National Sustainability Policy for the Aviation Sector

Overview of measures in the Netherlands, Belgium, Germany, France and the United Kingdom

CE Delft

Committed to the Environment

National Sustainability Policy for the Aviation Sector

Overview of measures in the Netherlands, Belgium, Germany, France and the United Kingdom

This report has been prepared by:
Stefan Grebe, Julius Király and Ward van Santen

Delft, CE Delft, January 2023

Publication reference: 23.210334.002

Public policy / Air traffic / Sustainable / Measures / National / International / Regulations / Capacity / Impact

Commissioned by:
The Foundation for Nature Conservation and Environmental Protection (Stichting Natuur en Milieu)

All of CE Delft's public publications are available at www.ce.nl

Further information about this study can be obtained from the project leader Stefan Grebe (CE Delft)

CE Delft
Committed to the Environment

CE Delft is helping build a sustainable world through its independent research and consultancy activities.
Our expertise is leading-edge in the areas of energy, transport and commodities. By applying our knowledge of technologies, policies and economic issues, we support government agencies, NGOs and industries in their pursuit of structural change. For more than 40 years, CE Delft's dedicated and skilled staff have been devoted to achieving this mission.

Contents

Summary

The future of the aviation sector is an issue on several national policy agendas. The sector faces declining social acceptance and regulatory constraints, such as noise level, nitrogen and climate targets, that are inhibiting further growth. As it currently stands, total global greenhouse gas emissions from aviation will continue to rise. Moreover, aviation's share of global emissions will increase even further in the future due to reductions in other sectors.

In this report for the Foundation for Nature Conservation and Environmental Protection, we first provide an overview of the scope of the aviation sector in the Netherlands, Belgium, Germany, France and the United Kingdom. We then identify and list the national and local measures currently being taken by these countries to:
- limit aviation growth to meet CO_2 reduction targets;
- make aviation more sustainable (both local and global emissions);
- impose higher prices on aviation.

The Foundation for Nature Conservation and Environmental Protection have asked us to indicate the most effective national measures. We have distinguished between four categories:
1. Capacity measures.
2. Taxes and other price measures.
3. Funding and promoting sustainable aviation.
4. Regulations, obligations and prohibitions.

The aviation sector in the Netherlands is larger than in the neighbouring countries

A comparison with the five countries shows that the Netherlands facilitates a relatively high amount of air traffic, when the number of passengers and aircraft movements are compared to the number of inhabitants. Schiphol Airport plays a major hub function in Europe. The fact that the Dutch domestic market is too small for Schiphol's large destination network means that aircraft are largely filled with transfer passengers from outside the Netherlands. This differs substantially from the other countries. In contrast, in Germany, France and the United Kingdom many transfer passengers are residents of the country travelling to one of the hubs via a national flight. The high proportion of international transfer passengers in the Netherlands also ensures that it has the highest number of aircraft movements per inhabitant. The Netherlands also ranks among the top countries for air cargo, together with Belgium. This shows that both the Netherlands and Belgium are important transit countries for air cargo transport in Europe. Due to the high number of aircraft movements and the high proportion of intercontinental flights from Schiphol, the Dutch aviation sector emits a lot of greenhouse gases.

National policy of the Netherlands

In terms of current policies that have been adopted, measures to make aviation more sustainable are still very limited in the Netherlands and similar to the other countries studied. When it comes to proposed policies, however, the Netherlands is relatively ambitious. It should be noted that greenhouse gas reduction is not the central goal of most of the measures: particularly noise level reduction and nitrogen limits also play an

important role. Nevertheless, if the Netherlands is to take a leading position in making aviation more sustainable, the proposed policies must actually be implemented. The key proposed measures are: increasing air passenger tax above € 26.00, temporarily reducing capacity of Schiphol to 440,000 flights per year, opening/not opening Lelystad Airport and introducing a national CO_2 cap for aviation.

National policies of other countries

Compared to other countries, Belgium has the least specifically formulated sustainability policy for the aviation sector. Germany has relatively low goals with regard to measures to reduce or regulate air traffic. On the other hand, Germany does make relatively large amounts of money available for subsidies that could eventually contribute to making the aviation sector more sustainable. Finally, France and the United Kingdom have relatively high tax rates on flying. A wide range of policies are also being explored and partially implemented. For example, France will ban domestic flights and the United Kingdom will introduce the Carbon Budget.

Effective measures with short-term impact

The various measures considered in this study differ markedly in effectiveness. There are three types of national measures that can effectively reduce the climate impact of air travel in the short term:

1. **Capacity constraints**: by imposing a restriction on supply, demand is simultaneously capped. An example of this is a restriction on the number of aircraft movements at an airport.
2. **Charging higher prices to fly**: this causes the demand for air travel to decrease, which in time will also reduce the supply. Most of the countries surveyed have some form of air tax, but these taxes are still quite low and do not cover the actual societal costs of flying.
3. **Reducing total emissions**: again, this limits supply and therefore demand. An example of this is the CO_2 cap for the aviation sector, as envisaged in the Netherlands. Since such a cap is a strict limit on emissions that decreases over time, it provides a guarantee for achieving reduction targets both in the short term and the long term.

Measures with medium-term impact

In addition to the measures taken by the government to reduce the number of flights, the aviation sector has been constantly improving the efficiency of aircraft and, for several years, intensively developing sustainable fuels: Sustainable Aviation Fuels (SAF). National policies are primarily supportive in the form of subsidies. A number of countries are also trying to introduce national blending requirements that are higher than in the European Commission's ReFuel Aviation proposals. However, it is unclear whether this is possible under European rules. Because technological developments related to aircraft efficiency take time, as do the replacement of aircraft and the scaling up of production capacities for SAF, national policies in this area mainly contribute something in the medium term.

Although more efficient aircraft and higher admixture rates of SAF are undoubtedly necessary, there are three caveats:

1. The life-cycle greenhouse gas reduction of SAF compared to fossil kerosine is often merely 70%.
2. The use of SAF produced entirely from renewable energy still leads to global warming due to the non-CO_2 impact of flying.
3. Financially incentivising sustainable fuels and more efficient aircraft reduces ticket prices, thereby increasing the demand for flying.

The role of national policies in complementing global and European policies

Making the aviation sector more sustainable plays an important role in the struggle to meet the Paris climate targets. Current sustainability policies in aviation are insufficient to meet the Paris targets. More urgency is needed and a long-term vision is crucial. This vision must not only include a reduction in CO_2 emissions, but the non-CO_2 climate impact of flying must also be drastically reduced.

The level at which a sustainability policy is organised in the aviation sector is extremely important. Ideally, agreements should be made on the largest possible geographical scale (global, European, bilateral), as this ensures a level playing field which minimises avoidance and leakage effects. Nevertheless, many countries feel that global and European measures do not go far enough and there are discussions at many airports concerning the local environmental impact and the reduction of disturbance of aviation activities.
The implementation of proposed national policies in the five countries studied can help to reduce emissions from aviation. If these countries live up to their goals and actually implement the proposed plans, they can potentially spur other countries into taking more action and ensuring that their national goals and measures are adopted on a European or global scale.

1 Introduction

The future of the aviation sector is a theme that features on several national policy agendas. The sector has grown significantly since the 1990s. It is currently confronted with circumstances, such as acceptance, noise and climate targets, which inhibit further growth. Aviation growth was temporarily halted by the corona crisis, but as normal life resumes, so does aviation. As it currently stands, total global emissions from aviation will continue to rise. Moreover, aviation's share of global emissions will increase even further in the future due to reductions in other sectors. The public debate on how to make the sector more sustainable has been fuelled by the increasingly visible climate crisis, the Paris targets to be met and financial support from governments.

This issue has been given a higher priority on the political agenda in some countries than in others. European countries are taking different approaches to address this challenge. For example, the Netherlands has made sustainability agreements with Schiphol Airport and KLM, and it is currently exploring a national CO_2 cap for aviation. From a European perspective, reduction targets and aviation policies are currently being pursued at three levels: globally (through ICAO), at a European level (in the context of Fit for 55, EU ETS, RED3, ReFuel Aviation and ETD) and nationally.

The focus of this study is to identify national measures taken by the Netherlands, Belgium, Germany, France and the United Kingdom to:
- limit aviation growth to meet CO_2 reduction targets;
- make aviation more sustainable (both local and global emissions);
- impose higher prices on aviation.

These countries were chosen for this study either because they are important players in the European aviation market or because their geographical location is of interest to the Dutch aviation sector. By comparing the measures in these countries side by side, we can make a comparison of the target level of each country relative to each other. In addition, we attempt to assess the effectiveness and efficiency of the different types of measures in order to formulate some recommendations regarding policies to be implemented.

In Chapter 2 we juxtapose the key features of aviation in the Netherlands, Belgium, Germany, France and the United Kingdom. This includes examining passenger numbers, aircraft movements, air cargo traffic and CO_2 emissions. In Chapter 3 we outline the national aviation sustainability measures in the five countries. We distinguish between four categories of measures:
1. Capacity measures.
2. Taxes and other price measures.
3. Funding and promoting sustainable aviation.
4. Regulations, obligations and prohibitions.

In Chapter 4 we compare the effectiveness and efficiency of aviation sustainability measures and the implementation across countries. In Chapter 5 we end with the conclusions and recommendations that follow from this study.

2 Basic features of the aviation sector

The focus of this report is a comparison of five European countries' national efforts to make the aviation sector more sustainable. To put the existing and proposed policies in context, in this chapter we provide an overview of the aviation sector in these countries, namely: Belgium, Germany, France, the Netherlands and the United Kingdom. Aviation features are summarised in a series of statistics, such as: numbers of passengers, amount of air cargo, number of aircraft movements and total CO_2 emissions of the aviation sector by country. In addition, we provide some statistics for the main airports of the countries studied. We then highlight some statistics per million inhabitants in order to facilitate a comparison and put the relative size of the aviation sector into perspective on a country-by-country basis. Finally, we compare the situation of the aviation sector in the Netherlands with that in other countries.

2.1 Basic features by country

All statistics presented here describe the situation in the year 2019; this is the most recent year when the number of aircraft movements and passengers was not yet affected by the corona pandemic. Most of the data was obtained via (Eurostat, 2022)[1]. Any other sources that were used are listed in the text.

The countries compared differ significantly in the numbers of passengers (pax) and cargo transported by air. Passenger flows and flights are divided into domestic, intra-EU and extra-EU. Intra-EU passenger flows or flights refer to a passenger or flight from an EU country to another EU country. Extra-EU passenger flows or flights refer to a passenger or flight from an EU country to a non-EU country, or a passenger or flight from a non-EU country to an EU country. Due to the fact that the United Kingdom was still a member of the European Union (EU) in 2019, flights to and from the United Kingdom also fall under intra-EU flights.

Passenger numbers

Table 1 shows the number of passengers transported by country, divided into national traffic (origin and destination are airports in the country in question), traffic to intra-EU countries and traffic to extra-EU countries. Table 2 shows passenger flows divided into origin-destination (OD), transfer and transit. OD represents an *origin-destination* journey of a passenger. An OD passenger takes a direct flight to the destination, without transferring. *Transit* refers to passengers who, after a short stopover, continue their journey on the same aircraft on a flight with the same flight number as the flight on which they arrived.

Transfer passengers are travellers who arrive at an airport on one aircraft and depart again on another aircraft (different flight numbers) within 24 hours. These could be travellers transferring from a domestic flight to an international flight or vice versa. This type of transfer passenger comprises a large proportion of transfer passengers at London, Paris,

1 See Transport database Eurostat, *Air transport measurement* 2019.

Frankfurt and Munich airports. Transfer passengers can also transfer at a hub, where both the inbound and outbound flight are international connections. All transfer passengers at Schiphol Airport are in this category, as no national passenger flights are operated in the Netherlands. In the statistics of total passenger numbers, transfer passengers are counted twice: once on arrival and once on departure. Publicly available sources do not distinguish between domestic and international transfers for transfer passengers.

Table 1 - Number of passengers transported, in millions

Country	Total pax	National	Intra-EU	Extra-EU
BE	35.4	0.0	25.1	10.3
DE	226.8	23.2	124.2	79.4
FR	168.7	31.7	76.2	60.8
NL	81.2	0.0	51.1	30.1
UK	277.4	23.0	171.0	83.4

Table 2 - Passenger flows subdivided by type of travel

Country	Total pax	Direct transit	Transfer	OD-pax
BE	35.4	0.1	4.7	30.6
DE	250.7	0.4	28.8	221.5
FR	200.7	0.5	12.7	187.5
NL	81.2	0.0	25.9	55.3
UK	296.7	0.1	41.7	255.0

Source: Eurostat.

NB: Total passenger numbers in Table 1 and Table 2 differ from each other[2].

It can clearly be seen that the geographically smaller countries of the Netherlands and Belgium have almost no national passengers. The larger countries (France, Germany and the United Kingdom (UK)) also have larger total passenger flows. National passengers are also an important segment in these countries. The data also include passenger flows to overseas areas of countries where this is relevant (FR, NL, UK).

Air cargo

Table 3 shows the amount of air cargo carried. Germany is the country with the highest volume of air cargo in Western Europe, both in the intra-EU and extra-EU markets.

Table 3 – Amount of air cargo carried, in 1,000 tons, including fuselage cargo

Country	Total cargo	National	Intra-EU	Extra-EU
BE	1,470	0.4	391	1,080
DE	4,870	139	1,260	3,480
FR	2,370	202	519	1,650
NL	1,700	2	94	1,610
UK	2,650	95	515	2,040

[2] This data comes directly from the database of Eurostat. It is unclear why the totals differ.

Table 4 shows the flows of air cargo by country. Germany and France have a surplus in air cargo transport volume, while the other countries import more than they export by air. Since much aviation from airports is transported further in Europe via trucks, this does not mean that the origin or final destination of the cargo is in the same country as the airport. Part of the air cargo is transit cargo: such as goods that enter the Netherlands and leave the Netherlands again in a virtually unprocessed state. In 2019, this accounted for about 66% of inbound air cargo in the Netherlands (CBS, 2022).

Table 4 - Flows and trade balance of air cargo, in 1,000 tonnes

Country	Inbound	Outbound	Balance (inbound - outbound)	Trade status
BE	754	715	+39	Import
DE	2,422	2,584	-162	Export
FR	1,213	1,326	-113	Export
NL	869	835	+34	Import
UK	1,389	1,322	+67	Import

Flight movements

The number of aircraft movements includes all scheduled and unscheduled take-offs and landings of commercial passenger and cargo flights. The number of flight movements are rounded to the nearest hundred. Although the Netherlands has no scheduled flights between domestic airports, a number of take-offs or landings to and from airports within the Netherlands have been recorded.

Table 5 - Number of flight movements (take-offs and landings separately) of commercial passenger flights

Country	Total pax	National	Intra-EU	Extra-EU
BE	283,000	Not available	209,200	67,700
DE	1,742,500	245,900	1,023,700	472,900
FR	1,280,500	310,200	604,900	365,300
NL*	548,800	100	400,200	148,500
UK	1,929,700	338,300	1,187,100	404,300

* NL excludes flights to overseas territories falling under the Netherlands.

The number of movements of *dedicated*[3] cargo flights (full freighters) is presented in Table 6.

Table 6 - Number of flight movements (take-offs and landings separately) of cargo flights

Country	Total cargo	National	Intra-EU	Extra-EU
BE	41,000	0	25,600	15,300
DE	114,600	10,200	63,000	41,300
FR	42,900	11,800	22,500	8,600
NL	15,600	0	2,900	12,600
UK	48,000	15,200	26,500	6,300

3 *Dedicated* cargo flights are flights where only cargo is transported. This does not include cargo transported in the fuselage of passenger flights.

The total number of aircraft movements per country and segment has been calculated by adding up all movements of passenger flights and cargo flights. Germany and the UK have the largest aviation sectors among the countries surveyed, with almost 2 million aircraft movements per year. With over 300,000 and over 550,000 flights, the size of the aviation sector in Belgium and the Netherlands respectively is significantly smaller. For both passenger flights and full freighters, it can be seen that the numbers of aircraft movements correlate significantly with the numbers of passengers and the amount of air cargo.

Table 7 - Total aircraft movements, passenger and cargo flights

Country	Total	National	Intra-EU	Extra-EU
BE	324,000	Not available	234,800	83,000
DE	1,857,100	256,100	1,086,700	514,200
FR	1,323,400	322,000	627,400	373,900
NL	564,400	100	403,100	161,100
UK	1,977,700	353,500	1,213,600	410,600

CO_2 emissions from aviation

Data on 2019 CO_2 emissions from departing flights by country was obtained from the EASA database (2022). The amount of aviation emissions by country is in line with the volume of aircraft movements. Average emissions per flight movement were calculated from both data. This follows from the differences in average flight distance and aircraft deployed. In none of the countries studied did the blending of Sustainable Aviation Fuel (SAF) as a result of lower carbon content in 2019 lead to a reduction in emissions.

Table 8 - CO_2 emissions from the aviation sector in 2019

Country	Total CO_2 emissions (in megatons)	Number of departing flight movements	Emissions per flight movement (tons of CO_2 per departing flight)
BE	4.88	170,898	28.6
DE	31.09	1,198,179	22.5
FR*	22.40	994,655	25.9
NL*	11.14	323,389	34.5
UK	37.26	1,250,892	29.8

* National emissions for FR exclude flights to and from overseas territories of these countries. For NL, these are included.

The average CO_2 emissions from departing flights from Germany and France are lower compared to those from the other countries studied. This is due to a higher proportion of short flights. The average emissions from flights from the Netherlands are the highest and are due to relatively few short flights and relatively many intercontinental destinations.

2.2 Basic features of major airports

In addition to the size of the aviation sector by country, in this section we describe the basic data of the main airports in these countries. These are airports with many aircraft movements, both passenger flights and cargo flights. These airports have a large destination network with many connections to European and intercontinental destinations. As a result, they serve an important function for international air traffic and facilitate the transfers of transfer passengers at the airport.

An airport that facilitates the transfers of transfer passengers is called a *hub*. An important role at the hub is played by the *home-carrier*: a Full-Service Carrier (FSC) that has many aircraft based at the airport. For example, for Schiphol Airport this is KLM and for Frankfurt Airport this is Lufthansa. Smaller regional airports generally focus on direct connections and do not facilitate transfer passengers. However, these regional airports do sometimes transport transfer passengers to national hubs; others focus mainly on OD traffic.
An explanation of the differences between hubs and regional airports and the cooperation of individual airports in an airport system is provided in Section 3.2.

The airports that are being compared are the main airports of the countries studied. These airports also play a major role in international passenger and cargo air travel. We single out the following airports: Brussels (BRU), Frankfurt am Main (FRA), Munich (MUC), Paris-Charles de Gaulle (CDG), Amsterdam Schiphol (AMS) and London Heathrow (LHR).

Passenger numbers

Table 9 shows passenger numbers by airport and the respective shares by transit, transfer and OD passengers. London Heathrow Airport transported the highest number of passengers of any airport in our comparison. Followed closely in numbers by Charles de Gaulle, Frankfurt am Main and Amsterdam Schiphol. Transit passengers make up a very small proportion of passengers at all airports. Germany's second largest airport, Munich, has almost twice as many passengers as Belgium's largest airport.

Table 9 - Numbers of passengers (in millions) transported by each airport in 2019

Country	Airports	Total	% Transit	% Transfer	% OD	Number of destinations*
BE	BRU	26.3	0.3%	17.8%	81.9%	185
DE	FRA	70.4	0.1%	25.1%	74.7%	297
	MUC	47.9	0.1%	19.7%	80.2%	212
FR	CDG	76.1	0.0%	14.6%	85.3%	268
NL	AMS	71.7	0.0%	36.1%	63.9%	271
UK	LHR	80.9	0.0%	33.8%	66.2%	218

* Status of the number of destinations in September 2022, consulted on FlightsFrom.

Amsterdam Schiphol, London Heathrow and Frankfurt am Main airports have the highest proportion of transfer passengers, with more than a quarter (Frankfurt am Main) to more than a third transfer passengers at Amsterdam Schiphol and London Heathrow. The number of OD passengers exceed 80% at Brussels, Munich and Paris-Charles de Gaulle airports. Brussels and Munich airports have less of a hub function. Paris-Charles de Gaulle is a major national hub, but also has a high OD share. One explanation is the large home market of

Paris and its surrounding area. This allows aircraft to be filled with passengers to both national and global destinations.

Amsterdam Schiphol, London Heathrow and Frankfurt am Main airports also have a high number of direct connections to other airports. Amsterdam Schiphol has a very high share of intercontinental transfers, with this airport fulfilling the function of a European hub with many OD destinations in and around the EU (CE Delft, 2021). Transfer passengers flying from a European destination to another European destination account for 26% of the total transfer share. About 63% of transfer passengers come from intercontinental flights and have a destination in Europe, or come from an airport in Europe and transfer to an intercontinental flight. 10% of all transfer passengers use Amsterdam Schiphol Airport without having a destination in Europe. These passengers are therefore flying between two different continents, where both the departure and the destination locations are outside Europe.

London, Paris, Frankfurt and Munich airports play an important role as national hubs. These airports provide flights to and from a relatively high number of national destinations. Passengers from other English, French and German airports travel through these hubs to foreign airports with which there are no direct connections.

Air cargo

Table 10 shows the volumes of cargo transported through the airports. Frankfurt am Main and Paris-Charles de Gaulle airports have the largest volume of air cargo. Schiphol and London are somewhat smaller, but also important for international air cargo. In Brussels and Munich, cargo volumes are significantly smaller.

Table 10 - Total volume of cargo transported by airport

Country	Airports	Cargo (million tons)
BE	BRU	0.6
DE	FRA	2.1
	MUC	0.4
FR	CDG	2.1
NL	AMS	1.6
UK	LHR	1.7

Flight movements

The total number of aircraft movements as shown in Table 11 does not vary much between most airports. The vast majority of airports had between 400,000 and 500,000 aircraft movements in 2019, with the exception of Brussels, with just over 200,000 flights. As for the volume of air traffic in 2019, while the Frankfurt, Paris, Amsterdam and London hubs are similar in the total number of aircraft movements, the nature of the flights differ.

Table 11 - Total number of aircraft movements (take-offs and landings) and capacity constraints by airport

Country	Airports	Total number of flight movements	Capacity restriction	Form of restriction
BE	BRU	223,400	Night flights banned	Regulatory restriction
DE	FRA	507,400	Night flights banned, except H4 (= noise category) aircraft	Regulatory restriction
	MUC	407,400	Night flights banned	Regulatory restriction
FR	CDG	494,800	*Unknown*	-
NL	AMS	500,700	Maximum 500,000 flight movements, of which a maximum of 32,000 during night hours	Regulatory annual standard
UK	LHR	479,800	Maximum 480,000 flight movements, ban on night flights	Physical capacity take-off/landing runways

For a number of airports, it is clear that they have reached the physical or regulatory maximum capacity. This is mainly the case at Amsterdam Schiphol and London Heathrow, where in the former case the regulatory standard is the limiting factor. At London's largest airport, the almost full utilisation of the capacity of the two runways has reached physical capacity, leaving zero remaining slots. Both London and Amsterdam experienced unaccommodated demand in 2019. OD passengers divert to nearby airports as a result of higher ticket prices due to scarcity, or they travel by land transport instead of air travel, or they forgo travel. Transfer passengers mostly divert to competing hubs.

2.3 Basic features per million inhabitants

To put the statistics in perspective and make it easier to compare policies in different countries, we have expressed some of the statistics for each country in terms of numbers per million inhabitants. This provides a clearer picture of which countries, relative to population, have more or fewer passengers traveling through them and how important air cargo is. These relative figures provide a deeper look into the significance of aviation in the countries in question.

Passenger numbers

Of the five countries studied, the Netherlands has the highest number of passengers per inhabitants, for both intra-EU and extra-EU destinations (see Table 12). In particular, the proportion of transfer passengers is comparatively many times higher than in the other countries (see Table 13). This is due to the fact that KLM operates a very large international destination network at Amsterdam Schiphol and the home market is too small for sufficient OD passengers. As a result, flights are largely filled with international transfer passengers.

Table 12 - Number of passengers transported, per million inhabitants

Country	Total	National	Intra-EU	Extra-EU
BE	3,089,000	1,000	2,188,000	901,000
DE	2,731,000	279,000	1,496,000	956,000
FR	2,512,000	472,000	1,134,000	905,000
NL	4,698,000	0	2,955,000	1,743,000
UK	4,163,000	345,000	2,566,000	1,251,000

Table 13 - Passenger flows per million inhabitants subdivided by type of travel

Country	Total	Direct transit	Transfer-pax	OD-pax
BE	3,088,000	7,000	409,000	2,673,000
DE	3,020,000	5,000	347,000	2,668,000
FR	2,987,000	8,000	189,000	2,791,000
NL	4,698,000	3,000	1,497,000	3,198,000
UK	4,452,000	1,000	625,000	3,825,000

Air cargo

Belgium has a significant volume of air cargo relative to its population. Due to their central location in Western Europe and their business model, Brussels and Liège airports account for a large proportion of the Western European air cargo market. Following in second place is the Netherlands. In addition to airports, both countries have large seaports and a large logistics sector. These combinations allow the Netherlands and Belgium to provide a complete range of services and transport products worldwide.

Table 14 - Air cargo transported, in kilograms per inhabitant

Country	Total cargo	National	Intra-EU	Extra-EU
BE	128	0	34	94
DE	59	2	15	42
FR	35	3	8	25
NL	99	0	5	93
UK	40	1	8	31

Flight movements

The relative number of flight movements per inhabitant is a relatively simple indicator that says something about the inconveniences (noise, emissions) and benefits (available connections and height of flight frequencies) - depending, of course, on the exact location of airports in relation to natural and inhabited areas. Table 15 shows the number of aircraft movements per thousand population in 2019 for all registered commercial passenger and cargo flights. The Netherlands has the highest numbers for both total flight movements and international flight movements. This means that Dutch residents face a relatively higher number of flight movements, and therefore a relatively higher level of inconvenience compared to residents of other countries. On the other hand, the Dutch have relatively high direct and indirect connectivity with other countries and continents. Higher accessibility can manifest itself in a higher number of direct destinations and in higher frequency on these routes. A detailed analysis of accessibility is not part of this study.

Table 15 - Total number of aircraft movements, passenger and cargo flights, per thousand inhabitants

Country	Total	National	Intra-EU	Extra-EU
BE	28.3	0.5	20.5	7.3
DE	22.4	3.1	13.1	6.2
FR	19.7	4.8	9.3	5.6
NL	32.7	0	23.3	9.3
UK	30.0	5.3	18.2	6.2

2.4 Aviation in the Netherlands relative to other countries

In the Netherlands, as in Belgium, there are almost no national flights because these countries are geographically too small. This differs in Germany, France and the United Kingdom: in these countries the number of national flights varies between 14 and 24% of total aircraft movements. The number of extra-EU flights is very similar in all countries except the United Kingdom (21%), with proportions of between 26 and 29%. The remaining flights are intra-EU flights, which dominate the number of aircraft movements in all countries and range between 47% in France and more than 70% in the Netherlands and Belgium.

The differences between transfer passengers are striking. In France, this proportion is low at 6%, while transfer passengers account for 32% of all passengers in the Netherlands. The other countries in our comparison have between 11 and 13% transfer passengers. The fact that the Netherlands has almost three times more transfer passengers than the other countries means that the large destination network is only made possible by the number of non-Dutch transfer passengers. This is substantially different in the other countries. In Germany, France and the United Kingdom, many transfer passengers are actually residents of the country, traveling to one of the hubs via a domestic flight. The high proportion of transfer passengers in the Netherlands also ensures that it has the highest number of flight movements per inhabitant (33 per 1,000 inhabitants). The United Kingdom follows with 30 flights per 1,000 inhabitants in 2019, while in the other countries it is around 20 per 1,000 inhabitants. As a result, the number of flights from the Netherlands exceeds the need for travellers wishing to travel to or from the Netherlands.

The Netherlands also ranks among the top in air cargo, with nearly 100 kg per inhabitant. In Belgium the amount is even higher at 128 kg, while through the other countries only 35 to 59 kg per inhabitant is transported. This shows that both the Netherlands and Belgium are important transit countries for air cargo transport in Europe. Air cargo should be considered together with the major ports of Rotterdam and Antwerp in this context.

The main characteristics of aviation in the five countries studied is summarised in Table 16.

Table 16 - Share of flights by segment and by country

	The Netherlands	Belgium	Germany	France	United Kingdom
National flights	0%	2%	14%	24%	18%
Intra-EU flights	71%	72%	59%	47%	61%
Extra-EU flights	29%	26%	28%	28%	21%
Transfer passengers	32%	13%	11%	6%	14%
Number of flight movements per inhabitant	28	22	20	33	30
Kg air cargo per inhabitant	99	128	59	35	40

3 National measures in five countries

3.1 Introduction

This chapter discusses national measures for Belgium, Germany, France, the Netherlands and the United Kingdom. This includes only measures that are complementary to EU policies, such as the Fit for 55 proposals. A description of the Fit for 55 measures and the effects on the Dutch aviation sector is given in REF CE Delft 2021. The national measures are divided into four categories:
1. Capacity measures.
2. Taxes and other price measures.
3. Financing and encouraging sustainable aviation.
4. Regulations, obligations and prohibitions.

3.2 Background information: types of airports, airport systems and capacity restrictions

The effect of individual measures depends in part on the type of airport to which they are applied. As background information for the rest of this chapter, we explain some key features and differences between airports in this section.

Hub airports

Large airports have high passenger numbers and a large number of destinations. Major airlines (often called *flag-carriers*) operate a *hub-and-spoke* system at these airports. A major goal of this system is to increase load factors on long-haul air routes. To do this, passengers are brought to the hub via *feeder flights*, where they transfer to fly (sometimes via a second hub) to their destination. At the hub, these passengers are called *transfer passengers*.

Because of this business model, the number of destinations a hub can offer is greater than that of an airport without a hub function. A significant portion of flights are generally intercontinental connections. A hub is also used to transfer passengers between cities that are otherwise unconnected or less connected, because there is not enough demand for a direct connection to do so. There are a number of major hubs in the countries studied: Brussels (cargo hub), Frankfurt, Munich, Paris-Charles de Gaulle, Amsterdam Schiphol and London Heathrow.

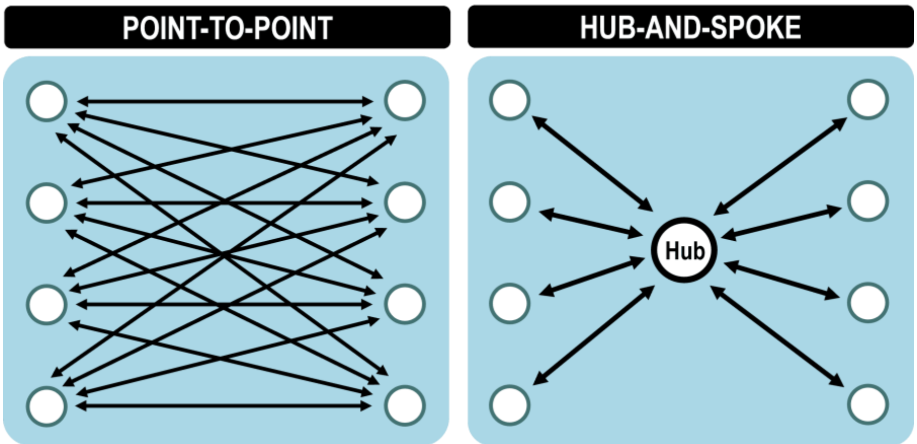
Basically, a hub airport operates on a fixed principle, but there are differences in the elaboration. In a national hub, the most important element is connecting national airports with foreign intercontinental destinations. In other words, the proportion of passengers departing via a national feeder flight through the hub is relatively high in the total. London Heathrow, Paris-Charles de Gaulle and German airports largely fulfil the role of national hubs.

There are also European/global hubs in which the airports serve relatively large numbers of passengers from other countries in addition to inhabitants of the country of residence.
In other words, the proportion of passengers travelling through the hub via a European or international feeder flight is a relatively high proportion of the total number of passengers. This type of airport also facilitates transfers for people travelling between two continents other than Europe. Amsterdam Schiphol, Paris-Charles de Gaulle and Frankfurt am Main airports fulfil this role to some extent. For Schiphol in particular, this function is very important.

Regional airports

Regional airports often lack intercontinental connections and are often smaller in size, in both passenger numbers, cargo throughput and number of aircraft movements. The main purpose of these airports is to transport OD passengers, who travel *point-to-point* between two airports. The difference between *point-to-point* connections and a *hub-and-spoke* system is shown in Figure 1.

Figure 1 - Graphical representation of point-to-point and hub-and-spoke flight networks



Source: Transportgeography.org.

Some regional airports have connections to one or more hubs, where passengers can transfer to many different destinations. Other hubs focus mainly on point-to-point connections to tourist destinations.

Both hubs and regional airports can have a function of transporting goods in addition to their passenger transport function. If specific cargo aircraft (full freighters) depart from an airport, it is called a cargo airport. The remaining cargo is carried in the fuselage (belly) of passenger aircraft.

In summary, generally a regional airport serves OD passengers and a hub airport serves OD and transfer passengers. Both types of airports can also function as cargo airports. In the Netherlands, Schiphol (hub airport) and Maastricht (regional airport) are cargo airports, while the other Dutch regional airports focus on passenger transport.

Airport capacity and multi-airport system

An important feature is whether an airport is operating at the limit of its capacity or not. That is, whether the number of actual flight movements is close to its permitted capacity limit, which may be capped by a policy or a physical operational limit, or whether there is still some scope for more flights.

Because capacity is an issue for many large hubs, they often operate as part of a multi-airport system rather than individually. There are several definitions of a multi-airport system (SEO, 2007). For this report, the only important criterion is that several geographically close airports cooperate. This means they are not competing for the same passengers, but rather ensuring that aviation demand is spread across individual airports. One example is the opening of Lelystad Airport as an overflow airport for Schiphol. The intention is that typical holiday flights will be handled via Lelystad and the space freed up at Schiphol can be used for the hub-and-spoke system at Schiphol. Airport systems not only exist in the Netherlands, but also in the countries studied, namely:
- Brussels: Brussel-Zaventem, Brussels South-Charleroi;
- Frankfurt: Frankfurt am Main, Frankfurt-Hahn;
- London: Heathrow, Gatwick, Stansted, Luton, City, Southend;
- Paris: Charles de Gaulle-Roissy, Paris-Orly, Beauvais-Tillé.

Effect of capacity scarcity

When the number of aircraft movements approaches an airport's capacity, at some point no further growth is possible. That means airlines will no longer be able to get additional slots. If capacity is reduced, it may even become necessary to reduce the number of slots. Scarcity occurs in both cases. If an airport serves only one segment, for example only point-to-point passenger connections or only full freighters, this segment will be unable to grow further or may even shrink. At the large airports described, different segments compete for limited capacity, namely OD passengers, transfer passengers and cargo. In the event of scarcity, full freighters are the segment that generally comes under pressure first because, under the current rules of the European Slot Regulation (Europese Slotverordening), they cannot easily retain their slots.

When the number of flights at a hub is at the capacity limit, for example due to a government-imposed restriction, tickets will generally become more expensive and frequencies will decrease/not increase further. The latter may have an effect on the average transfer time for transfer passengers. All in all, this may lead to a decrease in the supply of transfer passengers, who are also on average more cost-sensitive than OD passengers. After all, these passengers can more easily choose a route with a change of airport than OD passengers, who will have to choose other departure airports.

If a hub can serve fewer transfer passengers, it can potentially have a negative impact on network quality, i.e. the accessibility of the number of destinations, in both absolute number of direct destinations and the frequency of flights. This means that from a hub’s perspective, it is important to remain attractive to transfer traffic in order to maintain the network.

An important aspect in aviation is that demand depends heavily on supply. If many cheap tickets are offered, it creates a need for travel that otherwise would not be there. Until the 1970s, flying was only affordable for a small segment of the population. Later that group grew larger and larger, and the airplane was also discovered for new types of travel. For example, before the emergence of low-cost carriers, hardly anyone went on a weekend city trip by airplane. This phenomenon emerged at the beginning of this millennium and today airplanes are full of travellers visiting destinations across Europe for leisure before and after the weekend. A key driver here was that airlines offered tickets below cost and marketed tickets at dumped prices in all kinds of advertisements. The economic fact is that this stimulates demand, through low prices on the one hand and new supply on the other, for which there was previously no clear market demand. Demand for destinations is thus a dynamic that depends on the price and attractiveness of the trip, including flight frequency and travel time to and from the destination. Adding capacity thus drives demand for flying; reducing capacity dampens it.

3.3 Capacity measures

This section discusses, country by country, the applicable and possible capacity measures used to make aviation more sustainable. This includes both capacity restrictions and possible expansion or opening of new airports. Often, capacity policies not only aim to reduce the climate impact of aviation, but the limiting of excessive noise levels for airport residents and reduction of local nitrogen emissions also play an important role. In this context, making aviation more sustainable is only one element in the overall consideration, which sometimes carries more and sometimes less weight. Another important aspect, for example, is noise.

In Belgium, two measures stand out. First, there has been a restriction on the number of night flights at Brussels Airport since 2009. This means that a maximum of 16,000 'night slots' are available per year, 5,000 of which are for departing flights. No flights may be operated at night during the weekend and higher landing and departure fees apply to night flights. Second, plans for an additional terminal, which would have increased capacity from 26 to 40 million passengers per year, have been temporarily shelved due to reduced demand as a result of the corona pandemic (RINGtv, 2021). Although this is not a direct sustainability measure, this development could have a major impact due to decreased demand.

In Germany, night flights are banned at major airports (Berlin, Düsseldorf, Frankfurt, Hamburg, Munich) (Peter, 2019). Frankfurt Airport has plans for substantial expansion (Frankfurt Airport, ongoing). The completion of a new terminal is scheduled for 2026 and will offer an additional capacity of 19 million passengers per year. There is also the possibility of further expansion of this terminal over time, which should accommodate an additional 6 million passengers per year.
In France, Paris-Orly Airport has a restriction of 250,000 aircraft movements per year (Garric & Mandard, 2021). This applies to all types of flights. In addition, plans involving a new terminal and an additional runway at Paris-Charles de Gaulle Airport have been cancelled (Ministère de la Transition écologique et solidaire, 2018b). The expansion was intended to allow an additional capacity of 160,000 flights per year. The decision to cancel the plans was made by the French government in view of climate targets.

The United Kingdom currently has no direct capacity restrictions on aviation. As a result, the physical capacity of the existing runways indirectly constitutes a maximum capacity for the number of flights. The British government has allowed, under certain conditions, plans for an expansion of London Heathrow with a third runway (Bloomberg, 2022). This will significantly increase capacity for the possible number of flights.

There are several restrictions in place in the Netherlands to reduce flight movements. At Schiphol, this number is currently limited to 500,000 per year (Ministerie van I&W, 2022); a legal limit based on the Alders Agreement (Aldersakkoord) and lower than operational capacity. In the Framework Letter Schiphol (Hoofdlijnenbrief Schiphol), the Ministry of Infrastructure and Water Management informed the Lower House in June 2022 that it plans to reduce Schiphol's capacity to 440,000 movements per year for the period 2024 to 2029 and to allow growth thereafter only if aircraft are quieter and more fuel-efficient[4]. Eindhoven Airport currently has a maximum of 41,500 flights per year.

There is also a limit on the number of flight movements at Rotterdam The Hague Airport as well as a limit on permits for Maastricht and Groningen, although the number of flights at the latter two airports mentioned are not currently near the limit.

In contrast to capacity constraints, there are desires and plans for a possible expansion of Schiphol Airport: through the construction of the second Kaag runway, the construction of a new 'Zuid' terminal (TenderNed, 2022) and the possible opening of Lelystad Airport (VVD et al., 2021). These expansions should provide additional capacity for OD passengers, freeing up capacity for transfer passengers. No final decision has yet been made on these expansion options. However, the Lelystad Airport terminal has already been built.

An overview of the main measures by country is given in Table 17.

[4] The current limit of 500,000 movements per year is a tolerated situation. Formally, only LVB1 capacity is possible, but it is also without a permit. It is currently unclear whether growth is possible. A prerequisite is obtaining the necessary permits from Schiphol. The critical issue here is nitrogen emissions.

Table 17 - Overview of capacity measures at airports

Country	Description of measures	Status	Segment/ target group	Global climate impact (measured)	Expected impact (CE Delft estimate)	Sources
Belgium	**Restriction on night flights Brussels Airport** – a maximum of 16,000 night slots per year (of which 5,000 departing) – no (departing) night flights during the weekend – higher landing and departure fees for night flights *When: since 2009.*	Current policy	All types of flights	Not measurable (as yet).	0 - *Total impact on number of flight movements and thus reduction of global CO_2 emissions probably limited.*	[ref. 20]
	Brussels Airport expansion plans – extra terminal capacity: from 26 to 40 million passengers per year *When: postponed until further notice due to corona pandemic.*	Potential policy	All types of passengers	Not measurable (as yet).	0 - *Airport expansion postponed due to drop in demand. Therefore, no reduction potential for global CO_2emissions as a result of this decision.*	[ref. 21, 25]
Germany	**Night flights banned** – Berlin, Dusseldorf, Frankfurt, Hamburg, Leipzig/Halle, Munich, Stuttgart *Varying time slots introduced at different times.*	Current policy	All types of flights	Not measurable (as yet).	0 - *Total impact on number of flight movements and thus reduction of global CO_2 emissions probably limited.*	[ref. 34]
	Frankfurt Airport expansion – new terminal: additional capacity of 19 million passengers per year (with expansion possibilities to 25 million passengers per year) *When: scheduled completion in 2026.*	Current policy	All types of passengers	Not measurable (as yet).	[--] - *Extra capacity will lead to more aircraft movements, likely resulting in higher overall CO_2 emissions.*	[ref. 36]
France	**Restriction of flight movements** – Paris-Orly: restriction of 250,000 flights per year	Current policy	All types of flights	Demand is lower at Paris-Orly. Impact is unclear and questionable, as demand and therefore flights may have shifted to other Paris airports. No major impact on avoided emissions expected.	[0/+] - *Growth in demand may be held steady, however, there will also be diversion to other airports in the Paris region.*	[ref. 5]

Country	Description of measures	Status	Segment/ target group	Global climate impact (measured)	Expected impact (CE Delft estimate)	Sources
	Cancellation of plans for a new terminal and additional runway at Paris-Charles de Gaulles — the government cancelled this plan in early 2021 due to climate concerns	Current policy	All types of flights	Extra runway and terminal would allow 160,000 extra flights per year. The effect is the number of flights avoided in the future. Capacity constraint of current and future demand.	+ - *Significant number of extra flights avoided in future. It should be noted that flights could potentially divert to other Paris airports and ICA flights to other European hubs, if these can still grow in capacity.*	[ref. 4]
The Netherlands	**Capacity of number of flight movements (landings or take-offs)** — Schiphol: a maximum of 500,000 per year, of which a maximum of 32,000 are allowed at night (between 23:00 and 07:00 hours) — Eindhoven: a maximum of 41,500 flights per year. No night flights.	Current policy	All types of flights	Demand is lower at Schiphol Airport. Impact is unclear, as other hubs may take some of that market potential. No major impact on avoided emissions expected.	+ - *Some reduction of the number of flights. However, it is also possible that these ICA flights are now going to other European hubs, which ultimately does not reduce emissions.*	[ref. 8]
	Reduction in number of night flights at Schiphol — a maximum of 29,000 movements at night — potential policy: maximum 27,000 or 25,000 movements at night	Potential policy	All types of flights	Possible effect: shifting of flights to the daytime period. No reduction in emissions expected.	0 - *Flights divert to other airports or move flights to the day or fringes of the night.*	[ref. 8]
	Reduction in number of flight movements (landings or take-offs) — Schiphol: a maximum of 440,000 per year	Proposed policy	All types of flights	Supply is reduced and demand is dampened by higher ticket prices (scarcity gains). Impact is unclear, as other airports (e.g. Lelystad) may take some of that market potential.	+ - *Significant reduction in the number of aircraft movements, however it is likely that a large proportion of transfer passengers will divert to other European hubs and OD passengers will divert to nearby airports.*	[ref. 45]
	Postponement of Schiphol expansion — no decision on second Kaag runway	Current policy	All types of flights	The effect is the number of flights avoided in the future. Capacity constraint of current and future demand.	+ - *Possible significant number of extra flights avoided in future.*	[ref. 12]

Country	Description of measures	Status	Segment/ target group	Global climate impact (measured)	Expected impact (CE Delft estimate)	Sources
	Opening Lelystad Airport – extra capacity OD flights, possibly shifting from Schiphol	Potential policy	All OD passengers	Effect depends entirely on precise interpretation of regulations: does Lelystad facilitate the relocation of flights from Schiphol or additional flights?	+ - *Possible significant number of extra flights avoided in future.*	[ref. 12]
United Kingdom	**Permitted expansion of third runway at London Heathrow** – Heathrow allowed to plan for third runway within certain conditions	Current policy	All types of flights	The effect is the number of flights avoided in the future. Capacity constraint of current and future demand.	+ - *Significant number of additional flights avoided in the future. It should be noted that potential flights could divert to other London airports, if they can still grow in capacity.*	[ref. 18]

3.4 Taxes and other price measures

This section discusses by country the taxes and other pricing measures used to make aviation more sustainable. This includes flight taxes, excise taxes and other levies that determine the price of air travel, and covers both current and possible future policies.

In addition to these price measures, there are other levies and taxes in aviation. However, these were not considered in this study because their purpose is not to mitigate climate effects. Nevertheless, these price measures may have indirect side effects that are in line with climate policies. Examples include LTO levies by heaviness (MTOW) of aircraft and NO_x levies. These are correlated with fuel consumption, and thus with emissions from flying. For example, at several European airports there are reduced fares for aircraft that produce fewer NO_x emissions. We found no instances where the level of levies is determined depending on the composition of the fuel. However, it is the case at some airports that price incentives are given to aircraft that have refuelled SAF, in order to encourage SAF use (FNG, 2022).

In Belgium, an air passenger tax was introduced in April 2022. This ticket tax is aimed at taxing short-haul flights in particular: for flights shorter than 500 km there is a € 10.00 fee, for other flights within Europe it is € 2.00 and for all other flights € 4.00 (Horenbeek & Wauters, 2022). The tax applies only to departing OD passengers.
In addition, the desire has been expressed to eventually introduce further fiscal measures, such as excise taxes on kerosene (NEKP, 2019). However, this should preferably follow EU policy.

Germany currently applies a distance-based air passenger tax (Die Bundesregierung, 2019). Originally introduced in 2011, the ticket tax was significantly increased from 1 April 2020. The minimum rate is € 13.03 and the maximum rate is € 59.43. The rates can be found in Table 18.

Airlines also face an emissions-related levy applied by German airports. It is calculated based on the nitrogen oxide (NO_x) equivalent emitted within the LTO cycle. Fares for the various airports are listed in Table 18.

In France, the air tax for departing OD passengers is twofold (PWC, 2017). On one hand, it consists of a distance-based levy: € 4.66 for flights within the EU and shorter than 1,000 km and € 8.37 for flights outside the EU or longer than 1,000 km. On the other hand, there is a so-called solidarity tax, with the proceeds going to financially support developing countries, especially in the area of health. Fares for these depend on both distance and ticket class (see Table 18) and range between € 2.63 and € 63.07.
In addition to OD passengers, departing cargo flights are also taxed in France. The fee for this is € 1.38 per ton and applies to all departing flights.

In the United Kingdom, the Air Passenger Duty applies that affects all departing passengers (HM Revenue & Customs, 2018). Fares depend on distance and vary between £ 13.00 and £ 554.00 (see Table 18). In addition, an excise duty must be paid on private pleasure flights, about 10 pence (£ 0.1) per litre (HMRC, 2022).

An air passenger tax was reintroduced in the Netherlands in 2021 It previously existed in 2008 and 2009. Currently, the government plans to increase the tax for departing OD passengers from € 7.95 to € 26.43 (Rijksoverheid, 2022). The current version and plans exclude transfer passengers and cargo. In addition, there are plans to introduce excise tax

on kerosene from 2028 and cargo flights are to be taxed (Duurzame Luchtvaarttafel, 2020). The amount would then depend on noise class and maximum take-off weight (MTOW).
In addition, the Ministry of Infrastructure and Water Management (I&W) has non-concrete ideas about levies for business and charter passengers (Ministerie van I&W, 2020), where the proceeds would benefit more sustainable aviation. Emissions-related levies are also intended to become part of the package of measures (Duurzame Luchtvaarttafel, 2019).

Table 18 - Overview of taxes and other price measures

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
Belgium	**Ticket tax** – flights < 500 km: € 10.00 – flights within Europe: € 2.00 – all other flights: € 4.00 *When: reportedly from 1 April 2022.*	Proposed policy	Departing OD-passengers	Not measurable (as yet).	0 - *Very low rates. No reduction potential for global CO_2 emissions.*	[ref. 23, 26]
	Fiscal measures that internalise the external environmental costs of aviation activities *Scope (€): unknown.* *When: unknown.*	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible.*	[ref. 24]
	Excise tax on kerosene *Scope (€): unknown.* *When: unknown.*	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible.*	[ref. 24]
Germany	**Ticket tax** – flights within Europe: € 13.03 – flights < 6,000 km: € 33.01 – flights > 6,000 km: € 59.43 *Exception: transit and transfer passengers.* *When: from 1 April 2020.*	Current policy	Departing OD-passengers	Measure 2011 (with lower rates): 2 to 2.5% reduction in demand for air traffic (4-5 million passengers) on an annual basis. The actual reduction in the number of flights is unknown.	+ - *Significant increase in fares over 2011 is expected to cause reduction in demand for air travel.*	[ref. 30, 31, 33]
	Emission-based levy (per kg of NO_x equivalent emitted within the LTO cycle) – Keulen, Düsseldorf, Bremen, Dortmund: € 3.00 – Hamburg, Stuttgart: € 3.12 – Frankfurt: € 6.42 – Munich: € 9.11	Current policy	All types of flights	Not measurable (as yet).	0 - *Incentive for airlines to modernise aircraft/make aircraft more sustainable. Potentially limited, indirect reducing effect on global CO_2 emissions.*	[ref. 37, 38, 39. 40, 41, 42, 43, 44]
France	**Civil Aviation Tax** – flights within EU and < 1,000 km: € 4.66 – flights outside EU and > 1,000 km: € 8.37	Current policy	Departing OD-passengers	Not measured (as yet).	0 - *No reduction potential for global CO_2 emissions.*	[ref. 3]

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
	Solidarity tax (for funding of developing countries, mainly health) – flights within EU/EEA and < 1,000 km • first/business class: € 20.27 • other classes: € 2.63 – all other flights • first/business class: € 63.07 • other classes: € 7.51 *Exception: transfer passengers.*	Current policy	Departing OD-passengers	Not measured (as yet). No known impact assessments. This levy is a means of collecting taxes to pay for development aid.	*+ - Significant effect on ticket prices creates reduction in demand for air travel.*	[ref. 3]
	Cargo – € 1.38 per tonne (all destinations)	Current policy	All departing cargo flights	Not measured (as yet).	*0 - Price incentive is too low for a modal shift. Therefore, there is no reduction potential for global CO_2 emissions. Capacity for cargo at other European airports is sufficient for diverting European cargo flights.*	[ref. 3]
The Netherlands	**Ticket tax** – for all departing passengers: € 7.95 *Exception: transfer passengers.* *When: from 1 January 2021.*	Current policy	Departing OD-passengers	Around 0.5 million fewer OD passengers from the Netherlands. Impact on total number of flights is zero. Only in the event of low economic growth is there expected to be a decrease of 15,000 flights by 2030.	*0 - Passengers divert, no reduction potential for overall CO_2 emissions.*	[ref. 8]
	Ticket tax increase – for all departing passengers: € 26.43 *Exception: transfer passengers.*	Adopted policy	Departing OD-passengers	Similar effect as the abovementioned tax. Expected higher impact of general decrease in CO_2 emissions as more people forgo traveling or travel by land. Due to caps at Dutch airports, there is no increased impact on emissions	*+ - Significant increase in fares compared to current policy is expected to cause reduction in demand for air travel.*	[ref. 8]

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
				from more transfer passengers (Rijksoverheid, 2022).		
	Excise tax on kerosene (from 2028) – amount of excise duty not specified	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible (as yet).*	[ref 8]
	Tax on cargo flights – tax per departing cargo flight, depending on noise class and total weight	Proposed policy	All departing cargo flights	Not measurable (as yet).	*No estimate possible (as yet).*	[ref. 9]
	Levy on business and charter passengers – proceeds from the levy to innovation for sustainable aviation	Proposed policy	All departing OD passengers, business segment and non-scheduled flights	Not measurable (as yet).	0 - *Reduction in business travellers is absorbed by ICA transfer travellers. No reduction potential for global CO_2 emissions.*	[ref. 10]
	Emission-related LTO levies	Proposed policy	All types of flights	Not measurable (as yet).	0 - *More energy-efficient aircraft may be deployed to NL, while other aircraft continue to fly other routes. No reduction potential for global CO_2 emissions.*	[ref. 11]
United Kingdom	**Air Passenger Duty** – tax per departing passenger Group A: destinations up to 2,000 miles • £ 13 reduced rate • £ 26 standard rate • £ 78 high rate Group B: destinations starting at 2,000 miles • £ 84 reduced rate • £ 185 standard rate • £ 554 high rate *Excludes transit/foreign inbound transfers < 24h.*	Current policy	All departing passengers, including national transfer passengers (travel starts in UK with a transfer within 24 hours)	Impact studies show 7% increase in demand when ADP falls by 50%. Sometimes the impact is zero because low-cost airlines (Ryanair/Wizzair) internalise the levy (offer tickets under £ 13). Shifting demand from Northern Ireland to Dublin. PWC calculated that the APD dampens demand for flights from UK by 10%.	+ - *Curb on the growth of OD passengers.*	[ref. 13, 14, 15]

3.5 Funding and promoting sustainable aviation

This section discusses the existing and potential measures regarding funding (subsidies) and other incentives for making aviation more sustainable on a country-by-country basis. The measures include subsidies, commitment to sector-wide agreements and (investment) projects driven or coordinated by the national government.

In Belgium, there are currently no concrete measures involving funding or incentives.

In Germany, the national government is committing large sums of money to technology improvement and the development of production sites for SAF. A billion-euro incentive program to modernise airline fleets should accelerate efficiency improvements and reduce the CO_2 intensity of German air traffic. In addition, an equivalent amount has been made available for the development of SAF and € 200 million for research into hybrid-electric aircraft (BMVI, 2020). Stuttgart Airport independently encourages the use of SAF by giving discounts to airlines that refuel with SAF (Stuttgart-Airport, 2022). For this purpose, € 500,000 was made available in 2021. It is unknown whether this is a structural measure to encourage SAF use.

France is also investing heavily in the development of SAF production. The national government has made € 3.4 billion available for biokerosene (Gouvernement de France, 2021).

In the United Kingdom, the government is focusing on different parts of the future SAF production chain. The government has set aside £ 15 million (€ 17.8 million) for the investment of SAF production sites. In addition, the government plans to establish an SAF *clearing house* to make testing for biofuels faster and more efficient (DfT, 2021).

In the Netherlands, the national government plans to invest in the development of production of SAF, also specifically focusing on the development of synthetic kerosene (VVD et al., 2021). The Aviation in Transition growth fund supports investments in the field of synthetic kerosene (Luchtvaart in Transitie, 2021). In addition, the Netherlands is also committed to hybrid electric aircraft (AHEV, 2022).

Table 19 – Overview of Sustainable aviation funding and incentives

Country	Description of measures	Status	Segment / target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
Belgium	*No policy known*					
Germany	**Modernisation of aircraft fleet** – incentive programme valued at € 1 billion for accelerated fleet replacement *Decided June 2020.*	Current policy	All types of flights	Not measurable (as yet.)	*+ - Investments in modern, more efficient aircraft expected to lead to a reduction in global CO_2 emissions.*	[ref. 29]
	Development of renewable fuels for aviation – € 1 billion *Available until 2023.*	Current policy	All types of flights	Not measurable (as yet).	*No estimate possible - supports blending requirement for synthetic kerosene.*	[ref. 29]
	Study into hybrid-electric aircraft – € 200 million *Available until 2024.*	Current policy	All types of flights	Not measurable (as yet).	*No estimate possible.*	[ref. 29]
	Discount on SAF fuelling – Stuttgart Airport: aircraft using SAF can get a discount of up to € 300.00 per 1,000 litres – Budget: € 500,000 *Valid from 10 May 2021.*	Current policy	All types of flights	Not measurable (as yet).	*0 - Although the discount may be attractive to airlines, the budget is too small to have significant reduction potential for global CO_2 emissions.*	[ref. 35]
France	**Support for the development of SAF production sites** – € 3.4 billion allocated to R&D of biokerosene. Main goal is scaling up the most promising production methods.	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible - supports other measures.*	[ref. 7]
The Netherlands	**Investment in the development and production of sustainable aviation fuels** – including the production of synthetic kerosene	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible - supports other measures.*	[ref. 12]
United Kingdom	**Support for the development of SAF production sites** – £ 15 million (€ 17.8 million) allocated for investment in SAF production	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible - supports other measures.*	[ref. 17]

Country	Description of measures	Status	Segment / target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
	UK SAF clearing house – £ 3 million (€ 3.6 million) allocated for the development of hubs for biofuel testing	Proposed policy	All types of flights	Not measurable (as yet).	*No estimate possible*.	[ref. 17]
	Investment in R&D low/zero emission technologies – £ 1.95 billion (€ 2.3 billion) allocated to sustainable aviation technology projects (aircraft and propulsion; not SAF)	Proposed policy	All types of flights (depending on features of newly developed aircraft)	Not measurable (as yet).	*No estimate possible - supports other measures.*	[ref. 17]

3.6 Regulations, obligations and prohibitions

This section highlights existing and potential regulations for each country. Regulations include all obligations, prohibitions and legal agreements with the aviation industry.

There was social outrage in Belgium about the existence of a scheduled flight between Charleroi and Liège, which is a very short distance for an aviation route (80 km as the crow flies). In response, the Minister of Transport of the Government of Wallonia banned domestic flights up to 100 km by ministerial decree for environmental reasons and this scheduled flight was scrapped (DeMorgen, 2008, 2009). There are no known cases of other scheduled flights affected by this ban. Belgium has no regulations besides this ban that exceed existing and potential EU regulations for making aviation more sustainable.

Germany has local restrictions and capacity measures at several airports (e.g. banning night flights or certain aircraft from a relatively loud noise class), and plans to establish an SAF mandate that exceeds the EU mandate[5]. The German government has issued a mandate requiring that 2% of all jet fuel refuelled at German airports must be synthetic kerosene by 2030 (BMUV, 2021). This percentage is higher than the 0.7% required by EU policy. Germany's national emissions trading system (nEHS) covers the built environment and transport fuels. Due to the fact that emissions from aviation fuels are covered by the EU ETS, these fuels are excluded from the German system (DEHSt, 2021)[6]. Despite the fact that aviation allowances are now largely freely given to the sector, Germany has not brought fuels for use in aviation under the national system.

French climate law has a number of stipulations, prohibitions and obligations that greatly affect the sustainability of the aviation sector. The climate law bans the construction of new airports and the expansion of existing airports in France[7]. It is also noted that there will eventually be a ban on domestic flights on routes where another mode of transport can make the trip in two and a half hours (e.g., high-speed rail) (Ministère de la Transition écologique et solidaire, 2019, Gouvernement de France, 2021). There are also exceptions to this rule, such as domestic flights used mainly for a transfer to a faraway destination. This exception makes the precise implementation uncertain.

Airlines operating domestic flights in France will be required to offset emissions starting in 2022. Partial compensation will begin in 2022. Starting in 2024, there are plans to offset 100% of CO_2 emissions. The French government is exploring a ban on fossil products, which includes aviation. French ambitions regarding the SAF obligation exceed EU policy. The EU mandate for mandatory biokerosene blending is 35% by 2050. France has a national aviation fuel blending obligation of 50% for biokerosene by the year 2050, in addition to the 28% synthetic kerosene required by EU (Gouvernement de France, 2021). This brings the total use of renewable fuels in aviation to at least 78%[5].

The national government of the United Kingdom is currently considering an SAF mandate, but no percentages or concrete plans are known to date (DfT, 2021). The United Kingdom has a national CO_2 'budget' (UK Carbon Budget), which stipulates by law the maximum

---

[5] There is a potential conflict with the European ReFuel Aviation proposal that does not allow national blending obligations to exceed this. However, legal assessments are currently being carried out in several countries and there is lobbying in Europe to make national blending relief possible.

[6] See Umweltbundesambt, CLEW and ICAP for Germany's national EHS.

[7] Some exceptions are construction or expansion in French overseas territories, construction or expansion for national security (defence), or if EU standards or regulations require the adaptation of airports.

amount of carbon emissions that the United Kingdom may emit (UK Government, 2021). From 2035, the aviation sector will also be included in the emissions budget (this has yet to be legislated) and by then emissions must be 78% lower than the level of emissions in the United Kingdom in 1990. Emission reductions may occur in sectors other than aviation.

The Netherlands may adopt policies mandating electric taxiing by 2030 and 100% electric aircraft by 2050 on flights up to 500 km from Dutch airports (Ministerie van I&W, 2020). In addition, the coalition agreement includes the introduction of a policy for a CO_2 cap for the aviation sector. The implementation of this is currently being studied. This cap would mean that the airline industry would have an upper limit on CO_2 emissions for all flights departing in the Netherlands. By 2030, CO_2 emissions must be at 2005 levels, by 2050 they must be reduced by 50% and by 2070 departing flights must be completely emission-free. The reduction must be achieved in the aviation sector; the system does not permit offsets. As a result, aviation may only grow in numbers of flights or passengers (and a reduction is also conceivable) if CO_2 emissions fit within the limits of the cap. Growth would be only possible under a CO_2 cap for flights that have lower emissions. In addition, the Netherlands has plans to introduce a national SAF blending requirement of 14% by 2030 and 100% by 2050, with additional limits on synthetic kerosene (Ministerie van I&W, 2020).
These percentages are significantly higher than the percentages included in the EU policy 'Fit for 55'.

The climate Impact of aviation is not only limited to CO_2. One of the main examples of this is condensation streaks. Condensation streaks occur when an aircraft emits particulates; substances released by burning kerosene in the jet engines, such as water vapor, soot, sulphur oxide (SO_2) and nitrogen oxide (NO_x). Moreover, CO_2 emissions at altitude create a larger warming effect than emissions at ground level. As a result, non-CO_2 effects create a much larger impact on global warming than the industry's CO_2 emissions.

In none of the countries studied is there current focus on the non-CO_2 climate impact of aviation. However, several airports do have a levy per flight for the amount of kg of NO_x emitted when taking off and/or landing. This measure is mainly for local air quality reasons and has does not aim to reduce non-CO_2 climate effects.

Table 20 – Overview of Regulations, obligations and prohibitions

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
Belgium	**Ban on flights up to 100 km within Wallonia** – flights up to 100 km banned; scheduled flights between Charleroi-Liège affected and scrapped *When: banned by ministerial decree in 2009.*	Current policy	All types of flights	No impact estimates known.	*0 - Given the limited distance of this flight (less than 100 km) and the limited use of this flight, it will not have a significant effect on overall CO_2 reduction.*	[ref. 22]
Germany	**SAF mandate** – 0.5% synthetic kerosene by 2026, 2% by 2030 *This is higher than EU policy (0.7% by 2030).*	Current policy	All types of flights	Not measurable (as yet).	+ - *Up to 2030 positive impact expected on global CO_2 reduction. Path initiated may yield greater long-term impact.*	[ref. 28]
France	**Ban on expansion of existing airports and construction of new airports** – only if expansion allows sustainable development and in the case of national defence or adaptation to new EU standards *Ban does not apply to overseas French territories.*	Current policy	Aviation infrastructure	Expected effect is a restriction on flight growth where demand exceeds airport capacity.	+ - *Significant number of extra flights avoided in future. It should be noted that ICA flights may divert to other European hubs if these hubs can still grow in capacity.*	[ref. 7]
	SAF mandate – France takes the same line as Fit for 55 with increased use of biokerosene by 2050: 50% (relative to 35% biokerosene)	Current policy		Expected reduction of emissions of all departing flights of around 50% by 2050, depending on carbon proportion SAF. Total effect emissions reduction aviation depends on the volume of French aviation until 2050.	++ - *This measure increases biokerosene use by 15 percentage points in 2050 compared to Fit for 55. Direct effect on carbon intensity of flights in and out of France.*	[ref. 2]
	Ban on domestic flights – if an alternative form of transport is possible on routes with less than 2.5 hours travel time. *Exceptions are flights used primarily for transfer to a distant destination.*	Adopted policy	All types of flights	Unclear what exception is in practice. Rule suspended until European Commission decides on the legality to ensure a level playing field in a free market.	+ - *Assuming there is sufficient capacity at most French airports, no other flights will replace the banned flights as a result of this measure. There will therefore be an immediate reduction effect due to*	[ref. 7]

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
					fewer short-haul flights. In addition, a potential positive impact through behavioural change: adjusted travel behaviour may also increase use of trains for short international trips.	
	Domestic flight compensation obligation – partial compensation will begin in 2022. 100% of emissions from domestic flights to be offset by 2024.	Proposed policy	All types of flights	All emissions from domestic flights in France are offset or reduced in other sectors. (4.53 Mt CO_2 for domestic flights - including overseas flights).	0 - *No reduction in aviation sector.*	[ref. 7]
	Ban on advertising fossil products including aviation – with the aim of less stimulating of demand	Potential policy	All passenger flights	Impact not assessable (as yet).	0 - *Expected decrease in demand, the number of passengers. Impact on the number of flights and emissions is still unclear.*	[ref. 1]
The Netherlands	**Operational liabilities** – 100% electric taxiing by 2030 – 100% electric flying on flights up to 500 km away by 2050	Potential policy	All types of flights	No impact estimates known.	+ - *If green energy is used for taxiing and charging electric aircraft, the TTW climate impact of short-haul OD passenger flights can be significantly reduced.*	[ref. 8]
	CO_2 cap aviation – to guarantee reduction targets for CO_2 emissions from aviation in coming decades	Potential policy	All types of flights	Obligation of aviation to achieve a result. No compensation possible in other sectors. Effect of measure depends on effect of other policies and penalties for violating emissions cap.	0/+++ - *The effect depends entirely on the level of the CO_2 cap. A strict cap on aviation emissions of aircraft travelling to and from the Netherlands and no compensation option in other sectors could provide significant emissions reductions in the sector. If reducing becomes difficult, flights may divert to other surrounding countries.*	[ref. 12]

Country	Description of measures	Status	Segment/ target group	Impact (measured)	Expected impact (CE Delft estimate)	Sources
	SAF mandate: — 14% blending requirement starting in 2030, 100% in 2050. This applies to several types of sustainable jet fuel: biokerosene, synthetic fuel and green hydrogen.	Potential policy	All types of flights	Potential effect 1 Mt CO_2 in 2040, 2 Mt in 2050.	++ - *This measure increases biokerosene use by 9 percentage points in 2030 compared to Fit for 55. Direct effect on carbon intensity of flights to and from the Netherlands.*	[ref. 8, 9, 10]
United Kingdom	**UK Carbon Budget** — legislated that UK aviation sector also counts in the 2035 emissions budget (-78% compared to 1990)	Adopted policy; not yet in effect	All types of flights	Expected impact 1 Mt CO_2 in 2025; increasing to 5 Mt in 2050. Reduction or compensation can take place in other sectors. Stronger decrease in emissions compared to a situation where aviation falls outside the budget.	++ - *Incentive for reduction and contribution of the aviation sector in total CO_2 reduction. However, reduction is unlikely to take place entirely in the sector.*	[ref. 16]
	SAF mandate — is currently being considered, no decision as yet on percentages and year-on-year increase share	Proposed policy	All types of flights	Not measurable (as yet), depending on extent of the mandate.	*No estimate possible (as yet).*	[ref. 17]

4 Comparison of measures

4.1 Introduction

In this chapter we compare the effectiveness and efficiency of aviation sustainability measures and the implementation across countries. We initially focus on the general effect of the different types of measures and then explain the implementation and expected impact of specific measures. This will allow us to compare the policies of different countries. Effectiveness refers to the degree of impact on reducing CO_2 emissions from the aviation sector by implementing a measure. Efficiency refers to the ratio of resources (financial resources, administrative burden for both government and industry, raw materials) to the magnitude of the impact on emissions reduction.

Where applicable, in this comparison we look at the impact of policies on different segments of aviation: OD and transfer passengers, passenger and cargo flights, and European and intercontinental flights.

Where no effectiveness studies on particular measures are available in the literature, we made our own estimates of expected effects. In this assessment, we focus primarily on overall CO_2 emissions. For emissions, we describe the effects of the aircraft during flights from the country in question, taking into account possible waterbed effects (diverting to other countries). We also briefly include the effects on transport flows, air pollutant emissions during the LTO phase, excessive noise levels for those living near the airport and fiscal effects.

4.2 Capacity measures

In this section, we address capacity measures. Capacity measures have a unique effect relative to the other types of measures. They affect both the supply and demand sides and may effect all previously defined segments. When supply is reduced, scarcity will eventually affect prices, which will also reduce demand. Demand will also follow supply when supply is increased; offering new destinations creates additional demand that did not otherwise exist. In general, this leads to stronger effects on transfer passengers and freight traffic, as they are more cost-sensitive than OD passengers.

In the discussion of capacity reduction measures, it is important to keep in mind that operational constraints always apply at airports. After all, an airport can only facilitate a maximum number of flight movements. Therefore, a policy constraint only has an effect if operational capacity is less than demand and the imposed limit is less than operational capacity. A good example is Schiphol Airport, where the maximum number of flight movements per year is 500,000, while operational capacity could be higher.

Chapter 3 identified three types of capacity measures:
1. Restrictions of the number of flight movements.
2. The limiting of night flights.
3. Stopping or allowing airport expansions.

We will evaluate the effectiveness of these three types of measures in this section.

Restrictions of the number of flight movements

A restriction of the number of flight movements is a powerful sustainability policy tool. Currently, of the countries studied, this is used only in the Netherlands (Schiphol, Rotterdam, Eindhoven) and France (Paris-Orly). According to EU slot rules, there must be no discrimination against users and, moreover, these users have the freedom to use these slots as they see fit. As a result, there is currently no way to actively target certain segments, such as OD and transfer passengers, cargo and passenger flights, or European and intercontinental flights. However, the government does have options by guiding the capacity statements of individual airports. This will affect the segments as individual airports perform different functions.

We estimated the impact of the Dutch capacity constraints on global CO_2 reduction as a limited positive effect (+). We do not estimate this to be higher due to the dampening effect of diversion to other airports. The effect becomes stronger once diversion becomes more difficult, for example, if all major EU hubs limit their capacity. The economy of scale in this case leads to an actual reduced impact on demand and thus a higher potential CO_2 reduction (++). We estimate the effect of capacity constraints on Paris-Orly to be lower (0), as there are more diversionary options in the close vicinity (Paris-Charles de Gaulle).

Capacity constraints are an incentive for airlines to deploy larger aircraft. This allows more passengers to be carried, but reduces average CO_2 emissions per passenger. A disadvantage of the larger aircraft is that they create more excessive noise and more LTO emissions per flight movement.

The effects on flight movements of a capacity limitation are obvious. In addition, there will be less air pollutant emissions in absolute terms during the LTO phase and the excessive noise levels for local residents will also decrease. As far as we know, there are no fiscal effects as a result of this measure.

Limiting night flights

Restrictive measures for night flights are in place in Belgium, Germany and the Netherlands. Under current policy, this ranges from a total ban on night flights at all major airports in Germany and Eindhoven Airport, to a maximum number of flights at both Brussels Airport and Schiphol. In none of these cases does it distinguish between OD and transfer passengers, cargo and passenger flights, or European and intercontinental flights.

Limiting night flights primarily serves the purpose of reducing noise pollution for nearby residents. A direct effect on emissions does not exist. Thus, looking at the overall CO_2 emissions, the effect of restricting night flights is small, both in the case of a restriction and a total ban. The local effect, however, is stronger. It is intended that the excessive noise levels at night will be drastically reduced. There will also be a limited effect on local air pollution. In the case of the maximum number of night flights, both will have a lesser effect depending on the original number of flights. To the best of our knowledge, there is no fiscal impact as a result of this policy.

Airport expansions

Airport expansions are a topic of discussion in all the countries studied. Allowing an expansion ultimately has a directly positive effect on supply and stopping it has a directly negative effect. Depending on the situation, this may or may not result in reduced demand.

It is clear that policies at the EU level once again have a stronger effect. Nevertheless, our assessment is that the cancelation of the Paris-Charles de Gaulle expansion and the delayed decision on Schiphol's expansion will have a positive effect on future CO_2 reductions.

The effects on transport flows are obvious. In addition, there will be less air pollutant emissions in absolute terms during the LTO phase and the excessive noise levels for local residents will also decrease. An estimate of the fiscal effects, both direct and indirect, cannot be made at this time.

4.3 Taxes and other price measures

In this section, we contrast various taxes and other price measures. When properly deployed, these measures can be a strong tool for governments and help to indirectly manage demand.

Airline taxes can be seen as a way to internalise the external social costs and impact caused by air travel into the price of travel and reduce demand. In this way, the people who use air travel pay for the direct and indirect costs. To determine the degree of internalisation, Schroten & Wijngaarden (CE Delft, 2019) offset the actual costs against levies and taxes for different types of transport. This shows that flying is taxed significantly less than other modes of transport. This imbalance becomes more pronounced for long-haul flights.

To illustrate the operation of this price mechanism, we can use two common price elasticities: -0.5 for business travellers and -1 for non-business travellers (Grebe et al., 2020). Under these conditions and the assumption that all other circumstances remain unchanged, raising the air passenger tax in the Netherlands from € 7.95 to € 26.43 for an EU flight of € 100.00 quickly leads to a reduction in demand from 4 to 13% for business travellers and from almost 8 to 26% for non-business travellers. Looking at a € 500.00 intercontinental flight, the demand reduction is smaller but still significant: from 0.8 to 2.4% for business travellers and from 1.6 to 4.7% for non-business travellers. However, these reductions in demand would only occur if there are diversion routes through other airports where the tax does not have to be paid. With diversion options, the effects are much smaller. In fact, a higher price can cause different behavioural responses. These are:
1. No adjustment: choose the same route and accept the higher tax.
2. Choose to adjust the route: divert to a foreign airport (with a lower air tax).
3. Choose to adjust the mode of transport: travel by car or train instead of airplane.
4. Choose to adjust travel frequency: forgo travel.

Options 1 and 2 do not generally reduce CO_2 emissions, while Options 3 and 4 do.
The proportions of the respective options depend on the level of taxation, both domestically and in neighbouring countries, and the other features of the various modes of transport. If taxes with similar rates are levied broadly across the EU, waterbed effects (Option 2) can be avoided.

By levying air taxes at capacity-constrained airports, the market segments for cargo flights and passenger flights (OD and transfer passengers) compete with each other due to the limited number of available slots. The moment one of the market segments faces higher costs due to an air tax, demand in that segment falls and the other segments 'benefit'. Thus, the current air passenger tax in the Netherlands causes a decrease in OD passenger demand and an increase in transfer passengers and cargo flights compared to a situation without air tax. Since transfer passengers fly longer routes on average than price-sensitive OD passengers, this could theoretically even lead to an increase in CO_2 emissions from flights departing in the Netherlands. On a global scale, the effects do have positive climate effects: see REF CE Delft Vliegbelasting 2022.

In terms of taxes and other price measures, the countries studied have relatively progressive sustainability policies. However, one measure that none of these countries employs is a general tax on (CO_2 and/or non-CO_2) emissions, as applies in Norway. There, CO_2, NO_x and SO_x taxes exist for domestic flights (full emissions).

Chapter 3 identified four types of price measures:
1. The ticket tax.
2. Emission-related levies.
3. Excise duty.
4. Tax on cargo flights.

We evaluate the effectiveness of these four types of measures in this section.

Ticket tax

The introduction of Belgian ticket tax in April 2022, following the example of the other countries studied, means that diverting to other countries to avoid the tax will become increasingly difficult. As a result, the air tax increasingly reduces the number of air journeys, particularly for short distances. In all countries, the tax affects only departing OD passengers. Transfer passengers are exempted, allowing hubs to remain competitive with international hubs in other countries. In the case of limited capacity, the air tax even increases the number of transfer passengers.

We have estimated the impact on potential global CO_2 reduction differently for each country. For the current policies in the Netherlands and France and the intended policies in Belgium, we estimate that there will be no significant effect. Fares here are relatively low and the demand reduction already in place may lead to travellers diverting to other countries.

With the significant increase in air tax announced in the Netherlands and current policies in the United Kingdom and Germany, we do expect this to have a significant impact. Before Germany raised its air tax rates in 2020, the demand reduction was already estimated at 2 to 2.5% of passengers by Intraplan Consult GmbH, (2012) and Peter, (2019). In addition to the anticipated effects on CO_2 emissions, this measure obviously generates revenue for governments. The effect on air pollutant emissions during the LTO phase and noise levels for those residing near airports will be delayed. Once demand has fallen, supply will eventually adjust accordingly by moving toward a new equilibrium.

Cargo tax

France is currently the only country to implement a tax on cargo, while the Netherlands is also considering introducing it. In France, the policy applies to all flights both inside and outside the EU.

In principle, cargo transport and air cargo are very cost sensitive. Because air cargo is primarily used for intercontinental transport, aircraft compete only with ships. Transport by air is many times faster and more expensive than transport by water. Therefore, a small price increase will not lead to an adjusted choice of mode of transport, but it may lead to an adjusted airport choice to a country without a levy on cargo.

Assuming a cargo aircraft loaded with 250 tons of air cargo, the total levy is less than € 350.00 at a rate of € 1.38 per ton. This is not expected to cause large-scale relocation of truck traffic to other countries. Therefore, the potential CO_2 reduction will be zero.
The same is true for the effect on air pollutant emissions during the LTO phase. Noise levels for people residing near airport will also be very low. On the other hand, this measure obviously generates revenue for governments and more external costs are internalised.

Emissions-based levy

Germany is currently the only country to have an emissions-based levy at airports.
The policy in Germany focusses on the NO_x equivalent emitted within the LTO cycle and applies to all types of flights.

Although this measure is a good incentive for airlines to make their airplanes more sustainable, we expect the impact on the number of flights and thus the potential overall CO_2 reduction to be small. This will also affect excessive noise levels to a limited extent. The effect on air pollutant emissions during the LTO phase will be relatively larger.
In addition, this measure does generate additional revenue for the airports.

Excise duty

The Council for the Environment and Infrastructure (Raad voor de leefomgeving en infrastructuur) in the Civil Aviation Policy Memorandum 2020-2050 (Luchtvaartnota 2020-2050) cites global kerosene taxes as a recommendation for making aviation policy more sustainable. Kerosene taxes can be an effective means of both incentivising airlines to become more sustainable (more efficient aircraft or SAF blending) and reducing demand once this is passed on to consumers in price. This involves encouraging passengers to fly fewer and shorter distances. However, the likely impact of this measure is still difficult to estimate, as there is no concrete elaboration of these plans as yet.

4.4 Funding and promoting sustainable aviation

In this section, we contrast the various means of funding and incentives. When used appropriately, these measures can boost development and innovation.

Modernisation of aircraft fleet

The modernisation of the aircraft fleet, a measure taken by Germany, has a direct effect on CO_2 emissions from flights operated with replaced aircraft, including outside the country in which the measure was taken. The degree of emission reduction depends on the difference in fuel efficiency of the engines of the new aircraft compared to the engines of the aircraft to be replaced. The number of aircraft to be replaced depends on the preferred aircraft and the implementation of the policy programme. A single-aisle aircraft (e.g., A321) with discount for airlines[8] costs about € 50 million. With the full German subsidy of € 1 billion, 200 aircraft can be purchased, if we assume that the subsidy is 10% of the price. Another percentage involves more or fewer new aircraft. The impact depends on whether the phased-out aircraft are no longer used or whether they replace other even older aircraft in other countries. In any case, assuming replacement rather than additional capacity in the

[8] Based on interviews with industry experts and historical sales prices from annual reports.

aviation sector will result in a positive impact on the overall CO_2 emissions of the aviation sector. However, it is unclear how much extra replacement this measure leads to compared to fleet renewal that airlines also implement autonomously and whether smaller aircraft may be replaced by larger ones. Because of this uncertainty, we rate the measure slightly positive (+).

Investing in the development of SAF and sustainable flight technology

Funding research for innovation and the scale-up of sustainable aviation fuels and new aviation technologies (electric/hybrid/hydrogen engines in aircraft) is an indirect means of emission reduction. The potential reduction depends very much on developments, market potential and other factors, such as production and availability of raw materials and renewable energy. This applies to both the investments of Germany (€ 1.2 billion), France (€ 3.4 billion), the Netherlands (unknown amount) and the United Kingdom (converted to euros more than € 2.5 billion). It is impossible to say directly what the expected effects might be if a country invests a sum of money in the development of SAF. Depending on future developments and outcomes, we estimate the impact on reducing global CO_2 emissions from aviation to be (0 to +).

4.5 Regulations, obligations and prohibitions

In this section, we compare the effectiveness and efficiency of various regulations. These may include requirements, prohibitions, obligations and legal arrangements. When properly implemented, these measures can have a direct or indirect impact on the demand, supply and carbon intensity of air travel.

Because of their relatively progressive sustainability policies, the countries studied use a relatively broad set of measures in terms of regulations, obligations and prohibitions.

We take a quick look at other countries actively pursuing aviation emission reduction policies. Finland and Sweden both have emission reduction targets. Although Sweden has no national blending requirement, it has a greenhouse gas reduction target aimed at fuel suppliers. By 2021, emissions from aviation fuel sold must be reduced by 0.8%, rising to 27% by 2030. It is unclear how legally feasible a higher blending obligation is for Sweden under the current EU rules for biofuel blending in aviation.

The Finnish reduction target covers emissions from departing flights (domestic and international) and must be achieved in-sector. The target is 15% reduction by 2030 and 50% by 2045, compared to emissions in 2018 (Traficom, 2021). They see this reduction as possible as a result of improvements in aircraft energy efficiency, SAF blending and operational measures. This puts both countries ahead of the Netherlands, which envisages a similar policy with the CO_2 cap but has not yet implemented it.

Flight bans and capacity restrictions

General bans on certain routes (e.g. all domestic air traffic in Belgium and France in the future) and restrictions on the number of flights at airports are measures that have a direct effect on the volume of air traffic on a local scale. The effects of these bans or restrictions depend on the type of passengers affected and airport capacity.

If demand for intercontinental flights exceeds capacity at the airport where many transfer passengers would be affected by a restriction, in many cases the affected flights could divert to other airports or countries. This would have no significant effect on the overall CO_2 emissions from aviation. In theory, if a less centrally located airport were to receive the diverted flights, total emissions could even increase due to longer routes.

Banning a certain type or segment of flights[9] may have a small but positive effect. If an airport is nearing its capacity limit, there is a risk that the vacated slot space of the expired flights will be filled by other medium-haul (European) or long-haul (intercontinental) flights. Since these routes are in most cases longer than the distance of domestic flight routes, overall emissions from the aviation sector are very likely to increase. To avoid this, the annual capacity would have to be reduced to accommodate the number of aircraft movements banned by the restriction.

We estimate the changed residual flows of travellers from the cancelled flights as follows: as a rule, where possible, some of the travellers will travel by another means of transport and some of the travellers will forgo the trip due to higher costs or longer journey times. Ultimately, there will still be a small proportion of travellers who will continue to fly, but they will do so via another airport abroad, potentially increasing their emissions.

We rate this measure as efficient (+), as no funding is required and the limited administrative burden. Control of this measure may lie with the airport authority that issues slots to airlines. It can allow and deny flights in slots when they do not comply with the rules, such as a flight that has a destination at a shorter distance than allowed from that country.

SAF mandate

A SAF mandate is a direct obligation on the fuel used by aircraft. This directly affects *tailpipe* emissions, due to the fact that SAF has a lower carbon content. A higher SAF blending obligation compared to established EU policy means lower CO_2 emissions on all flights from the countries that oblige such a higher SAF mandate[5]. The mandate affects all types of flights.
The actual reduction in CO_2 depends on the production method, location and the type of energy or raw materials used to produce SAF and transport it to the airport. Overall, this is expected to have a small to significant positive impact on reducing aviation CO_2 emissions. Moreover, the cost of air tickets will rise, which will have an additional demand-reducing effect. We rate the overall impact with (++).

The efficiency of this measure depends on the availability of raw materials for the renewable jet fuel. In addition, the monitoring of this measure has an administrative burden for reporting and monitoring the proportion of SAF admixture in the chain[10]. Depending on which party the SAF share has to be reported to, the administrative burden may be higher or lower. We foresee that if the reporting and monitoring of SAF lies with the fuel suppliers supplying the airports, this will have the least administrative burden.

[9] For example, a ban can be imposed in a country on all domestic flights or flights up to a certain distance (e.g. up to 300 km).

[10] The administration and control of commodity trading is also a burden.

CO_2 cap

Setting a cap on emissions from the aviation sector puts a brake on the growth of air traffic supply and demand in a country. Nor can this measure offset emissions in other sectors, as a *cap-and-trade* emissions trading scheme might. Depending on how it is implemented, it may cause demand to shift to other airports in neighbouring countries in the long run.
In practice, it therefore depends on whether additional policies, such as ticket taxes in neighbouring countries or the cap, are constrictive. In our estimation, this type of measure may have no impact or a very high impact (0 or +++) on aviation CO_2 reduction.
Because aviation emissions are a direct result of the fuels used, the efficiency of this measure is similar to that of the SAF mandate.

4.6 Overview of measures

Table 21 presents an overview of the categories of possible national measures, the potential impact and trade-offs, and the current and planned commitment of the Dutch government. Much of the policy is still in the planning stage. If it is all implemented, together with planned European (Fit for 55) and planned international policies (CORSIA and LTAG), it will lead to significant sustainability of the aviation sector. However, it is then necessary that the plans are translated into concrete policies, both internationally and in individual countries.
Implementation of measures is most effective when undertaken globally. This is because it minimises unfair competition and carbon leakage. Measures at the EU level are the second-best option. Measures at the national level are the least effective, because airlines, travellers and air cargo shippers can fairly easily divert to other countries, allowing the measures to be partially circumvented. On the other hand, implementation at a global level is likely to be slower than at the EU or national level. Although national policies are in principle less effective than global or EU policies, they can make a significant contribution to achieving climate goals. Leaders are also pushing other countries to take more action and further strengthen their national ambitions. The greatest opportunity lies in adopting national measures from frontrunners on a European or global scale, because they have already demonstrated that these measures work.

Table 21 - Overview of effectiveness measures deployed nationally

Category of measure	Effect of measure	Consequence	Possible impact	Possibility of diversion or leakage effect	Dutch policy	Current ambition of the Netherlands vs. other countries studied*
Airport capacity constraints	Restriction of flight movements	Limitation of supply	+	Current supply may move to other airports.	Proposed policy: limit flight movements at Schiphol Airport to 440,000 flights per year.	High
Ticket tax	Increase price of air travel (stop the tax burden difference with other modes of transport)	Limitation of demand	+	Existing demand may shift (in part) to other airports depending on price difference.	Ticket tax for departing OD passengers € 26.00 per ticket from 2023, adopted policy.	Medium
Limitation of emissions: CO_2 cap	Restriction of fossil flight movements	Limitation of supply	+++	Depending on the interpretation of the measure, no leakage effect is possible.	Proposed policy: adopt legislation for reduction of absolute emissions in CO_2 cap.	High
Ban on airport expansions	Restriction of capacity/number of aircraft movements	Limitation of supply	++	Current supply may move to other airports.	Decision on opening Lelystad Airport postponed.	Low[a]
Emission-related levies	Increase levy for operating (fossil) flights	Limitation of demand	+	Current demand may move to other airports.	None.	Low
Excise duty on fuels	Increase price of fuel (close the difference in tax burden compared to other modes of transport)	Limitation of demand	+	Current demand may move to other airports.	No policy, problematic with European regulations.	Low
SAF mandate	Reduction of CO_2 intensity fuels	Reduction of emissions per flight	++	Existing, if number of flight movements increases more than reduction.	Dutch blending obligation being studied, but legally problematic (ReFuel EU).	High
Flight ban	Restriction on scope of activities	Limitation of supply	+	Current supply may move to other airports.	No concrete policy (but currently no national flights either).	Low
Modernisation of aircraft fleet	More economical fuel consumption due to improved energy efficiency engines and use of lighter materials	Reduction of emissions per flight	+	Limited presence, number of aircraft movements may increase due to lower costs and overall emissions may therefore increase.	100% electric flying under 500 km from 2050.	Unknown

* The assessment of the level of ambition is relative to measures in other European countries.

[a] As long as the restrictions at Amsterdam, Rotterdam and Eindhoven airports are in place AND Lelystad does not open.

5 Conclusion

This report has examined aviation sustainability policies for the Netherlands, Belgium, Germany, France and the United Kingdom. As background information, the basic features of aviation in each country have been identified and listed. The national measures of the five countries were then examined in more detail. In doing so, we distinguished between four categories:

1. Capacity measures.
2. Taxes and other price measures.
3. Funding and promoting sustainable aviation.
4. Regulations, obligations and prohibitions.

In this chapter, we first outline the main findings from the comparison between the five countries. Then we do the same for the comparison of the different measures, after which we conclude with the main conclusions and recommendations.

Comparison of countries

In terms of current policies that have been adopted, aviation sustainability measures in the Netherlands are comparable to the other countries studied. In its proposed policies, the Netherlands is relatively ambitious. Nevertheless, if the Netherlands is to take a leading position in making aviation more sustainable, the proposed policies must actually be implemented.

The Dutch aviation sector cannot be compared one-to-one with other countries.
The comparison shows that the Netherlands facilitates a relatively high amount of air traffic, when looking at the number of passengers and aircraft movements compared to the number of inhabitants. Schiphol Airport plays a major hub function in Europe. Because the Dutch domestic market is too small for Schiphol's large destination network, aircraft are largely filled with transfer passengers.

Compared to the other countries, Belgium has the least concretely formulated sustainability policy for the aviation sector. Germany has relatively low goals with regard to measures to reduce or regulate air traffic. In contrast, it makes a relatively large amount of money available for subsidies that can indirectly contribute to making the aviation sector more sustainable. France and the United Kingdom have relatively high tax rates on flying and a wide range of policies are being explored and partially implemented. For example, France will ban domestic flights and the United Kingdom will introduce the Carbon Budget.

It is important to note that compared to other European countries, and certainly globally, the countries studied are relatively progressive in terms of aviation sustainability policies. Similar or higher ambitions are still seen mainly in the Scandinavian countries. Sweden and Finland have a similar CO_2 cap and Norway has a general emissions tax.

Comparison of measures

Among the various measures considered in this study, there are clear differences in effectiveness. There are three types of measures that can reduce or at least not increase the climate impact of air travel in the short term. The first type of measures are capacity constraints. Restricting supply simultaneously limits demand. An example is a restriction on the number of flight movements at an airport, as already occurs in the Netherlands and France. The second type of measures is increasing the price of flying. This causes the demand for air travel to decrease, which in time will also reduce the supply. Most of the countries surveyed have some form of air passenger tax, but these taxes are still quite low and do not cover the actual societal costs of flying. The third type of measures are those that reduce absolute emissions. This again limits supply and therefore demand. An example of this is the CO_2 cap for aviation, as discussed in the Netherlands. Since such a cap sets a strict limit on emissions, it can thereby provide a guarantee that targets are achieved.

Much work is currently being done in aviation to increase the efficiency of flying and renewable fuels. National policies are primarily supportive in the form of subsidies. Because technological developments, aircraft replacement and scaling up production capacities for alternative fuels take time, reducing CO_2 emissions will also take time. While there is no doubt that these developments are necessary, there are two caveats:

1. It is important to realise that the climate impact of aviation in the form of non-CO_2 effects are much larger than CO_2 emissions. Therefore, flying on all-green fuel still leads to global warming.
2. In principle, however, encouraging renewable fuels and more efficient aircraft also reduces costs and ticket prices, potentially driving demand.

The level at which a sustainability policy is organised in the aviation sector is extremely important. Aviation is a global industry and agreements to make aviation more sustainable should therefore ideally also be made on a global scale. In this ideal world, a ‘level playing field’ exists and waterbed effects are minimal. In practice, however, this happens too little and too slowly because the interests of individual stakeholders are often too varied. The result is a lack of consensus for taking effective action.

The next possibility is for policies to be mutually agreed upon by groups of countries, or bilaterally between individual countries. In Europe, the European Commission is taking the lead in this regard and the Fit for 55 proposals are an important package of measures to make aviation more sustainable.

However, many countries feel that the measures do not go far enough and at many airports there are discussions regarding the impact on the local environmental and the reduction of excessive noise levels of aviation activities. Therefore, they are developing additional national measures to make aviation more sustainable, better priced or restricted.
A drawback of local and national measures is that defection of passengers, cargo and flights leads to leakage effects. Although national policies are in principle less effective than global or EU policies, they can make a significant contribution to achieving climate goals. Leaders are also pushing other countries to take more action and further strengthen their national ambitions. The greatest opportunity lies in adopting national measures from frontrunners on a European or global scale, because they have already demonstrated that these measures work. The best results can be achieved by cleverly combining measures.

Conclusions and recommendations

Making the aviation sector more sustainable plays an important role in the struggle to meet the Paris climate targets. Although the corona crisis showed that a temporary contraction of this sector is possible, aviation has currently resumed its growth in full force. Current sustainability policies in aviation are insufficient to meet the Paris targets. While current policies are making a small contribution, more urgency is needed and a long-term vision is crucial.

Although aircraft are becoming more efficient, the sector's emissions are still rising globally due to high growth. To limit accelerating growth, capacity reduction measures, higher pricing of flying and a cap on absolute CO_2 emissions can be deployed. Examples of this include a restriction on the number of flight movements per airport, a higher flight tax and a CO_2 cap. Such a cap is an example of an instrument that ensures that emissions actually fall and efficiency gains are not largely offset by growth in air traffic.

To make the policy as effective as possible, it must be organised at the highest possible level. Implementation of these measures would be most effective if it were undertaken globally. It would be less effective at the EU level, but more effective than if applied only at national level. Although national policies are, in principle, less effective than global or EU policies, they can still contribute to climate goals and get other countries on board. Implementation at the global level is likely to be a relatively slow process. From the perspective of the pioneering role that the EU can play, harmonisation of European policy and particularly Northern European policy would therefore be an important first step.

6 References

AHEV, 2022. *Ontwerp Actieprogramma Hybride Elektrisch Vliegen*, https://open.overheid.nl/repository/ronl-718b4f5b-01d4-4b62-b3b1-d037e5920097/1/pdf/bijlage-1-ontwerp-ahev.pdf 2022.

Bloomberg, 2022. *Heathrow Puts New Runway Back on Agenda as Travel Edges Back*, 23 February 2022 https://www.bloomberg.com/news/articles/2022-02-23/heathrow-puts-new-runway-back-on-agenda-as-travel-edges-back 10 maart 2022.

BMDV, 2018. *ICAO State Action Plan for CO2 Emissions Reduction - Germany -*, Federal Ministry of Transport and Digital Infrastructure (BMDV), Directorate General for Civil Aviation, https://bmdv.bund.de/SharedDocs/DE/Publikationen/LF/icao-aktionsplan-reduzierung-co2-engl.pdf?__blob=publicationFile.

BMUV, 2021. *Beschlossene Anpassungen der Treibhausgasminderungsquote (THG-Quote)*, Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (BMUV), https://www.bmuv.de/media/beschlossene-anpassungen-der-treibhausgasminderungsquote-thg-quote 2022.

BMVI, 2020. *Den Luftverkehr stabilisieren ; Gemeinsame Erklärung zum hochrangigen Treffen „Die Herausforderungen durch die COVID-19-Pandemie meistern“ am 6. November 2020 in Berlin*, Bundesministers für Verkehr und digitale Infrastruktur (BMVI), https://www.bmvi.de/SharedDocs/DE/Anlage/LF/luftverkehrsgipfel-2020-pressestatement.pdf?__blob=publicationFile.

Borbely, D., 2019. A case study on Germany's aviation tax using the synthetic control approach. *Transportation Research Part A: Policy and Practice*, 377-395.

Bremen Airport, 2021. *Schedule of Fees and Charges*, Bremen Airport, https://www.bremen-airport.com/uploads/xdownloads/Airport_Charges___Incentive_Scheme_effective_from_1st_of_February_2020.pdf 2022.

Brussels Airport, 2015. *Milieurapport 2015*, Brussels Airport Company, https://media.brusselsairport.be/bruweb/default/0001/04/54dcbcc33e5c3795fd3ee793ce5355dda3c9a4e8.pdf.

Brussels Airport, s.d. *Uitgebreid terminalcomplex biedt groeiend aantal meer reiscomfort*, https://www.brusselsairport2040.be/nl/visie-2040/48/terminal-en-gatecapaciteit.

CBS, 2022. *Statline: Internationale handel en doorvoer; waarde, gewicht, goederen, vervoerwijze*, 17 maart 2022 https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84668NED/table?ts=1664806843606.

CE Delft, 2019. *De prijs van een vliegreis : Een onderzoek naar de kosten van en voor de luchtvaart in Nederland*, Delft: CE Delft.

CE Delft, 2021. *Effects of the Fit for 55 Package on the Dutch Aviation Sector*, Delft: CE Delft.

Cologne Bonn Airport, 2022. *List of Fees*, https://www.cologne-bonn-cargo.com/fileadmin/user_upload/docs/list_of_fees.pdf.

DEHSt, 2021. *Deutsche Emissionshandelsstelle : Understanding national emissions trading*, https://www.dehst.de/EN/national-emissions-trading/understanding-national-emissions-trading/understanding-nehs_node.html 24 maart 2022.

DeMorgen, 2008. Jet4You mag niet van Charleroi naar Luik vliegen. In: *DeMorgen*, 28 november 2008.

DeMorgen, 2009. Wallonië verbiedt vluchten korter dan 150 kilometer. In: *DeMorgen*, 9 maart 2009.

DfT, 2021. *UK State Action Plan on International Aviation CO2 Emissions Reduction Activities*, London: Department for Transport (DfT).

Die Bundesregierung, 2019. *Fliegen wird teurer : Bundesregierung beschließt Erhöhung der Luftverkehrssteuer*, 17 december 2019 https://www.bundesregierung.de/breg-de/themen/klimaschutz/luftverkehrsteuer-1681874#:~:text=Konkret%20soll%20die%20Luftverkehrsteuer%20f%C3%BCr,25%20Euro%20mehr%20als%20bisher.
Dortmund Airport, 2021. *Schedule of Charges : List of charges and fees*, Dortmund Airport, https://www.dortmund-airport.com/aviation/schedule-of-charges 2022.
Düsseldorf Airport, 2022. *Tariff Regulations for Düsseldorf Airport*, https://www.dus.com/en/businesspartner/aviation/charges-and-regulations.
Duurzame Luchtvaarttafel, 2019. *Ontwerpakkoord Duurzame Luchtvaart, 2019,* Den Haag: Rijksoverheid.
Duurzame Luchtvaarttafel, 2020. *Akkoord Duurzame Luchtvaart ; Nederland versnelt op duurzame luchtvaart*, https://duurzaam-vliegen.nl/wp-content/uploads/2021/03/Akkoord-Duurzame-Luchtvaart.pd.
EASA, 2022. *CO2 Emissions by State*, Eurocontrol, https://ansperformance.eu/data/#img-srcimagesprcq-operations-airportpng-width50-height50-altoperations-at-airports-operations-at-airports 10 maart 2022.
Eurostat, 2022. *Air transport (avia) - Air transport measurement (passengers | freight and mail)*, https://ec.europa.eu/eurostat/web/transport/data/database 11 april 2022.
FNG, 2022. *List of Airport Charges*, Nürnberg, DE: Flughafen Nürnberg GmbH (FNG).
Frankfurt Airport, 2022. *Airport Charges according to Art. 19b Air Traffic Act (LuftVG) Charges for Central Ground Handling Infrastructure*, https://www.fraport.com/en/business-areas/operations/airport-charges.html.
Frankfurt Airport, ongoing. *Building the Future - Terminal 3*, Fraport AG Frankfurt Airport Services Worldwide, https://terminal3.frankfurt-airport.com/en/highlights-of-terminal-3/facts-und-figures October 2022.
Garric, A. & Mandard, S., 2021. Jugé « obsolète », le projet de nouveau terminal à l'aéroport de Roissy abandonné par le gouvernement. In: *Le Monde*, 11 février 2021.
Gouvernement de France, 2021. *Loi climat et résilience : l'écologie dans nos vies*, Paris: Ministère de la Transition écologique et de la Cohésion des territoires ; Ministère de la Transition énergétique
Gouvernement de France, 2022. *Biocarburants*, Ministère de la Transition écologique et de la Cohésion des territoires ; Ministère de la Transition énergétique, https://www.ecologie.gouv.fr/biocarburants#scroll-nav__7 03/10/2022.
Auteur, Jaar. Titel. Editie ed. Plaats van uitgave: Uitgever.
Grebe, S., Eggers, L., Eck, G. v. & Kouwenhoven, M., 2020. *AEOLUS Documentatie 1.1*.
Hamburg Airport, 2022. *Airport Charges Part 1*, Flughafen Hamburg GmbH, https://www.hamburg-airport.de/resource/blob/45192/295ff2e452947287fafae7d9b217ea69/airport-charges-part-1-2022-data.pdf.
HM Revenue & Customs, 2018. *Rates for Air Passenger Duty*, https://www.gov.uk/guidance/rates-and-allowances-for-air-passenger-duty 10 maart 2022.
Horenbeek, J. v. & Wauters, R., 2022. De vliegtaks komt er: tien euro extra voor korte vluchten, alle andere reizen worden ook duurder. In: *HLN (bron De Morgen)*, 28 januari 2022.
Intraplan Consult GmbH, 2012. *Untersuchung zur verkehrlichen und volkswirtschaftlichen Wirkung der Luftverkehrsteuer*, Intraplan Consult GmbH, 19 april 2012 https://www.bdl.aero/wp-content/uploads/2018/08/Intraplan-Studie-zur-Auswirkung-der-Luftverkehrsteuer-April-2012.pdf.
Luchtvaart in Transitie, 2021. *Samenvatting Groeifondsaanvraag NL* https://vaartindeluchtvaart.nl/#downloads 2022.

Ministère de la Transition écologique et solidaire, 2018a. *Paris Charles de Gaulle - Restrictions d'exploitation pour raisons envrionnementales*, https://www.ecologie.gouv.fr/sites/default/files/Restrictions_exploitation_raisons_environnementales_Roissy.pdf 03/10/2022.
Ministère de la Transition écologique et solidaire, 2018b. *Paris Orly - Restrictions d'exploitation*, https://www.ecologie.gouv.fr/sites/default/files/Restrictions_exploitation_raisons_environnementales_Orly.pdf 10 maart 2022.
Ministère de la Transition écologique et solidaire, 2019. *Plan d'action de la France pour la reduction des emissions de gaz à effet de serre de l'aviation civile internationale,* Paris: Ministère de la Transition écologique et solidaire, Direction générale de l'Aviation civile
Ministerie van I&W, 2020. *Verantwoord vliegen naar 2050 : Luchtvaartnota 2020-2050,* Den Haag: Ministerie van Infrastuctuur en Waterstaat (I&W).
Ministerie van I&W, 2022. *Overzicht huidig, voorgenomen en mogelijk beleid in de luchtvaartsector - mailverkeer*, Ministerie van Infrastructuur en Waterstaat (I&W).
Munich Airport, 2022. *Airport Charges : Tariff Regulations 2022, part 1,* Flughafen München GmbH, https://www.munich-airport.com/airport-charges-1325117 2022.
NEKP, 2019. *Belgisch geïntegreerd Nationaal Energie- en Klimaatplan 2021-2030*, Nationaal Energie Klimaat Plan (NEKP), https://www.nationaalenergieklimaatplan.be/admin/storage/nekp/nekp-finaal-plan.pdf.
Northern Ireland Centre for Economic Policy, 2014. *Air Connectivity in Northern Ireland: The economic impact of changes to air fares and short-haul Air Passenger Duty,* Ulster: University of Ulster.
Peter, M., 2019. *Night Flight Bans Or Restrictions At European Airports*, European Union Against Aircraft Nuisances (UECNA), https://www.uecna.eu/night-flight-bans-or-restrictions-at-european-airports.
PWC, 2013. *The economic impact of Air Passenger Duty,* London: PricewaterhouseCoopers UK.
PWC, 2017. *The economic impact of air taxes in Europe: European Economic Area*: PricewaterhouseCoopers
Rijksoverheid, 2022. *Kabinet beperkt aantal vluchten op Schiphol*, 24 juni 2022 https://www.rijksoverheid.nl/actueel/nieuws/2022/06/24/kabinet-beperkt-aantal-vluchten-op-schiphol.
RINGtv, 2021. *Uitbreidingsplannen Brussels Airport gaan voor jaren de koelkast in*, 20 april 2021 https://www.ringtv.be/nieuws/uitbreidingsplannen-brussels-airport-gaan-voor-jaren-de-koelkast.
SEO, 2007. *Luchthavensystemen,* Amsterdam: Stichting Economisch Onderzoek (SEO).
Stuttgart Airport, 2022. *Charges Regulation*, https://www.stuttgart-airport.com/business-to-business/airport-charges/.
TenderNed, 2022. *Utiliteitsprojecten portfolio Schiphol 2022-2030, Marktconsultatie*, 28 augustus 2022 https://www.tenderned.nl/aankondigingen/overzicht/270537/publicatie 2022.
The Geography of Transport Systems. Point-to-Point versus Hub-and-Spoke Networks, https://transportgeography.org/?page_id=653.
UK Government, 2021. *UK enshrines new target in law to slash emissions by 78% by 2035*, https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035 10 maart 2022.
VRT, 2022. *Federale regering bereikt ook akkoord over mini-taxshift: werken wordt beloond, vliegen en roken meer belast*, https://www.vrt.be/vrtnws/nl/2022/02/01/minitaxshift/.

VVD, D66, CDA & ChristenUnie, 2021. *Coalitieakkoord 'Omzien naar elkaar, vooruitkijken naar de toekomst',* Den Haag: Rijksoverheid.

Numbered reference to table references

1. Ministère de la Transition écologique et solidaire, (2019)
2. Gouvernement de France, (2022)
3. PWC, (2017)
4. Garric & Mandard, (2021)
5. Ministère de la Transition écologique et solidaire, (2018b)
6. Ministère de la Transition écologique et solidaire, (2018a)
7. Gouvernement de France, (2021)
8. Ministerie van I&W, (2022)
9. Duurzame Luchtvaarttafel, (2020)
10. Ministerie van I&W, (2020)
11. Duurzame Luchtvaarttafel, (2019)
12. VVD et al., (2021)
13. HM Revenue & Customs, (2018)
14. Northern Ireland Centre for Economic Policy, (2014)
15. PWC, (2013)
16. UK Government, (2021)
17. DfT, (2021)
18. Bloomberg, (2022)
19. Grebe et al., (2020)
20. Brussels Airport, (2015)
21. Brussels Airport, (s.d.)
22. DeMorgen, (2008)
23. Horenbeek & Wauters, (2022)
24. NEKP, (2019)
25. RINGtv, (2021)
26. VRT, (2022)
27. BMDV, (2018)
28. BMUV, (2021)
29. BMVI, (2020)
30. Borbely, (2019)
31. Die Bundesregierung, (2019)
32. Graver et al., (2020)
33. Intraplan Consult GmbH, (2012)
34. Peter, (2019)
35. (Stuttgart-Airport, 2022)
36. Frankfurt Airport, (ongoing)
37. Bremen Airport, (2021)
38. Cologne Bonn Airport, (2022)
39. Dortmund Airport, (2021)
40. Düsseldorf Airport, (2022)
41. Frankfurt Airport, (2022)
42. Hamburg Airport, (2022)
43. Munich Airport, (2022)
44. Stuttgart Airport, (2022)
45. Rijksoverheid, (2022)

A Additional tables of basic features

Table 22 - Flight movements (take-offs and landings) of commercial passenger flights, per million inhabitants

Country	Total pax	National	Intra-EU	Extra-EU
BE	24,700	540	18,260	5,910
DE	20,990	2,960	12,330	5,700
FR	19,060	4,620	9,000	5,440
NL	31,760	10	23,160	8,590
UK	28,950	5,080	17,810	6,070

Table 23 - Flight movements (take-offs and landings) of cargo flights, per million inhabitants

Country	Total cargo	National	Intra-EU	Extra-EU
BE	3,580	0	2,230	1,340
DE	1,380	120	760	500
FR	640	180	330	130
NL	900	0	170	730
UK	720	230	400	90