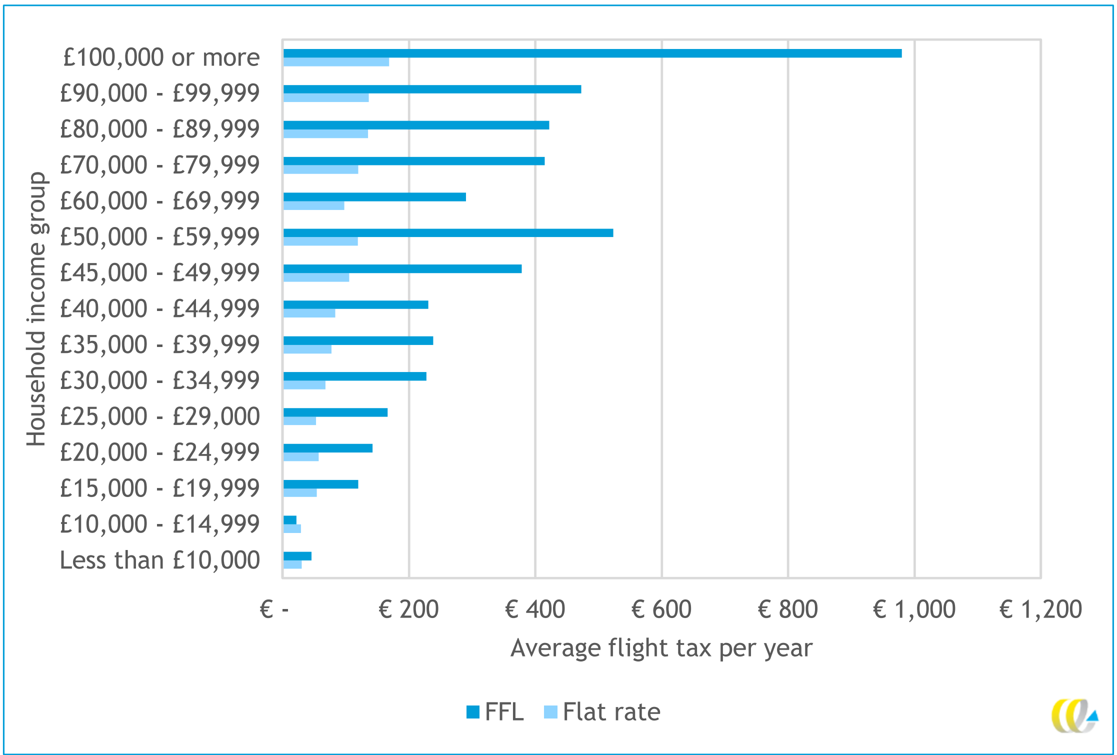
The impacts of the FFL differ significantly for households belonging to different income groups. We show this in this report as an example for the United Kingdom based on the case study from Section 3.2 and a fictive flat tax rate of € 80. Note, that the UK has one of the highest ticket taxes in Europe, which also distinguishes the flight distance and the comfort class (see Table 16). For other countries the qualitative effects would be very similar, but the tax paid per income category would be lower, due to lower national taxes.

Figure 11 shows the average yearly flight tax paid for each household income group for the proposed FFL and the fictive flat tax rate of € 80. Notice that the FFL tax rate is strongly dependent on the household income. The highest household income groups pay on average almost € 1,000 a year, while the lowest income groups just pay around € 30. This is due to the fact that most frequent flyers are in the higher income groups, paying incremental tax rates for each additional flight per year. While in the lower income groups most people do not fly, or just once a year, being exempted from the FFL.

A flat tax rate of € 80 per return flight results on average in about the same tax rate as the FFL for the low household income groups (although now also people flying once a year are taxed). For the higher income groups the taxes of the FFL are about a factor six higher than the flat rate. This comparison clearly shows that the FFL puts a much higher tax burden on high income groups, since they statistically fly significant more than low income groups. On individual household level the differences are even bigger. Households that fly once a year, profit from a reduction of the taxes when flying short-haul, since they are completely exempted from the FFL. Since many low and middle-income households do not fly or fly once per year, their tax burden is reduced, whereas the tax burden for most individual households with a high income is significantly increased.

In addition, passengers in high income categories buy relatively more long distance flights in the business class and first class, the shown comparison is even an underestimation of the distinction between low and high income groups. Due to the surcharges on the travel class and long distance, the tax contribution of high income groups is even higher compared to the lower incomes.

Figure 11 – Average yearly flight tax per household income group (in British Pounds) for the proposed FFL rates and a flat tax rate of € 80 per return flight. Analysis based on EDF data for the UK (see Section 3.2)



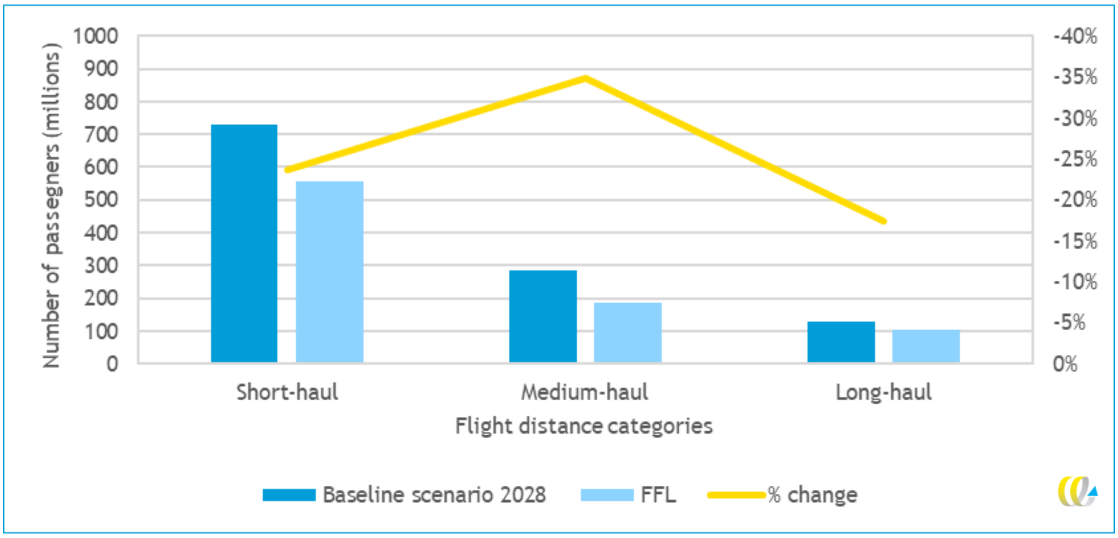
4.6 Impacts of FFL on travel distance

Next, we discuss the impacts of the FFL in more detail, identifying the different factors and their dependencies with respect to the taxation policy. The impact of the FFL on the flight distances in terms of the number of passengers and CO_2 emissions is shown in Figure 12 and Figure 13, respectively for short-haul (distances below 1,500 km), medium-haul (distances between 1,500 km and 4,000 km), and long-haul flights (distances above 4,000 km).

Impact on passenger demand

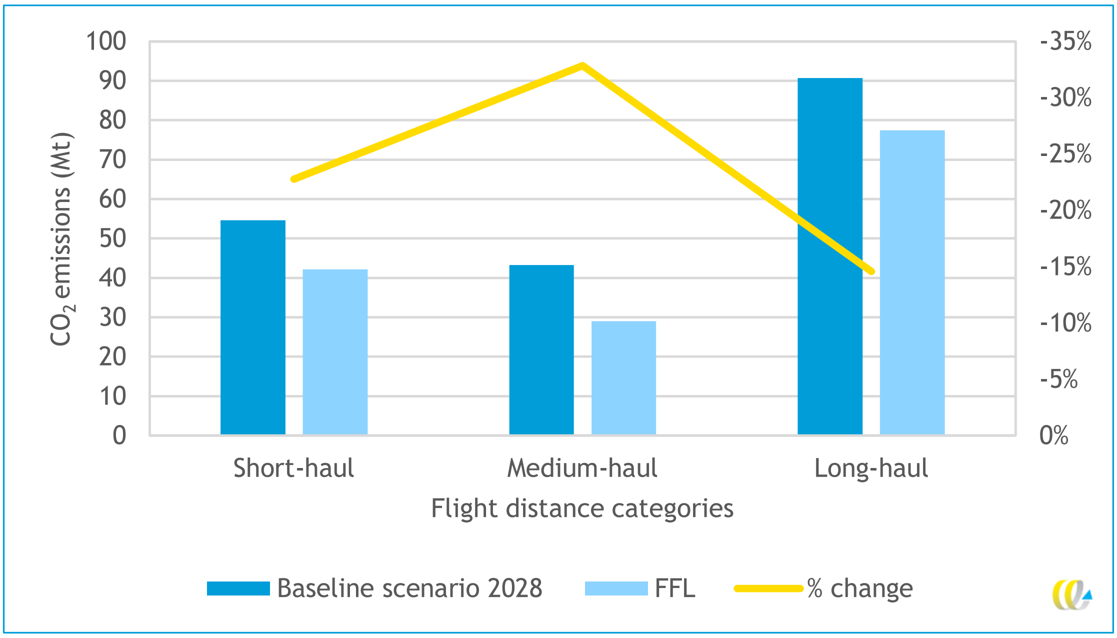
In the forecast almost 65% of all passengers travel short-haul in the baseline scenario. In this segment the FFL leads with a reduction of 172 million passengers to the largest absolute reduction. The relative effect is -24%, which is smaller than the -35% observed for the medium-haul segment. The reasons are the surcharges in this segment and a higher share of non-business travellers. For long-haul flights, however, passengers generally pay higher ticket prices with the result that the relative increase in ticket prices is lower than for the short- and medium-haul segments, even with an additional surcharge of € 100. Hence, in this segment demand drops by only 17%. An overview of the impacts of more detailed distance classes are shown in Annex B.

Figure 12 - Impact of FFL per distance category in terms of the number of passengers (in millions) and relative change



Impact on CO_2 emissions

Figure 13 - Impact of FFL per distance category in terms of the CO_2 emissions (Mt) and relative change



The relative impact of the FFL on CO_2 emissions is similar to the change observed for passenger demand, highest in the medium-haul segment and lowest for long-haul flights. However, the high amount of emissions on long-haul flights compared to short-haul flights leads to very different results for the absolute emissions. Although only 11% of the passengers travel long-haul in the baseline scenario, a relative CO_2 effect of -15% leads to an absolute reduction of 13.2 Mt CO_2, which is similar to the 12.4 Mt for short-haul and 14.2 Mt for medium-haul.

4.7 Impact on the flight frequency distribution for economy and first class and business class passengers

The general levy increases for each consecutive return flight (with a free first return flight) and has an additional surcharge of € 100 per flight for business class and first class tickets. This implies that return tickets in the business class increase by € 200 extra compared to economy class, with the same flight frequency. In this section the effects for the comfort classes economy and the combination of business class and first class are investigated. Figure 14 shows the effect on the passenger demand in the economy class, while Figure 15 depicts the results on the business/first seating class.

In the baseline about 96% passengers travel economy class and 4% travel premium. For the economy class a very strong decrease in flying frequency is overserved, whereas demand of comfort class passengers is only slightly reduced. For five and more flights the effect is -83% for economy class and only -14% for premium class. The reason is a lower price sensitivity in the business and first class.

Figure 14 - Effect of FFL on economy class passenger demand for each return flight

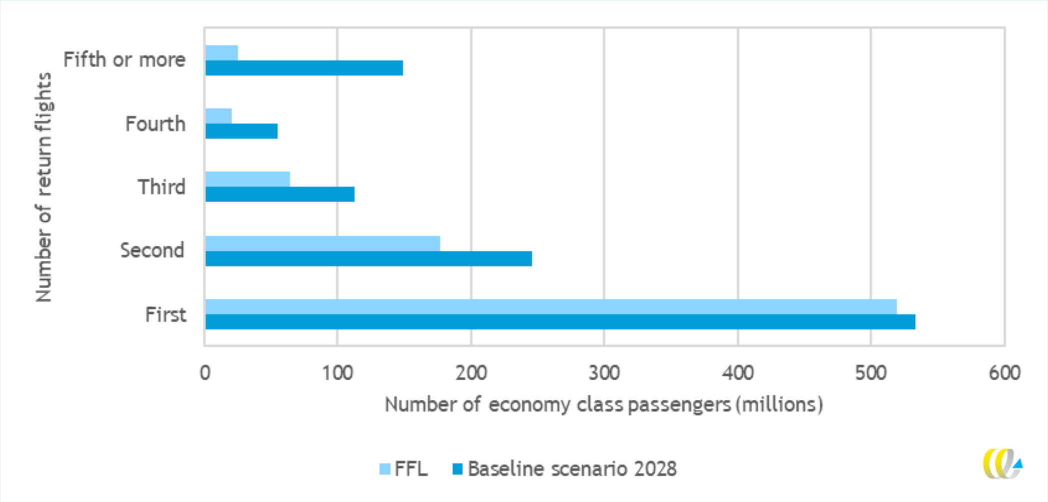
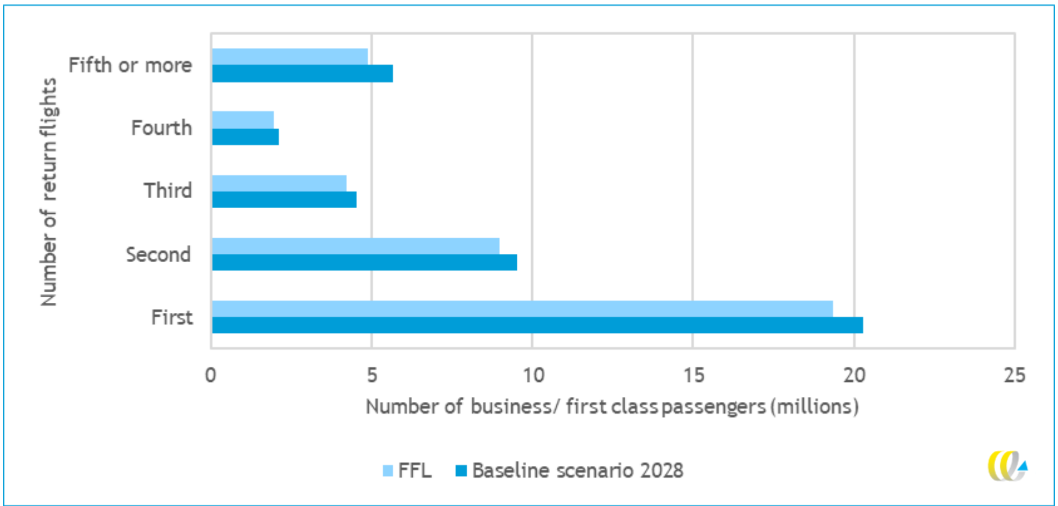


Figure 15 - Effect of FFL on business/first class passenger demand for each return flight



4.8 Effects of surcharges

In the previous sections the effects of a FFL including surcharges for distance and seating class have been presented. In this section, the effect of the surcharges is investigated by redoing the analysis without the surcharges, see Table 11 for the results. Without the distance surcharges the FFL will cause a 20.5% decrease in passenger demand, compared to the larger 25.8% reduction for the FFL including surcharges. Since these surcharges are applied to the distance where the carbon footprint is relatively higher, the FFL without surcharges will be significantly less effective in CO_2 emission reductions, -13.1% instead of -21.1%. Also, the surcharges represent a significant amount of the taxation revenues.
The tax revenues drop by more than 30% from € 74 billion to € 49 billion. We find that the effects of also removing the surcharges for seating class are relatively small, with changes in the number of passengers and CO_2 of only 0.2% point. It however has an effect on the revenues: without class surcharges, it would mean € 6.2 billion less tax revenues. For the

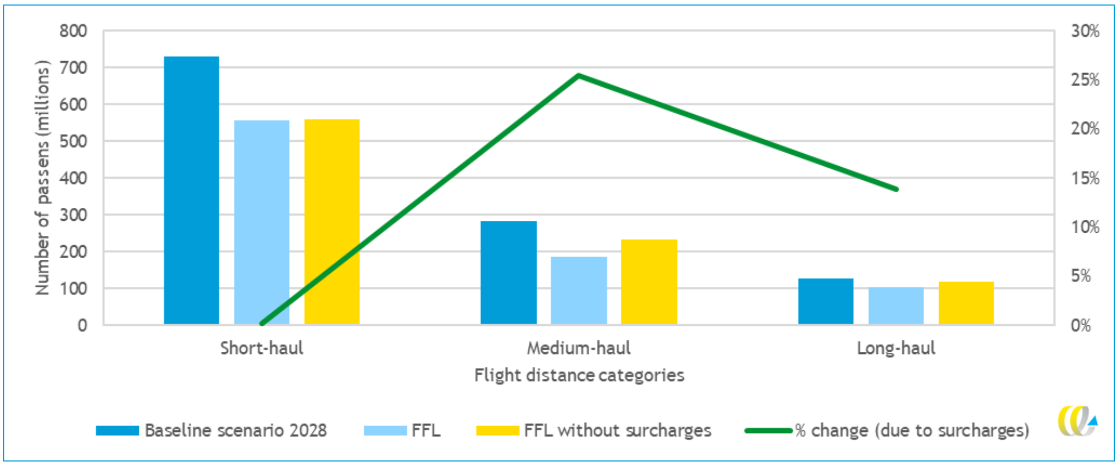
goal of reducing emission, the surcharges the distance component is by far the most important.

Table 11 - Overall impacts of the FFL with or without surcharges

	Baseline scenario 2028	FFL with surcharges		FFL without distance surcharges		FFL without distance and seating class surcharges	
		Absolute values	% change (compared to baseline)	Absolute values	% change (compared to baseline)	Absolute values	% change (compared to baseline)
Passengers (millions)	1,138	844	-25.8%	905	-20.5%	906	-20.3%
CO_2 emissions (Mt)	188.5	148.6	-21.1%	163.7	-13.1%	164.2	-12.9%
Taxation revenues (billion €$_{2023}$)	10.5	74.1	607%	48.8	359%	42.6	307%

Figure 16 depicts the effects including or excluding the distance dependent surcharge on the passenger demand in three distance classes. For short-haul there is no effect, since prices are identical, but for the medium- and long-haul segments significant differences are observed. Compared to the situation with the surcharges, demand for medium- and long-haul increases by 25% and 14% when the surcharges on distance would not be applied.

Figure 16 - Impacts of surcharges on passenger demand for different flight distances



4.9 Effects of replacing national taxation

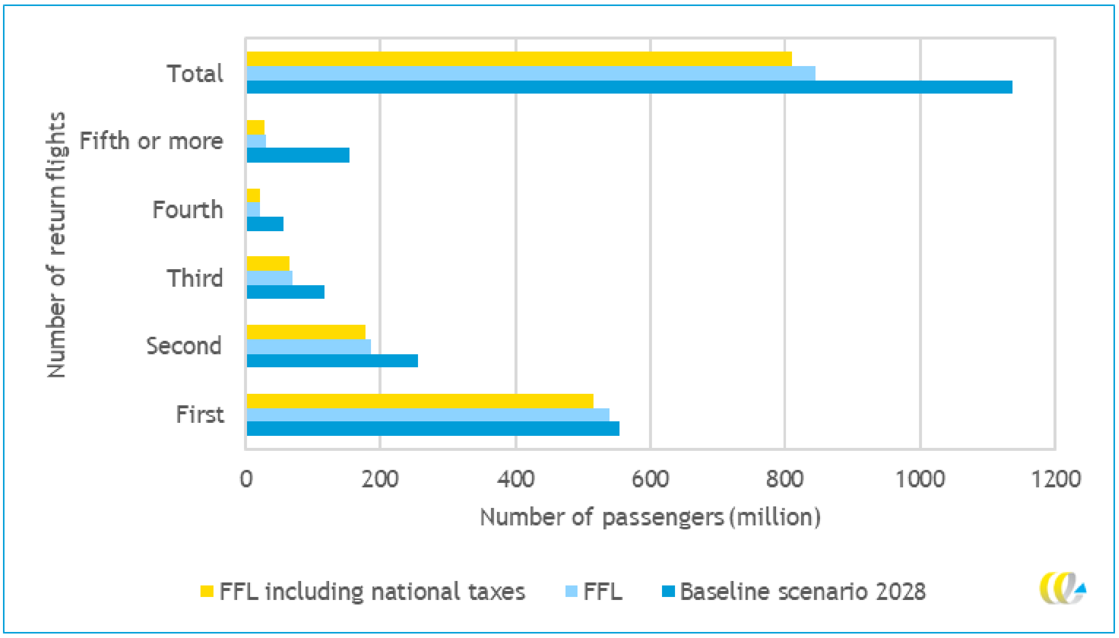
In all estimations presented in this section, it is assumed that the FFL will replace current national departure taxes. In this section, an alternative is investigated, in which the current national taxation is kept in place and the FFL is added on top.

Table 12 - Overall impacts of the FFL including or excluding national taxes

	Baseline scenario 2028	FFL excluding national taxes		FFL including national taxes	
		Absolute values	Absolute values	Absolute values	% change (compared to 2028)
Passengers (millions)	1,138	844	-25.8%	810	-28.8%
CO_2 emissions (Mt)	188.5	148.6	-21.1%	144.6	-23.3%
Taxation revenues (billion €$_{2023}$)	10.5	74.1	607%	80.4	667%

In general, the FFL with added national taxes, leads to higher final ticket price and will therefore cause a larger impact. This leads to approximately 3% extra reduction in demand, 2.2% in CO_2 and an increase of tax revenues by 10%. The effect on the number of flights per passenger is visualised in Figure 17.

Figure 17 - Impact of national taxation on the flight frequency



5 Discussion

Today, climate change has impacts on both nature and human beings. In the next decades the intensity will increase. Evidence accumulates that the physical impacts of a temperature increase of 2˚C above pre-industrial levels may be disproportionally larger than those of a 1.5˚C increase. Therefore, the global leaders have agreed in the Paris Agreement to limit global warming to well below 2˚C and to aim for 1.5˚C.

CO_2 is the key driver of global warming and it adds up cumulatively in the atmosphere. Therefore, the goal of the Paris Agreement can be translated into remaining global carbon budgets. Based on the latest estimates from IPCC for these global budgets and possible ethical principles, part of this budget can be allocated to the European aviation sector.

The estimations of realistic remaining European aviation budgets in combination with expected growth rates for aviation, show that immediate reduction of carbon emissions is necessary. Otherwise, aviation requires a disproportional large amount of the remaining carbon budget. In the future, the demand of aviation for clean energy and land for biomass production competes with other sectors. A socially fair and balanced allocation between different sectors and different parts of the world is desirable and will set limits to the access of aviation to theses scarce resources. In addition, most decarbonisation roadmaps of the aviation sector depend on uncertain technological breakthroughs. This report concludes that the expected technological and operational efficiency improvements and upscaling of SAF production are not sufficient. As a last resort, immediate demand management measures are necessary to align the aviation sector with the goals of the Paris Agreement. We have estimated necessary reductions of 25% to 82% in 2028 compared to 2019 levels.

Currently, non-CO_2 effects of aviation are estimated to be responsible for 2/3 of the total aviation climate effect. Since they do not add up cumulatively, they are not considered in the remaining carbon budgets. However, it is very important to develop efficient non-CO_2 policies and to reduce them as soon and as fast as possible. In a net-zero situation non-CO_2 emissions have to be compensated. Due to this specific challenge for the aviation industry and its high historic aviation emissions and welfare, the European aviation sector should set ambitious targets.

Stay Grounded and other NGOs propose a European Frequent Flying Levy to reduce demand for aviation and hence emissions in the short term, applying the polluter pays principle. The proposed levy with an exemption for the first return flight and an incremental increase of the levy per flight (€ 50 - flight 3 and 4, € 100 - flight 5 and 6, € 200 - flight 7 and 8, € 400 - 9 and more flights) in combination with surcharges per flight for first/business class (€ 100), medium-haul (€ 50) and long-haul flights (€ 100) per individual flight leads to a significant reduction in demand and additional annual tax revenues of € 63 billion, assuming that the FFL replaces existing national ticket taxes. Due to this policy the number of passengers at European airports is estimated to reduce by 25.8% and CO_2 emissions by 21.1%. The reduction in emissions is comparable to the -25%, which would be required to align with a remaining European aviation carbon budget of 3.2 Gt. The main characteristics of this budget are:

- Based on 500 Gt global budget, which corresponds to a 50% likelihood that global warming is limited to below 1.5˚C.
- The share of aviation in global emissions rises from 2.4 to 3.9%, since aviation is a costly-to-abate sector. Other allocation principles (see Section 2.3 and below) lead to lower shares for aviation.

- A socio-economic forecast based on current aviation activities in Europe is applied to set the European share to 16.4%, which is only slightly lower than the 2019 share of 18.2%. This share is much higher than an equally distributed share per world citizen, which would allocate only 6.8% to Europe (which would result in an approximately 60% smaller budget).

Budgets estimated from larger remaining global carbon budgets would increase the aviation budgets, but it is questionable whether they can be considered to be aligned with the Paris Agreement. Most other principles to allocate the budget between aviation and other sectors as well as between Europe and the rest of the World, would lead to smaller budgets for European aviation and hence require more reductions in 2028.

Test estimations with a doubling of the levy per flight and all surcharges lead to a reduction of CO_2 emissions by 34%. It has to be noted that the elasticities used in this study are not valid anymore for price changes that are so large. Hence, the results are very uncertain. However, this test shows that the emission reduction targets of 65 to 82% in 2028 estimated for remaining carbon budgets based on a constant or decreasing share of aviation emissions are very difficult to achieve with a European FFL as a single policy. To further reduce demand the zero-rate for the first return-flight would need to be adapted and other policies should be added to increase the speed for the decarbonisation of European aviation.
This study shows that a European FFL is a promising policy to drastically reduce aviation's CO_2 emission on the short term. If the tax revenues would be spend to further reduce emissions in aviation or other sectors, the impact could even be bigger.

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A Methodology and used data

A.1 AERO-MS and baseline scenario

The Aviation Emissions and evaluation of Reduction Options Modelling System (AERO-MS)[20] is an aviation model designed to quantify economic and environmental impacts of policy measures related to the emission reduction in the air transport system. The Intellectual Property Rights (IPR) for the AERO-MS are with the European Union Aviation Safety Agency (EASA). AERO-MS has been used for many studies for the European Commissions, including impact assessments of the EU ETS and other recent policies.

The main characteristic of the model are:
- Capability to assess impacts of global and regional policy options to reduce aircraft engine emissions.
- The model is able to assess the impacts of Market Based Measures (EU ETS, CORSIA, ticket taxes, SAF policies). Impacts are computed relative to a future baseline scenario.
- The model computes both economic and environmental impacts of emission reduction policies.
- Global coverage of international and domestic aviation.
- Starting point of the model is a global operations database. This database contains the number of operations by aircraft type and demand data for over 113,000 airport pairs.
- The model is used to quantify economic and environmental impacts of policy measures related to the emission reduction in the air transport system emissions taking into account the responses of and effects on all relevant actors (airlines, consumers, governments and manufacturers).
- The effects of policies are computed relative to a future scenario, whereby a scenario reflects an expectation of autonomous developments with respect to air transport and flight activities.

In an assignment for EASA in the years 2022-2023, the model has been updated to base year 2019. In this update the Mid growth ICAO traffic forecast has been implemented[21]. The 2028 forecast of this scenario is the baseline for the estimation of the effect of the FFL.

The baseline scenario contains the number of passengers, average return ticket prices and CO_2 emissions for both economy and business/first class passengers travelling from Europe31 countries. The impact of SAF blending as a consequence of ReFuelEU Aviation is taken into account.

In the AERO-MS no interaction between individual flights is considered. Each (return-)trip of a passenger is considered to be an independent choice. This implies, that it is not possible to directly estimate the effects of a FFL with the basis functionality of the model. Therefore for this study a tool was developed in which data from the AERO-MS are combined with flight frequency distribution data. This tool is further described in the following section of this annex.

[20] A more detailed description of the model can be found here: https://web.jrc.ec.europa.eu/policy-model-inventory/explore/models/model-aero-ms/

[21] https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2022/ENVReport2022_Art7.pdf

A.2 Tool to assess impact of flying frequency

In the tool only CO_2 emissions from passenger flights are considered. Belly-hold cargo capacity of the passenger flights is not corrected for, and hence all emissions of these flights are allocated to passengers. For the baseline scenario the following data for 2028 is extracted from AERO-MS:
- number of passengers (first class vs economy class);
- average return ticket price (first class vs. economy class);
- CO_2 emissions.

This data is segmented for each combination of:
- Europe31 Departure country (Europe31 = EU27 + NO + IS + LI + UK).
- Route type: Domestic, intra Europe31, Extra Europe31 with split out by destination region (Rest of Europe, Africa, Asia/Pacific, Latin America/Caribbean, Middle East, North America).
- Distance class in km (<500, 500-1,000, 1,000-1,500, 1,500-2,000, 2,000-3,000, 3,000-4,000, etc.).

In the tool the user is able to define a charging level in terms of a ticket tax in absolute terms by:
- Return flight number: first flight, second flight, third flight, fourth flight and fifth or more flight.
- Distance class: Short-haul (<1,500 km); medium-haul (1,500-4,000 km) and long-haul (>4,000 km). In the tool these three distance classes are mapped to the more refined distance classes in the AERO-MS data (see above). The AERO-MS data include more refined distance classes because ticket prices (and hence % percentage price increase from a taxation) strongly varies by distance class.
- First class vs. economy class.
- Same rate for intercontinental flights or double rate to compensate departure at non-Europe31 airport.
- On top of national taxation or replacement.
- Including transfer passengers or not.

Within the tool the following computation steps are carried out for each combination of European departure country, route type and distance class:
1. Assign the applicable distribution across flight number to the total number of passengers from AERO-MS (see Section A.3).
2. Assess the % ticket price increase by flight number and class based on user specification of charging level and the baseline scenario ticket price.
3. Assess the % impact on passenger demand by flight number and class using the applicable elasticity values (see Section A.4) and the % ticket price increase from Step 2.
4. Assess the total % impact on passenger demand.
5. Assess the total % impact on CO_2 emissions whereby it is assumed that for each AERO-MS data segment the % impact on CO_2 emissions is equal to % impact on passenger demand.
6. Compute taxation revenues (multiplication of remaining passengers by flight number and class with the charging levels).

After the detailed computations, aggregated results are generated showing the impacts on passenger demand, CO_2 emissions and taxation revenues per country for 2028 by comparing the results of the estimates in the reference scenario with the FFL to the baseline without this policy.

A.3 Representative country profiles

To perform the first step in the tool ‘Assign the applicable distribution across flight number to the total number of passengers from AERO-MS’, it is necessary to estimate the current flight frequency of the passengers departing from each Europe31 country. Due to the limited amount of data for those distributions in Europe31 countries, a select number of representative flight frequency distributions have been allocated to the Europe31 countries. Flight frequency distributions have been found for France, Germany, Italy/Portugal/Spain, the Netherlands and the United Kingdom (ICCT, 2022; Lublin Airport, 2017).
These distributions are used as representative distribution profiles. Since, similar distributions for the other European countries are not available, we have chosen to map the distribution profiles onto the other Europe31 countries as shown in Table 4.
The representative distribution profiles are named as follows:
A France.
B Germany.
C Italy, Portugal, Spain.
D Netherlands.
E United Kingdom.

Table 13 – Mapping of representative distribution profiles to all Europe31 countries

Country	Distribution profile
Austria	B
Belgium	A
Bulgaria	B
Croatia	C
Cyprus	C
Czech Republic	B
Denmark	D
Estonia	B
Finland	D
France	A
Germany	B
Greece	C
Hungary	B
Iceland	E
Ireland	E
Italy	C
Latvia	B
Lithuania	B
Luxembourg	A
Malta	C
Netherlands	D
Norway	D
Poland	B
Portugal	C
Romania	B
Slovakia	B
Slovenia	B
Spain	C
Sweden	D
Switzerland	B
United Kingdom	E

A.4 Price elasticities

Price elasticities describe the sensitivity of passengers to ticket price changes. It is therefore a crucial input for the estimation of the effects of the FFL. It is important to realise that the price elasticity varies between individual passengers, travel distances and geographical regions, as well as the travel purpose:

- Business passengers are generally less sensitive to price changes (less elastic) compared to passengers travelling for other purposes. This is because their tickets are often paid by the company, business travellers have less flexibility to postpone or cancel their trips and are constrained to given business locations.
- Passengers visiting friends and relatives have a larger price elasticity than business travellers, however they are also constrained by the travel destination. In addition, there is usually an increase of passengers visiting family during the festive seasons although ticket prices are high (high willingness to pay).
- Passengers travelling for recreation purposes are generally the most elastic group. Those passengers can choose to travel to different destinations, are often more flexible in the travel time (different day or time of day) or can choose to use other modes of transport to travel to their final destination (car, train) for shorter distances.

However, there is only limited information available in the literature on the exact values of price elasticities for different segments. For airlines response of travel demand on price changes is difficult to quantify since it is only known to a very limited degree. Most studies refer to price elasticities that have been estimated more than 15 years ago by Intervistas InterVISTAS (2007), and which do not distinguish between income and flight frequency, important categories for estimating the response of introducing a FFL. This implies that there is no solid scientific base to estimate the effects on demand.

Therefore in this study, like in other recent studies regarding a Frequent Flying Levy (ICCT, 2022; NEF, 2021) elasticities for frequent flyers are assumed as variations around known elasticities. The AERO-MS model has an average elasticity for passengers on European departing flights of -0.8 for economy class and -0.225 for business/first class. These values are used as the 'median elasticity' in this study. We apply it to passengers with two return flights in one year and assume that passengers with one return flight are more price sensitive and frequent flyers are less price sensitive, since they generally have higher household incomes. The assumed elasticities are shown in Table 14.

Table 14 – List of price elasticities by passenger class and frequent flyer class

Frequent flyer class	Economy class elasticity	Business/first class elasticity
Passengers with one return ticket in a year	-0.85	-0.250
Passengers with two return tickets in a year	-0.80	-0.225
Passengers with three return tickets in a year	-0.75	-0.200
Passengers with four return tickets in a year	-0.70	-0.175
Passengers with five or more return tickets in a year	-0.60	-0.125

A.5 Correction for transfer passengers

The FFL is intended to charge passengers on their route between the flight origin to the final destination. Potential distance surcharges depend on the total flight distance. Whether the passenger travels on a direct route or with an intermediate transfer, does not affect the rate. As a consequence, transfer passengers are not charged (extra).

Since, the two legs of a transfer connection are counted as two flights in AERO-MS and most passenger statistics, this has to be corrected. To calculate a more accurate tax revenue from each country of departure flights, only origin-destination (OD) passengers are taken into account. We have estimated the share of OD passengers based on the reported total number of passengers in European countries and the number of transfer passengers at international hubs in the countries. The results are summarised in Table 15. In the Netherlands the share of OD passenger is the lowest due to the large share of transfer passengers at Amsterdam airport Schiphol. Other countries like Cyprus have 100% OD traffic, as they do not have a hub airport which facilitates transfers.

Table 15 - Percentage of OD passengers of the total number of passengers at airports in European countries

Percentage of passengers eligible to FFL	
Country	**% OD passengers**
Austria	89%
Belgium	90%
Bulgaria	100%
Croatia	98%
Cyprus	100%
Czech Republic	100%
Denmark	87%
Estonia	100%
Finland	86%
France	94%
Germany	87%
Greece	100%
Hungary	100%
Iceland	77%
Ireland	96%
Italy	99%
Latvia	81%
Lithuania	100%
Luxembourg	99%
Malta	100%
Netherlands	69%
Norway	92%
Poland	90%
Portugal	88%
Romania	99%
Slovakia	100%
Slovenia	100%
Spain	100%
Sweden	95%
Switzerland	92%
United Kingdom	83%

A.6 National ticket taxation

The existing national ticket taxes for European countries are summarised in Table 16 in Euro2023. Countries that are not listed in the table, have no ticket tax in place. The table of national taxation is based on (T&E, 2023) and updated, where more recent information was found. We consider only the national taxes that raise the taxation revenues for the specific countries and no infrastructure charges.

Table 16 - Overview of national ticket taxes for EFTA+UK countries for 2028

Country	Tax name	Tax rates	Comments
Austria	Flugabgabe/Austria Air Transport Levy	2023 rates: <350 km (GCD): € 30 ≥350 km (GCD): € 12	In case of domestic flights, the ticket taxes are € 26.55 and € 10.62, when excluding VAT
Belgium	Belgium Plane tax	<500 km from Brussels airport: € 10 ≥500 km (from Brussels airport), to EEA, UK, CH: € 2 Outside EEA, UK or CH: € 4	
France	Eco tax	Domestic, EEA, CH, countries situated less than 1,000 km from France: € 1.5/eco - € 9/business Others: € 3/eco - € 18/business	
Germany	German aviation tax (Luftverkehrsteuergesetz)	Short-haul: € 13.03 Medium-haul: € 33.01 Long-haul: € 59.43	The tax increase by 20% from 1 May 2024 was after the moment when the study was conducted and is not considered.
Greece	Spatosimo air passenger tax	€ 12 for passengers departing Greek airports	
Hungary		For EU, UK, Iceland, Norway, Switzerland - € 10.18 Otherwise € 24.88	
Italy	City Council tax	€ 7.07 (weighted average)	Rates from 2018
Netherlands	Vliegbelasting Dutch tax	€ 26.43	
Norway	Norway Passenger fees	To EEA: NOK82, € 7.50 → 7.12 Others: NOK320, € 29.20 → 27.79	
Portugal	Portugese Carbon Tax	€ 2.00	
Sweden	Swedish aviation tax	2023: Short-haul: SEK69, € 6.00 Medium-haul: SEK288, € 25.08 Long-haul: SEK461, € 40.14	
United Kingdom	Air passenger Duty	Domestic: £ 7 eco, £ 14 business (€ 8.04, € 16.09) Band A: £ 13 eco, £ 26 business (€ 14.94, € 29.88) Band B: £ 87 eco, £ 191 (€ 99.98 eco, € 219.49 business) Band C: £ 91 eco, £ 200 business (€ 104.58 eco, € 229.84 business)	For 2025, we used the latest rate available which goes until April 2024.

B Detailed results

In this annex more detailed results are presented.

B.1 Impacts of FFL related to the distance distribution

In Section 4.5, the distance dependence of the effects of the FFL is presented for short-haul, medium-haul and long-haul flights. Figure 18 (passenger demand) and Figure 19 (CO_2 emissions) show the same results but segmented in 11 instead of 3 distance bands. The surcharge of € 50 for medium-haul flights is charged for flights above 1,500 km and the long-haul surcharge of € 100 for distance above 4,000 km. Especially, between short-haul and medium-haul the effect of the surcharge is clearly visible with a jump from -22% to -38%.

Figure 18 - Impact of FFL on the passenger demand for different flight distances

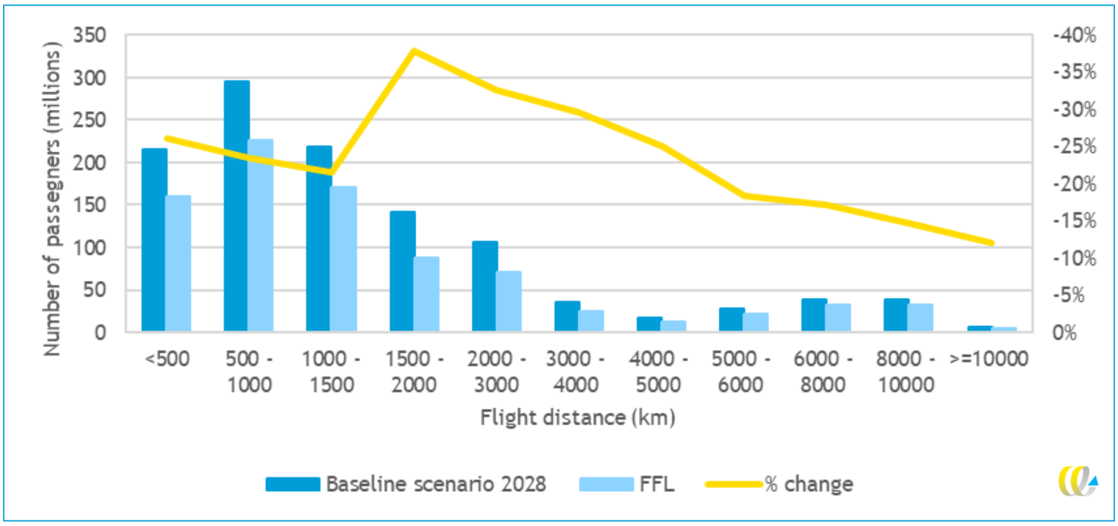
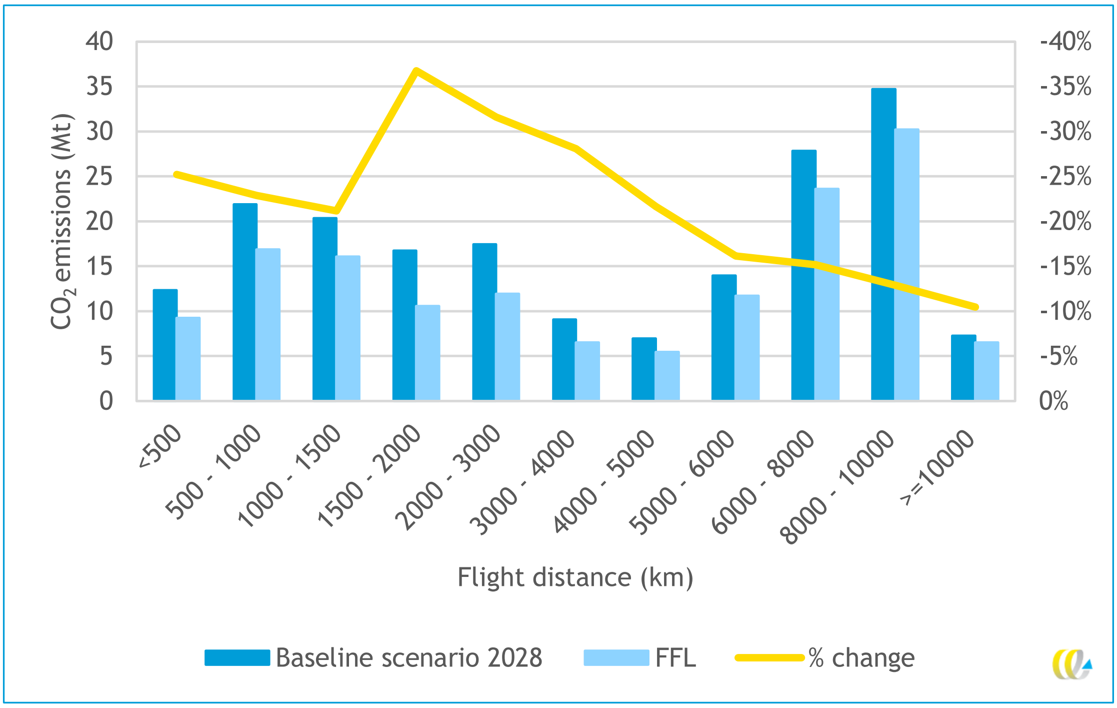


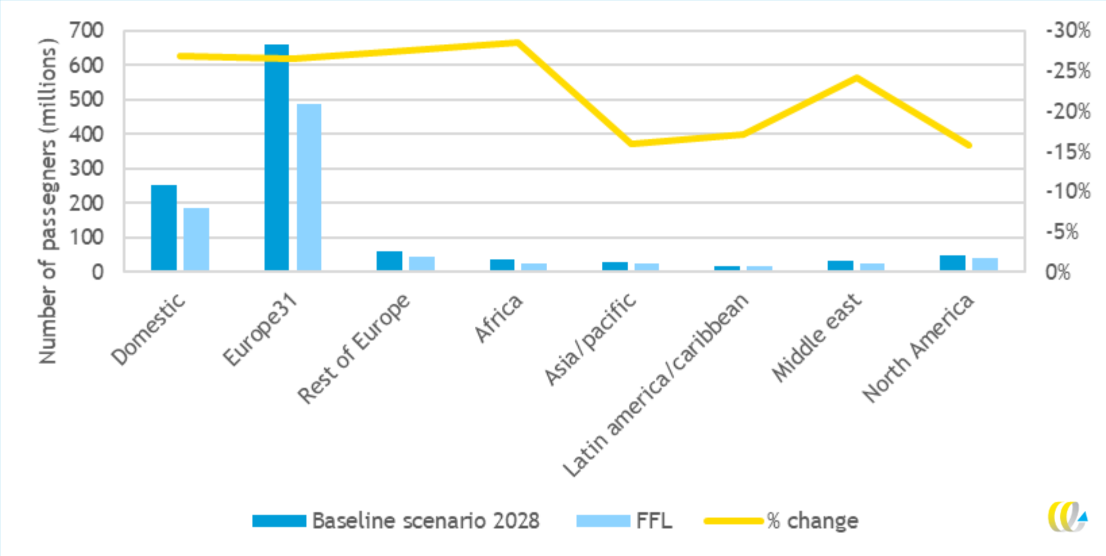
Figure 19 - Impacts of FFL on the CO_2 emissions for different flight distances



B.2 Impacts of FFL related to the destination regions

The FFL imposes taxes on flights departing at European airports to destination regions around the world. The impact of the FFL on the passenger demand to all destination regions is shown in Figure 20, As previously mentioned, the majority of flights in Europe are short-haul flights, highlighting the relatively high passenger numbers for domestic and Europe31 flights. That is also where we see the highest relative changes in passenger demand due to the FFL. The FFL has a different impact on each destination region mainly due to the relative increase in ticket prices due to the FFL tariffs. For passengers travelling to North America and Asia, the passenger demand changes the least due to the FFL. In the case of Africa, there is a lot of demand to touristic destinations (with a low share of business passengers) in the North of Africa, with rather low ticket prices and moderate distances. This leads to the strongest relative change in demand.

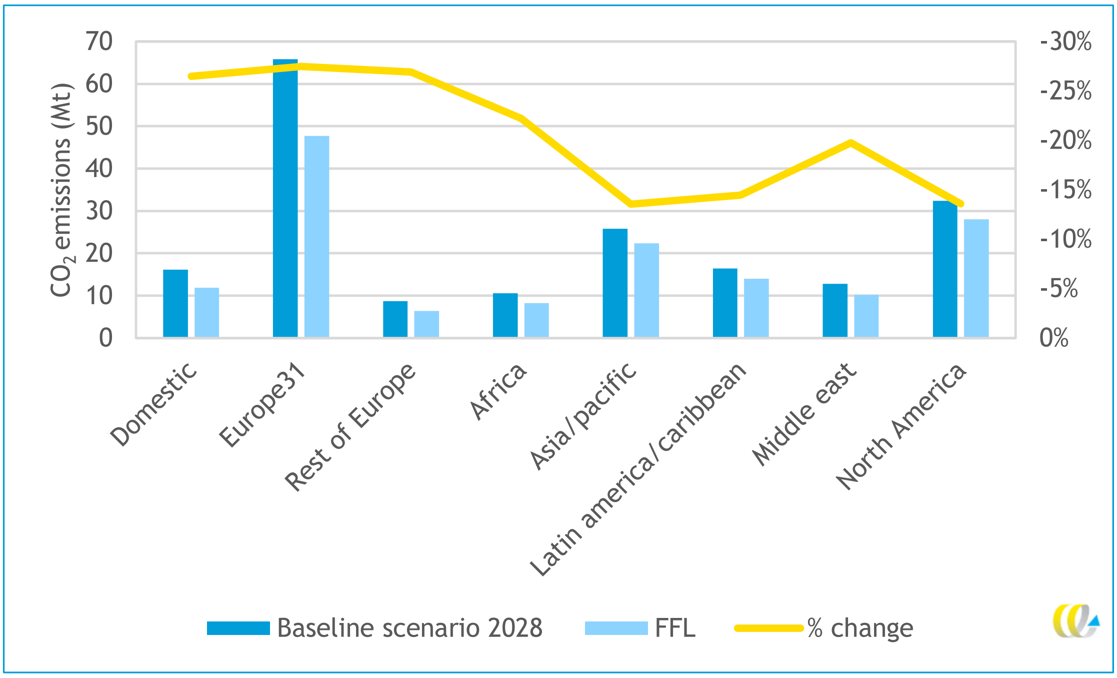
Figure 20 - Passenger demand for each destination region (millions)



Impact on CO_2 emissions

In terms of CO_2 emissions, the FFL has the largest impact for domestic flights and intra-continental flights, similarly to the passenger demand impact. For inter-continental flights we can see from Figure 21 that a relatively small proportion of passengers, considerably contribute to the total emissions of aviation. Within the inter-continental flights, the effects of the FFL are relatively larger in Africa and smallest in North America, due to the initial ticket price difference.

Figure 21 - CO_2 emissions for each destination region (Mt)



B.3 Impact per European country

The same FFL levy is applied to all countries of Europe31. However, the effects on the passenger demand (Figure 22 and Table 17) and the CO_2 emissions (Figure 23 and Table 18) shows large variations. The passenger demand in the Netherlands decreases by only 12% whereas Belgium faces -33%. The main reason for this difference is the high share of transfer passengers in the Netherlands in combination with the fact that the FFL replaces a Dutch taxation of almost € 30 per passenger, whereas passengers departing in Belgium currently only pay € 2 or € 4 departure tax. In addition, the country specific mix between business passengers (less price sensitive) and leisure passengers (more price sensitive) and the underlying distribution of the flying frequency results in the variation.

Figure 22 - Impact of the FFL on passenger per country

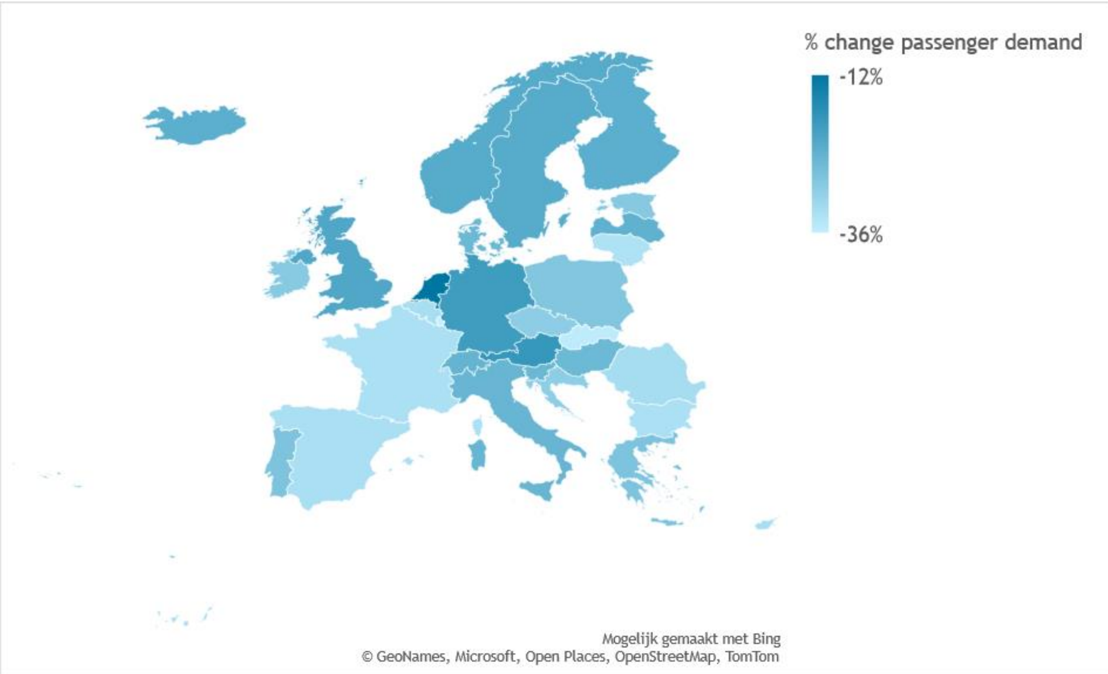


Table 17 – Detailed impact of the FFL on departing passengers per country

Europe31 countries	Absolute numbers (millions)						% change to baseline scenario		
	Baseline scenario 2028 (destination)			FFL (destination)			FFL (destination)		
	Europe31	Intercontinental/ rest of Europe	Total	Europe31	Intercontinental/ rest of Europe	Total	Europe31	Intercontinental/ rest of Europs	Total
Austria	17.04	5.43	22.48	13.91	4.32	18.22	-18%	-21%	-19%
Belgium	16.16	5.00	21.17	10.75	3.46	14.22	-33%	-31%	-33%
Bulgaria	6.02	1.31	7.33	4.00	0.90	4.90	-33%	-32%	-33%
Croatia	5.64	0.68	6.31	3.95	0.50	4.45	-30%	-26%	-30%
Cyprus	4.17	4.20	8.36	2.77	2.85	5.62	-33%	-32%	-33%
Czech Republic	8.24	3.17	11.41	5.87	2.19	8.06	-29%	-31%	-29%
Denmark	18.23	3.36	21.60	13.46	2.64	16.10	-26%	-22%	-25%
Estonia	1.57	0.33	1.90	1.12	0.24	1.36	-29%	-28%	-29%
Finland	12.53	2.86	15.39	9.48	2.29	11.77	-24%	-20%	-23%
France	82.10	32.21	114.31	53.15	23.30	76.45	-35%	-28%	-33%
Germany	112.94	40.06	153.01	90.77	31.66	122.43	-20%	-21%	-20%
Greece	32.50	4.55	37.05	23.40	3.44	26.84	-28%	-24%	-28%
Hungary	8.25	1.95	10.20	6.22	1.37	7.59	-25%	-30%	-26%
Iceland	3.30	1.26	4.57	2.46	1.03	3.50	-26%	-18%	-23%
Ireland	16.60	3.56	20.16	11.54	2.83	14.37	-30%	-20%	-29%
Italy	96.61	17.78	114.40	72.43	13.40	85.84	-25%	-25%	-25%
Latvia	3.50	1.09	4.60	2.63	0.86	3.49	-25%	-22%	-24%
Lithuania	2.96	0.78	3.74	1.97	0.52	2.48	-34%	-34%	-34%
Luxembourg	2.52	0.12	2.64	1.61	0.08	1.69	-36%	-31%	-36%
Malta	3.97	0.38	4.35	2.64	0.28	2.91	-34%	-28%	-33%
Netherlands	31.03	14.03	45.06	27.48	12.01	39.49	-11%	-14%	-12%
Norway	36.27	1.26	37.53	27.99	0.96	28.96	-23%	-23%	-23%
Poland	23.12	5.70	28.82	16.61	4.12	20.73	-28%	-28%	-28%
Portugal	29.65	4.64	34.29	21.11	3.72	24.83	-29%	-20%	-28%
Romania	11.89	1.87	13.76	8.05	1.25	9.30	-32%	-33%	-32%
Slovakia	1.20	0.61	1.81	0.80	0.37	1.17	-33%	-39%	-35%
Slovenia	0.67	0.36	1.03	0.50	0.27	0.77	-26%	-24%	-25%
Spain	141.22	17.00	158.22	92.92	13.14	106.06	-34%	-23%	-33%
Sweden	26.12	2.99	29.11	20.18	2.27	22.45	-23%	-24%	-23%
Switzerland	22.31	7.94	30.25	16.71	6.13	22.84	-25%	-23%	-25%
United Kingdom	133.15	39.69	172.84	101.65	33.20	134.86	-24%	-16%	-22%
Total	**911.51**	**226.17**	**1 137.69**	**668.13**	**175.59**	**843.72**	**-27%**	**-22%**	**-26%**

Figure 23 – Impact of the FFL on CO_2 emissions per country

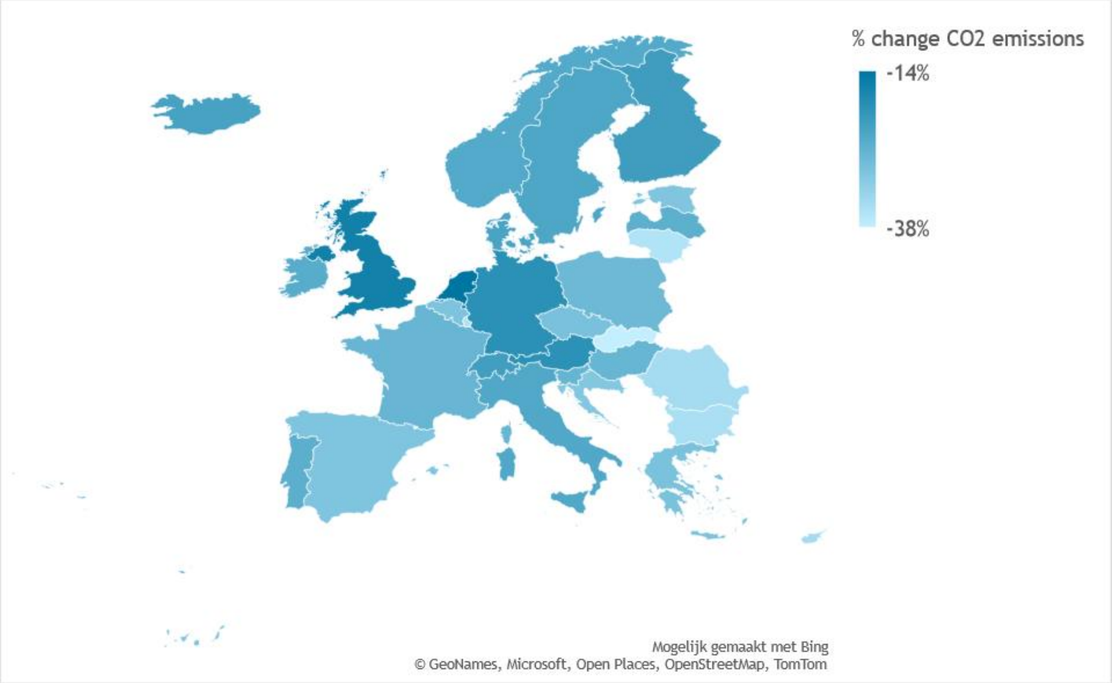


Table 18 – Detailed impacts of the FFL on CO_2 emissions of departing flights per country

Europe31 countries	Absolute numbers (Mt CO_2)						% change to baseline scenario		
	Baseline scenario 2028 (destination)			FFL (destination)			FFL (destination)		
	Europe31	Intercontinental/ rest of Europe	Total	Europe31	Intercontinental/ rest of Europe	Total	Europe31	Intercontinental/ rest of Europe	Total
Austria	1.45	2.04	3.49	1.19	1.70	2.89	-18%	-17%	-17%
Belgium	1.48	1.89	3.37	0.99	1.45	2.44	-33%	-23%	-28%
Bulgaria	0.60	0.19	0.79	0.40	0.13	0.53	-34%	-30%	-33%
Croatia	0.52	0.19	0.72	0.37	0.14	0.51	-30%	-24%	-28%
Cyprus	0.74	0.40	1.15	0.49	0.28	0.77	-34%	-29%	-33%
Czech Republic	0.69	0.77	1.47	0.50	0.58	1.07	-29%	-26%	-27%
Denmark	1.53	1.71	3.24	1.14	1.42	2.56	-26%	-17%	-21%
Estonia	0.15	0.05	0.20	0.11	0.03	0.14	-28%	-27%	-28%
Finland	1.38	1.67	3.06	1.06	1.40	2.46	-24%	-16%	-20%
France	6.50	14.62	21.12	4.27	11.61	15.89	-34%	-21%	-25%
Germany	9.34	17.59	26.93	7.46	14.87	22.33	-20%	-15%	-17%
Greece	3.40	1.20	4.59	2.40	0.94	3.34	-29%	-21%	-27%
Hungary	0.73	0.48	1.21	0.54	0.37	0.91	-25%	-24%	-25%
Iceland	0.47	0.44	0.91	0.35	0.37	0.72	-24%	-16%	-21%
Ireland	1.67	2.08	3.75	1.17	1.72	2.89	-30%	-17%	-23%
Italy	7.45	7.83	15.27	5.57	6.36	11.94	-25%	-19%	-22%
Latvia	0.36	0.13	0.49	0.27	0.11	0.38	-24%	-21%	-24%
Lithuania	0.27	0.08	0.36	0.18	0.05	0.23	-34%	-35%	-34%
Luxembourg	0.24	0.02	0.26	0.16	0.01	0.17	-34%	-29%	-34%
Malta	0.42	0.05	0.47	0.28	0.04	0.32	-34%	-25%	-33%
Netherlands	2.71	9.25	11.96	2.36	8.22	10.58	-13%	-11%	-12%
Norway	3.02	0.63	3.65	2.33	0.51	2.84	-23%	-19%	-22%
Poland	2.04	1.42	3.46	1.46	1.12	2.58	-28%	-21%	-25%
Portugal	3.15	2.39	5.55	2.25	2.00	4.25	-29%	-16%	-23%
Romania	1.14	0.32	1.46	0.76	0.22	0.98	-33%	-31%	-33%
Slovakia	0.10	0.07	0.17	0.07	0.04	0.11	-34%	-40%	-37%
Slovenia	0.06	0.04	0.11	0.05	0.03	0.08	-25%	-24%	-25%
Spain	13.72	9.91	23.63	8.86	8.18	17.04	-35%	-17%	-28%
Sweden	2.50	1.30	3.79	1.93	1.05	2.97	-23%	-19%	-22%
Switzerland	1.77	4.14	5.91	1.34	3.39	4.73	-24%	-18%	-20%
United Kingdom	12.30	23.63	35.93	9.27	20.73	30.00	-25%	-12%	-17%
Total	**81.93**	**106.53**	**188.46**	**59.56**	**89.07**	**148.64**	**-27%**	**-16%**	**-21%**

In Table 19 the impact of the FFL on the national tax revenues is described. Overall the FFL leads to € 64 billion extra tax revenues. Flights departing from France (€ 9.9 billion), UK (€ 9.1 billion), Germany (€ 8.3 billion) and Spain (€ 8.1 billion) would generate most extra revenues due to the large aviation markets in these countries. The way the revenues generated by the European FFL will be distributed across the European countries will have to be subject to political debate.

Table 19 – Overview of tax revenues per country in million $€_{2023}$

Europe31 countries	Current national taxations (Baseline scenario 2028)	FFL revenues (without national taxation in 2028)	Extra taxation revenues (relative to baseline scenario in 2028)
Austria	240	1,370	1,130
Belgium	55	1,720	1,664
Bulgaria	0	349	349
Croatia	0	265	265
Cyprus	0	493	493
Czech Republic	0	680	680
Denmark	0	1,167	1,167
Estonia	0	88	88
Finland	0	1,149	1,149
France	195	10 ,094	9,899
Germany[22]	2,535	10,863	8,328
Greece	445	1,956	1,512
Hungary	112	491	380
Iceland	0	460	460
Ireland	0	1,487	1,487
Italy	797	5,840	5,043
Latvia	0	206	206
Lithuania	0	161	161
Luxembourg	0	123	123
Malta	0	212	212
Netherlands	817	3,835	3,018
Norway	287	1,162	875
Poland	0	1,340	1,340
Portugal	61	2,301	2,240
Romania	0	575	575
Slovakia	0	79	79
Slovenia	0	49	49
Spain	0	8,097	8,097
Sweden	276	1,404	1,128
Switzerland	0	2,275	2,275
United Kingdom	4,659	13,767	9,108
Total	**10,478**	**74,059**	**63,581**

22 Revenues in the baseline scenario are based on the German tax rate before 1 May 2024.