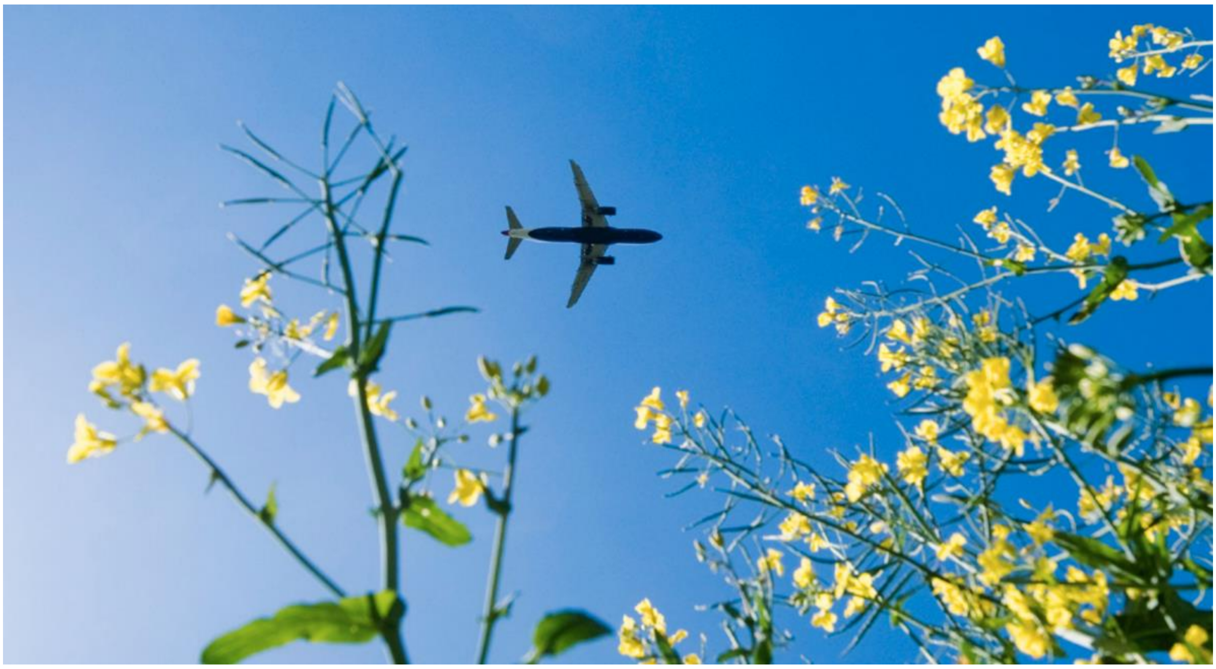
Ministry of Infrastructure and Water Management

Kingdom of the Netherlands

State Action Plan for the reduction of CO_2 emissions from aviation



Colophon

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List of abbreviations

AAM – Advanced Air Mobility

AAT - Aircraft Assignment Tool

ACARE – Advisory Council for Research and Innovation in Europe

ACA – Airport Carbon Accreditation

ACI – Airports Council International

AIRE – The Atlantic Interoperability Initiative to Reduce Emissions

ANSP - Air Navigation Service Providers

APER TG - Action Plans for Emissions Reduction Task Group of the ECAC/EU Aviation and Environment Working Group (EAEG)

ASTM - American Society for Testing and Materials

AtJ – Alcohol-to-Jet

ATM – Air Traffic Management

CAEP – Committee on Aviation Environmental Protection

CBP - Netherlands Bureau for Economic Policy Analysis (Centraal Planbureau)

CBS – Statistics Netherlands (Centraal Bureau voor de Statistiek)

CNG – Carbon neutral growth

CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation

DAC – Direct Air Capture

DARP - Dutch Airspace Redesign Programme

DCCA - Dutch Caribbean Cooperation of Airports

EAER – European Aviation Environmental Report

EASA – European Aviation Safety Agency

EC – European Commission

ECAC – European Civil Aviation Conference

EEA – European Economic Area

EFTA – European Free Trade Association

EU – European Union

EU ETS – the EU Emissions Trading System

eVTOL - Electric Vertical Take-off and Landing

GHG – Greenhouse Gas

HEFA - Hydroprocessed Esters and Fatty Acids

ICAO – International Civil Aviation Organisation

IFR – Instrumental Flight Rules

IPCC – Intergovernmental Panel on Climate Change

IPR – Intellectual Property Right

JU – Joint Undertaking

KiM – Kennisinstituut voor Mobiliteitsbeleid (Netherlands Institute for Transport Policy Analysis)

LVNL – Luchtverkeersleiding Nederland (Air Traffic Control the Netherlands)

MaaS - Mobility as a Service

MBM – Market-based Measure

MUAC – Maastricht Upper Area Control Centre

MT – Million tonnes

OEM – Original Equipment Manufacturer

PBL - Netherlands Environmental Assessment Agency (Planbureau voor de Leefomgeving)

PRISME - Pan European Repository of Information Supporting the Management of EATM

PtL – Power to Liquid

RED – Renewable Energy Directive

RPK – Revenue Passenger Kilometre

RTK – Revenue Tonne Kilometre

RTD – Research and Technological Development

SAF – Sustainable Aviation Fuels

SDG - Sustainable Development Goal

SES – Single European Sky

SESAR – Single European Sky ATM Research

SESAR JU – Single European Sky ATM Research Joint Undertaking

SESAR R&D – SESAR Research and Development

SMEs - Small and Medium Enterprises

VFR – Visiting Friends or Relatives

WLO - Welfare, Prosperity and Human Environment (Welvaart en leefomgeving)

1. Introduction

1.1. Common introductory section for European States' Action Plans for CO_2 emissions reductions

a) The ICAO Contracting State, the Kingdom of the Netherlands, is a member of the European Union[1] and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States[2] of any European organisation dealing with civil aviation. It is currently composed of 44 Member States, and was created in 1955.

b) ECAC States share the view that the environmental impacts of the aviation sector must be mitigated, if aviation is to continue to be successful as an important facilitator of economic growth and prosperity, being an urgent need to achieve the ICAO goal of Carbon Neutral Growth from 2020 onwards (CNG2020), and to strive for further emissions reductions. Together, they fully support ICAO's on-going efforts to address the full range of those impacts, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.

c) All ECAC States, in application of their commitment in the 2016 Bratislava Declaration, support CORSIA implementation and have notified ICAO of their decision to voluntarily participate in CORSIA from the start of its pilot phase and have effectively engaged in its implementation.

d) The Netherlands, like all of ECAC's 44 States, is fully committed to and involved in the fight against climate change and works towards a resource-efficient, competitive and sustainable multimodal transport system.

e) The Netherlands recognises the value of each State preparing and submitting to ICAO an updated State Action Plan for CO_2 emissions reductions as an important step towards the achievement of the global collective goals agreed since the 38th Session of the ICAO Assembly in 2013.

f) In that context, it is the intention that all ECAC States submit to ICAO an action plan[3]. This is the action plan of the Netherlands.

g) The Netherlands strongly supports the ICAO basket of measures as the key means to achieve ICAO's CNG2020 target and shares the view of all ECAC States that a comprehensive approach to reducing aviation CO_2 emissions is necessary, and that this should include:

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1 As are Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

2 Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom.

3 ICAO Assembly Resolution A40-18 also encourages States to submit an annual reporting of international aviation CO2 emissions, which is a task different in nature and purpose to that of action plans, strategic in their nature. Also this requirement is subject to different deadlines for submission and updates as annual updates are expected. For that reason, the reporting to ICAO of international aviation CO2 emissions referred to in paragraphs 10 & 14 of ICAO Resolution A40-18 is not necessarily part of this Action Plan, and may be provided separately, as part of routine provision of data to ICAO, or in future updates of this action plan.

i. emission reductions at source, including European support to CAEP work in this matter (standard setting process);

ii. research and development on emission reductions technologies, including public-private partnerships;

iii. development and deployment of sustainable aviation fuels, including research and operational initiatives undertaken jointly with stakeholders;

iv. improvement and optimisation of Air Traffic Management and infrastructure use within Europe, in particular through the Single European Sky ATM Research (SESAR), and also beyond European borders through participation in international cooperation initiatives; and

v. Market Based Measures, which allow the sector to continue to grow in a sustainable and efficient manner, recognizing that the measures at (i) to (iv) above cannot, even in aggregate, deliver in time the emissions reductions necessary to meet the ICAO 2020 CNG global goal.

h) In Europe, many of the actions which are undertaken within the framework of this comprehensive approach are in practice taken collectively, most of them led by the European Union. They are reported in Section I of this Action Plan, where the involvement of the Netherlands is described, as well as that of other stakeholders.

i) In the Netherlands a number of actions are undertaken at the national level, including those by stakeholders. These national actions are reported in Section II of this Plan.

j) In relation to European actions, it is important to note that:

- The extent of participation will vary from one State to another, reflecting the priorities and circumstances of each State (economic situation, size of its aviation market, historical and institutional context, such as EU/non-EU). The ECAC States are thus involved in different degrees and on different timelines in the delivery of these common actions. When an additional State joins a collective action, including at a later stage, this broadens the effect of the measure, thus increasing the European contribution to meeting the global goals.

- Acting together, the ECAC States have undertaken measures to reduce the region's emissions through a comprehensive approach. Some of the measures, although implemented by some, but not all of ECAC's 44 States, nonetheless yield emission reduction benefits across the whole of the region (for example research, SAF promotion or ETS).

1.2. Current state of aviation in the Kingdom of the Netherlands

1.2.1. Geographical and demographical characteristics

The Kingdom of the Netherlands (Figure 1) is a sovereign state and monarchy. It consists of four autonomous countries with their own constitutions and parliamentary democracies: Aruba, Curaçao, St Maarten and the Netherlands. The head of state is King Willem-Alexander. The kingdom covers an area of 42,525 km^2 and had a total population of 17,737,438 as of November 2019.

The Netherlands is the largest of the four autonomous countries (41,545 km^2) and includes the twelve European provinces and the *Caribbean Netherlands*: the public bodies Bonaire, St Eustatius and Saba. These Caribbean islands have been part of the Netherlands as special municipalities as of 10 October 2010. The twelve European provinces of the Netherlands, often called Holland (erroneously) or simply the Netherlands but legally referred to as the *European part of the kingdom*, make up the vast majority of the country. The European part of the kingdom is located in Western Europe, borders Belgium and Germany, and is one of the founding member states of the European Union (EU) and the European Civil Aviation Conference (ECAC).

Figure 1 - Kingdom of the Netherlands

Aruba, Bonaire and Curaçao are located near the coast of Venezuela and are part of the Leeward Antilles. St Eustatius, St Maarten (which shares the island with a French overseas collectivity) and Saba are similarly located closely together to the North-East, and are part of the Leeward Islands. These three public bodies and three island countries combined are also known as the *Caribbean part of the kingdom*.

The Netherlands literally translates to the 'low country'. Only about half of the land surface of the European part of the kingdom is one meter or more above sea level. Most of the areas in the western part of the country are below sea level in artificial polders. Since the late 16th century these large areas of reclaimed lands amount to nearly 17% of the country's current land mass. Additionally, the province of Flevoland was almost entirely reclaimed from waterbodies in the 20th century. The Netherlands is known for its advanced knowledge of flood protection systems. The Delta and Zuiderzee Works are known as one of the Seven Wonders of the Modern World.

The market-based mixed economy of the Netherlands is the 17th largest in the world (2021) in terms of GDP according to the World Bank and International Monetary Fund (World Bank, 2021). The Dutch economy mainly depends on foreign trade and its economy is noted for stable industrial relations, low unemployment rates and low inflation. Rotterdam is the largest seaport in Europe and Amsterdam Airport Schiphol belongs to the five largest European airports (Royal Schiphol Group, 2021a). Amsterdam Airport Schiphol is an important driver for the Dutch economy because it provides over 68,000 jobs and ensures the Netherlands stays connected to the world (Decisio, 2020). These people work at many different organizations such as airlines (46%), ground handlers (19%), passenger services (restaurants, shops, car rental etc.) and border security but also ICT services and maintenance of the buildings (Decisio, 2020). The service sector dominates the Dutch economy, the main segments are transportation, goods distribution, financial services and tourism. Despite its small size, the Netherlands has a large highly mechanized agricultural sector which provides large surpluses for the food-processing industry and exports. The Netherlands (with agricultural exports exceeding 100 billion euros in 2021) is the world's third-largest exporter of agricultural products (Statistics Netherlands, 2022a).

1.2.2. Aviation in the European part of the Kingdom

The Netherlands has a long history in aviation closely linked to Fokker, KLM and Schiphol. Anthony Fokker was a Dutch aviation pioneer who built the *Fokker Spin* back in 1910. The aircraft manufacturer Fokker became the world's largest in the 1920s with its sales of the Fokker F.VII. In 1958 the Fokker F-27 was introduced and later, amongst others, the F-28 and modernized versions of these aircraft: the Fokker 50, Fokker 70 and Fokker 100. These aircraft are still flying as of today. Nowadays, there is still a large Original Equipment Manufacturing (OEM) industry for aviation in the Netherlands. Various aircraft components are produced for both (large) civilian and military aircraft. The aerospace engineering faculty of Delft University of Technology and the Netherlands Aerospace Centre (NLR) are widely recognized for their expertise in aerospace engineering and operations.

In 2019, a record of 71 million departing and arriving passengers travelled to or from Amsterdam Airport Schiphol. The four other airports of national interest are Eindhoven Airport[4], Rotterdam The Hague Airport, Groningen Airport Eelde and Maastricht Aachen Airport. The expansion of the domestic Lelystad Airport (see Figure 2) is completed. The government intends for Lelystad Airport to become operational in the near future to relieve Amsterdam Airport Schiphol of limitations due to (noise) pollution and congestion of airspace.

Royal Schiphol Group is a Dutch airport management company. The majority shareholder of Royal Schiphol Group is the government, minority shareholders are the municipalities of Amsterdam and Rotterdam, and Groupe ADP[5]. Royal Schiphol Group is 100% shareholder in Amsterdam Airport Schiphol, Rotterdam The Hague Airport and Lelystad Airport and has a 51% stake in Eindhoven Airport. The province of Limburg is 100% shareholder of Maastricht Aachen Airport (SEO Economisch Onderzoek, 2021). The provinces of Groningen and Drenthe and three municipalities have a 74% share in Groningen Airport Eelde (Groningen Airport, 2020).

Besides these airports, there are numerous smaller domestics airports and airfields serving general aviation, military, and search and rescue operations, as well as helicopter ports. These are out of the scope of this document.

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4 This is a civil operation making use of part of RNLAF Eindhoven Air Base

5 RSG and ADP have an 8% stake in each other as part of a cooperation agreement, these shares will be sold by May 2023.

Figure 2 - Airports of national interest in the European part of the Kingdom (RoyalHaskoningDHV, 2020)

1.2.3. Aviation in the Caribbean part of the Kingdom

Aviation is of vital importance for the economy, transportation of people and cargo, tourism and medical transport in the Caribbean part of the Kingdom. Aviation is fundamental to the social development of these islands and there has been a strong connection with the European part of the Kingdom. The COVID-19 crisis has greatly affected the aviation sector as tourism was reduced massively. Safety, connectivity, sustainability and quality of life are important themes that need to be addressed and it requires a suitable approach to fulfill the goals of these public values compared to the European part of the kingdom. The Caribbean part of the Kingdom comprises the countries Aruba, Curaçao and St Maarten and the three public bodies Bonaire, St Eustatius and Saba, which are referred to as the Caribbean Netherlands in this document.

Curaçao is the largest island, and its Queen Beatrix International Airport mainly serves connections to the European part of the Kingdom. Aruba mainly serves airlines inbound from the United States at Hato International Airport. Princess Juliana International Airport is located on St Maarten and also serves as the international airport for the French overseas collectivity of Saint-Martin. Princess Juliana International Airport is the largest airport in the Caribbean part of the Kingdom, however, the devasting aftermath of hurricane Irma in 2017 has greatly reduced the number of tourists visiting the island. The airport of Bonaire is Flamingo Airport, St Eustatius has F.D. Roosevelt Airport and Saba has Juancho E. Yrausquin Airport. The islands and airports are shown below in Figure 3.

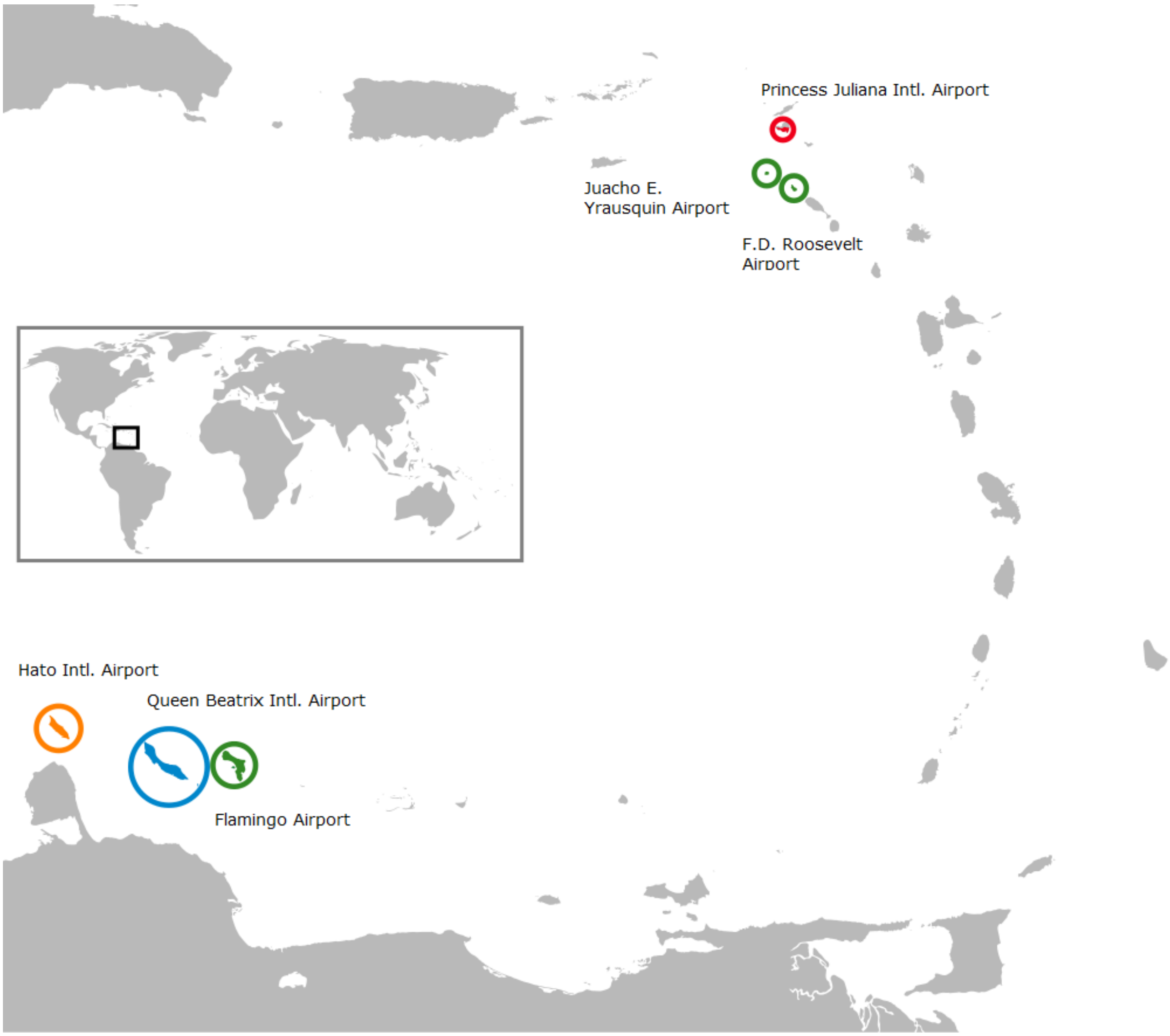

Figure 3 - Airports in the Caribbean part of the Kingdom, autonomous countries shown in orange/blue/red and public bodies (Caribbean Netherlands) in green.

1.3. Statistics and projections the Netherlands

1.3.1. Passenger volumes (European part of the Kingdom)

Amsterdam Airport Schiphol is the largest airport in the kingdom in terms of aircraft movements, passenger volume and cargo and post volumes. The four other airports of national interest in the European part of the Kingdom are also included in the tables and figures below. In terms of passengers, Eindhoven Airport is second followed by Rotterdam The Hague Airport and the smaller airports Maastricht Aachen and Groningen Eelde Airport. COVID-19 has resulted in a rapid decline in aircraft movements and the number of passengers in the year 2020 as shown in Table 1 and Figure 4 below.

Table 1 - Passengers airports in the European part of the Kingdom 2005-2020 (Statistics Netherlands, 2022b)

	Total (number x 1000)	**Amsterdam Airport Schiphol**	**Eindhoven Airport**	**Rotterdam The Hague Airport**	**Maastricht Aachen Airport**	**Groningen Airport Eelde**
2021	29 070	25 491	2 698	755	98	27
2020	23 586	20 885	2 113	490	81	18
2019	81 167	71 680	6 781	2 095	436	176
2018	79 606	70 957	6 238	1 908	275	229
2017	76 204	68 400	5 701	1 733	168	202
2016	70 280	63 526	4 780	1 644	177	152
2015	64 635	58 245	4 374	1 639	195	181
2014	60 933	54 941	3 956	1 625	241	169
2013	58 048	52 528	3 425	1 489	430	176
2012	55 653	50 976	3 005	1 187	305	181
2011	53 868	49 681	2 664	1 075	334	114
2010	48 592	45 137	2 183	923	227	123
2009	46 456	43 523	1 739	922	136	136
2008	50 426	47 392	1 666	987	232	149
2007	50 518	47 745	1 443	1 060	135	136
2006	48 597	45 989	1 171	1 038	270	129
2005	46 488	44078	973	1 011	304	123

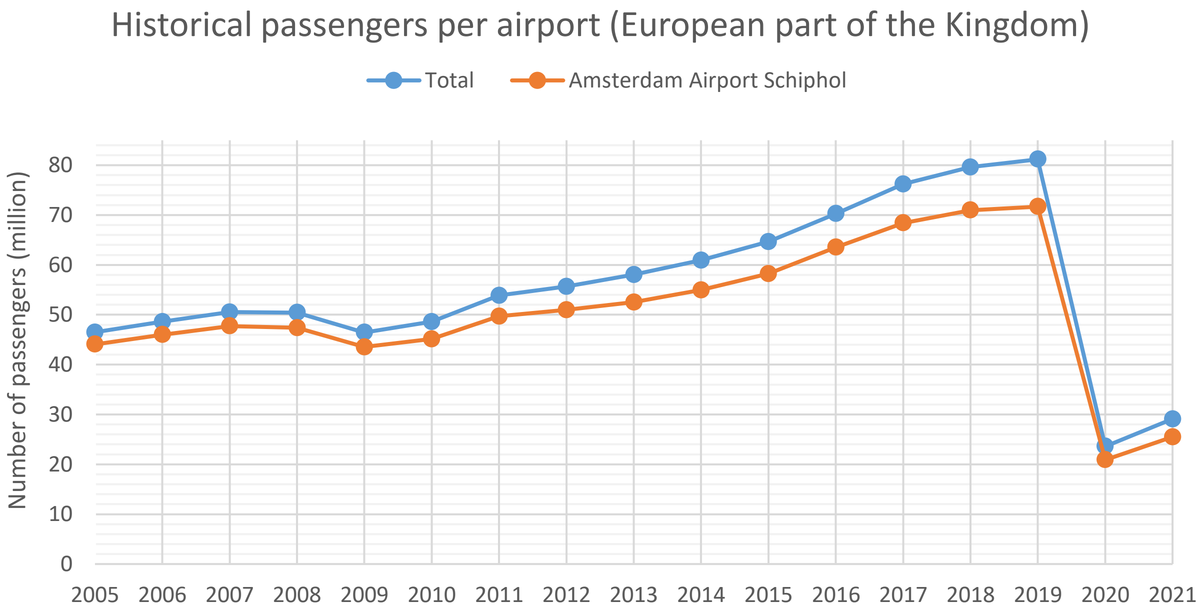

Figure 4 - Passengers airports total (European part of the Kingdom) and Amsterdam Airport Schiphol (Statistics Netherlands, 2022b)

1.3.2. Passenger volumes (Caribbean Netherlands)

Figure 5 shows the number of passenger arrivals and departures at the largest airports in the Caribbean Netherlands: Bonaire (Flamingo Airport), St Eustatius (F.D. Roosevelt Airport) and Saba (Juancho E. Yrausquin Airport).

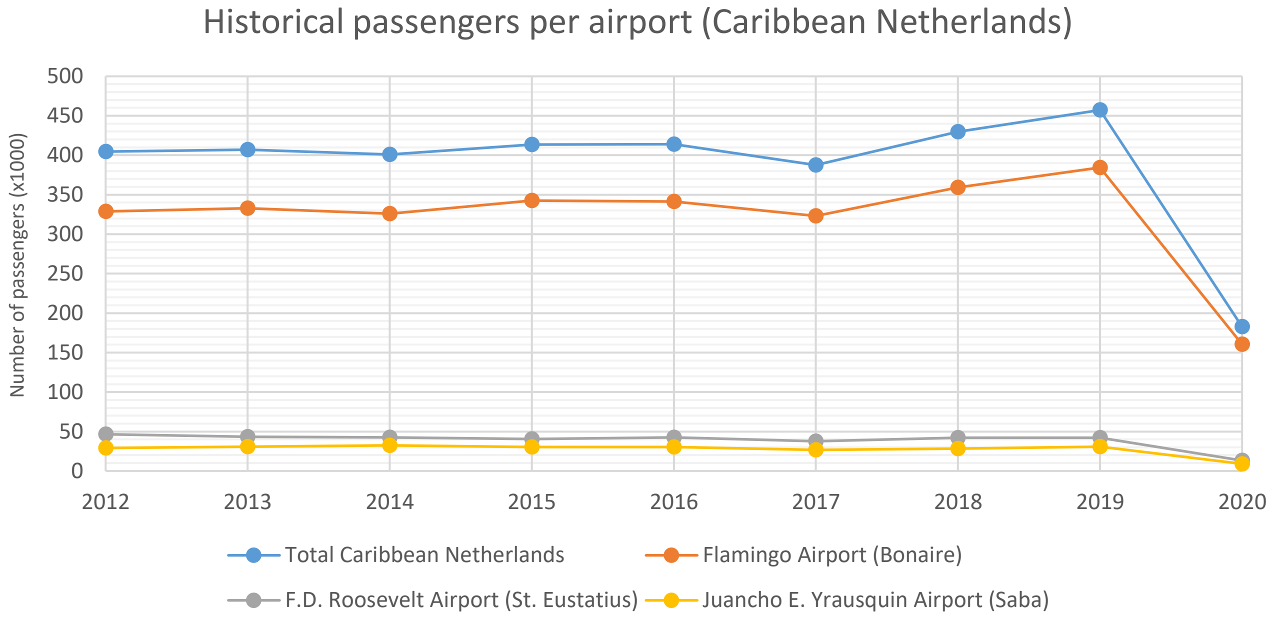

Figure 5 - Historical passengers per airport (Caribbean Netherlands) (Statistics Netherlands, 2021b)

1.3.3. Cargo and post volumes (European part of the Kingdom)

In terms of cargo and post volumes, Maastricht Aachen Airport is second, while the other airports process a low amount of cargo and post. Due to COVID-19, cargo and post volumes have declined, but only slightly compared to passenger volumes. Amsterdam Airport Schiphol is responsible for 96% of cargo and post volumes and Maastricht Aachen Airport processes about 4%. The amount of cargo and post processed at other airports of national interest is insignificant as shown in Table 2 below.

Table 2 - Tonnes of cargo and post Dutch Airports 2005-2020 (Statistics Netherlands, 2022b)

	Total (tonnes of cargo/post)	**Amsterdam Airport Schiphol**	**Eindhoven Airport**	**Rotterdam The Hague Airport**	**Maastricht Aachen Airport**	**Groningen Airport Eelde**
2021	1 795 298	1 667 304	0	0	127 994	
2020	1 592 413	1 456 428	0	0	135 985	0
2019	1 703 662	1 592 205	0	0	111 457	0
2018	1 840 441	1 729 618	0	0	110 823	0
2017	1 864 952	1 778 168	0	14	86 770	0
2016	1 754 689	1 694 126	0	82	60 480	0
2015	1 711 837	1 655 135	0	80	56 622	0
2014	1 727 457	1 670 673	0	91	56 693	0
2013	1 620 042	1 565 958	0	54	54 029	0
2012	1 564 430	1 511 821	0	46	52 562	1
2011	1 615 133	1 549 683	0	47	65 402	0
2010	1 600 476	1 538 129	351	21	61 975	0
2009	1 371 505	1 317 118	1 031	5	53 351	0
2008	1 658 651	1 602 585	663	15	55 383	6
2007	1 709 776	1 651 385	473	18	57 898	2
2006	1 621 626	1 566 873	571	15	54 152	16
2005	1 551 110	1 495 919	605	17	54 569	0

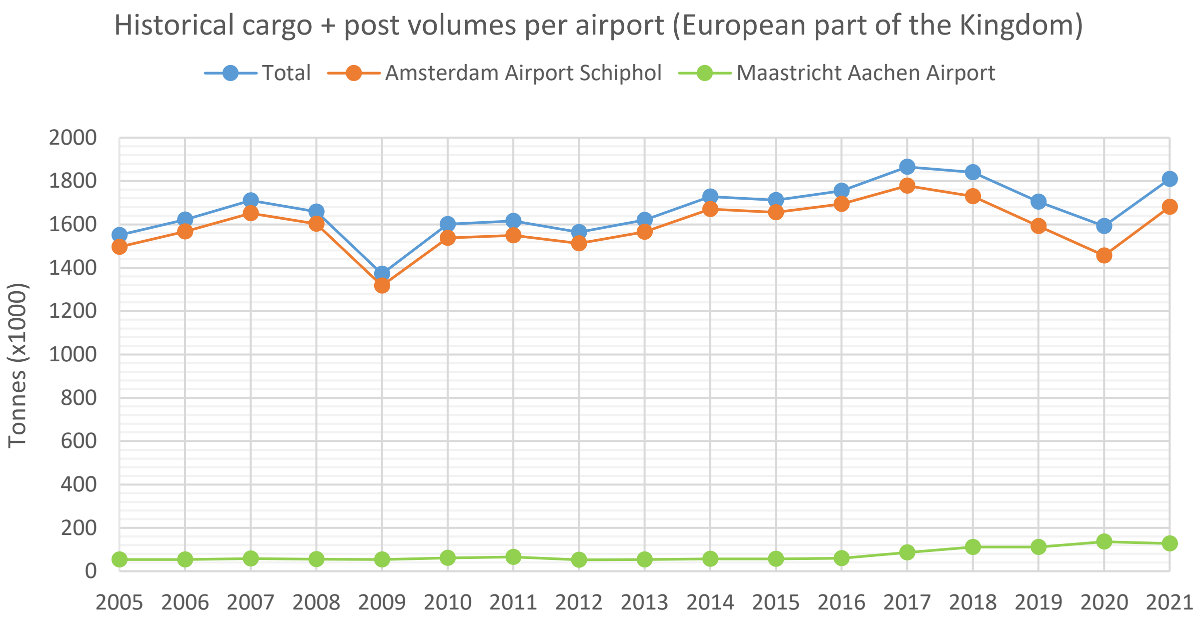

Figure 6 – Kilotonnes of cargo and post in the European part of the Kingdom (Statistics Netherlands, 2022b)

1.3.4. Aircraft movements (European part of the Kingdom)

The number of aircraft movements has gradually increased since 2005, with a reduction in 2009 and 2010 due to the financial crisis. In 2020, the number of aircraft movements reduced drastically due to COVID-19. Aircraft movement data was retrieved from Statistics Netherlands (*Centraal Bureau voor de Statistiek,* CBS) (2022b). The data is based on take-off and landings for commercial air traffic (i.e., all commercial air traffic by airlines transporting passengers, cargo and mail for remuneration and for hire).

Table 3 - Aircraft movements to and from airports in the European part of the Kingdom (Statistics Netherlands, 2022b)

	Total (aircraft movements x 1000)	**Amsterdam Airport Schiphol**	**Eindhoven Airport**	**Rotterdam The Hague Airport**	**Maastricht Aachen Airport**	**Groningen Airport Eelde**
2021	303	267	21	8	7	1
2020	258	227	18	6	6	1
2019	566	497	40	18	7	3
2018	565	499	37	18	6	4
2017	556	497	35	16	4	3
2016	535	479	31	19	4	2
2015	505	451	29	19	4	2
2014	491	438	27	19	5	2
2013	477	426	25	19	6	2
2012	469	423	22	15	5	2
2011	462	420	20	15	6	2
2010	427	386	16	15	8	2
2009	420	391	13	15	7	2
2008	474	428	14	17	11	2
2007	480	436	12	18	10	3
2006	467	423	11	18	12	2
2005	442	405	11	18	7	2

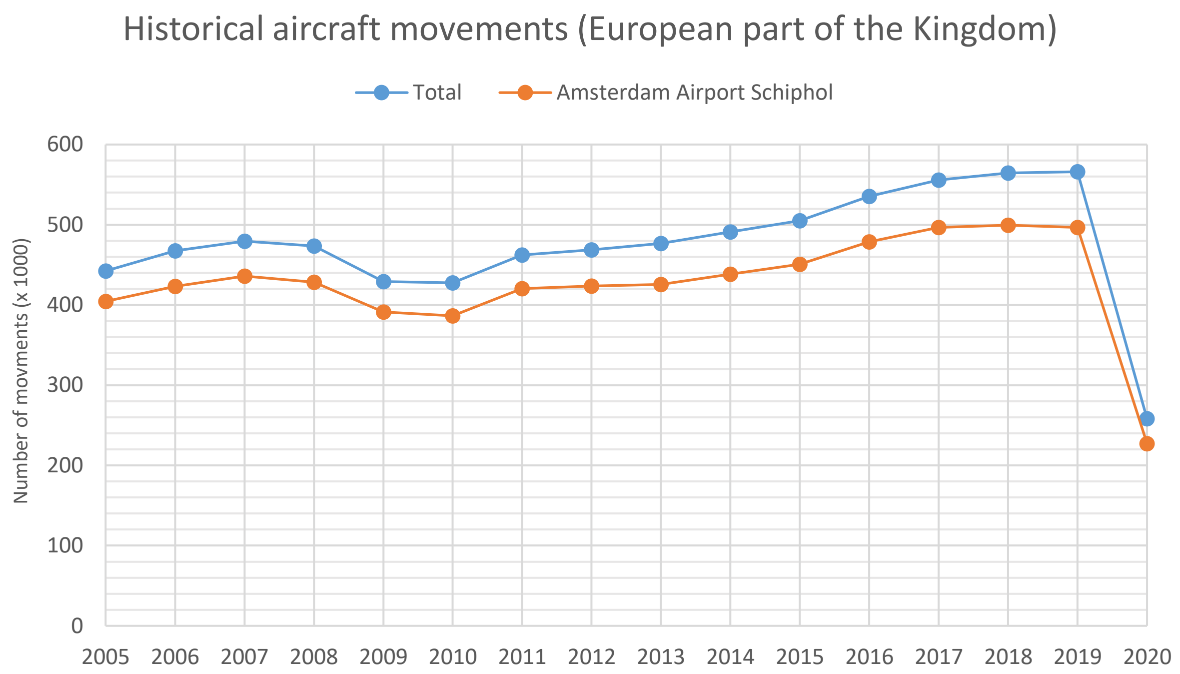

Figure 7 - Aircraft movements to and from Schiphol and total in the Netherlands (Statistics Netherlands, 2022b)

1.3.5. Aircraft movements (Caribbean Netherlands)

The following figure describes the number of aircraft movements for the Caribbean public bodies (Statistics Netherlands, 2021b).

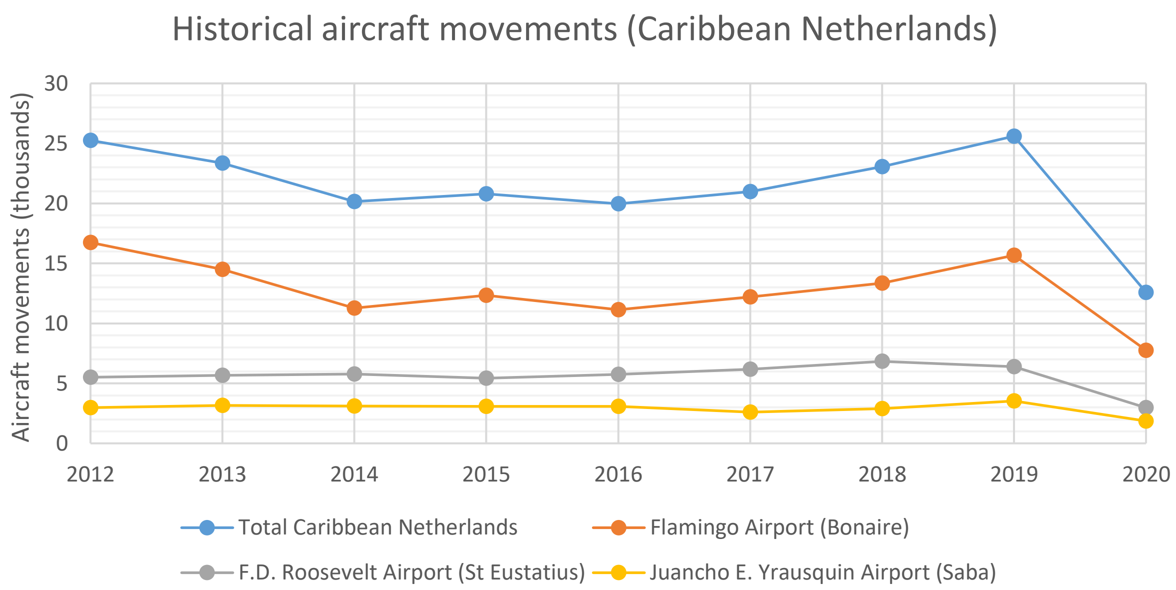

Figure 8 - Historical aircraft movements (Caribbean Netherlands) (Statistics Netherlands, 2021b)

1.3.6. Share per airline (number of flights) for airports (European part of the Kingdom)

Figure 9 below shows the share of flights for Dutch carriers and other carriers for the five largest airports of national interest in the European part of the Kingdom. The Dutch carriers include KLM, Transavia, TUI Fly Netherlands, Martinair Cargo and Corendon Dutch Airlines.

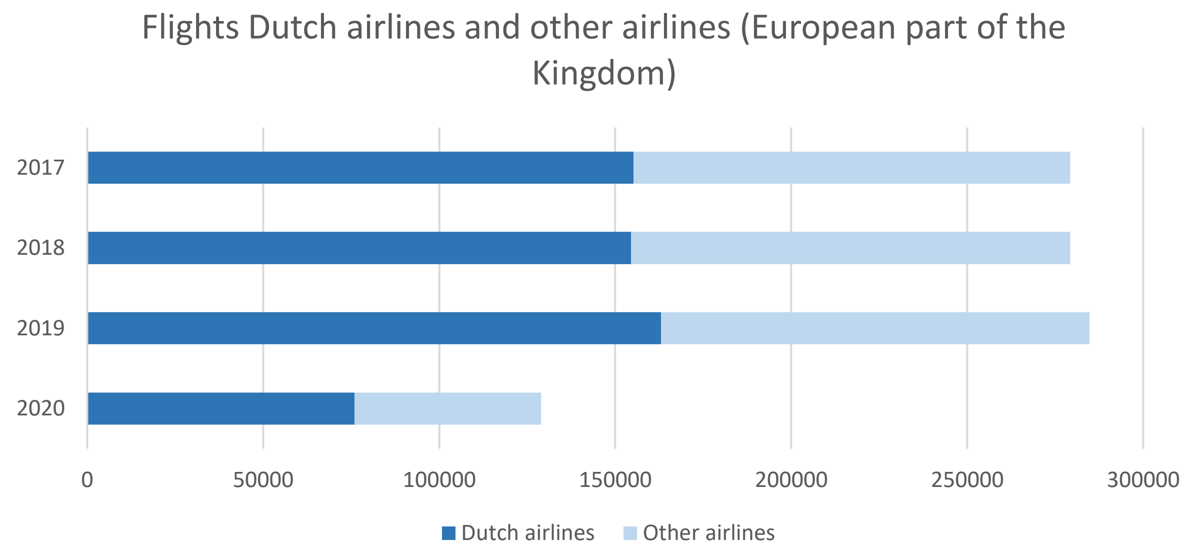

Figure 9 - Flights Dutch airlines and other airlines in the European part of the Kingdom (data provided by Eurocontrol (2021), based on Small emitters tool (SET))

1.3.7. Projected passenger volumes, cargo volumes and aircraft movements (European part of the Kingdom)

The projected passengers (arriving and departing) and cargo volumes, and aircraft movements are based on the Welfare, Prosperity and Human Environment (*Welvaart en leefomgeving,* WLO) scenarios developed by the Netherlands Environmental Assessment Agency (*Planbureau voor de Leefomgeving,* PBL) and Netherlands Bureau for Economic Policy Analysis (*Centraal Planbureau*, CPB). Two different scenarios are modelled: high and low. For WLO high a combination of relatively high population growth and high economic growth of about 2% per year is considered. The WLO low scenario assumes a limited population growth and a mediocre economic growth of about 1% per year. Table 4 shows the numbers for both scenarios for aviation for the years 2030 and 2050. The graphs in this section include the current figures for both European and intercontinental passengers and an interpolation for both scenarios towards the years 2030 and 2050.

Table 4 - Low and high scenario projections for passenger, cargo and aircraft movements for the European part of the Kingdom (PBL, 2020)

	Low scenario		**High scenario**	
Year	2030	2050	2030	2050
Passengers Europe	72 000 000	94 000 000	88 000 000	111 000 000
Passengers intercontinental	28 000 000	40 000 000	32 000 000	42 000 000
Cargo Europe (ton)	400 000	600 000	400 000	500 000
Cargo intercontinental (ton)	2 200 000	3 000 000	2 000 000	2 100 000
Aircraft movements Europe[6]	554 000	662 000	665 000	767 000
Aircraft movements intercontinental	120 000	163 000	132 000	163 000

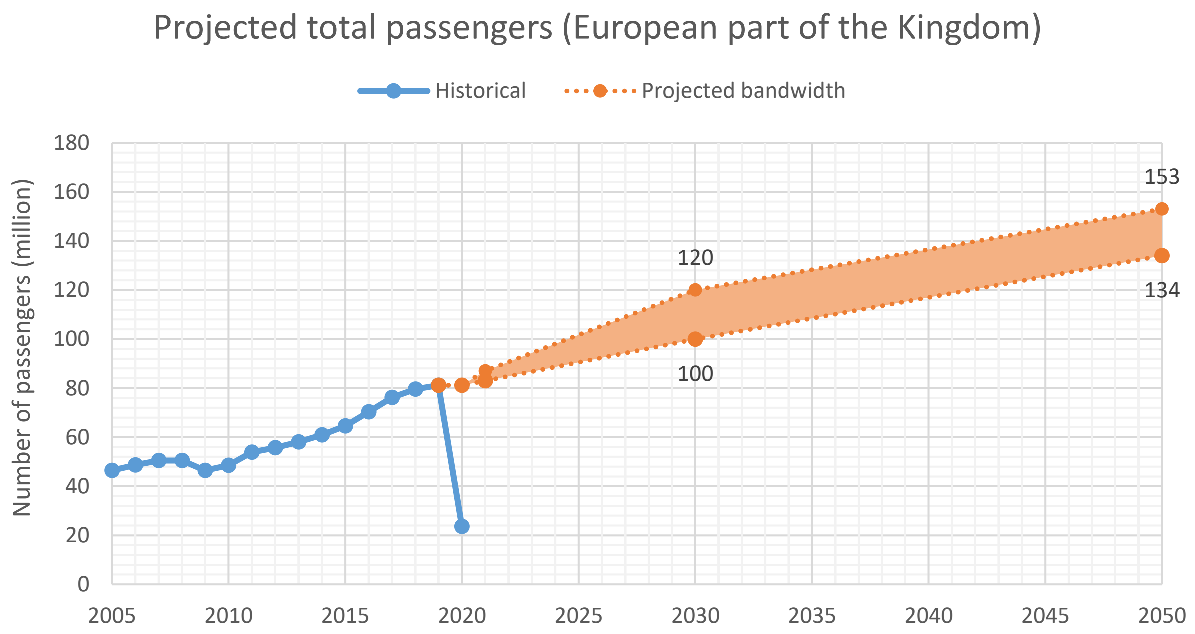

Figure 10 - Projected total passengers (European part of the kingdom) (Statistics Netherlands 2022b; Netherlands Environmental Assessment Agency, 2020)

6 The scenarios assume, as was politically agreed at the time, that Lelystad Airport will be opened and Amsterdam Airport Schiphol can continue to grow based on the 50/50-principle. According to this principle 50% of gained environmental noise reduction benefits allow to be used for a continued growth (PBL, 2020). Political debate on this matter is on-going.

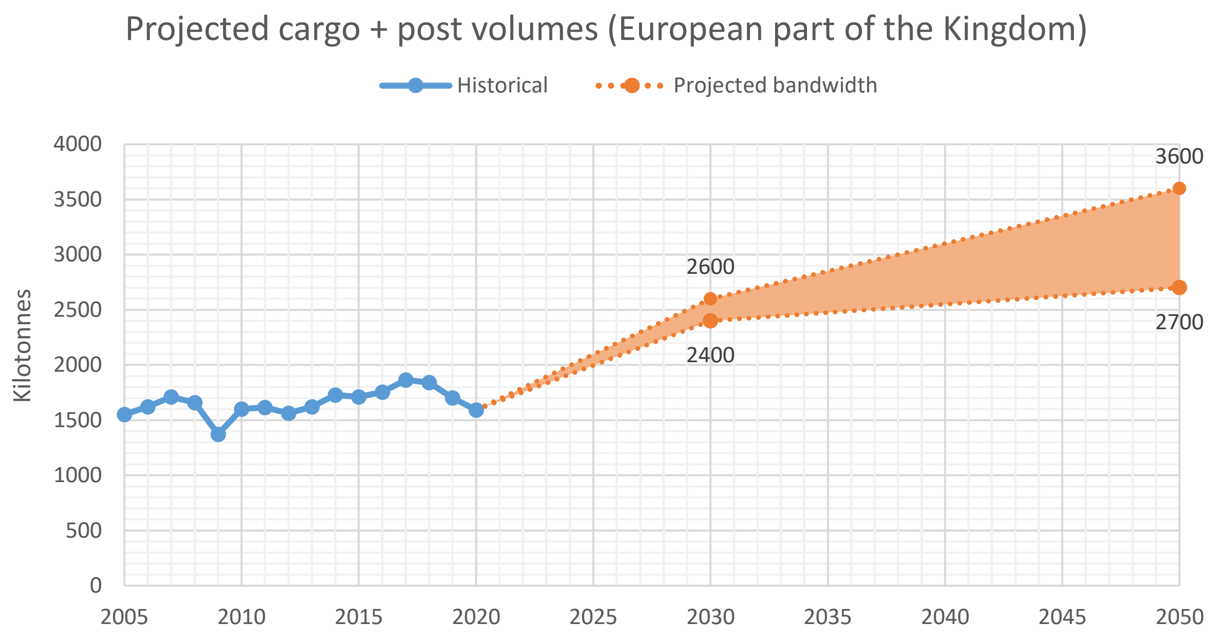

Figure 11 - Projected cargo and post (European part of the Kingdom) (Statistics Netherlands, 2022b; Netherlands Environmental Assessment Agency, 2020)

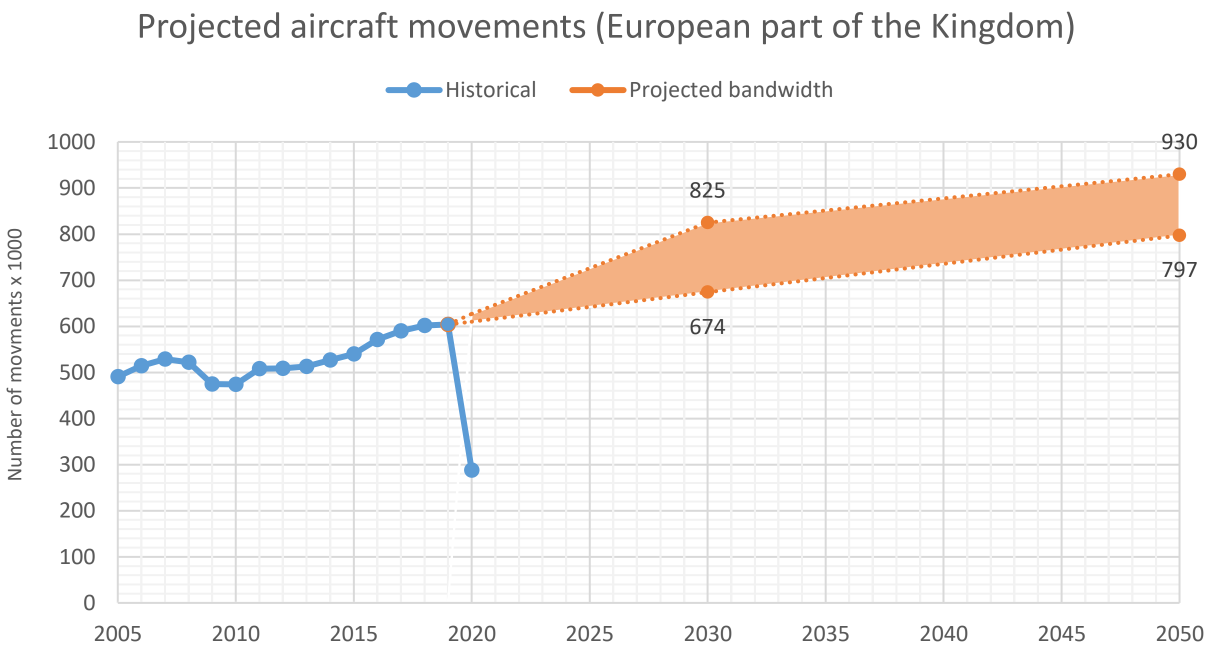

Figure 12 - Projected aircraft movements[6] (European part of the Kingdom) (Statistics Netherlands, 2022b; Netherlands Environmental Assessment Agency, 2020)

1.3.8. Historical CO_2 emissions (1990 – 2020) (European part of the Kingdom)

CO_2 emissions generated by international flights departing from the European part of the kingdom have increased significantly over the past decades in spite of efficiency gains due to the rapid growth of aviation. The Netherlands is a small country with a relatively large aviation sector. Within the country, there is little domestic aviation activity. Domestic aviation mainly consists of general aviation, military activities and search & rescue operations. Together these makeup about 1% of the total amount of aviation emissions based on fuels sold in the Netherlands. Therefore these emissions are excluded from the scope of the tables and figures. The CO_2 emission data in Figure 13 are based on bunker fuel sales as reported annually to Statistics Netherlands (CBS) and provide an accurate indicator for the amount of related CO_2 emissions (Statistics Netherlands, 2021a).

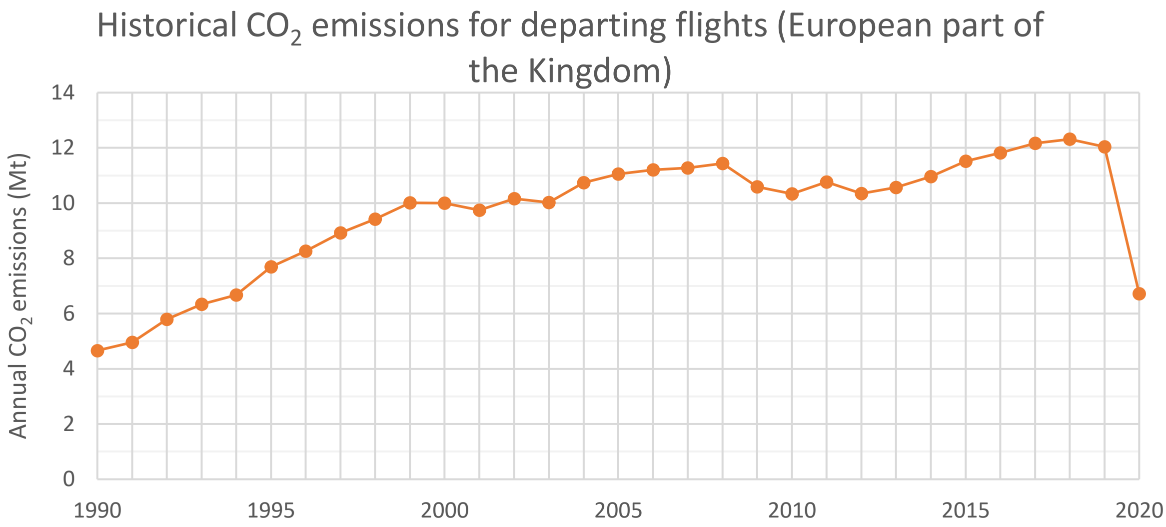

Figure 13 - Total CO_2 emissions based on bunker fuel data for the European part of the Kingdom (Statistics Netherlands, 2021a)

Figure 14 shows the CO_2 emissions divided into three distance categories: up to 750 km, more than 750 km within Europe, and intercontinental. Based on assumptions for energy usage in petajoule (PJ) indicated for different types (commercial passenger flights and cargo flights) and distances of flights (up to 750 km and more than 750 km within Europe and international flights of over 4000 km) (Netherlands Environmental Assessment Agency, 2020).

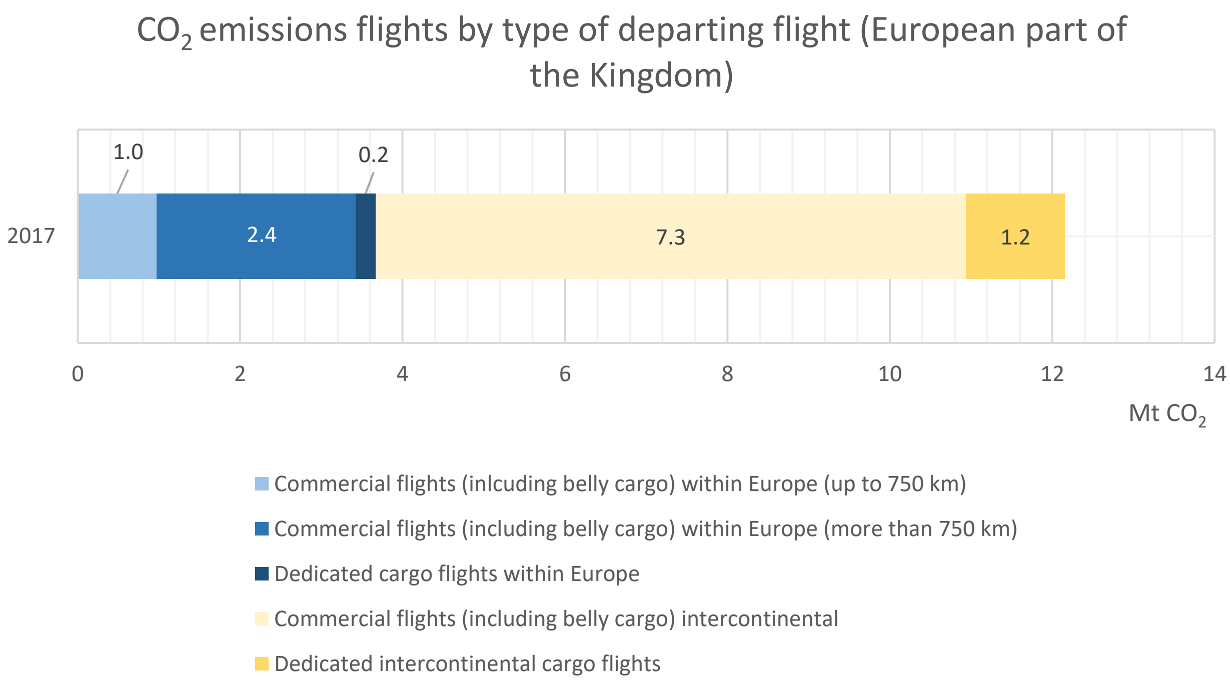

Figure 14 - CO_2 emissions flights departing from the European part of the Kingdom based on distance in 2017 (Netherlands Environmental Assessment Agency, 2020)

Figure 15 below shows the relative breakdown of CO_2 emissions from flights from the Netherlands for Dutch and non-Dutch airlines in the years 2017-2020.

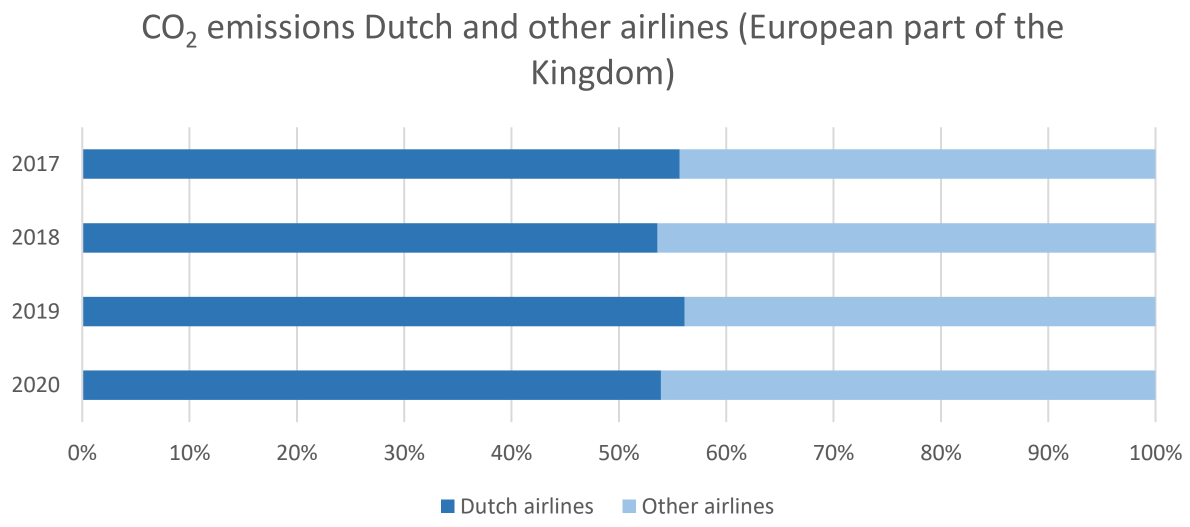

Figure 15 - CO_2 emissions Dutch airlines and other airlines in the European part of the Kingdom (data provided by Eurocontrol, based on SET tool)

1.3.9. Projected emissions without mitigation measures (European part of the Kingdom)

Following a temporary drop during the COVID-19 pandemic, emissions from aviation are expected to increase further in the next few years according to the Welfare, Prosperity and Human Environment (WLO) scenarios (PBL, 2020). The figure below shows historic trends in emissions and how they are projected to develop in the future under a high and low economic development. These scenarios as shown here do not take into account factors such as future use of sustainable fuels, nor do they incorporate the effects of the COVID-19 pandemic. The low scenario increases steadily towards 2030 and then increases further towards 2050. The high-scenario increases more rapidly towards 2030, but then decreases gradually towards 2050 and crosses the low-scenario due to the assumptions in the data as explained in 1.3.5.

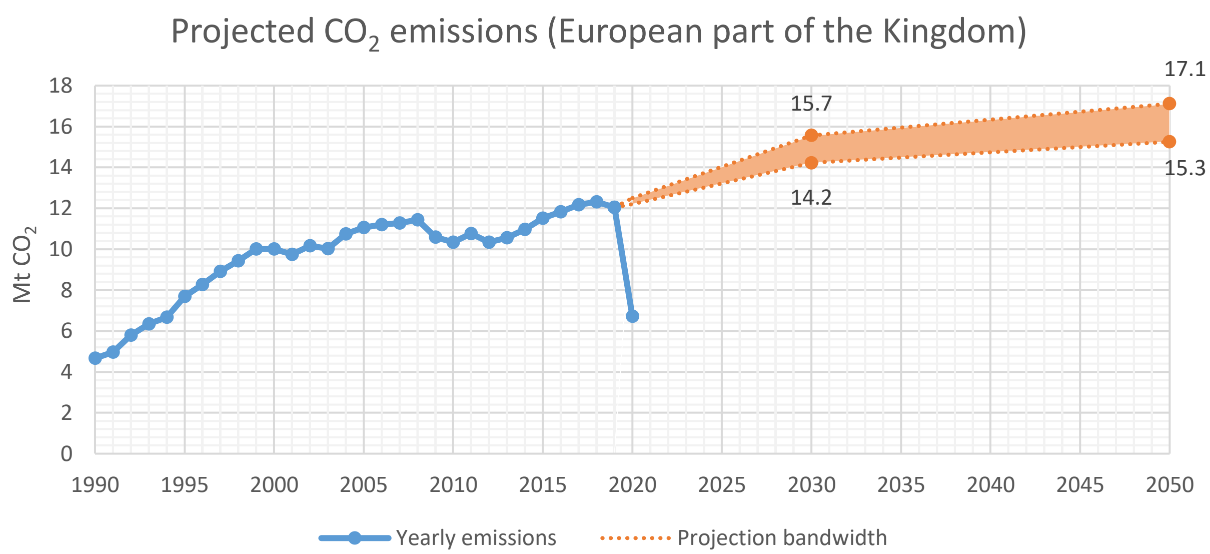

Figure 16 - Total CO_2 emissions international aviation and projection without measures for the European part of the Kingdom (Netherlands Environmental Assessment Agency, 2020)

1.3.10. Ground operations (European part of the Kingdom)

Amsterdam Airport Schiphol and Eindhoven Airport are ACI ACA 3+ accredited for their sustainability performance and Rotterdam The Hague Airport has level 4+ (Table 5). In 2019, international flights departing from the Netherlands were responsible for about 97.5% (11.89 Mt, see Figure 17) of the total emissions (Statistics Netherlands, 2021c). About 0.9% of the total CO_2 emissions stem from domestic aviation and ground aviation operations at other airports and 1.5% was caused by the ground operations at the largest airport: Amsterdam Airport Schiphol (Statistics Netherlands, 2021c; Royal Schiphol Group, 2020).

Table 5 - Dutch airports and their ACA level

Airport	ACA level
Schiphol	3+
Rotterdam – the Hague	4+
Lelystad	None
Eindhoven	3+
Maastricht	None (review for ACA 2 ongoing)

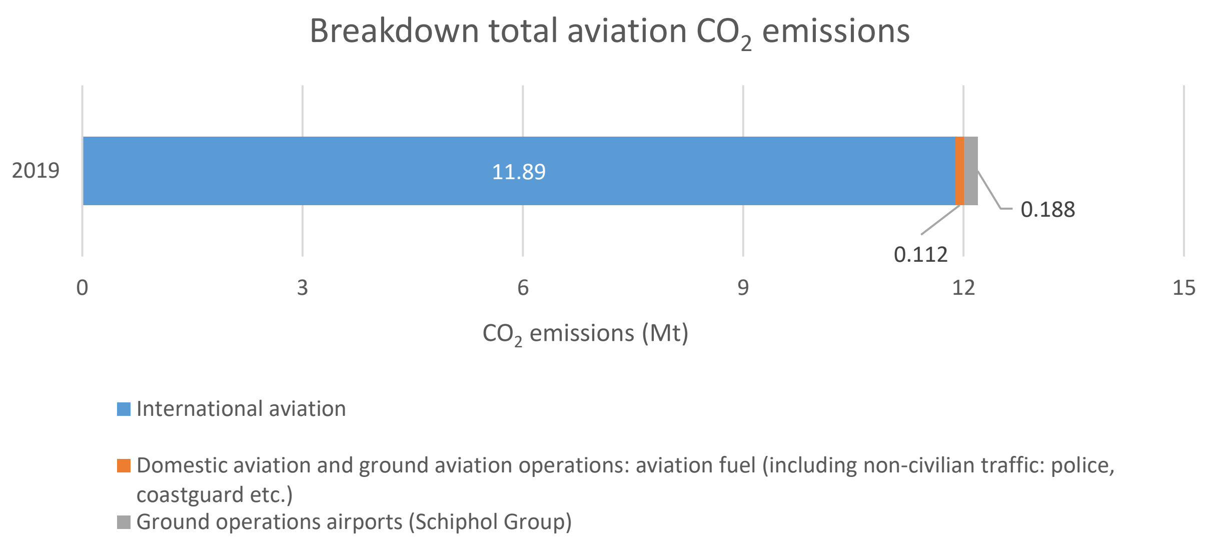

Figure 17 - Breakdown of total aviation emissions (European part of the Kingdom) (Statistics Netherlands, 2021c; Royal Schiphol Group, 2020)

2. The European Civil Aviation Conference (ECAC) common section

2.1. Executive summary

The European section of this action plan presents a summary of the actions taken collectively throughout the 44 States of the European Civil Aviation Conference (ECAC) to reduce CO_2 emissions from the aviation system and which are relevant for each State, and provides an assessment of their benefit against an ECAC baseline. It also provides a description of future measures aimed to provide additional CO_2 savings.

Aviation is a fundamental sector for the European economy, and a very important means of connectivity, business development and leisure for European citizens and visitors. For over a century, Europe has promoted the development of new technology, and innovations to better meet societies' needs and concerns, including addressing the sectorial emissions affecting the climate.

Since 2019, the COVID-19 pandemic has generated a world-wide human tragedy, a global economic crisis and an unprecedented disruption of air traffic, significantly changing European aviation's growth and patterns and heavily impacting the aviation industry. The European air transport recovery policy is aiming at accelerating the achievement of European ambitions regarding aviation and climate change.

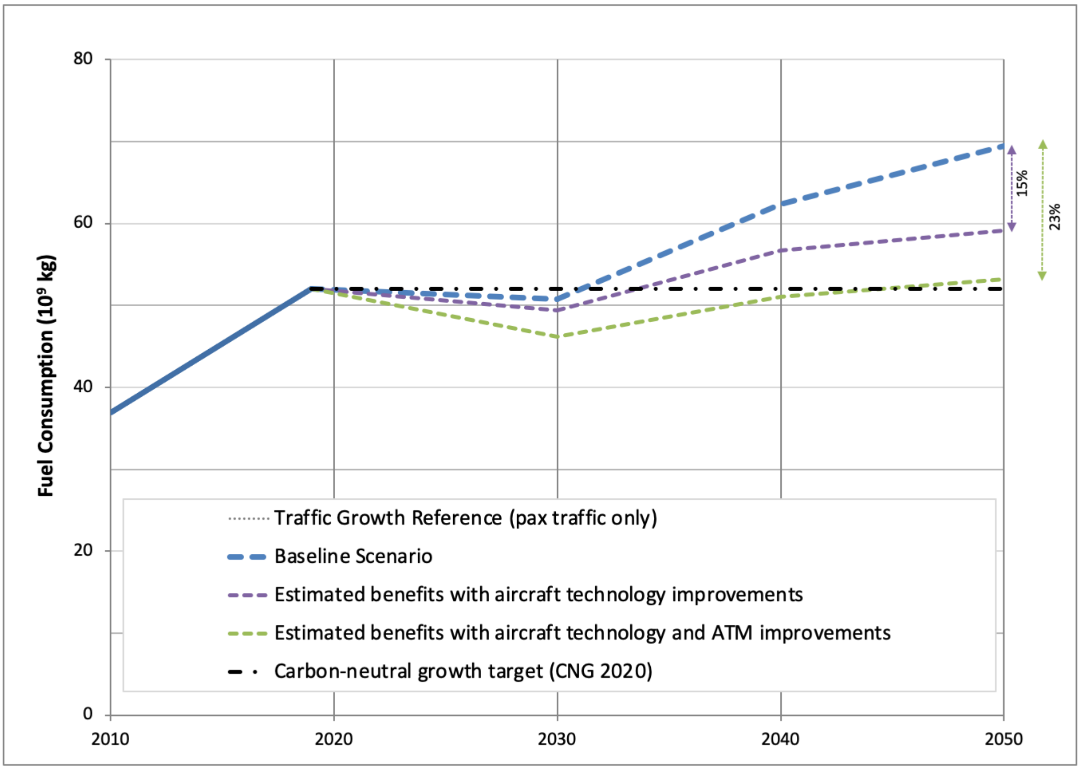

Figure 18 - Overview of fuel consumption forecasts

2.1.1. Aircraft related technology

European members have actively contributed to support progress in the ICAO Committee on Aviation Environmental Protection (CAEP). This contribution of resources, analytical capability and co-leadership has facilitated leaps in global certification standards that have helped drive the markets demand for technology improvements. Europe is now fully committed on the implementation of the 2017 ICAO CO_2 standard for newly built aircraft and on the need to review it on a regular basis in light of developments in aeroplane fuel efficiency.

Environmental improvements across the ECAC States are knowledge-led and at the forefront of this is the Clean Sky EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies". The second joint undertaking (Clean Sky 2 – 2014-2024) has the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. Under the Horizon Europe programme for research and innovation, the European Commission has proposed the set-up of a European Partnership for Clean Aviation (EPCA) which will follow in the footsteps of CleanSky2, recognizing and exploiting the interaction between environmental, social and competitiveness aspects of civil aviation, while maintaining sustainable economic growth. For such technology high end public-private partnerships to be successful, and thus, benefit from this and from future CO2 action plans, securing the appropriate funding is key.

The main efforts under Clean Sky 2 include demonstrating technologies: for both large and regional passenger aircraft, improved performance and versatility of new rotorcraft concepts, innovative airframe structures and materials, radical engine architectures, systems and controls and consideration of how we manage aircraft at the end of their useful life. This represents a rich stream of ideas and concepts that, with continued support, will mature and contribute to achieving the goals on limiting global climate change. The new European Partnership for Clean Aviation (EPCA) has objectives in line with the European Green Deal goals to reach climate neutrality in 2050 and will focus on the development of disruptive technologies and maximum impact.

2.1.2. Sustainable Aviation Fuels (SAF)

ECAC States are embracing the introduction of sustainable aviation fuels (SAF) in line with the 2050 ICAO Vision and are taking collective actions to address the many current barriers for SAF widespread availability or use in European airports.

The European collective SAF measures included in this Action Plan focuses on its CO_2 reductions benefits. Nevertheless SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM), which can provide important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

At European Union (EU) level, the ReFuelEU Aviation regulatory initiative aims to boost the supply and demand for SAF at EU airports, while maintaining a level playing field in the air transport market. This initiative is expected to result in a legislative proposal in the course of 2021. The common European section of this action plan also provides an overview of the current sustainability and life cycle emissions requirements applicable to SAF in the European Union's States as well as estimates of life cycle values for a number of technological pathways and feedstock.

Collective work has also been developed through EASA on addressing barriers of SAF penetration into the market.

The European Research and Innovation programme is moreover giving impulse to innovative technologies to overcome such barriers as it is highlighted by the number of recent European research projects put in place and planned to start in the short-term.

2.1.3. Improved Air Traffic Management

The European Union's Single European Sky (SES) policy aims to transform Air Traffic Management (ATM) in Europe towards digital service provision, increased capacity reduced ATM costs with high level of safety and 10% less environmental impact. SES policy has several elements, one of which is developing and deploying innovative technical and operational ATM solutions.

SESAR 1 (from 2008 to 2016), SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022) are the EU programmes for the development of SESAR solutions. The SESAR solutions already developed and validated are capable of providing: 21% more airspace capacity; 14% more airport capacity; a 40% reduction in accident risk; 2.8% less greenhouse emissions; and a 6% reduction in flight costs. Future ATM systems will be based on 'Trajectory-based Operations' and 'Performance-based Operations'.

Much of the research to develop these solutions is underway and published results of the many earlier demonstration actions confirm the challenge but give us confidence that the goals will be achieved in the ECAC region with widespread potential to be replicated in other regions.

2.1.4. Market Based Measures (MBMs)

ECAC States, in application of their commitment in the 2016 Bratislava Declaration, have notified ICAO of their decision to voluntarily participate in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from its pilot phase, and have effectively engaged in its implementation and they encourage other States to do likewise and join CORSIA.

ECAC States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on CORSIA.

The 30 European Economic Area (EEA)[7] States in Europe have implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap-and-trade approach to limit CO_2 emissions. Subject to preserving the environmental integrity and effectiveness it is expected that the EU ETS legislation will continue to be adapted to implement CORSIA.

As a consequence of the linking agreement with Switzerland, from 2020 the EU ETS was extended to all departing flights from the EEA to Switzerland, and Switzerland applies its ETS to all departing flights to EEA airports, ensuring a level playing field on both directions of routes.

In accordance with the EU-UK Trade and Cooperation Agreement reached in December 2020, the EU ETS shall continue to apply to departing flights from the EEA to the UK, while a UK ETS will apply effective carbon pricing on flights departing from the UK to the EEA.

In the period 2013 to 2020, EU ETS has saved an estimated 200 million tonnes of intra-European aviation CO_2 emissions.

2.1.5. ECAC Scenarios for Traffic and CO_2 Emissions

The scenarios presented in this common section of State Action Plans of ECAC States take into account the impacts of the COVID-19 crisis on air transport, to the extent possible, and with some unavoidable degree of uncertainty. The best-available data used

7 The EEA includes EU countries and also Iceland, Liechtenstein and Norway.

for the purposes of this action plan has been taken from EUROCONTROL's regular publication of comprehensive assessments of the latest traffic situation in Europe.

Despite the current extraordinary global decay on passengers' traffic due to the COVID-19 pandemic, hitting European economy, tourism and the sector itself, aviation is expected to continue to grow in the long-term, develop and diversify in many ways across the ECAC States. Air cargo traffic has not been impacted as the rest of the traffic and thus, whilst the focus of available data relates to passenger traffic, similar pre-COVID forecasted outcomes might be anticipated for cargo traffic both as belly hold freight or in dedicated freighters.

The analysis by EUROCONTROL and EASA have identified the most likely scenario of influences on future traffic and modelled these assumptions out to future years. On the basis of this traffic forecast, fuel consumption and CO_2 emissions of aviation have been estimated for both a theoretical baseline scenario (without any additional mitigation action) and a scenario with estimated benefits from mitigation measures implemented since 2019 or provided benefits beyond 2019 that are presented in this action plan.

Under the baseline assumptions of traffic growth and fleet rollover with 2019 technology, CO_2 emissions would significantly grow in the long-term for flights departing from ECAC airports without mitigation measures. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline. Whilst the data to model the benefits of ATM improvements may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall CO2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

In the common section of this action plan the potential of sustainable aviation fuels and the effects of market-based measures have not been simulated in detail. Notably, CORSIA being a global measure, and not a European measure, the assessments of its benefits were not considered required for the purposes of the State Action Plans. But they should both help reach the ICAO carbon-neutral growth 2020 goal. As further developments in policy and technology are made, further analysis will improve the modelling of future emissions.

2.2. ECAC baseline scenario and estimated benefits of implemented measures

2.2.1. ECAC baseline scenario

The baseline scenario is intended to serve as a reference scenario for CO_2 emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2019) and forecasts (for 2030, 2040 and 2050) were provided by EUROCONTROL for this purpose:

- European air traffic (includes all commercial and international flights departing from ECAC airports, in number of flights, revenue passenger kilometres (RPK) and revenue tonne-kilometres (RTK);
- its associated aggregated fuel consumption; and
- its associated CO_2 emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of "Regulation and Growth", while corresponding fuel consumption and CO_2 emissions assume the technology level of the year 2019 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, sustainable aviation fuels or market based measures).

Traffic Scenario "Regulation and Growth"

As in all forecasts produced by EUROCONTROL, various scenarios are built with a specific storyline and a mix of characteristics. The aim is to improve the understanding of factors that will influence future traffic growth and the risks that lie ahead. The latest EUROCONTROL long-term forecast[8] was published in June 2018 and inspects traffic development in terms of Instrument Flight Rule (IFR) movements to 2040.

In the latter, the scenario called 'Regulation and Growth' is constructed as the 'most likely' or 'baseline' scenario for traffic, most closely following the current trends[9]. It

8 Challenges of Growth - Annex 1 - Flight Forecast to 2040, EUROCONTROL, September 2018.
9 Prior to COVID-19 outbreak.

considers a moderate economic growth, with some regulation particularly regarding the social and economic demands.

Amongst the models applied by EUROCONTROL for the forecast, the passenger traffic sub-model is the most developed and is structured around five main group of factors that are taken into account:

- **Global economy** factors represent the key economic developments driving the demand for air transport.
- Factors characterising the **passengers** and their travel preferences change patterns in travel demand and travel destinations.
- **Price of tickets** set by the airlines to cover their operating costs influences passengers' travel decisions and their choice of transport.
- More hub-and-spoke or point-to-point **networks** may alter the number of connections and flights needed to travel from origin to destination.
- **Market structure** describes size of aircraft used to satisfy the passenger demand (modelled via the Aircraft Assignment Tool).

Table 6 below presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year 2016 served as the baseline year of the 20-year forecast results[8] (published in 2018 by EUROCONTROL). Historical data for the year 2019 are also shown later for reference.

Table 6 - Summary characteristics of EUROCONTROL scenarios

	Global Growth	***Regulation and Growth***	***Fragmenting World***
2023 traffic growth	High ↗	Base →	Low ↘
Passenger			
Demographics (Population)	Ageing UN Medium-fertility variant	Ageing UN Medium-fertility variant	Ageing UN Zero-migration variant
Routes and Destinations	Long-haul ↗	No Change →	Long-haul ↘
Open Skies	EU enlargement later +Far & Middle East	EU enlargement Earliest	EU enlargement Latest
High-speed rail (new & improved connections)	20 city-pairs faster implementation	20 city-pairs	20 city-pairs later implementation.
Economic conditions			
GDP growth	Stronger ↗	Moderate →	Weaker ↘↘
EU Enlargement	+5 States, Later	+5 States, Earliest	+5 States, Latest
Free Trade	Global, faster	Limited, later	None
Price of travel			
Operating cost	Decreasing ↘↘	Decreasing ↘	No change →
Price of CO_2 in Emission Trading Scheme	Moderate	Lowest	Highest
Price of oil/barrel	Low	Lowest	High
Change in other charges	Noise: ↗ Security: ↘	Noise: ↗ Security: →	Noise: → Security: ↗
Structure			
Network	Hubs: Mid-East ↗↗ Europe ↘ Turkey↗ Point-to-point: N-Atlantic.↗↗	Hubs: Mid-East ↗↗ Europe & Turkey ↗ Point-to-point: N-Atlantic.↗	No change →
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

COVID-19 impact and extension to 2050

Since the start of 2020, COVID-19 has gone from a localised outbreak in China to the most severe global pandemic in a century. No part of European aviation is untouched by the human tragedy or the business crisis. This unprecedented crisis hindered air traffic growth in 2020: flight movements declined by 55% compared to 2019 at ECAC level. It continues to disrupt the traffic growth and patterns in Europe in 2021. In Autumn 2020, EUROCONTROL published a medium-term forecast[10] to 2024, taking into account the impact of the COVID-19 outbreak. The latter is based on three different scenarios depending on how soon an effective vaccine would be made widely available to (air) travellers. Other factors have been included amongst which the economic impact of the crisis or levels of public confidence, to name a few. The Scenario 2: vaccine widely made available for travellers by Summer 2022, considered as the most likely, sees ECAC flights only reaching 92% of their 2019 levels in 2024.

In order to take into account the COVID-19 impact and to extend the horizon to 2050, the following adaptations have been brought to the original long-term forecast[8]. Considering the most-likely scenarios of the long-term forecast[8] and the medium-term forecasted version of the long-term flight forecast has been derived:

a) Replace the long-term forecast[8] horizon by the most recent medium-term forecast[10] to account for COVID impact;
b) Update the rest of the horizon (2025-2040) assuming that the original growth rates of the long-term forecast[8], would remain similar to those calculated pre-COVID-19; and
c) Extrapolate the final years (2040-2050) considering the same average annual growth rates as the one forecasted for the 2035-2040 period, but with a 0.9 decay[11].

The method used relies on the calculation of adjustment factors at STATFOR[12] region-pair level and have been applied to the original long-term forecast[8]. Adjusting the baseline enables to further elaborate the baseline scenario as forecasted future fuel consumption and to 2030, 2040 and 2050, in the absence of action.

Figure 19 below shows the ECAC scenario of the passenger flight forecasted international departures for both historical (solid line) and future (dashed line) years.

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10 Five-Year Forecast 2020-2024, IFR Movements, EUROCONTROL, November 2020.
11 As the number of flights has not been directly forecasted via the system but numerically extrapolated, it does not include any fleet renewal, neither network change (airport pairs) between 2040 and 2050. This factor is aimed at adjusting the extrapolation to capture the gradual maturity of the market.
12 STATFOR (Statistics and Forecast Service) provides statistics and forecasts on air traffic in Europe and to monitor and analyse the evolution of the Air Transport Industry.

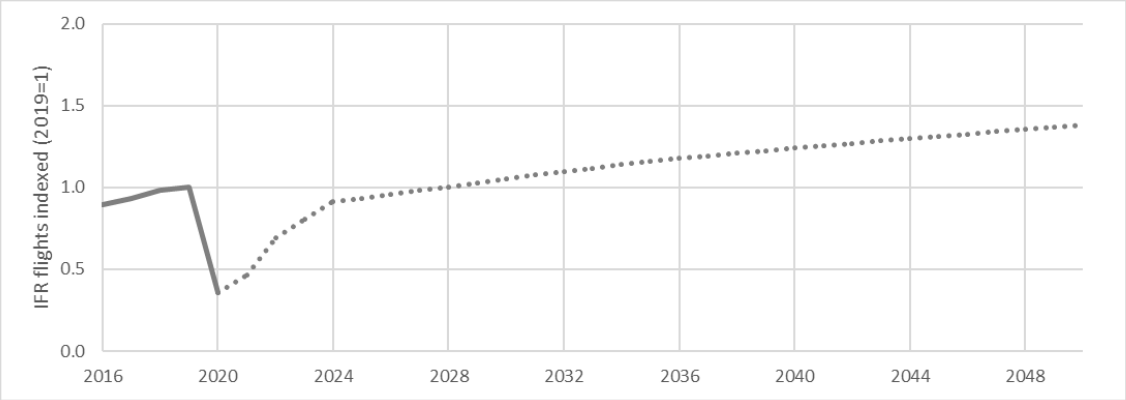

Figure 19 - Updated EUROCONTROL "Regulation and Growth" scenario of the passenger flight forecast for ECAC international departures including the COVID-19 impact in 2020 and the following 4 years

Further assumptions and results for the baseline scenario

The ECAC baseline scenario was generated by EUROCONTROL for all ECAC States. It covers all commercial international passenger flights departing[13] from ECAC airports, as forecasted in the aforementioned traffic scenario. The number of passengers per flight is derived from Eurostat data.

EUROCONTROL also generates a number of all-cargo flights in its baseline scenario. However, no information about the freight tonnes carried is available. Hence, historical and forecasted cargo traffic have been extracted from another source (ICAO[14]). This data, which is presented below, includes both belly cargo transported on passenger flights and freight transported on dedicated all-cargo flights.

Historical fuel burn and emission calculations are based on the actual flight plans from the PRISME[15] data warehouse used by EUROCONTROL, including the actual flight distance and the cruise altitude by airport pair. These calculations were made for about 99% of the passenger flights (the remaining flights had information missing in the flight plans). Determination of the fuel burn and CO_2 emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample characteristics. Fuel burn and CO_2 emission results consider each aircraft's fuel burn in its ground and airborne phases of flight and are obtained by use of the EUROCONTROL IMPACT environmental model, with the aircraft technology level of each year.

Forecast years (until 2050) fuel burn and modelling calculations use the 2019 flight plan characteristics as much as possible, to replicate actual flown distances and cruise levels, by airport pairs and aircraft types. When not possible, this modelling approach uses past years traffics too, and, if needed, the ICAO CAEP forecast modelling. The forecast fuel burn and CO_2 emissions of the baseline scenario for forecast years uses the technology level of 2019.

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13 International departures only. Domestic flights are excluded. A domestic is any flight between two airports in the State, regardless of the operator or which airspaces they enter en-route. Airports located overseas are attached to the State having the sovereignty of the territory. For example, France domestic include flights to Guadeloupe, Martinique, etc.
14 ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016. Cargo forecasts have not been updated as new ICAO forecast including COVID-19 effects will be made available after the end of June 2021, so those cannot be considered in this action plan common section.
15 PRISME is the name of the EUROCONTROL data warehouse hosting the flight plans, fleet and airframe data.

For each reported year, the revenue per passenger kilometre (RPK) calculations use the number of passengers carried for each airport pair multiplied by the great circle distance between the associated airports and expressed in kilometres. Because of the coverage of the passenger estimation data sets (Scheduled, Low-cost, Non-Scheduled flights, available passenger information, etc.) these results are determined for about 99% of the historical passenger traffic, and 97% of the passenger flight forecasts. From the RPK values, the passenger flights RTK were calculated as the number of tonnes carried by kilometers, assuming that 1 passenger corresponds to 0.1 tonne.

The fuel efficiency represents the amount of fuel burn divided by the RPK for each available airport pair with passenger data, for the passenger traffic only. Here, the RPK and fuel efficiency results corresponds to the aggregation of these values for the whole concerned traffic years.

The following tables and figures show the results for this baseline scenario, which is intended to serve as a reference case by approximating fuel consumption and CO_2 emissions of European aviation in the absence of mitigation actions.

Table 7 - Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[16] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[17] FTKT (billion)	Total Revenue Tonne Kilometres[18] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

Table 8 - Fuel burn and CO_2 emissions forecast for the baseline scenario

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK[16])	Fuel efficiency (kg/RTK[18])
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

16 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.
17 Includes passenger and freight transport (on all-cargo and passenger flights).
18 A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

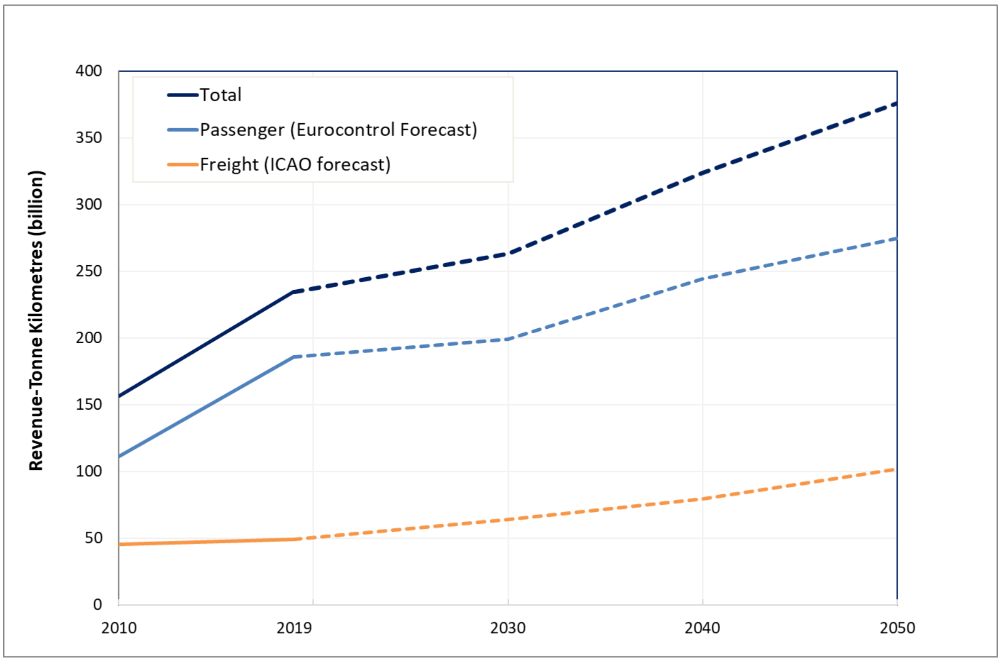

Figure 20 - Forecasted traffic until 2050 (assumed both for the baseline and implemented measures scenarios)

The impact of the COVID-19 in 2020 is not fully reflected in Figure 20, as this representation is oversimplified through a straight line between 2019 and 2030. The same remark applies for Figure 21 and Figure 22.

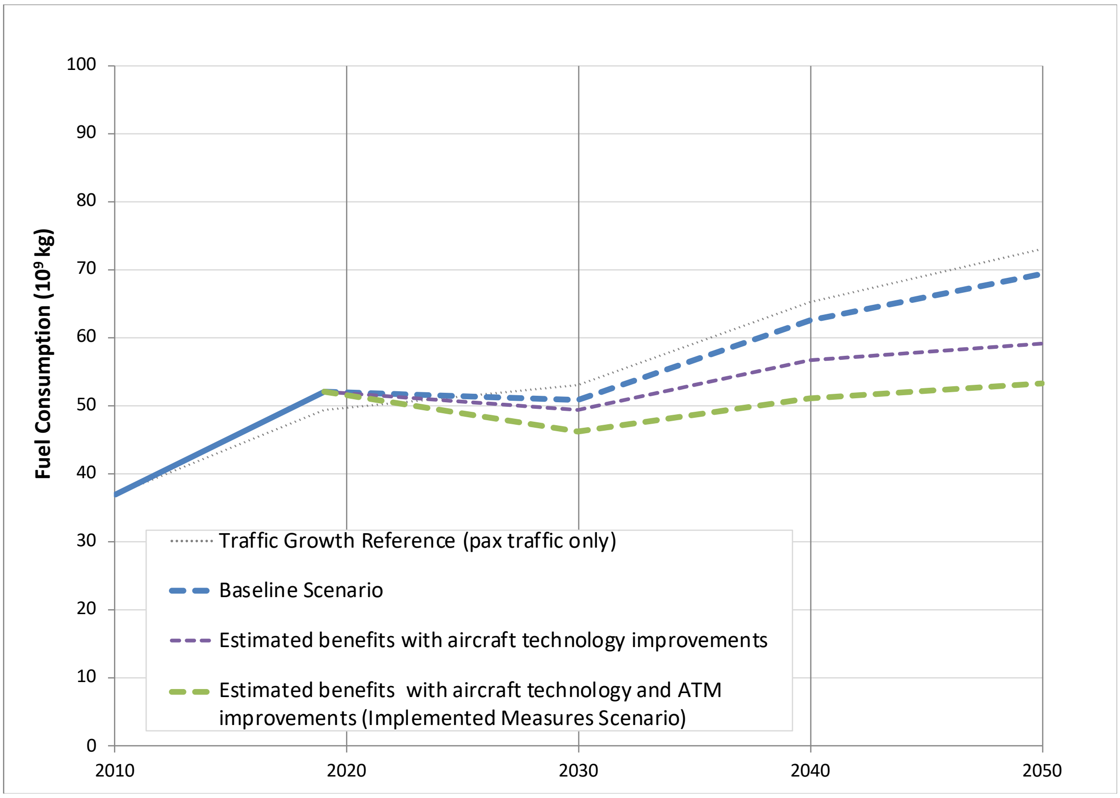

Figure 21 - Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports)

2.2.2. ECAC Scenario with Implemented Measures: Estimated Benefits

In order to improve the fuel efficiency and to reduce future air traffic emissions beyond the projections in the baseline scenario, ECAC States have taken further action. Assumptions for a top-down assessment of effects of mitigation actions are presented here, based on modelling results by EUROCONTROL and EASA. Measures to reduce aviation's fuel consumption and emissions will be described in the following chapters.

For reasons of simplicity, the scenario with implemented measures is based on the same traffic volumes as the baseline case, i.e. updated EUROCONTROL's 'Regulation and Growth' scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development and improvements in ATM/operations are considered here for a projection of fuel consumption and CO_2 emissions up to the year 2050.

Effects of **improved aircraft technology** are captured by simulating fleet roll-over and considering the fuel efficiency improvements of new aircraft types of the latest generation (e.g. Airbus A320NEO, Boeing 737MAX, Airbus A350XWB etc.). The simulated future fleet of aircraft has been generated using the Aircraft Assignment Tool[19] (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of AAT is performed year by year, allowing the determination of the number of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 1.16% per annum is assumed for each aircraft type with entry into service from 2020 onwards. This rate of improvement corresponds to the 'Advanced' fuel technology scenario used by CAEP to generate the fuel trends for the Assembly. This technology improvement modelling is applied to the years 2030 and

19 https://www.easa.europa.eu/domains/environment/impact-assessment-tools

2040. For the year 2050, as the forecast traffic reuses exactly the fleet of the year 2040, the technological improvement is determined with the extrapolation of the fuel burn ratio between the baseline scenario and the technological improvement scenario results of the years 2030 to 2040.

The effects of **improved ATM efficiency** are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. In SESAR, a value of 5,280 kg of fuel per flight for ECAC (including oceanic region) is used as a baseline[20]. Based on the information provided by the PAGAR 2019 document[21], and compared to a 2012 baseline, the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4 kg of fuel/flight. So far, the target for Wave 2 remains at about 7% more CO_2/fuel savings (352.6 kg of fuel) to reach the initial Ambition target of about 10% CO_2/fuel savings (500 kg fuel) per flight by 2035. The 2030 efficiency improvement is calculated by assuming a linear evolution between 2025 and 2035. As beyond 2035, there is no SESAR Ambition yet, it is assumed that the ATM efficiency improvements are reported extensively for years 2040 and 2050.

The as yet un-estimated benefits of Exploratory Research projects[22] are expected to increase the overall future fuel savings.

While the effects of **introduction of Sustainable Aviation Fuels (SAF)** were modelled in previous updates on the basis of the European ACARE goals[23], the expected SAF supply objectives for 2020 were not met, and in the current update the SAF benefits have not been modelled as a European common measure in the implemented measures scenario. However, numerous initiatives related to SAF (e.g. ReFuelEU Aviation) are largely described in Section Sustainable aviation fuels2.3.2 and it is expected that future updates will include an assessment of its benefits as a collective measure.

Effects on aviation's CO_2 emissions of **market-based measures** including the EU Emissions Trading System (ETS) with the linked Swiss ETS, the UK ETS and the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) have not been modelled in the top-down assessment of the implemented measures scenario presented here as, at the time of the submission of this action plan, a legislative proposal for the revision of the EU ETS Directive concerning aviation, is under development to complete the implementation of CORSIA by the EU and to strengthen the ambition level of the EU ETS. CORSIA is not considered a European measure but a global one. It aims for carbon-neutral growth (CNG) of aviation as compared to the average of 2019 and 2020 levels of emissions in participating States, and an indication of a corresponding (hypothetical) target applied to Europe is shown in Figure 22, while recalling that this is just a reference level, given that CORSIA was designed to contribute to the CNG 2020 globally and not in individual States or regions.

Table 9Table 10Table 11 and Figure 22 summarise the results for the scenario with implemented measures. It should be noted that Table 9 shows direct combustion emissions of CO_2 (assuming 3.16 kg CO_2 per kg fuel). More detailed tabulated results are found in Appendix A: , including results expressed in equivalent CO_2 emissions on a well-to-wake basis (for comparison purposes of SAF benefits).

20 See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) - eATM.
21 See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021.
22 See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch
23 https://www.acare4europe.org/sria/flightpath-2050-goals/protecting-environment-and-energy-supply-0

Table 9 - Fuel burn and CO2 emissions forecast for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK[24])	Fuel efficiency (kg/RTK[17])
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	46.16	145.86	0.0229	0.229
2040	51.06	161.35	0.0206	0.206
2050	53.18	168.05	0.0192	0.192
2050 vs 2019			*-32%*	
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

Table 10 - Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

Table 11 - CO_2 emissions forecast for the scenarios described in this chapter

Year	CO_2 emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario		
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	116,78			NA
2019	164,35			NA
2030	160,3	156,0	145,9	-9%
2040	197,1	179,3	161,4	-18%
2050	219,4	186,7	168,0	-23%
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.				

[24] Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

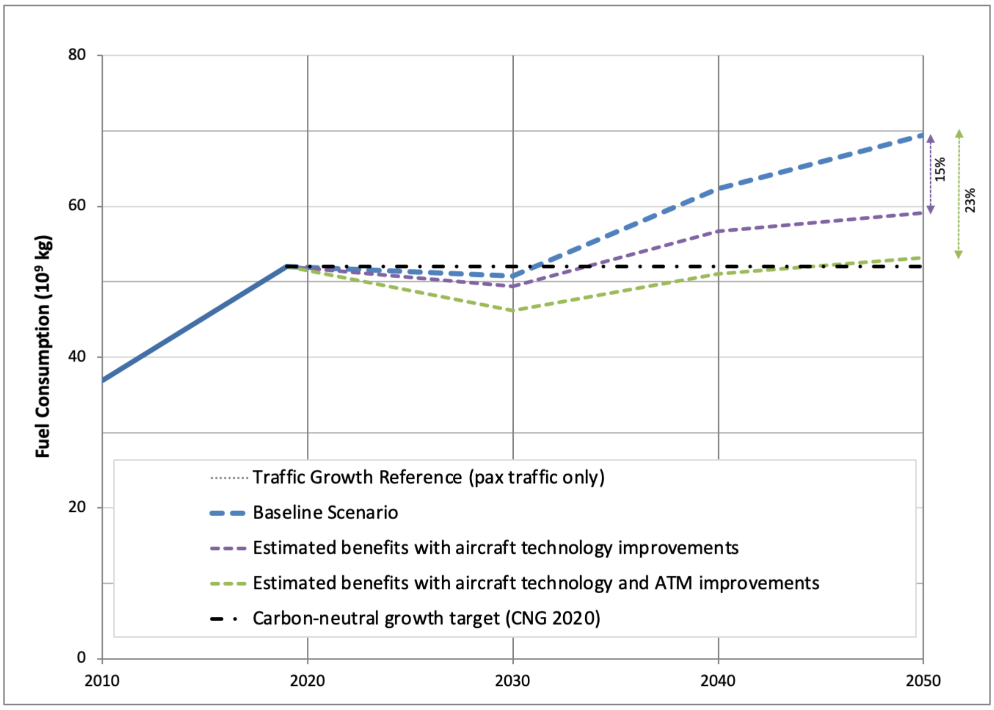

Figure 22 - Fuel consumption forecast for the baseline and implemented measures scenarios

As shown in Figure 22, the impact of improved aircraft technology indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline scenario. Overall CO_2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

From Table 9, under the currently assumed aircraft technology and ATM improvement scenarios, the fuel efficiency is projected to lead to a 32% reduction from 2019 to 2050. Indeed, the annual rate of fuel efficiency improvement is expected to progressively slow down from a rate of 1.82% between 2019 and 2030 to a rate of 0.74% between 2040 and 2050. Aircraft technology and ATM improvements alone will not be sufficient to meet the post-2020 carbon neutral growth objective of ICAO. This confirms that additional action, particularly market-based measures and SAF, are required to fill the gap. There are among the ECAC Member States additional ambitious climate strategies where carbon neutrality by 2050 is set as the overall objective. The aviation sector will have to contribute to this objective.

2.3. Actions taken collectively in Europe

2.3.1. Technology and standards

Aircraft emissions standards

European Member States fully support ICAO's Committee on Aviation Environmental Protection (CAEP) work on the development and update of aircraft emissions standards, in particular to the **ICAO Aircraft CO_2 Standard** adopted by ICAO in 2017. Europe significantly contributed to its development, notably through the European Aviation Safety Agency (EASA). It is fully committed to its implementation in Europe and the need to review the standard on a regular basis in light of developments in aeroplane fuel efficiency. EASA has supported the process to integrate this standard into European legislation (2018/1139) with an applicability date of 1 January 2020 for new aeroplane types.

ASSESSMENT

This is a European contribution to a global measure (CO_2 standard). Its contribution to the global aspirational goals are available in CAEP.

Research and development

Clean Sky

Clean Sky[25] is an EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies" for air transport globally. Joint Undertakings are Public Private Partnership set up by the European Union on the EU research programmes. By accelerating their deployment, the Joint Undertaking will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth. The first Clean Sky Joint Undertaking (**Clean Sky 1 -** 2011-2017) had a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry. It aimed to develop environmental-friendly technologies impacting all flying-segments of commercial aviation. The objectives were to reduce aircraft CO_2 emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

This was followed up with a second Joint Undertaking (**Clean Sky 2** – 2014-2024) with the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. The current budget for the programme is approximately €4 billion.

The two Interim Evaluations of Clean Sky in 2011 and 2013 acknowledged that the programme is successfully stimulating developments towards environmental targets. These preliminary assessments confirm the capability of achieving the overall targets at completion of the programme.

Main remaining areas for Research and Technological Development (RTD) efforts under Clean Sky 2 were:

- **Large Passenger Aircraft**: demonstration of best technologies to achieve the environmental goals whilst fulfilling future market needs and improving the competitiveness of future products.
- **Regional Aircraft:** demonstrating and validating key technologies that will enable a 90-seat class turboprop aircraft to deliver breakthrough economic and environmental performance and a superior passenger experience.
- **Fast Rotorcraft:** demonstrating new rotorcraft concepts (tilt-rotor and compound helicopters) technologies to deliver superior vehicle versatility and performance.
- **Airframe:** demonstrating the benefits of advanced and innovative airframe structures (like a more efficient wing with natural laminar flow, optimised control surfaces, control systems and embedded systems, highly integrated in metallic and advanced composites structures). In addition, novel engine integration strategies and innovative fuselage structures will be investigated and tested.
- **Engines:** validating advanced and more radical engine architectures.
- **Systems:** demonstrating the advantages of applying new technologies in major areas such as power management, cockpit, wing, landing gear, to address the needs of a future generation of aircraft in terms of maturation, demonstration and Innovation.
- **Small Air Transport:** demonstrating the advantages of applying key technologies on small aircraft demonstrators to revitalise an important segment of the aeronautics sector that can bring new key mobility solutions.
- **Eco-Design:** coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship with intelligent Re-use, Recycling and advanced services.

25 http://www.cleansky.eu/

In addition, the **Clean Sky Technology Evaluator**[26] will continue to be upgraded to assess technological progress routinely and evaluate the performance potential of Clean Sky 2 technologies at both vehicle and aggregate levels (airports and air traffic systems).

Disruptive aircraft technological innovations: European Partnership for Clean Aviation

With the Horizon 2020 programme coming to a close in 2020, the Commission has adopted a proposal to set up a new Joint Undertaking under the Horizon Europe programme (2021-2027). The **European Partnership for Clean Aviation (EPCA)**[27] will follow in the footsteps of CleanSky2. The EU contribution proposed is again €1.7 billion. The stakeholder community has already formulated a Strategic Research and Innovation Agenda (SRIA), which is intended to serve as a basis of the partnership once established. Subject to the final provisions of the partnership and the EU budget allocation, industry stakeholders have proposed a commitment of €3 billion from the private side.

General objectives of EPCA:

(a) To contribute to reduce the ecological footprint of aviation by accelerating the development of climate neutral aviation technologies for earliest possible deployment, therefore significantly contributing to the achievement of the general goals of the European Green Deal, in particular in relation to the reduction of Union-wide net greenhouse gas emissions reduction target of at least 55% by 2030, compared to 1990 levels and a pathway towards reaching climate neutrality by 2050.

(b) To ensure that aeronautics-related research and innovation activities contribute to the global sustainable competitiveness of the Union aviation industry, and to ensure that climate-neutral aviation technologies meet the relevant aviation safety requirements, and remains a secure, reliable, cost-effective, and efficient means of passenger and freight transportation.

Specific objectives:

(a) To integrate and demonstrate disruptive aircraft technological innovations able to decrease net emissions of greenhouse gasses by no less than 30% by 2030, compared to 2020 state-of-the-art technology while paving the ground towards climate-neutral aviation by 2050.

(b) To ensure that the technological and the potential industrial readiness of innovations can support the launch of disruptive new products and services by 2035, with the aim of replacing 75% of the operating fleet by 2050 and developing an innovative, reliable, safe and cost-effective European aviation system that is able to meet the objective of climate neutrality by 2050.

(c) To expand and foster integration of the climate-neutral aviation research and innovations value chains, including academia, research organisations, industry, and SMEs, also by benefitting from exploiting synergies with other national and European related programmes.

26 https://www.cleansky.eu/technology-evaluator-te
27 https://clean-aviation.eu/

ASSESSMENT

The quantitative assessment of the technology improvement scenario from 2020 to 2050 has been calculated by EUROCONTROL and EASA and it is included in Section 2.2 (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures) and in Appendix A: .

Table 12 - Fuel consumption and CO2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	49.37	156.00	191.54	0.0232	0.232
2040	56.74	179.28	220.13	0.0217	0.217
2050	59.09	186.72	229.26	0.0202	0.202
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

Table 13 - Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

2.3.2. Sustainable aviation fuels

Sustainable aviation fuels (SAF) including advanced biofuels and synthetic fuels, have the potential to significantly reduce aircraft emissions and ECAC States are embracing their large-scale introduction in line with the 2050 ICAO Vision.

The European collective SAF measures included in this Action Plan focuses on its CO_2 reductions benefits. Nevertheless SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM) with up to 90% and sulphur (SO_X) with 100%, compared to fossil jet fuel[28]. As a result, the large-scale use of SAF can have important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

ReFuelEU Aviation Initiative

On 15 January 2020, the European Parliament adopted a resolution on the European Green Deal in which it welcomed the upcoming strategy for sustainable and smart mobility and agreed with the European Commission that all modes of transport will have to contribute to the decarbonisation of the transport sector in line with the objective of reaching a climate-neutral economy. The European Parliament also called for "*a clear regulatory roadmap for the decarbonisation of aviation, based on technological solutions, infrastructure, requirements for sustainable alternative fuels and efficient operations, in combination with incentives for a modal shift*".

The Commission's work programme for 2020 listed under the policy objective on Sustainable and smart mobility, a new legislative initiative entitled "*ReFuelEU Aviation – Sustainable Aviation Fuels*".

This initiative aims to boost the supply and demand for sustainable aviation fuels (SAF) in the EU including not only advanced biofules but also synthetic fuels. This in turn will reduce aviation's environmental footprint and enable it to help achieve the EU's climate targets.

The EU aviation internal market is a key enabler of connectivity and growth but is also accountable for significant environmental impact. In line with the EU's climate goals to

28 ICAO 2016 Environmental Report, Chapter 4, Page 162, Figure 4.

reduce emissions by 55% by 2030 and to achieve carbon neutrality by 2050, the aviation sector needs to decarbonise.

While several policy measures are in place, significant potential for emissions savings could come from the use of SAF, i.e. liquid drop-in fuels replacing fossil kerosene. However, currently only around 0.05% of total aviation fuels used in the EU are sustainable.

The ReFuelEU Aviation initiative aims to maintain a competitive air transport sector while increasing the share of SAF used by airlines. The European Commission aims to propose in spring 2021 a Regulation imposing increasing shares of SAF to be blended with conventional fuel. This could result in important emission savings for the sector, given that some of those fuels (e.g. synthetic fuels) have the potential to save up to 85% or more of emissions compared to fossil fuels, over their total lifecycle.

ASSESSMENT

A meaningful deployment of SAF in the aviation market will lead to a net decrease of the air transport sector's CO_2 emissions. SAF can achieve as high as 85% or more emissions savings compared to conventional jet fuel, and therefore, if deployed at a large scale, have important potential to help aviation contribute to EU reaching its climate targets.

At the time of the submission of this action plan the legislative proposal under the ReFuelEU Aviation initiative, as well as its supporting impact assessment, were not yet adopted. As a result, the assessment of the benefits provided by this collective European measure in terms of reduction in aviation emissions is expected to be included in a future update of the common section of this action plan.

Addressing barriers of SAF penetration into the market

SAF are considered to be a critical element in the basket of measures to mitigate aviation's contribution to climate change in the short-term using the existing global fleet.

However, the use of SAF has remained negligible up to now despite previous policy initiatives such as the European Advanced Biofuels Flightpath, as there are still significant barriers for its large-scale deployment.

The European Aviation Environmental Report (EAER) published in January 2019, identified a lack of information at European level on the supply and use of SAF within Europe. EASA completed two studies in 2019 to address the lack of SAF monitoring in the EU.

Sustainable Aviation Fuel 'Facilitation Initiative'

The first study, addressing the barriers of SAF penetration into the market, examines how to incentivise the approval and use of SAF as drop-in fuels in Europe by introducing a SAF Facilitation Initiative.

The remaining significant industrial and economic barriers limit the penetration of SAF into the aviation sector. To reduce the costs and risk that economic operators face in bringing SAF to the aviation market, this study examined how to incentivise the approval and use of SAF as drop-in fuels in Europe by introducing a SAF Facilitation Initiative.

The report begins by analysing the status of SAFs in Europe today, including both more established technologies and ones at a lower Technology Readiness Level (TRL). It reviews one of the major solutions to the obstacle of navigating the SAF approval process, namely the US Clearing House run by the University of Dayton Research Institute and funded by the Federal Aviation Administration (FAA). The issue of sustainability is also examined, via an analysis of the role of Sustainability Certification Schemes (SCS) and how they interact with regulatory sustainability requirements, particularly those in the EU's Renewable Energy Directive (RED II) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Through interviews with a wide range of stakeholders the best form of European facilitation initiative has been identified. This study recommends that such an initiative be divided into two separate bodies, the first acting as an EU Clearing House and the second acting as a Stakeholder Forum.

The report is available at EASA's website: 'Sustainable Aviation Fuel 'Facilitation Initiative'.

Sustainable Aviation Fuel 'Monitoring System'

In response to a lack of information at the EU level on the supply and use of SAF within Europe identified by the European Aviation Environmental Report, EASA launched a second study to identify a cost effective, robust data stream to monitor the use and supply of SAF, as well as the associated emissions reductions. This included identifying and recommending performance indicators related to the use of SAF in Europe, as well as the associated aviation CO_2 emissions reductions achieved.

The study followed five steps:

1. Identification of possible performance indicators by reviewing the current 'state of the art' SAF indicators and consultation with key stakeholders.
2. Identification of regulatory reporting requirements, and other possible sources of datasets and information streams in the European context, with the potential to cover the data needs of the proposed performance indicators.
3. Examination of sustainability requirements applicable to SAF, and potential savings in greenhouse gas (GHG) emissions compared to fossil-based fuels.
4. Review of SAF use today and future expectations for SAF use within Europe.
5. Definition of a future monitoring and reporting process on SAF use in Europe and related recommendations to implement it.

The results will be used as a basis for subsequent work to include SAF performance indicators in future EAERs, which will provide insight into the market penetration of SAF over time in order to assess the success of policy measures to incentivize uptake.

The report is available at EASA's website: 'Sustainable Aviation Fuel 'Monitoring System'.

ASSESSMENT

While these studies are expected to contribute to addressing barriers of SAF penetration into the market, its inclusion is for information purposes and the assessment of its benefits in terms of reduction in aviation emissions is not provided in the present action plan.

Standards and requirements for SAF

European Union standards applicable to SAF supply

Within the European Union there are currently applicable standards for renewable energy supply in the transportation sector, which are included in the revised Renewable Energy Directive (RED II) that entered into force in December 2018 (Directive 2018/2001/EU).

It aims at promoting the use of energy from renewable sources, establishing mandatory targets to be achieved by 2030 for a 30% overall share of renewable energy in the EU and a minimum of 14% share for renewable energy in the transport sector, including for aviation but without mandatory SAF supply targets.

<u>Sustainability and life cycle emissions methodologies:</u>

Sustainability criteria and life cycle emissions methodologies have been established for all transport renewable fuels supplied within the EU to be counted towards the targets, which are fully applicable to SAF supply.

These can be found in RED's[29] Article 17, *Sustainability criteria for biofuels and bioliquids*. Those requirements remain applicable on the revised RED II (Directive (EU) 2018/2001)38, Article 29 *Sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels* paragraphs 2 to 7, although the RED II introduces some new specific criteria for forestry feedstocks.

Transport renewable fuels (thus, including SAF) produced in installations starting operation from 1 January 2021 must achieve 65% GHG emissions savings with respect to a fossil fuel comparator for transportation fuels of 94 g CO_2eq/MJ. In the case of transport renewable fuels of non-biological origin[30], the threshold is raised to 70% GHG emissions savings.

To help economic operators to declare the GHG emission savings of their products, default and typical values for a number of specific pathways are listed in the RED II Annex V (for liquid biofuels). The European Commission can revise and update the default values of GHG emissions when technological developments make it necessary.

Economic operators have the option to either use default GHG intensity values provided in RED II (Parts A & B of Annex V) so as to estimate GHG emissions savings for some or all of the steps of a specific biofuel production process, or to calculate "actual values" for their pathway in accordance with the RED methodology laid down in Part C of Annex V;

In the case of non-bio based fuels, a specific methodology is currently under development to be issued in 2021.

ICAO standards applicable to SAF supply

Europe is actively contributing to the development of the ICAO CORSIA Standards and Recommended Practices (SARPs), though the ICAO Committee on Aviation and Environmental Protection (CAEP), establishing global Sustainability Requirements applicable to SAF as well as to the CORSIA Methodology for Calculating Actual Life Cycle Emissions Values and to the calculation of CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels; CORSIA standards are applicable to any SAF use to be claimed under CORSIA in order to reduce offsetting obligations by aeroplane operators.

ASSESSMENT

The inclusion of European requirements for SAF respond to ICAO Guidance (Doc 9988) request (Para. 4.2.14) to provide estimates of the actual life cycle emissions of the SAF which are being used or planned to deploy and the methodology used for the life cycle analysis. It is therefore provided for information purposes only and no further assessment of its benefits in terms of reduction in aviation emissions is provided in this action plan common section.

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29 Directive 2009/28/EC.

30 In the case of renewable fuels of non-biological origin, two types are considered: a) Renewable liquid and gaseous transport fuels of non-biological origin (including categories commonly referred as Power to Liquid -PtL-, Electro-fuels and Synthetic fuels). b) Waste gases, which are under the category of REcycled FUel from NOn-BIOlogical origin (also known as REFUNIOBIO).

Research and Development projects on SAF

European Advanced Biofuels Flightpath

An updated and renewed approach to the 2011 Biofuels FlightPath Initiative[31], was required to further impulse its implementation. As a result, the European Commission launched in 2016 the new Biofuels FlightPath to take into account recent evolutions and to tackle the current barriers identified for the deployment of SAF.

The Biofuels FlightPath was managed by its Core Team, which consists of representatives from Airbus, Air France, KLM, IAG, IATA, BiojetMap, SkyNRG and Lufthansa from the aviation side and Mossi Ghisolfi, Neste, Honeywell-UOP, Total and Swedish Biofuels on the biofuel producers' side.

A dedicated executive team, formed by SENASA, ONERA, Transport & Mobility Leuven and Wageningen UR, coordinated for three years the stakeholder's strategy in the field of aviation by supporting the activities of the Core Team and providing sound recommendations to the European Commission.

A number of communications and studies were delivered and are available[32].

The project was concluded with a Stakeholders conference in Brussels on 27 November 2019, and the publication of a report summarizing its outcomes.

Projects funded under the European Union's Horizon 2020 research and innovation programme

Since 2016, seven new projects have been funded by the Horizon 2020, which is the biggest Research and Innovation program of the EU.

BIO4A[33]: The "*Advanced Sustainable Biofuels for Aviation*» project plan to demonstrate the first large industrial-scale production and use of SAF in Europe obtained from residual lipids such as Used Cooking Oil.

The project will also investigate the supply of sustainable feedstocks produced from drought-resistant crops such as Camelina, grown on marginal land in EU Mediterranean areas. By adopting a combination of biochar and other soil amendments, it will be possible to increase the fertility of the soil and its resilience to climate change, while at the same time storing fixed carbon into the soil.

BIO4A will also test the use of SAF across the entire logistic chain at industrial scale and under market conditions, and it will finally assess the environmental and socio-economic sustainability performance of the whole value chain.

Started in May 2018, BIO4A will last until 2022, and it is carried out by a consortium of seven partners from five European countries.

KEROGREEN[34]: Production of sustainable aircraft grade kerosene from water and air powered by renewable electricity, through the splitting of CO_2, syngas formation and Fischer-Tropsch synthesis (KEROGREEN), is a Research and Innovation Action (RIA) carried out by six partners from four European countries aiming at the development and

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31 In June 2011 the European Commission, in close coordination with Airbus, leading European airlines (Lufthansa, Air France/KLM, & British Airways) and key European biofuel producers (Choren Industries, Neste Oil, Biomass Technology Group and UOP), launched the European Advanced Biofuels Flight-path. This industry-wide initiative aimed to speed up the commercialisation of aviation biofuels in Europe, with an initial objective of achieving the commercialisation of 2 million tonnes of SAF by 2020, target that was not reached due to the commercial challenges of SAF large-scale supply. https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf
32 https://www.biofuelsflightpath.eu/ressources
33 www.bio4a.eu
34 www.kerogreen.eu

testing of an innovative conversion route for the production of SAF from water and air powered by renewable electricity.

The new approach and process of KEROGREEN reduces overall CO_2 emission by creating a closed carbon fuel cycle and at the same time creates long-term large-scale energy storage capacity which will strengthen the EU energy security and allow creation of a sustainable transportation sector.

The KEROGREEN project expected duration is from April 2018 to March 2022.

FlexJET[35]: *Sustainable Jet Fuel from Flexible Waste Biomass* (flexJET) is a four-year project targeting diversifying the feedstock for SAF beyond vegetable oils and fats to biocrude oil produced from a wide range of organic waste. This is also one of the first technologies to use green hydrogen from the processed waste feedstock for the downstream refining process thereby maximising greenhouse gas savings.

The project aims at building a demonstration plant for a 12 t/day use of food & market waste and 4000 l/day of Used Cooking Oil (UCO), produce hydrogen for refining through separation from syngas based on Pressure Swing Absorption technology, and finally deliver 1200 tons of SAF (ASTM D7566 Annex 2) for commercial flights to British Airways.

The consortium with 13 partner organisations has brought together some of the leading researchers, industrial technology providers and renewable energy experts from across Europe. The project has a total duration of 48 months from April 2018 to March 2022.

BioSFerA[36]: The *Biofuels production from Syngas Fermentation for Aviation and maritime use* (BioSFerA)project, aims to validate a combined thermochemical - biochemical pathway to develop cost-effective interdisciplinary technology to produce sustainable aviation and maritime fuels. At the end of the project next generation aviation and maritime biofuels, completely derived from second generation biomass, will be produced and validated by industrial partners at pilot scale. The project will undertake a full value chain evaluation that will result in a final analysis to define a pathway for the market introduction of the project concept. Some crosscutting evaluations carried out on all tested and validated processes will complete the results of the project from an economic, environmental and social point of view.

The project is carried out by a consortium of 11 partners from 6 European countries and its expected duration is from 1 April 2020 to 31 March 2024.

BL2F[37]: The *Black Liquor to Fuel* (BL2F) project will use "Black Liquor" to create a clean, high-quality biofuel. Black liquor is a side-stream of the chemical pulping industry that can be transformed into fuel, reducing waste and providing an alternative to fossil fuels. Launched in April 2020, BL2F will develop a first-of-its-kind Integrated "Hydrothermal Liquefaction" (HTL) process at pulp mills, decreasing carbon emissions during the creation of the fuel intermediate. This will then be further upgraded at oil refineries to bring it closer to the final products and provide a feedstock for marine and aviation fuels.

BL2F aims to contribute to a reduction of 83% CO_2 emitted compared to fossil fuels. A large deployment of the processes developed by BL2F, using a variety of biomass, could yield more than 50 billion litres of advanced biofuels by 2050.

35 www.flexjetproject.eu
36 https://biosfera-project.eu
37 https://www.bl2f.eu

The project brings together 12 partners from 8 countries around Europe and its expected duration is from 1 April 2020 till 31 March 2023.

FLITE[38]: The *Fuel via Low Carbon Integrated Technology from Ethanol* (FLITE) consortium proposes to expand the supply of low carbon jet fuel in Europe by designing, building, and demonstrating an innovative ethanol-based Alcohol-to-Jet (ATJ) technology in an ATJ Advanced Production Unit (ATJ-APU). The ATJ-APU will produce jet blend stocks from non-food/non-feed ethanol with over 70% GHG reductions relative to conventional jet. The Project will demonstrate over 1000 hours of operations and production of over 30,000 metric tonnes of Sustainable Aviation Fuel.

The diversity of ethanol sources offers the potential to produce cost competitive SAF, accelerating uptake by commercial airlines and paving the way for implementation.

The project is carried out by a consortium of five partners from six European countries and its expected duration is from 1 December 2020 till 30 November 2024.

TAKE-OFF[39]: Is an industrially driven project aiming to be a game-changer in the cost-effective production of SAF from CO_2 and hydrogen. The unique TAKE-OFF technology is based on conversion of CO_2 and H_2 to SAF via ethylene as intermediate. Its industrial partners will team up with research groups to deliver a highly innovative process which produces SAF at lower costs, higher energy efficiency and higher carbon efficiency to the crude jet fuel product than the current benchmark Fischer-Tropsch process. TAKE-OFF's key industrial players should allow the demonstration of the full technology chain, utilising industrial captured CO_2 and electrolytically produced hydrogen. The demonstration activities will provide valuable data for comprehensive technical and economic and environmental analyses with an outlook on Chemical Factories of the Future.

The project is carried out by a consortium of nine partners from five European countries and its expected duration is from 1 January 2021 till 24 December 2024.

ASSESSMENT

This information on SAF European Research and Development projects are included in this common section of the action plan to complement the information on Sustainable Aviation Fuels measures and to inform on collective European efforts. No further quantitative assessment of the benefits of this collective European measure in terms of reduction in aviation emissions is provided in the common section of this action plan.

38 https://cordis.europa.eu/project/id/857839
39 https://cordis.europa.eu/project/id/101006799

2.3.3. Operational improvements

The EU's Single European Sky Initiative and SESAR

SESAR Project

SES and SESAR

The European Union's Single European Sky (SES) policy aims to reform Air Traffic Management (ATM) in Europe in order to enhance its performance in terms of its capacity to manage variable volumes of flights in a safer, more cost-efficient and environmentally friendly manner.

The SESAR (*Single European Sky ATM Research*) programme addresses the technological dimension of the single European sky, aiming in particular to deploy a modern, interoperable and high-performing ATM infrastructure in Europe.

SESAR contributes to the Single Sky's performance targets by defining, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner. SESAR coordinates and concentrates all EU research and development (RTD) activities in ATM.

SESAR is fully aligned with the Union’s objectives of a sustainable and digitalised mobility and is projected towards their progressive achievement over the next decade. To implement the SESAR project, the Commission has set up with the industry, an innovation cycle comprising three interrelated phases: definition, development and deployment. These phases are driven by partnerships (SESAR Joint Undertaking and SESAR Deployment Manager) involving all categories of ATM/aviation stakeholders.

Guided by the European ATM Master Plan, the SESAR Joint Undertaking (SJU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe’s ATM system and deliver benefits to Europe and its citizens. The SESAR JU research programme is developed over successive phases, SESAR 1 (from 2008 to 2016) and SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022). It is delivering SESAR solutions in four key areas, namely airport operations, network operations, air traffic services and technology enablers.

The SESAR contribution to the SES high-level goals set by the Commission are continuously reviewed by the SESAR JU and are kept up to date in the ATM Master Plan.

SESAR and the European Green Deal objectives

The European Green Deal launched by the European Commission in December 2019 aims to create the world's first climate-neutral bloc by 2050. This ambitious target calls for deep-rooted change across the aviation sector and places significantly stronger focus on the environmental impact of flying. Multiple technology pathways are required, one of which is the digital transformation of air traffic management, where SESAR innovation comes into play. Over the past ten years the SESAR JU has worked to improve the environmental footprint of air traffic management, from CO_2 and non-CO_2 emissions, to noise and local air quality. The programme is examining every phase of flight and use of the airspace and seeing what technologies can be used to eliminate fuel inefficiencies. It is also investing in synchronised data exchange and operations on the ground and in the air to ensure maximum impact. The ambition is to reduce by 2035 average CO_2 emissions per flight by 0.8-1.6 tonnes, taking into account the entire flight from gate to gate, including the airport.

Results

To date, the SESAR JU has delivered over 90 solutions for implementation, many of which offer direct and indirect benefits for the environment, with more solutions in the pipeline in SESAR 2020. Outlined in the SESAR Solutions Catalogue, these include solutions such as wake turbulence separation (for arrivals and departure), optimised use of runway configuration for multiple runway airports, or even optimised integration of arrival and departure traffic flows for single and multiple runway airports. Looking ahead, it is anticipated that the next generation of SESAR solutions will contribute to a reduction of some 450 kg CO_2 per flight.

Considering the urgency of the situation, the SESAR JU is working to accelerate the digital transformation in order to support a swift transition to greener aviation. Large-scale demonstrators are key to bridging the industrialisation gap, bringing these innovations to scale and encouraging rapid implementation by industry. Such large-scale efforts have started now with the recently launched ALBATROSS project. They will also be the focus of the future SESAR 3 Joint Undertaking, which is expected to give further and fresh impetus to this important endeavour.

The **Performance Ambitions for 2035** compared to a **2012 baseline** for Controlled airspace for each key performance area are presented in the figure below, with the ambition for environment, expressed in CO_2 reduction, highlighted by the green dotted rectangle of Figure 23 below:

Key performance area	SES high-level goals 2005	Key performance indicator	Performance ambition vs. baseline: Baseline value (2012)	Ambition value (2035)	Absolute improvement	Relative improvement
Capacity	Enable 3-fold increase in ATM capacity	**Departure delay**[4], min/dep	9.5 min	6.5-8.5 min	1-3 min	10-30%
		IFR movements at most congested airports[5], million	4 million	4.2-4.4 million	0.2-0.4 million	5-10%
		Network throughput IFR flights[5], million	9.7 million	~15.7 million	~6.0 million	~60%
		Network throughput IFR flight hours[5], million	15.2 million	~26.7 million	~11.5 million	~75%
Cost efficiency	Reduced ATM services unit costs by 50% or more	**Gate-to-gate direct ANS cost per flight**[1] · EUR(2012)	EUR 960	EUR 580-670	EUR 290-380	30-40%
Operational efficiency		**Gate-to-gate fuel burn per flight**[2], kg/flight	5280 kg	4780-5030 kg	250-500 kg	5-10%
		Additional gate-to-gate flight time per flight, min/flight	8.2 min	3.7-4.1 min	4.1-4.5 min	50-55%
		Within the: Gate-to-gate flight time per flight[3], min/flight	(111 min)	(116 min)		
Environment	Enable 10% reduction in the effects flights have on the environment	**Gate-to-gate CO_2 emissions**, tonnes/flight	16.6 tonnes	15-15.8 tonnes	0.8-1.6 tonnes	5-10%
Safety	Improve safety by factor 10	**Accidents with direct ATM contribution**[6], #/year Includes in-flight accidents as well as accidents during surface movement (during taxi and on the runway)	0.7 (long-term average)	no ATM related accidents	0.7	100%
Security		**ATM related security incidents resulting in traffic disruptions**	unknown	no significant disruption due to cyber-security vulnerabilities	unknown	-

1 Unit rate savings will be larger because the average number of Service Units per flight continues to increase.
2 "Additional" means the average flight time extension caused by ATM inefficiencies.
3 Average flight time increases because the number of long-distance flights is forecast to grow faster than the number of short-distance flights.
4 All primary and secondary (reactionary) delay, including ATM and non-ATM causes.
5 Includes all non-segregated unmanned traffic flying IFR, but not the drone traffic flying in airspace below 500 feet or the new entrants flying above FL 600
6 In accordance with the PRR definition: where at least one ATM event or item was judged to be DIRECTLY in the causal chain of events leading to the accident. Without that ATM event, it is considered that the accident would not have happened.

Figure 23 – Performance Ambitions for 2035 for Controlled airspace (Source: European ATM Master Plan 2020 Edition).

While all SESAR solutions bring added value to ATM performance, some have a higher potential to contribute the performance of the entire European ATM network and require a coordinated and synchronised deployment. To facilitate the deployment of these SESAR solutions, the Commission establishes common projects that mandate the synchronised implementation of selected essential ATM functionalities based on SESAR solutions developed and validated by the SESAR JU.

The first common project was launched in 2014 and its implementation is currently being coordinated by the SESAR Deployment Manager throughout the entire European ATM network. It includes six ATM functionalities aiming in particular to:

- Optimise the distancing of aircraft during landing and take-off, reducing delays and fuel burn while ensuring the safest flying conditions.
- Allow aircraft to fly their preferred and usually most fuel-efficient trajectory (free route).
- Implement an initial, yet fundamental step towards digitalising communications between aircraft and controllers and between ground stakeholders allowing better planning, predictability, thus less delays and fuel optimisation and passenger experience.

The first common project[40] is planned to be completed by 2027. However, the benefits highlighted in Figure 24 below have been measured where the functionalities have already been implemented.

40 https://ec.europa.eu/transport/modes/air/sesar/deployment_en

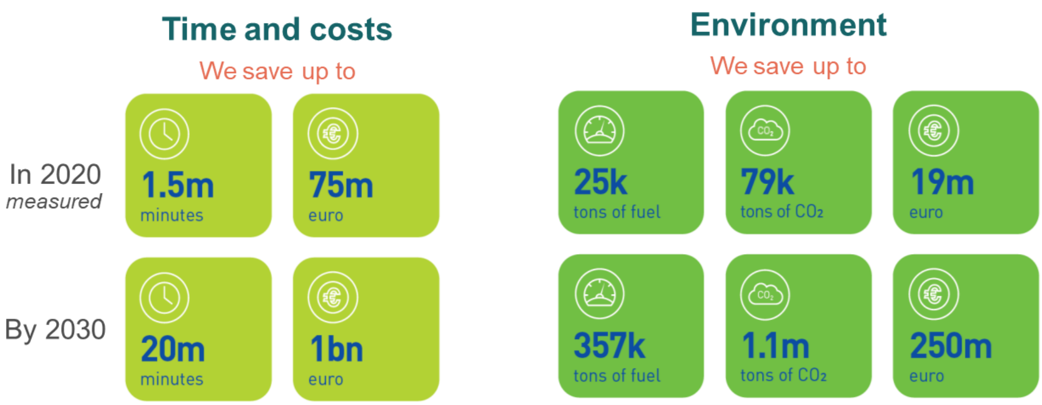

Figure 24 – First results of the first common project implemented

SESAR Exploratory Research (V0 to V1)

SESAR Exploratory Research projects explore new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods. The knowledge acquired can be transferred into the SESAR industrial and demonstration activities. SESAR Exploratory Research projects are not subject to performance targets but should address the performances to which they have the potential to contribute.

SESAR Industrial Research & Validation Projects (environmental focus)

The main outcomes of the industrial research and validation projects dedicated to the environmental impacts of aviation in SESAR 1 were:

- The initial development by EUROCONTROL of the IMPACT[41] web-based platform which allows noise impact assessments and estimates of fuel burn and resulting emissions to be made from common inputs, thus enabling trade-offs to be conducted. IMPACT has since been continuously maintained and developed by EUROCONTROL, used for ICAO Committee on Aviation Environmental Protection Modelling and Database Group (CAEP) assessments, the conduct of studies in support of the European Aviation Environment Report (EAER) editions 2016 and 2019, and has been adopted by a large range of aviation stakeholders.
- The initial development/maintenance Open-ALAQS that provides a mean to perform emissions inventory at airports, emissions concentration calculation and dispersion.
- The development of an IMPACT assessment process.[42]

It should be noted that these tools and methodology were developed to cover the research and the future deployment phase of SESAR, as well as to support European states and agencies in conducting environmental impact assessments for operational or regulatory purposes. They are still in use in SESAR.

SESAR Industrial Research and Validation assesses and validates technical and operational concepts in simulated and real operational environments according to a set of key performance areas. These concepts mature through the SESAR programme from V1 to V3 to become SESAR Solutions ready for deployment.

41 https://www.eurocontrol.int/platform/integrated-aircraft-noise-and-emissions-modelling-platform
42https://www.sesarju.eu/sites/default/files/documents/transversal/SESAR%202020%20-%20Environment%20Impact%20Assessment%20Guidance.pdf

SESAR has a wide range of solutions to improve the efficiency of air traffic management, some of which are specifically designed to improve environmental performance, by reducing noise impact around airports and/or fuel consumption and emissions in all phases of flight.

A catalogue of SESAR Solutions is available[43] and those addressing environment impacts are identified by the following pictogram:

SESAR2020 Industrial Research and Validation - Environmental Performance Assessment

The systematic assessment of environmental impacts of aviation are at the heart of SESAR Industrial Research and Validation activities since SESAR 1, with a very challenging target on fuel/CO2 efficiency of 500kg of fuel savings on average per flight.

SESAR Pj19.04 Content Integration members are monitoring the progress of SESAR Solutions towards this target in a document call Performance Assessment and Gap Analysis Report (PAGAR). The Updated version of PAGAR 2019 provides the following environmental achievements:

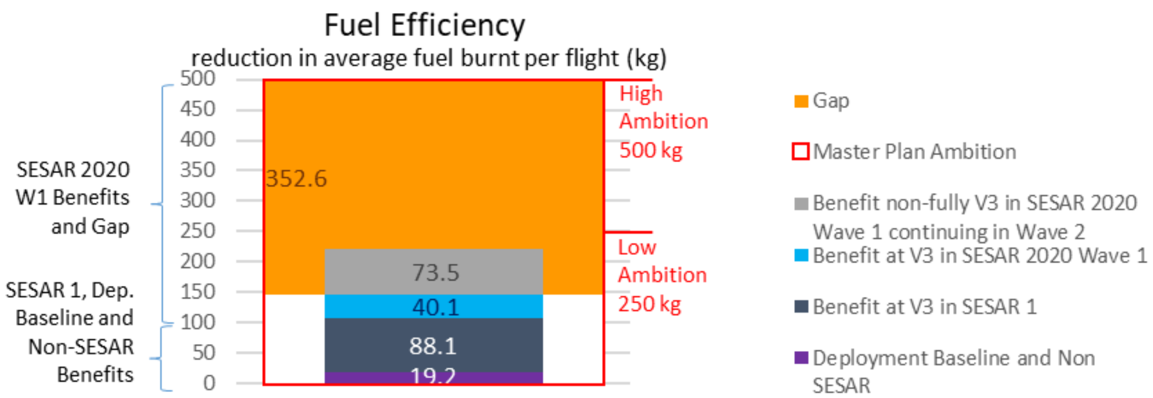

Figure 25 - SESAR fuel efficiency achievement versus gap (Source: Updated version of PAGAR 2019)

The Fuel Efficiency benefits at V3 maturity level in SESAR 2020 Wave 1 represents an average of 40.1 kg of fuel savings per flight. There would therefore be a gap of 352.6 kg in fuel savings per flight to be filled by Wave 2, compared to the high fuel savings Ambition target (and a gap of 102.6 kg with respect to the low Ambition target, as the Master Plan defines a range of 5-10% as the goal). Potentially 73.5 kg might be fulfilled from Wave 1 Solutions non-fully V3 continuing in Wave 2.

A fuel saving of 40.1 kg per ECAC flight equates to about 0.76% of the 5,280 kg of fuel burnt on average by an ECAC flight in 2012 (SESAR baseline). Although this might seem marginal, in 2035, ECAC-wide, it would equate to 1.9 million tonnes of CO_2 saved, equivalent to the CO_2 emitted by 165,000 Paris-Berlin flights; or a city of 258,000 European citizens; or the CO_2 captured by 95 million trees per year.

In SESAR, a value of 5,280 kg of fuel per flight for the ECAC (including oceanic region) is used as a baseline[44]. Based on the information provided by the PAGAR 2019 document[45],

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43 https://www.sesarju.eu/news/sesar-solution-catalogue-third-edition-now-out
44 See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) - eATM
45 See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021

the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4kg of fuel/flight. So far, the target for Wave 2 remains at about 7% more CO_2/fuel savings (352.6kg of fuel) to reach the initial Ambition target of about 10% CO_2/fuel savings (500kg fuel) per flight by 2035. Beyond 2035, there is no SESAR Ambition yet. To this could be added the as yet non-estimated benefits of Exploratory Research projects[46].

SESAR AIRE demonstration projects

In addition to its core activities, the SESAR JU co-financed projects where ATM stakeholders worked collaboratively to perform integrated flight trials and demonstrations of solutions. These aimed to reduce CO_2 emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 "green" projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE).

AIRE[47] is the first large-scale environmental initiative bringing together aviation players from both sides of the Atlantic. So far, three AIRE cycles have been successfully completed.

A total of 15 767 flight trials were conducted, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3150 kg of CO_2), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology.

SESAR 2020 Very Large-Scale Demonstrations (VLDs)

VLDs evaluate SESAR Solutions on a much larger scale and in real operations to prove their applicability and encourage the early take-up of V3 mature solutions.

SESAR JU has recently awarded ALBATROSS[48], a consortium of major European aviation stakeholder groups to demonstrate how the technical and operational R&D achievements of the past years can transform the current fuel intensive aviation to an environment-friendly industry sector.

The ALBATROSS consortium will carry a series of demonstration flights, which the aim to implementing a "perfect flight" (in other words the most fuel-efficient flight) will be explored and extensively demonstrated in real conditions, through a series of live trials in various European operating environments. The demonstrations will span through a period of several months and will utilise over 1,000 demonstration flights.

Preparing SESAR

Complementing the European ATM Master Plan 2020 and the High-Level Partnership Proposal, the Strategic Research and Innovation Agenda (SRIA) details the research and innovation roadmaps to achieve the Digital European Sky, matching the ambitions of the 'European Green Deal' and the 'Europe fit for the digital age' initiative.

The SRIA[49] identifies inter-alia the need to continue working on "optimum green trajectories", on non-CO_2 impacts of aviation, and the need to accelerate decarbonisation of aviation through operational and business incentivisation.

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46 See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch
47https://ec.europa.eu/transport/modes/air/environment/aire_en#:~:text=The%20joint%20initiative%20AIRE%20(Atlantic,NEXTGEN%20in%20the%20United%20States
48 https://www.sesarju.eu/projects/ALBATROSS
49 https://www.sesarju.eu/node/3697

ASSESSMENT

The quantitative assessment of the operational and ATM improvement scenario from 2020 to 2050 has been included in the modelled scenarios by EUROCONTROL on the basis of efficiency analyses from the SESAR project indicated in Figure 25 above and it is included in Section 2.2 above (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures).

Table 14 - CO_2 emissions forecast for the ATM improvements scenarios

Year	CO_2 emissions (10^9 kg)	
	Baseline Scenario	Implemented Measures Scenario
		ATM improvements
2030	160.29	149.9
2040	197.13	177.4
2050	210.35	197.4

For reasons of data availability, results shown in this table do not include cargo/freight traffic.

Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.

2.3.4. Market-based measures

The Carbon Offsetting and Reduction Scheme for International Aviation

ECAC Member States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The 39th General Assembly of ICAO (2016) reaffirmed the 2013 objective of stabilising CO_2 emissions from international aviation at 2020 levels. In addition, the States adopted the introduction of a global market-based measure, namely the '*Carbon Offsetting and Reduction Scheme for International Aviation*' (CORSIA), to offset and reduce international aviation's CO_2 emissions above average 2019/2020 levels through standard international CO_2 emissions reductions units which would be put into the global market. This major achievement was most welcome by European States which have actively promoted the mitigation of international emissions from aviation at a global level.

Development and update of ICAO CORSIA standards

European Member States have fully supported ICAO's work on the development of Annex 16, Volume IV to the Convention on International Civil Aviation containing the Standards and Recommended Practices (SARPs) for the implementation of CORSIA, which was adopted by the ICAO Council in June 2018.

As a part of the ICAO's Committee on Aviation Environmental Protection (CAEP) work programme for the CAEP/12 cycle, CAEP's Working Group 4 (WG4) is tasked to maintain the Annex 16, Volume IV and related guidance material, and to propose revisions to improve those documents as needed.

Europe is contributing with significant resources to the work of CAEP-WG4 and EASA in particular by providing a WG4 co-Rapporteur, and by co-leading the WG4 task on maintaining the Annex 16, Volume IV and related guidance material.

CORSIA implementation

In application of their commitment in the 2016 "Bratislava Declaration" the 44 ECAC Member States have notified ICAO of their decision to voluntarily participate in CORSIA from the start of the pilot phase in 2021 and have effectively engaged in its implementation. This shows the full commitment of the EU, its Member States and the other Member States of ECAC to counter the expected in-sector growth of total CO_2 emissions from air transport and to achieving overall carbon neutral growth.

On June 2020, the European Council adopted COUNCIL DECISION (EU) 2020/954 on the position to be taken on behalf of the European Union within the International Civil Aviation Organization as regards the notification of voluntary participation in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from 1 January 2021 and the option selected for calculating aeroplane operators' offsetting requirements during the 2021-2023 period.

ASSESSMENT

CORSIA is a global measure which assessment is undertaken globally by ICAO. Thus, the assessment of the benefits provided by CORSIA in terms of reduction in European emissions is not provided in this action plan.

The EU Emissions Trading System and its linkages with other systems (Swiss ETS and UK ETS)

The EU Emissions Trading System (EU ETS) is the cornerstone of the European Union's policy to tackle climate change, and a key tool for reducing greenhouse gas emissions cost-effectively, including from the aviation sector.

The 30 EEA States in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap-and-trade approach to limit CO_2 emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2013 to 2020 EU ETS has saved an estimated 200 million tonnes of intra-European aviation CO_2 emissions.

It operates in 30 countries: the 27 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS currently covers half of the EU's CO_2 emissions, encompassing those from around 11 000 power stations and industrial plants in 30 countries, and, under its current scope, around 500 commercial and non-commercial aircraft operators that fly between airports in the European Economic Area (EEA). The EU ETS Directive was revised in line with the European Council Conclusions of October 2014[50] that confirmed that the EU ETS will be the main European instrument to achieve the EU's binding 2030 target of an at least 40%[51], and will be revised to be aligned with the latest Conclusions in December 2020[52], prescribing at least 55% domestic reduction (without using international credits) of greenhouse gases compared to 1990.

The EU ETS began operation in 2005, for aviation in 2012; a series of important changes to the way it works took effect in 2013, strengthening the system. The EU ETS works on the "cap and trade" principle. This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants, other installations and aircraft operators in the system. Within this cap, companies can sell to or buy emission allowances from one another. The limit on allowances available provides certainty that the environmental objective is achieved and gives allowances a market value.

For aviation, the cap is calculated based on the average emissions from the years 2004-2006, while the free allocation to aircraft operators is based on activity data from 2010. The cap for aviation activities for the 2013-2020 phase of the ETS was set to 95% of

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50 http://www.consilium.europa.eu/en/meetings/european-council/2014/10/23-24/
51 Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0410
52 1011-12-20-euco-conclusions-en.pdf (europa.eu)

these historical aviation emissions. Starting from 2021, free allocation to aircraft operators is reduced by the linear reduction factor (currently of 2.2%) now applicable to all ETS sectors. Aircraft operators are entitled to free allocation based on a benchmark, but this does not cover the totality of emissions. The remaining allowances need to be purchased from auctions or from the secondary market. The system allows aircraft operators to use aviation allowances or general (stationary installations) allowances to cover their emissions. Currently, 82% of aviation allowances are distributed through free allocation, 3% are part of a special reserve for new entrants and fast growers, and 15% are auctioned.

The legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[53].

Following the 2013 ICAO agreement on developing CORSIA, the EU decided[54] to limit the scope of the EU ETS to flights between airports located in the European Economic Area (EEA) for the period 2013-2016, and to carry out a new revision in the light of the outcome of the 2016 ICAO Assembly. The European Commission assessed the outcome of the 39th ICAO Assembly and, in that light, a new Regulation was adopted in 2017[55].

The legislation maintains the scope of the EU ETS for aviation limited to intra-EEA flights and sets out the basis for the implementation of CORSIA. It provides for European legislation on the monitoring, reporting and verification rules through a delegated act under the EU ETS Directive of July 2019[56]. It foresees that a further assessment should take place and a report be presented to the European Parliament and to the Council considering how to implement CORSIA in Union law through a revision of the EU ETS Directive. The European Green Deal and 2030 Climate Target Plan clearly set out the Commission's intention to propose to reduce the EU ETS allowances allocated for free to airlines. This work is currently ongoing and is part of the "Fit for 55 package"[57].

The EU legislation foresees that, where a third country takes measures to reduce the climate change impact of flights departing from its airports, the EU will facilitate interaction between the EU scheme and that country's measures and flights arriving from the third country could be excluded from the scope of the EU ETS. This is the case between the EU and Switzerland[58] following the agreement to link their respective emissions trading systems, which entered into force on 1 January 2020.

As a consequence of the linking agreement with Switzerland, from 2020 the EU ETS was extended to all departing flights from the EEA to Switzerland, and Switzerland applies its ETS to all departing flights to EEA airports, ensuring a level playing field on both directions of routes. In accordance with the EU-UK Trade and Cooperation Agreement

53 Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0101
54 Decision No. 377/2013/EU derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/LexUriServLexUriServ.do?uri=CELEX:32013D0377:EN:NOT
55 Regulation (EU) 2017/2392 of the European Parliament and of the Council of 13 December 2017 amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.350.01.0007.01.ENG&toc=OJ:L:2017:350:TOC
56 Commission Delegated Regulation (EU) 2019/1603 of 18 July 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards measures adopted by the International Civil Aviation Organisation for the monitoring, reporting and verification of aviation emissions for the purpose of implementing a global market-based measure https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2019.250.01.0010.01.ENG
57 2021_commission_work_programme_new_policy_objectives_factsheet_en.pdf (europa.eu)
58 Commission Delegated Decision (EU) 2020/1071 of 18 May 2020 amending Directive 2003/87/EC of the European Parliament and of the Council, as regards the exclusion of incoming flights from Switzerland from the EU emissions trading system, OJ L 234, 21.7.2020, p. 16.

reached in December 2020, the EU ETS shall continue to apply to departing flights from the EEA to the UK, while a UK ETS will apply effective carbon pricing on flights departing from the UK to the EEA.

Impact on fuel consumption and/or CO_2 emissions
The EU ETS has delivered around 200 Mt of CO2 emission reductions between 2013 and 2020[59]. While the in-sector aviation emissions for intra-EEA flights kept growing, from 53,5 million tonnes CO_2 in 2013 to 69 million in 2019, the flexibility of the EU ETS, whereby aircraft operators may use any allowances to cover their emissions, meant that the CO2 impacts from these flights did not lead to overall greater greenhouse gas emissions. Verified emissions from aviation covered by the EU Emissions Trading System (ETS) in 2019 compared to 2018 continued to grow, albeit more modestly, with an increase of 1% compared to the previous year, or around 0.7 million tonnes CO_2 equivalent[60].

To complement the EU ETS price signal, EU ETS auctioning revenues should be used to support transition towards climate neutrality. Under the EU ETS (all sectors covered), Member States report that from 2012 until 2020, over €45 billion of ETS auction revenue has been used to tackle climate change, and additional support is available under the existing ETS Innovation Fund that is expected to deploy upwards of €12 billion in the period 2021-2030. The EU ETS' current price incentive per tonne for zero emission jet fuel, is by itself insufficient to bridge the price gap with conventional kerosene. However, by investing auctioning revenues through the Innovation Fund, the EU ETS can also support deployment of breakthrough technologies and drive the price gap down.

In terms of its contribution towards the ICAO carbon neutral growth goal from 2020, the states implementing the EU ETS have delivered, in "net" terms, the already achieved reduction of around 200 MT of aviation CO2 emissions will continue to increase in the future under the new legislation. Other emission reduction measures taken, either collectively throughout Europe or by any of the states implementing the EU ETS, will also contribute towards the ICAO global goals. Such measures are likely to moderate the anticipated growth in aviation emissions.

ASSESSMENT

A quantitative assessment of the EU Emissions Trading System benefits based on the current scope (intra-European flights) is shown in Table 15.

Table 15 – Summary of estimated EU ETS emission reductions[61]

Year	*Reduction in CO_2 emissions*
2013-2020	*~200 MT[62]*

Those benefits illustrate past achievements.

59 See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

60 https://ec.europa.eu/clima/news/carbon-market-report-emissions-eu-ets-stationary-installations-fall-over-9_en

61 Include aggregated benefits of EU ETS and Swiss ETS for 2020.

62 See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

2.3.5. Additional measures

ACI Airport Carbon Accreditation

Airport Carbon Accreditation is a certification programme for carbon management at airports, based on international carbon mapping and management standards, specifically designed for the airport industry. It was launched in 2009 by Airport Council International (ACI) EUROPE, the trade association for European airports. Since then, it has expanded globally and is today available to members of all ACI Regions.

airport carbon accreditation
MAPPING I REDUCTION I OPTIMISATION I NEUTRALITY

This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). The programme is overseen by an independent Advisory Board comprised of many distinguished, independent experts from the fields of aviation and environment, including the European Commission, ECAC, ICAO and the UNFCCC.

The underlying aim of the programme is to encourage and enable airports to implement best practice carbon and energy management processes and to gain public recognition of their achievements. It requires airports to measure their CO_2 emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party.

In addition to the already existing four accreditation levels, in 2020 two new accreditation levels were introduced: Level 4 and Level 4+. The introduction of those two new levels aims on one hand to align the programme with the objectives of the Paris

Agreement and on the other hand to give, especially to airports that have already reached a high level of carbon management maturity, the possibility to continue their improvements[63].

The six steps of the programme are shown in Figure 26 and are as follows: Level 1 "Mapping", Level 2 "Reduction", Level 3 "Optimisation", Level 3+ "Neutrality", Level 4 "Transformation" and Level 4+ "Transition".

Figure 26 - Six steps of Airport Carbon Accreditation

As of 31 March 2021, there are in total 336 airports in the programme worldwide. They represent 74 countries and 45.9% of global air passenger traffic. 112 reached a Level 1, 96 a Level 2, 63 a Level 3 and 60 a Level 3+ accreditation. Furthermore, five airports have already achieved accreditation at the newly introduced levels: 1 a Level 4 and 4 airports a Level 4+ accreditation.

One of its essential requirements is the verification by external and independent auditors of the data provided by airports. The Administrator of the programme has been collecting CO_2 data from participating airports since the programme launch. This has allowed the absolute CO_2 reduction from the participation in the programme to be quantified.

Aggregated data are included in the *Airport Carbon Accreditation* Annual Reports thus ensuring transparent and accurate carbon reporting. At Level 2 of the programme and above, airport operators are required to demonstrate CO_2 reductions associated with the activities they control.

The Annual Report, which is published in the fall of each year, typically covers the previous reporting year (i.e., mid-May to mid-May) and presents the programme's evolution and

63 Interim Report 2019 – 2020, Airport Carbon Accreditation 2020

achievements. However, because of the extraordinary conditions faced in 2020 due to COVID-19 pandemic, special provisions are applied to all accredited airports, including the merge of programme years 11 and 12, which implies the extension of accreditation validity by one year. Thus, the current *Airport Carbon Accreditation* certification period covers the timespan May 2019 to May 2021. For this reason, the last published Report is considered as an Interim Report which addresses only a part of the on-going reporting period (i.e., from 16th May 2019 to 11th December 2020), and as such does not include the usual carbon Key Performance Indicators, but only valuable information regarding key achievements and developments, the most significant global and regional trends, and case studies highlighting the airports' commitment to continued climate action in spite of the current crisis. Therefore, the tables below show carbon performance metrics until the 2018/2019 regular reporting cycle.

For historical reasons European airports remain at the forefront of airport actions to voluntarily mitigate and reduce their impact on climate change. The strong growth momentum is still being maintained as there are 167 airports in the programme. These airports account for 69.7% of European air passenger traffic.

Table 16 - Emissions reduction highlights for the European region

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Total aggregate scope 1 & 2 reduction (ktCO_2)	51.7	54.6	48.7	140	130	169	156	155	169	158
Total aggregate scope 3 reduction (ktCO_2)	360	675	366	30.2	224	551	142	899	1160	1763

Table 17 - Emissions offset for the European region

	2015-2016	2016-2017	2017-2018	2018-2019
Aggregate emissions offset, Level 3+ (tCO_2)	222,339	252,218	321,170	375,146

The table above presents the aggregate emissions offset by airports accredited at Level 3+ of the programme in Europe. The programme requires airports at Levels 3+ and 4+ to offset their residual Scope 1 & 2 emissions as well as Scope 3 emissions from staff business travel.

Table 18 - Airport Carbon Accreditation key performance indicators 2018/2019

Indicator	Unit	Time Period (2018/2019)	Absolute change compared to the 3-year rolling average	Change (%)
Aggregate scope 1 & 2 emissions from airports at Levels 1-3+	tCO_2	6,520,255	-322,297	-4.9%
Scope 1 & 2 emissions per passenger from airports at Levels 1-3+	kgs of CO_2	1.81	-0.09	-4.3%
Scope 1 & 2 emissions per traffic unit from airports at Levels 1-3+	kgs of CO_2	1.55	-0.08	-4.3%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Offsetting of aggregate scope 1 & 2 & staff business travel emissions from airports at Level 3+	tCO_{2e}	710,673	38.673	5.8%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Scope 3 emissions from airports at Levels 3 and 3+	tCO_2	60,253,685	6,895,954	12.9%

The programme's main immediate environmental co-benefit is the improvement of local air quality.

Costs for the design, development and implementation of *Airport Carbon Accreditation* have been borne by ACI EUROPE. *Airport Carbon Accreditation* is a non-for-profit initiative, with participation fees set at a level aimed at allowing for the recovery of the aforementioned costs.

The scope of *Airport Carbon Accreditation*, i.e. emissions that an airport operator can control, guide and influence, implies that as of Level 3, aircraft emissions are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions. This is consistent with the ambition of the European Green Deal, the inclusion of aviation in the EU ETS and the implementation of CORSIA and therefore can support the efforts of airlines to reduce these emissions.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

European industry roadmap to a net zero European aviation: Destination 2050

The Destination 2050[64] is an initiative and roadmap developed by aviation industry stakeholders (A4E, ACI EUROPE, ASD, CANSO and ERA) showing an ambitious decarbonisation pathway for European aviation.

These European industry organizations commit to work together with all stakeholders and policymakers to achieve the following climate objectives:

Reaching net zero CO_2 emissions by 2050 from all flights within and departing from the European Economic Area, Switzerland and the UK. This means that by 2050, emissions from these flights will be reduced as much as possible, with any residual emissions being removed from the atmosphere through negative emissions, achieved through natural carbon sinks (e.g., forests) or dedicated technologies (carbon capture and storage). For intra-EU flights, net zero in 2050 might be achieved with close to no market-based measures.

Reducing net CO_2 emissions from all flights within and departing from the European Economic Area, Switzerland and the UK by 45% by 2030 compared to the baseline[65]. In 2030, net CO_2 emissions from intra-EU flights would be reduced by 55% compared to 1990 levels.

Assessing the feasibility of making 2019 the peak year for absolute CO_2 emissions from flights within and departing from the European Economic Area, Switzerland and UK.

With the Destination 2050 roadmap and through these commitments, the European aviation sector contributes to the Paris Agreement, recognising the urgency of pursuing the goal of limiting global warming to 1.5°C.

By doing so, the European aviation sector is also effectively contributing to the collective European Green Deal and EU's climate neutrality objectives.

This roadmap is complementary to the WayPoint 2050 Air Transport Action Group (ATAG) global pathway for the decarbonization of aviation.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

Environmental Label Programme

In response to the growing expectations of citizens to understand the environmental footprint of their flights, the European Union Member States, Switzerland, Norway, Lichtenstein, the United Kingdom and the European Commission have mandated EASA to explore voluntary environmental labelling options for aviation organisations. The proposals will be aligned with the European Green Deal, established in December 2019 and that strives to make Europe the first climate-neutral continent. The overall objective of the EASA Environmental Labelling Programme is to increase awareness and transparency, and ultimately to support passengers and other actors in making informed

64 www.destination2050.eu

65 A hypothetical 'no-action' scenario whereby CO2 emissions are estimated based on the assumption that aircraft deployed until 2050 have the same fuel efficiency as in 2018.

sustainable choices by providing harmonised, reliable and easily understandable information on their choices' environmental impacts, co-ordinated within EASA Member States. It should allow rewarding those air transport operators making efforts to reduce their environmental footprint. The label initiative covers a wide range of components of the aviation sector, including aircraft, airlines and flights.

In the proof-of-concept phase, EASA developed potential technical criteria and label prototypes for aircraft technology and design as well as airline operations, to inform European citizens on the environmental performance of aviation systems. Such information would be provided on a voluntary basis by aviation operators that have chosen to use the label. Different scenarios were developed and tested to consider how citizens could interact with labelling information, e.g. on board the aircraft and/or during the booking process as well as on a dedicated website and smartphone application. Various key environmental indicators were reviewed, including the absolute CO_2 emissions and average CO_2 emissions per passenger-kilometre of airlines.

The pilot phase covering the period 2021-2023 will further expand the scope of indicators and take into account life-cycle considerations, e.g. to cover aspects from the extraction of raw materials to recycling and waste disposal. The pilot phase also foresees an impact assessment of the label.

While the potential CO_2 emissions reductions generated by such a label were not quantified at this stage, it is proposed to keep the ICAO updated on future developments concerning the European environmental labelling initiative, including on potential CO_2 emissions savings.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

Multilateral capacity building projects

The European Union is highly committed to ensuring sustainable air transport in Europe and worldwide. In this endeavour, the EU is launching a number of initiatives in different areas to assist partner States in meeting the common environmental commitments.

EASA capacity-building partnerships

EASA has been selected as an implementing Agency for several of these initiatives, including the **EU-South East Asia Cooperation on Mitigating Climate Change impact from Civil Aviation** (EU-SEA CCCA), launched in 2019, and a **Capacity Building Project for CO_2 Emissions Mitigation in the African and Caribbean Region**, launched in 2020.

The overall objective of these projects[66] is to enhance the partnership between the EU and partner States in the areas of civil aviation environmental protection and climate change, and to achieve long-lasting results that go beyond the duration of the projects. The specific objectives of the two projects are to develop or support existing policy dialogues with partner States on mitigating GHG emissions from civil aviation, to contribute to the CORSIA readiness process of partner States, as well as to implement CORSIA in line with the agreed international schedule, including considerations of joining the voluntary offsetting phase starting in 2021 or at the earliest time possible. On top of the CORSIA-related support, these projects are assisting the partner States in the development and update of the State Action Plans to reduce CO2 emissions from civil

66 https://www.easa.europa.eu/domains/international-cooperation/easa-by-country/map#group-easa-extra

aviation, as well as providing support in the development of emission data management tools supporting the implementation of State Action Plans and CORSIA.

By January 2021, the EU-SEA CCCA had improved the technical readiness of all the 10 partner States in the region, as well as their aeroplane operators' capabilities to comply with CORSIA requirements. Five States had implemented emission data management solutions to generate CORSIA Emission Reports, and eight States had successfully submitted their 2019 CORSIA CO_2 Emissions Reports to ICAO. 4 CORSIA verification bodies had been accredited in the region with dedicated support to their respective National Accreditation Bodies to finalise the accreditation process.

In addition, EASA is implementing, on behalf of the Commission, technical cooperation projects in the field of aviation in Asia, Latin-America and the Caribbean, which include an environmental component aiming at cooperation and improvement of environmental standards.

These projects have been successful in supporting regional capacity building technical cooperation to the partner States with regard to environmental standards. With regard to CORSIA, support is provided for the development or enhancement of State Action Plans, as well as for the implementation of the CORSIA MRV system. Projects have also been successful in engaging with key national and regional stakeholders (regulatory authorities, aeroplane operators, national accreditation bodies, verification bodies), thereby assessing the level of readiness for State Action Plan and CORSIA implementation on wider scale in the respective regions, and to identify further needs for additional support in this area.

ICAO - European Union Assistance Project

The assistance project *Capacity Building on CO_2 mitigation from International Aviation* was launched in 2013 with funding provided by the European Union, while implementation was carried out by ICAO Environment.

Fourteen States from Africa and the Caribbean were selected to participate in this 5-year programme, successfully implemented by ICAO from 2014 to 2019, achieving all expected results and exceeding initial targets.

The first objective of the ICAO-EU project was to create national capacities for the development of action plans. ICAO organized specific training-seminars, directed the establishment of National Action Plan Teams in the selected States, and assisted each civil aviation authority directly in the preparation of their action plans.

By June 2016, the 14 selected States had developed action plans fully compliant with ICAO's guidelines, including robust historical data and a reliable baseline scenario. A total of 218 measures to reduce fuel consumption and CO_2 emissions were proposed in the action plans, including those related to aircraft technology, operational measures, and sustainable aviation fuels.

Four pilot mitigation measures and five feasibility studies were executed with project funding in the beneficiary States. In addition to those, the beneficiary States implemented 90 mitigation measures within the project timeframe, which had been included in their action plans[67].

With the support provided by the ICAO-EU project, ICAO has succeeded in assisting the beneficiary States transform the organizational culture towards environmental protection in aviation, through the establishment of Environmental Units with dedicated staff in the

67 https://www.icao.int/environmental-protection/Documents/ICAO-EU_Project_FinalReport.pdf

Civil Aviation Authorities along with the voluntary decision of seven selected States of the project to join the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from its outset.

The Phase two of this project is currently being implemented by ICAO and EASA. It covers ten African States: Benin, Botswana, Cabo Verde, Comoros, Côte d'Ivoire, Madagascar, Mali, Rwanda, Senegal and Zimbabwe. The project will run between 2020 and 2023.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

Green Airports research and innovation projects

Under the EU research and innovation actions in support of the European Green Deal and funded by the Horizon 2020 Framework Programme, the European Commission has launched in 2020 the call for tenders: ***Green airports and ports as multimodal hubs for sustainable and smart mobility***.

A clear commitment of the European Green Deal is that "transport should become drastically less polluting", highlighting in particular the urgent need to reduce greenhouse gas emissions (GHG) in aviation and waterborne transport.

In this context, airports play a major role, both as inter-connection points in the transport networks, but also as major multimodal nodes, logistics hubs and commercial sites, linking with other transport modes, hinterland connections and integrated with cities.

As such, green airports as multimodal hubs in the post COVID-19 era for sustainable and smart mobility have a great potential to immediately contribute to start driving the transition towards GHG-neutral aviation, shipping and wider multimodal mobility already by 2025.

The scope of this research program is therefore addressing innovative concepts and solutions for airports and ports, in order to urgently reduce transport GHG emissions and increase their contribution to mitigating climate change.

Expected outcomes

The projects will perform large-scale demonstrations of green airports, demonstrating low-emission energy use (electrification or sustainable aviation fuels) for aircraft, airports, other/connected and automated vehicles accessing or operating at airports (e.g. road vehicles, rolling stock, drones), as well as for public transport and carpooling, with re-charging/re-fuelling stations and use of incentives.

They will also put the focus on the development of SAF for its use at airports.

The deadline to receive project proposals was closed in January 2021 and at the time of this action plan update the proposals are under revision. Future action plan updates will provide further information on the benefits of the implementation of this measure.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

2.3.6. Supplemental benefits for domestic sectors

Although the benefits of all the European collective measures included in this action plan are focused on international aviation, they are also applicable to domestic aviation (except CORSIA) and thus, will bring supplemental benefits in terms of CO2 emissions reductions in the domestic European air traffic.

In addition, a number of those measures taken collectively in Europe and contained in this action plan offer as well additional supplemental benefits for domestic sectors beyond CO_2 savings. Those are summarized below.

ACI Airport Carbon Accreditation

Airport Carbon Accreditation is referred among the measures contained in this action plan aiming to encourage and enable airports to implement best practice carbon and energy management processes.

While its main objective is supporting airport actions to voluntarily mitigate and reduce their impact on climate change, the programme's main immediate environmental co-benefit is the improvement of local air quality linked to the non-CO_2 additional emissions benefits from the reduction of fuel burn that an airport operator can control, guide and influence.

ReFuelEU Aviation Initiative

Through the large-scale use of SAF, emissions of other pollutants impacting local air quality and other non-CO_2 effects on the climate can also be reduced, implying important potential supplemental benefits beyond CO_2 emissions reductions.

In addition to the reduction of CO_2 emissions, SAF has the additional benefit of reducing air pollutant emissions around airports when emitted during take-off and landing as emissions of non-volatile Particulate Matter (nvPM) with up to 90% and sulphur (SO_X) with 100%, compared to fossil jet fuel[68].

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68 ICAO 2016 Environmental Report, Chapter 4, Page 162, Figure 4.

Preserving the quality of natural resources can be considered an additional benefit of any policy measure aiming to increase the sustainability of aviation by boosting the SAF market while paying particular attention to the overall environmental integrity of the SAF incentivised, as it is the case of the ReFuelEU Initiative.

Finally, the production of SAF notably from biogenic waste could contribute and be an incentive for more effective waste management in the EU.

SAF Research and development projects

One European research project funded by the Horizon 2020 Research and Innovation program of the EU, is currently assessing, among other objectives, the additional supplemental benefits for domestic sectors of the use of sustainable aviation fuels, beyond its climate benefits.

AVIATOR PROJECT[69]: The project *"Assessing aviation emission Impact on local Air quality at airports: Towards Regulation"* aim to better understand air quality impacts of aviation issues, developing new tools and regulation, and linking with the health community, providing unbiased data to society.

The project will measure, quantify and characterise airborne pollutant emissions from aircraft engines under parking (with functioning APU), taxiing, approach, take-off and climb-out conditions, with specific reference to total UFPs, NOx, SOx and VOC under different climatic conditions.

It includes among its objectives measuring emissions from aircraft engines using commercially available sustainable aviation fuels to investigate its impact on total Particulate Matter formation and evolution in the plume as well as the wider airport environment.

Will perform measurements of air quality in and around three international airports: Madrid-Barajas, Zurich and Copenhagen, to validate model developments under different operational and climatic conditions and develop a proof of concept low-cost and low-intervention sensor network to provide routine data on temporal and spatial variability of key pollutants including UFP, total PM, NO_x and SO_x.

With 17 partners from 7 countries involved, the project started in June 2019 and it is expected to finalize in 2022.

The EU's Single European Sky Initiative and SESAR

The European Union's Single European Sky (SES) initiative and its SESAR (*Single European Sky ATM Research Programme*) programme are aiming to deploy a modern, interoperable and high-performing ATM infrastructure in Europe, as has been described above in detail in this action plan, among its key operational measures to reduce CO_2 emissions.

But the environmental outcomes of SESAR implementation go far beyond reducing fuel burn, and the key deliverables from the SESAR Programme have also a significant potential to mitigate **non-CO_2 emissions and noise impacts**.

It should be noted that although no targets have yet been set for non-CO_2 emissions (at local or global level) and noise impacts, the ATM Master Plan requires that each SESAR solution with an impact on these environmental aspects assesses them to the extent possible and within available resources.

69 https://aviatorproject.eu

In this context, for example the EUROCONTROL *Integrated aircraft noise and emissions modelling platform* IMPACT, which delivers noise contour shape files, surface and population counts based on the European Environment Agency population database, estimates of fuel burn and emissions for a wide range of pollutants, and geo-referenced inventories of emissions within the landing and take-off portion, is one of the recommended models for conducting environmental impact assessments in SESAR.

Green Airports research and innovation projects

The European Commission's Green Airports research and innovation projects referred in this action plan among the "Other measures" commonly implemented in Europe has key objectives to achieve important supplemental benefits beyond CO_2 emissions reductions, among them:

Circular Economy:

- Developing the built environment (construction/demolition) using more ecologically friendly materials and processes and incorporating these improvements in the procurement processes to sustainably decrease the ecological footprint.
- Promoting the conversion of waste to sustainable fuels.
- Addressing the sustainable evolution of airports, also in the context of circular economy (e.g. activities linked to aircraft decommissioning and collection/sorting of recyclable waste), considering institutional and governance aspects, ownership, regulation, performance indicators and balance of force between regulators, airlines and airport operators.
- Addressing the feasibility of a market-based instrument to prevent/reduce Food Loss and Waste (FLW) and to valorise a business case of transformation of FLW into new bio-based products. This includes FLW measurement and monitoring methodologies and the subsequent mapping of FLW total volume at stake in the considered airport.

Biodiversity:

- Enhancing biodiversity, green land planning and use, as well as circular economy (e.g. repair, reuse and recycling of buildings and waste, in the context of zero-waste concepts).

Non-CO_2 impacts:

- Addressing air quality (indoor, outdoor, including decontamination from microbiological pathogens) and noise trade-off.
- Assessing non-technological framework conditions, such as market mechanisms and potential regulatory actions in the short and medium term, which can provide financial/operational incentives and legal certainty for implementing low emission solutions.
- Developing and promoting new multi-actor governance arrangements that address the interactions between all airport-related stakeholders, including authorities, aircraft owners and operators, local communities, civil society organisations and city, regional or national planning departments.

3. National actions in the Netherlands

The aviation sector is facing a global challenge to reduce its greenhouse gases in line with the temperature goals of the Paris agreement. Reducing CO_2 emissions from international aviation therefore requires first and foremost an international approach. The Netherlands works with other countries in the framework of ECAC, the EU and ICAO to develop international measures. An international approach will eventually lead to the largest CO_2 emissions reduction, since measures will be implemented and supported by more countries, while minimising waterbed effects.

Nevertheless, international policies need to be implemented by states and there is room for complementary national policies that accelerate the transition and set the right examples for other states.

This section describes the national actions taken by the European part of the Kingdom to reduce CO_2 emissions from aviation, first outlining how the policy is structured and discussed with stakeholders and then addressing specific details on actions.

3.1. National climate policy for aviation

3.1.1. Sustainable Aviation Agreement

In 2019, the Dutch Sustainable Aviation Agreement was concluded by representatives of airlines, airports, the ATM services provider, government, knowledge institutes, fuel companies, technology and aircraft manufacturers and industry associations. This agreement outlines ambitions to make aviation more sustainable by reducing its CO_2 emissions.

The agreement sets out targets for in-sector CO_2 reduction for international aviation, based on fuel uplifted at Dutch airports (i.e. bunker fuels):

- 2030: emissions at most equal to aviation emissions in 2005. This is a national target.
- 2050: at least 50% reduction compared to 2005 emissions. This is in line with existing global objectives[70] for international civil aviation.
- 2070: zero CO_2 emissions. This is a national target.

Two other national targets for domestic aviation activities were also set:

- 2030: ground operations in civil aviation, including terminal buildings and all ground vehicles (e.g. buses, tugs), must be zero-emission.
- 2050: zero CO_2 emissions from domestic[71] aviation.

To achieve these five targets a list of actions was agreed upon, including topics for research (such as non-CO_2 climate effects) and operational sub-targets (such as fleet renewal and SAF uptake) which are discussed in the relevant sections of this chapter.

3.1.2. Sustainable Aviation Table

The Sustainable Aviation Agreement was concluded in February 2019 by the Sustainable Aviation Table. The Sustainable Aviation Table is a body established at the beginning of 2018 to enhance the involvement and cooperation of all relevant stakeholders in the field of sustainable aviation and works with a focus on achieving the targets of the agreement.

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70 i.e. 50% net CO_2 reduction as advocated by ATAG as of 2019.
71 Here domestic refers to flights within the European part of the Kingdom, not flights to and from the Caribbean.

Activities addressing specific themes are brought together in action programmes (see Figure 27), and participants draw up joint plans for the action programme. The participants discuss progress on the programmes in working groups. The main, high-level Sustainable Aviation Table monitors and coordinates the overall process. The current structure is depicted in Figure 27 below for illustration, as a governance review is currently underway.

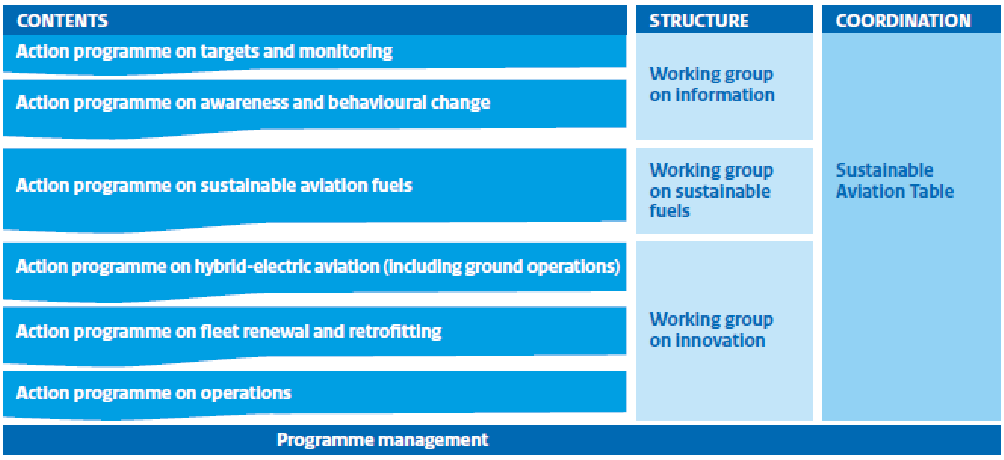

Figure 27 – Organisation of the Sustainable Aviation Table as of 2021 (Rijksoverheid, 2020a)

3.1.3. Dutch Civil Aviation Policy Memorandum 2020-2050

The Dutch Civil Aviation Policy Memorandum, in the form of a white paper, was made final in November 2020. The policy memorandum provides the direction towards a sustainable aviation sector that will safeguard the Netherlands' strong connections with the rest of the world now and in the future (Rijksoverheid, 2020a)[72]. The policy memorandum aims to put all the parties involved in the sector on a solid footing and provides them with an agenda for the years ahead, with clear goals and a detailed approach. This way the Netherlands is aiming at doing what it is good at: leading the way in the global changes in aviation that lie ahead. In December 2021, the new coalition government announced that it will continue all climate plans set out in the memorandum.

Smart and sustainable are the maxims of the new Civil Aviation Policy Memorandum, with safety as priority number one. The smooth functioning of Amsterdam Airport Schiphol and a successful national carrier are of major importance to the Dutch economy, enticing foreign businesses to locate in the Netherlands. The government seeks to make aviation future-proof. That means that it must cause fewer problems for people and emit fewer pollutants. In its further development, the aviation industry must reduce the negative effects on people and the environment. Within these parameters, aviation can continue to develop.

The memorandum is based on the outcome of a broad consultation process, several expert recommendations, the Strategic Environmental Assessment (RoyalHaskoningDHV, 2020) and the scientific knowledge base. As part of the consultation process, several regional dialogues were held about aviation, public support was surveyed, and input from civil society and stakeholders was taken into consideration.

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72 Full document only available in Dutch here: [Verantwoord vliegen naar 2050 Luchtvaartnota 2020-2050 | Rapport | Rijksoverheid.nl]. Translation of sustainability chapter is available upon request.

The memorandum addresses various Sustainable Development Goals (SDGs), i.e. Health (SDG 3), Energy (SDG 7), the Economy (SDG 8), Innovation and Infrastructure (SDG 9), Climate (SDG 13), Biodiversity (SDG 15) and Partnership (SDG 17) as demonstrated in Figure 28. The four public interests at the heart of the memorandum are shown in the center: safety, connectivity, liveability (including noise and air quality) and sustainability. Here sustainability refers specifically to climate impacts.

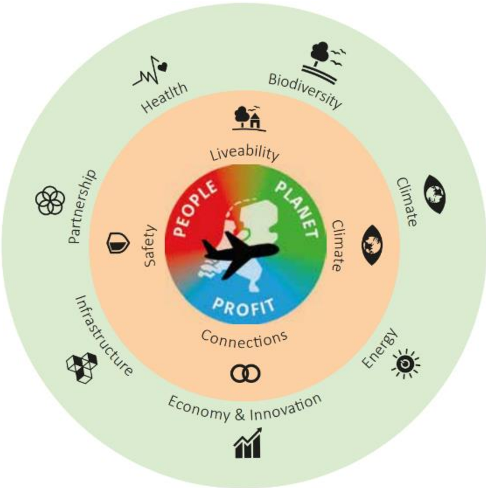

Figure 28 - Relation between four public interests (Rijksoverheid, 2020a)

Building upon the Sustainable Aviation Agreement

In terms of sustainability, the Civil Aviation Policy Memorandum largely builds upon the Sustainable Aviation Agreement which was already in place and formalises the government's support for the agreement. The targets outlined in section 3.1.1. were adopted and expanded upon, as shown in Figure 29. Additions include a 2030 CO_2 target for domestic aviation and specific targets for (hybrid) electric aviation.

	2030	**2050**	**2070**
Ground operations	• Zero CO_2 emissions from ground operations		
Domestic and general aviation	• 15% reduction in emissions from domestic aviation compared to 1990 • 'Living lab' for innovations for scaling up in commercial aviation	• Zero CO_2 emissions from domestic aviation	
Commercial aviation	• 14% SAF blending mandate • Emissions from international commercial flights departing from the Netherlands at most equal to aviation emissions in 2005 • First hybrid-electric aircraft with 20-50 passengers in use	• 100% SAF blending mandate • Emissions from international commercial flights departing from the Netherlands reduced by at least 50% compared to 2005 • All short-haul flights (<500km) from the Netherlands are fully electric	• Zero CO_2 emissions from international aviation as a long-term goal

Figure 29 – Overview of ambitions for sustainable aviation (Rijksoverheid, 2020a)

An important clarification was made regarding the principle CO_2 targets for commercial aviation. These three targets for 2030, 2050 and 2070 relate to <u>in-sector emission reductions</u>. The Dutch approach outlined in this chapter focuses on in-sector reductions to accelerate the energy transition within aviation. This is a complementary approach to international ambitions which generally include offsetting aviation emissions in other sectors (net emission reduction). Figure 30 below visualises the reduction targets for 2030, 2050 and 2070 in relation to the WLO projections made by the Netherlands Environmental Assessment Agency (PBL) in the purple envelope (see also section 1.3.5) and the National Climate Agreement for domestic emissions. As a future compliance measure, a CO_2-emissions ceiling is being developed to ensure these targets will be met.

Achieving the Paris agreement's temperature goals requires setting an ambitious long-term aspirational goal (LTAG) for international aviation worldwide, and the Netherlands is actively involved in the work done by CAEP. If ICAO sets a more ambitious CO_2 emission reduction target for 2050 than 50% in-sector reduction compared to 2005 levels, the government will increase its target for international flights departing from the Netherlands to the same target.

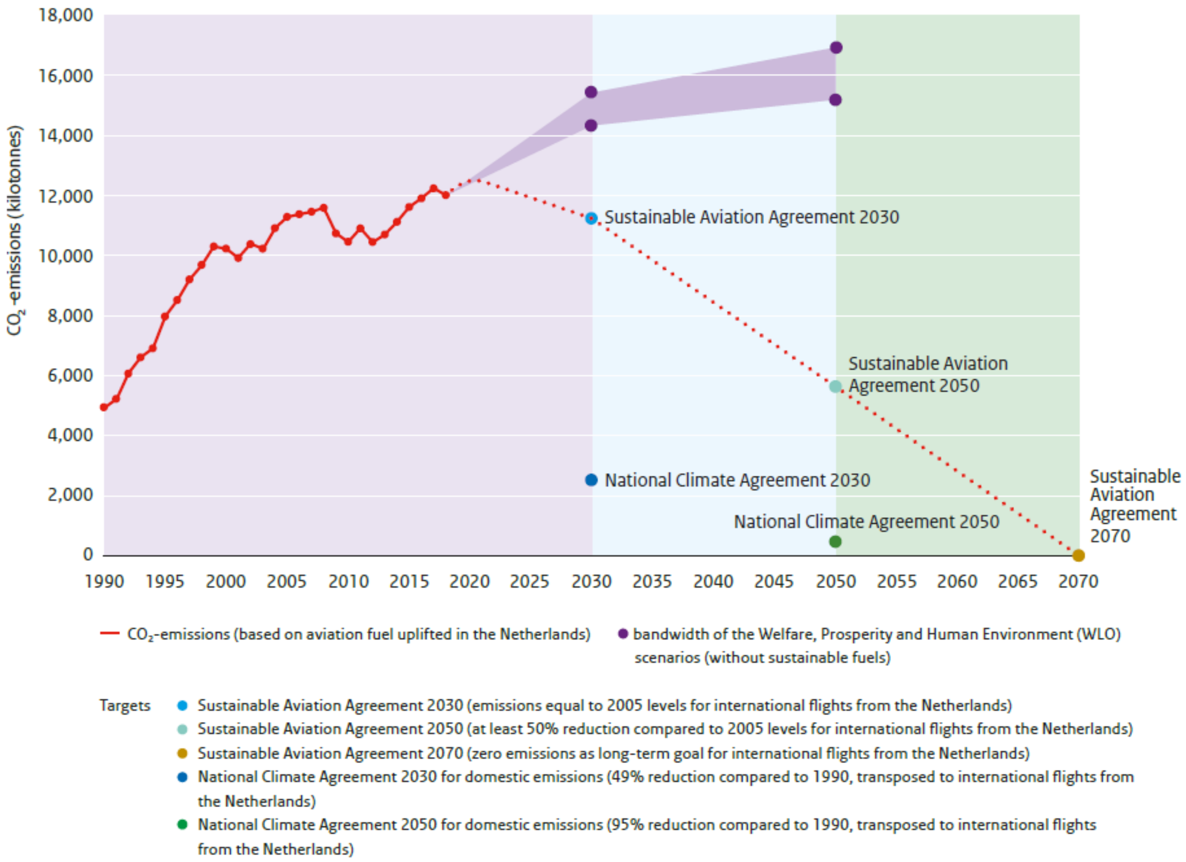

Figure 30 - Trends in CO_2 emissions from flights departing from the Netherlands and indication of targets compared to general climate policy for other sectors (Rijksoverheid, 2020a)

Approach towards aviation climate policy instruments

The government's approach is to accelerate the energy transition within the aviation sector because of both considerable lead times for technological innovations and certification within the aviation sector itself. Moreover, possibilities for offsetting are expected to decrease past 2030, due to other sectors in many economies aiming for zero emissions by 2050. In the government's approach to reducing aviation CO_2 emissions, three tracks are identified:

1. **More sustainable flights** using Sustainable Aviation Fuel (SAF) and technological innovations, such as new aircraft designs and new types of engines, powered by electricity or hydrogen.
2. **Offsetting carbon emissions** from aviation in other sectors through international systems such as the EU ETS and CORSIA
3. **Alternatives to flying**: taxation and other incentives to encourage international travel by train, as well as raising awareness and promoting behavioural change.

The three tracks are ranked according to preference. The government's preference is for the most direct and effective climate instruments, in which the costs for stakeholders in the sector contribute as much as possible to the actual reduction of CO_2 emissions within the aviation sector. The climate instruments selected will have to help accelerate the energy transition in the aviation sector, must be suitable for scaling up within the Netherlands and beyond (for extra impact), and preferably contribute to the economic value of companies in a sustainable economy.

The first track scores best to these criteria. Technological innovation and SAF will have the greatest effect and most likely lead to the achievement of the climate targets for the aviation sector, in both the shorter and longer-term. The Dutch government has therefore elected to pursue an approach focusing primarily on research into the development and use of sustainable fuels and technological innovations. Within the first track, the government expects to achieve the highest CO_2 emission reduction in the short term by using sustainable aviation fuels (SAF) including renewable biofuels and synthetic kerosene, and in the medium term by adopting innovations in aircraft designs, materials and engines. The government places extra emphasis on this aspect. The greening of the aviation sector through the use of SAF will be implemented in accordance with the national sustainability framework for biomass (Rijksoverheid, 2020b).

Offsetting emissions via reductions in other sectors through international systems such as EU ETS and CORSIA, part of the second track, would lead to direct CO_2 emission reduction outside the aviation sector and is important to achieving international targets. The national targets for international aviation departing from the Netherlands are determined based on the volume of aviation fuel (fossil fuel and others) uplifted in the Netherlands and the uplifted volume of fuel will not decrease as a result of carbon offsetting.

The effects of measures in the third track (alternatives to flying) depend heavily on other factors, so the effects are indirect and less certain. Moreover, these measures do not contribute directly to the energy transition in the aviation sector, can often be difficult to scale up to a global level, and economic value of Dutch companies in a sustainable economy. One example of a measure in the third track is an aviation tax. This could have an indirect effect as airlines might pass on the higher costs to passengers through higher ticket prices. This, possibly combined with greater awareness, could lead to a decline in passenger demand, which could eventually lead to reduced air traffic and lower CO_2 emissions. An impact study shows that available airport capacity plays a leading role in achieving CO_2 impact. If demand outstrips supply, a limited national tax will not lead to fewer flights, but to less scarcity. The Netherlands is therefore in favour of pricing instruments at a European or global level.

In the framework of the third track, one of the solutions sometimes advocated is reducing the number of flights to and from the Netherlands. The government rather wants to safeguard achievement of the climate targets by encouraging the development and use of sustainable fuels and other technological innovations. Therefore, by setting clear limits to the amount of permitted CO_2 emissions, the aviation sector can earn their license to grow staying within those boundaries.

3.2. Targets and monitoring

As shown in Figure 27 one of the action programmes of the Sustainable Aviation Table looks at targets and monitoring. This action programme has several projects, in all which the Ministry of Infrastructure and Water Management plays a leading role. The two most important projects are listed below.

3.2.1. CO_2 ceiling

The government is working on the concept of a 'ceiling' to safeguard achieving the CO_2 emission reduction targets set out in the Civil Aviation Policy Memorandum for 2030, 2050 and 2070. The ceiling should set a clear and enforceable limit for the allowed amount of CO_2 emissions which guarantees and creates an obligation to meet the targets. The aviation sector in the European part of the Kingdom can grow only if it stays within the limits of this CO_2 ceiling. Figure 31 shows the relationship between a ceiling, targets and the flanking measures which were described in the previous section.

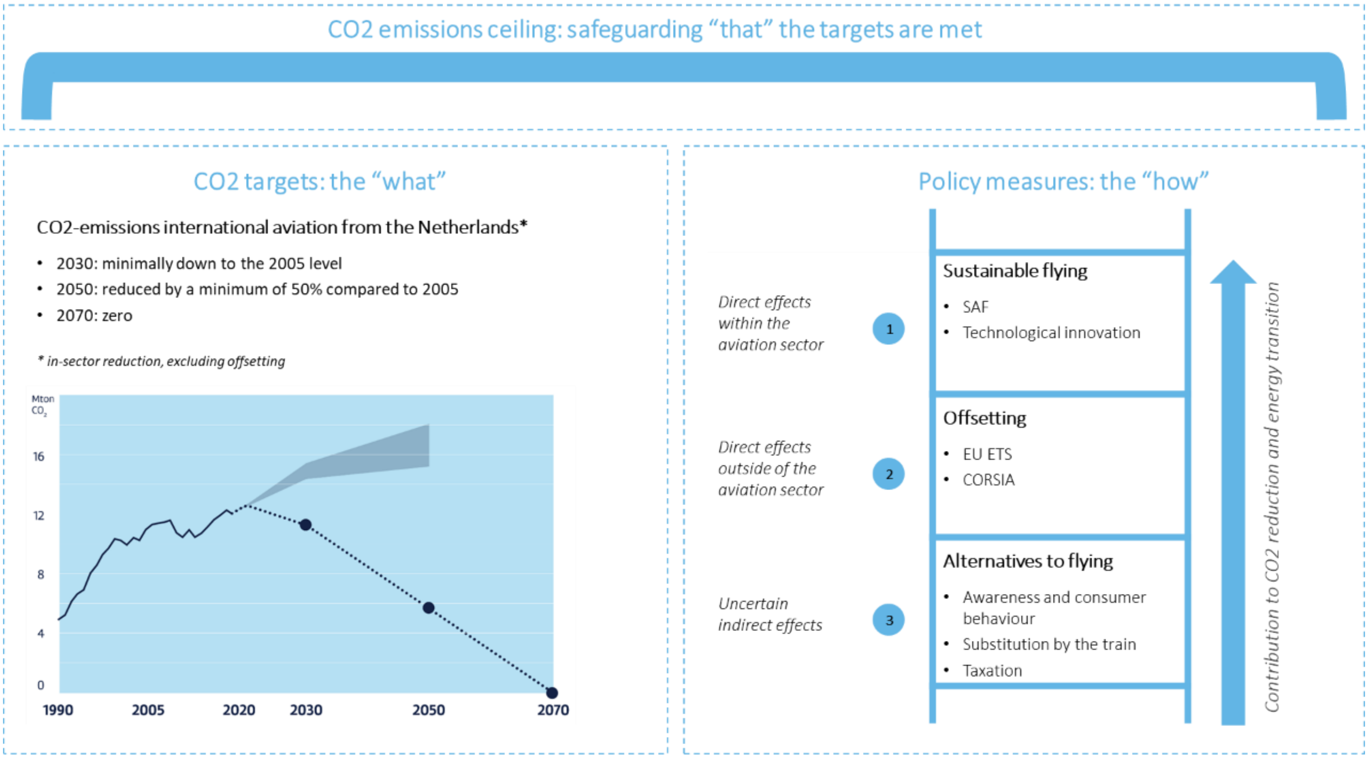

Figure 31 - Summary of the relationship between targets, measures and an emissions ceiling

The Minister of Infrastructure and Water Management has provided a list of requirements for the design of the CO_2 emission ceiling:

- The instrument is aimed at securing the CO_2 emission reduction targets for 2030, 2050 and 2070 from the Civil Aviation Policy Memorandum for international flights departing from the Netherlands.
- The ceiling results in in-sector emission reductions, offsetting does not count.

- The ceiling sets a clear and enforceable limit for the allowed amount of CO_2 emissions which guarantees and creates an obligation to meet the targets.

Three design options have been developed in cooperation with Sustainable Aviation Table stakeholders: a ceiling divided over airports, a national emissions trading system for airlines, and a ceiling for fossil fuel. Currently, an impact assessment study is on-going, with results expected in summer 2022. A political decision is expected in late 2022.

3.2.2. Non-CO_2 emissions

The government needs more information about the emissions of greenhouse gases other than CO_2 from aviation and their climate impact. There is still a great deal of scientific uncertainty about the behavior and climate impact of the following substances:

- Water vapour (H_2O)
- Nitrogen oxides (NO_x)
- Sulphur oxides (SO_x)
- Carbon monoxide (CO)
- Unburned hydrocarbons (UHC)
- Fine particulates (including soot)

These emissions contribute to global warming, partly in direct ways and partly in indirect ways, for example by forming contrails and cirrus clouds, ozone (O_3), methane (CH_4) and aerosols (fine particles of dust or liquid that float suspended in the air). How these greenhouse gas (GHG) emissions are created and what their climate impact is depends on atmospheric conditions, such as the time and location of the emissions (geographic location, altitude and temperature).

Some advocate an equivalence factor that derives the climate impact of non-CO_2 GHG emissions from the level of CO_2 emissions, as used in certain social cost-benefit analyses (SCBAs). However, there is no (direct) correlation between CO_2 emissions and the climate impact of non-CO_2 GHG emissions at this time. Moreover, non-CO_2 GHG emissions only have a climate impact at cruise altitudes and are relatively short-lasting (a few days to a maximum of 10 years), whereas CO_2 has the same climate impact at any emission altitude and persists in the atmosphere for centuries.

More research (nationally and internationally) is needed to gauge the scope and climate impact of non-CO_2 GHG emissions. The Netherlands contributes to the international body of knowledge through Delft University of Technology (TU Delft), the Netherlands Aerospace Centre (NLR) and the Royal Netherlands Meteorological Institute (KNMI). The Netherlands also hosted an international symposium in 2019 through the scientific network Airneth.

The Ministry of Infrastructure and Water Management is investigating whether it is possible to achieve a reliable estimate of the climate impact of non-CO_2 GHG emissions and how such impacts can be incorporated into climate policy for the aviation sector. Consultations with the European Commission on follow-ups to the 2020 EASA report on non-CO_2 emissions are on-going. In parallel, a national approach is in development in consultation with the Sustainable Aviation Table as part of the action programme on targets and monitoring.

The ministry is currently focusing its efforts on policy instruments that reduce both CO_2 emissions and non-CO_2 emissions, notably the uptake of sustainable aviation fuels (SAF). The next priority is instruments that tackle non-CO_2 emissions without presenting a trade-off in terms of CO_2 emissions. For this purpose, research is on-going into the potential of reducing contrails through tightening quality standards of fossil kerosene.

3.3. Sustainable aviation fuels

The development and uptake of SAF is widely considered to be one of the most important solutions to decarbonise the aviation sector, in addition to other technological, operational and infrastructural measures. Hydrogen propulsion to power future regional aircraft is expected by 2035 (NLR & SEO, 2021). However, for long-haul flights, which make up the vast majority of Dutch aviation CO_2 emissions, no large-scale technological alternatives are expected by 2050. With a market share of nearly 50% in western Europe, the Netherlands plays a key role in kerosene production and trade (Eurostat, 2020). With its chemical industry, infrastructure (oil refineries), airports and seaports, and knowledge institutions, the Netherlands is perfectly situated to take a leading role as a major European supplier of SAF. This is expected to yield economic advantages and new employment opportunities as well. The Dutch government has long recognised this opportunity, demonstrated by the fact that the Netherlands has had an opt-in for SAF under the EU Renewable Energy Directive (RED II) since 2013.

3.3.1. Targets and policy instruments

On July 14 2021, the European Commission adopted a package of policy proposals designed to reduce net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels ('fit for 55', EC, 2021). This includes a European SAF blending mandate of 2% in 2025, 5% in 2030 increasing every five years up to 63% in 2050. For synthetic kerosene, a growing 0.7% sub obligation is proposed in 2030 up to 28% in 2050. For the Netherlands, based on the Civil Aviation Policy Memorandum and the Sustainable Aviation Agreement a target of 14% SAF blending in 2030 has been agreed upon. The ambition is also a 100% replacement of fossil fuels by sustainable alternatives in 2050. In addition, the government aims to introduce a national blending mandate to reach these more ambitious national targets, and in 2019 commissioned a study on the potential effectiveness of such a mandate (E4tech, 2019).

The Netherlands has a preference for European SAF policies, to avoid patchwork, and played a large role in paving the way for a European blending mandate. This includes two joint statements from EU member states and the organisation of an international High-Level Conference on Synthetic SAF in March 2021. The ministry also collaborated with Shell and KLM to organise the world's first commercial aircraft flight on green synthetic fuel (KLM, 2021). The Ministry of Infrastructure and Water Management is also a customer of the KLM Corporate SAF Programme. This programme aims to accelerate the use and production of sustainable aviation fuel. In the negotiations on the proposed EU regulation[73], the Netherlands aims for a as high as possible percentage for a blending obligation based on availability of sustainable resources and production capacity.

3.3.2. SAF action programme

One of the working groups of the Sustainable Aviation Table is the working group on SAF. In March 2021 this working group presented its action programme (Rijksoverheid, 2021a). The members of the working group agreed to update this action programme every three years, to ensure that the latest developments in the Dutch SAF sector are included and so that targets can be adjusted if needed. The purpose of the SAF action programme is to accelerate and positively stimulate movement towards the targets set for the production and uptake of SAF in the Netherlands.

To achieve the ambitions and goals set by the SAF working group and to facilitate the existing and future SAF development projects, the working group is targeting three tracks in which concrete actions have been formulated. The action programme includes

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73 ReFuelEU proposal, COM(2021) 561 - EUR-Lex - 52021PC0561 - EN - EUR-Lex (europa.eu)

actions per track, including facilities to be opened per period. For legibility the most recent information on those actions is included in the next section. The goals per track are:

Track 1: Short term (2021-2024)

- The aim is to have at least 200,000 tonnes of SAF produced via the HEFA technology in 2024 in the Netherlands.
- The first Alcohol-to-Jet (AtJ) SAF demonstration plant in the Netherlands should be under development.
- The first Power to Liquid (PtL) demonstration plant in the Netherlands, based on CO_2 Direct Air Capture (DAC) or biogenic/industrial point sources, should be under development.
- Other feedstock opportunities for the HEFA pathway should be explored to meet growing international demand for biobased fuels, materials and chemicals.

Track 2: Midterm (2024-2028)

- The aim is to have at least 500,000 tonnes of SAF produced in the Netherlands via the HEFA technology by 2026.
- The aim is to have the first AtJ demo facility up and running in the Netherlands. Additional R&D incentives must be in place to create a solid business case for these first demo facilities. The support of the government for the development of these novel SAF pathways is needed.
- The aim is to support international efforts in solving some of the R&D challenges facing the SAF sector. For example, exploring the non-CO2 effects of aviation and SAF in particular, ensuring that ASTM allows 100% SAF in the engine of a plane, ensuring the ASTM certification of new SAF technology pathways etcetera.

Track 3: Long term (2028 >)

- Based on current estimates the aim is to produce between 640,000 and 702,000 tonnes of SAF annually from 2030 onwards, through which the Dutch aviation sector will achieve its 14% target. As the Dutch aviation sector has to reduce its 2030 emissions to the 2005 emission level, and as the fossil kerosene consumption of 2005 corresponds with 155 PJ, producing between 640.000-702.000 tonnes SAF in 2030 is estimated to contribute to achieving between 61-67% of the 2030 PJ target, respectively, in the low growth scenario and between 43%-47% of the 2030 PJ target in the high growth scenario.
- The working group will work hard to commercialise DAC (or industrial point source capture) technologies for SAF. Therefore, the aim is to have multiple commercial synthetic kerosene plants up and running before 2035.
- The aim is to have the first commercial AtJ facility up and running before 2030.
- The aim is to have all fossil kerosene replaced with SAF from 2050 onwards.

3.3.3. Planned SAF production facilities

The following projects are under development in the Netherlands:

Neste

The Finnish oil company Neste intends to expand its existing refinery capacity in the port of Rotterdam for biokerosene by 2023. This allows Neste to produce an annual amount of 500,000 tonnes of waste-based biokerosene. Engineering studies on the next world scale capacity expansion steps are ongoing for several sites globally, including current and selected new locations. Neste is also planning the construction of a second refinery for the production of SAF in Rotterdam. The final investment decision for this plan is expected to be taken at the end of 2022.

DSL-01

SkyNRG together with KLM, SHV Energy and other partners is currently developing Europe’s first dedicated SAF production facility in Delfzijl (northeastern part of the Netherlands). This production facility is focused superficially on the production of SAF based on residual flows from oils and fats and uses green hydrogen during this process. The design of the facility has a high sustainability profile to minimise CO_2, NO_x and SO_x emissions. This will result in an expected lifecycle CO_2 reduction of 85% compared to fossil kerosene. SkyNRG aims to produce annual amount 100,000 tonnes of bio-kerosene per year plus 35,000 tonnes of by-products (LPG and naphtha). KLM, SHV Energy and Royal Schiphol Group were the founding partners and enabled the development by participating in the round A financing. KLM has committed to purchasing a minimum of 75% of the 100,000 tonnes of SAF produced annually, which will be supplied to its home hub at Amsterdam Airport Schiphol. DSL-01 is planned to commence production in 2025/2026.

Shell

In September 2021, Shell announced plans for a SAF production facility in the port of Rotterdam with an annual capacity of 820,000 tonnes of which half is to be used for biokerosene. Residual flows will be used for biokerosene as well. Shell expects to commence production in 2024.

Synthetic kerosene

There are also two other initiatives to produce synthetic kerosene in the Netherlands with green hydrogen elaborated below. These initiatives are part of the National Growth Fund proposal “Aviation in Transition” which includes sector initiatives (Rijksoverheid, 2021b). The National Growth Fund proposal will be discussed in section 3.8 in more detail.

Synkero

Currently, preparations are taking place for a first pilot production facility by Synkero in the port of Amsterdam for an annual capacity of 50,000 tonnes of synthetic kerosene. This project originates from initial discussions in 2016. The project partners developed a business plan in 2020 to show the financial and technological feasibility of a commercial PtL facility in the North Sea Canal area. During the High-Level SAF event in March 2021, project partners announced a follow-up cooperation. Synkero will act as a development entity with the goal to develop a synthetic SAF facility based on renewable hydrogen and CO_2 from various (point) sources using the Fischer-Tropsch process. The aim is to have the plant operational by 2027. In addition, the work currently going on (until the realisation of the facility) will focus on creating the necessary conditions (policy inclusion of RFNBOs/RCFs, sustainable electricity, allocation of CO_2) for synthetic fuels to succeed.

Zenid

Zenid is working on a production facility for synthetic kerosene based on the DAC principle at Rotterdam The Hague Airport. Royal Schiphol Group, SkyNRG and Climeworks are working together to realise a demonstration plant capable of producing 1,000 – 4,000 L/day from CO_2 and H_2O captured from ambient air. The project uses a combination of innovative technologies. First CO_2 is captured directly from the air through Climeworks technology. CO_2 and water (H_2O) are combined and converted into syngas (a mixture of CO and H_2) through Sunfire co-electrolysis technology. Subsequently, this syngas is converted into a wax-like intermediate through the Fischer-Tropsch process (Ineratec), which is then upgraded to SAF. On the 8th of February 2021, the project announced a next step with the creation of the Zenid project entity and a Memorandum of Understanding (MoU) with Uniper, aimed to be the operator of the plant.

3.3.4. National hydrogen strategy

Making aviation more sustainable is a complex challenge in which the production and the consumption of sustainable fuels, including synthetic kerosene, is essential. Given the limited availability of biomass for biokerosene, a large part of SAF to reach national SAF targets after 2030 is expected to consist of synthetic fuels. Sufficient availability of green hydrogen for the aviation sector is a prerequisite in this regard as 80% is required for synthetic fuel and 20% for biokerosene. Blue hydrogen is considered a stepping stone to produce a fully sustainable synthetic fuel based on green hydrogen.

The Netherlands has a very large potential for offshore wind, an extensive on/offshore gas infrastructure and has the perfect location for hydrogen import and export. The central government will take on a stimulating role in this endeavour set out in the National Hydrogen Strategy 2020 (Rijksoverheid, 2020c). This strategy is in line with the vision presented by the government in the Long-term Growth Strategy for the Netherlands (*Groeistrategie voor Nederland op de lange termijn)* (Rijksoverheid, 2021b). In addition to synthetic kerosene, (liquid) hydrogen may become an important fuel for future aircraft concepts such as Airbus and AeroDelft are developing. There are currently clusters of projects with a total of up to 2125MW with an investment decision date to be taken before 2025. These projects are located in industrial port areas with existing infrastructure in Eemshaven (Northern Netherlands) (360MW), Port of Amsterdam (100MW), Port of Rotterdam (665MW) and Zeeland (1000MW), see Figure 32 below for a visualisation.

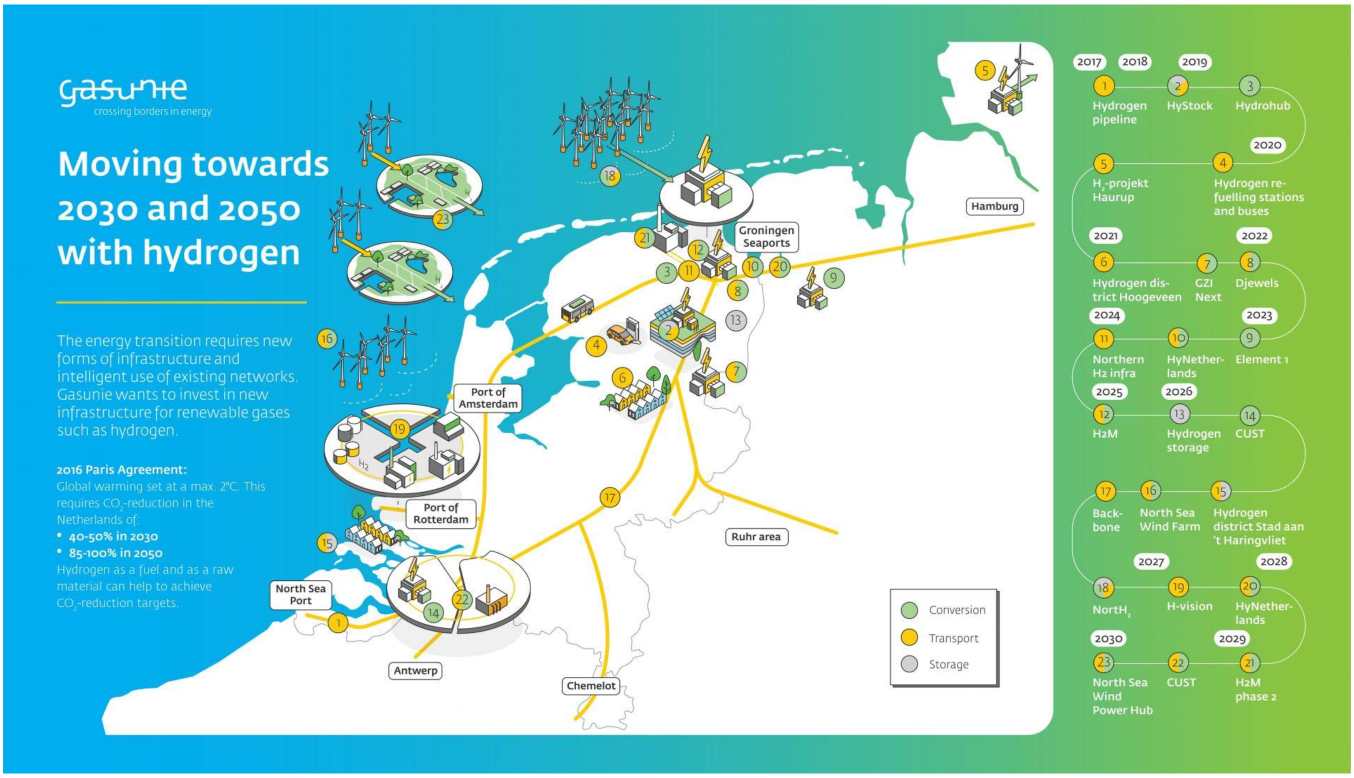

Figure 32 - Infographic showing hydrogen strategy towards 2030 and 2050 (Gasunie, 2020)

3.4. Technological improvements

The Netherlands has always been strong, innovative and enterprising where aviation is concerned: Fokker, TU Delft, NLR and many smaller players have influenced the sector far beyond our borders. The Netherlands was at the forefront of many innovations and views in aviation and we are still highly regarded within the (international) aviation industry. For example, the fibre metal laminate GLARE which was applied to large parts of the Airbus A380 fuselage originated at TU Delft and was patented by Akzo Nobel. Our unique knowledge infrastructure, strong collaboration qualities and innovative manufacturing industry form together a solid basis. For instance, the Netherlands Aerospace Group (NAG) has signed a Memorandum of Understanding (MoU) with Airbus and Embraer to foster a long-term strategic relationship in the field of sustainable aviation research and innovation (NAG, 2022). All this combined creates an ideal climate to join the international group of forerunners in technological improvements for aviation. This section is divided into aircraft platforms (aircraft designs and alternative propulsions), the innovation strategy and financial instruments for technologies and innovations).

3.4.1. Aircraft platforms (aircraft designs and alternative propulsion)

The Sustainable Aviation Agreement includes an aim that in 2030, 30% of the flights to and from Amsterdam Airport Schiphol and 60% to and from Eindhoven Airport will be performed using the newest and cleanest aircraft available (Duurzame Luchtvaarttafel, 2020). These different aircraft platforms could be new designs, alternative propulsion methods and lighter materials. Another way to fly cleaner is retrofitting: modifying aircraft to equip them with the latest fuel-efficient technologies. Fuel costs are a driver for the aviation industry to continuously improve and innovate to reduce the amount of fuel used and thereby save emissions as well.

Many projections forecast that towards 2050, increasingly larger aircraft will be able to fly longer distances powered by electricity and hydrogen. Innovators are working worldwide on hybrid-electric and fully electric aircraft. The Netherlands is an important player in this field of research.

The government and the Dutch aviation sector aim to have the first hybrid (fuel-) electric aircraft up to 50 passengers for short-haul flights up to 750km in use by 2030. For the longer term, all flights under 500 km should be fully electric aircraft by 2050. The end goal is that aviation will no longer emit any CO_2 by 2070. The ambition of the Netherlands is to become an international leader in hybrid-electric aviation by 2030, by joining forces together with users, the industry, operations and knowledge institutes in innovation and R&D. Through the action programme on hybrid-electric aviation (*Actieprogramma Hybride Elektrisch Vliegen,* AHEV) insights are offered on how the Netherlands could research and invest the coming years in the field of hybrid-electric aviation (Rijksoverheid, 2020d).

The action programme is divided into three sections: ground operations, (domestic and) general aviation and commercial aviation (see Figure 29 for an overview). This section discusses the latter and ground operations are discussed in this action plan under section 3.7. For electric aviation, a breakthrough in innovation is necessary. These innovations are not limited to technological developments, but also include the development of business models for aviation operations and their value chain. New power trains, components, sorts of energy storage and aircraft concepts with improved aerodynamics and propulsion need to be deployed to reduced aviation CO_2 emissions significantly in the future. The action programme will, beside the technological and organisational approach, also includes elements for financing, environmental impacts and specify the measures to take into consideration. Below are some examples elaborated of initiatives and collaborations between the sector and the government.

Initiatives and collaborations

This paragraph highlights some examples of initiatives and collaborations based on the action programme on hybrid-electric aviation in the Kingdom of the Netherlands.

The Netherlands

Dutch Electric Aviation Centre (DEAC) is a centre located at Teuge airport which investigates how general aviation can fly more sustainably in the future. Its goal is to make aviation cleaner, quieter and more affordable. To make electric aviation more accessible they conduct research and experiments with aircraft, infrastructure and regulations that can support its implementation.

In the shared learning environment 'Power Up', the aim is to gain knowledge of the feasibility and handling of electric flights. Eindhoven Airport, Rotterdam The Hague Airport, Groningen Airport Eelde and Maastricht Aachen Airport are working together. Power Up aims to have the first domestic commercial electric flight in the Netherlands by 2026.

In 2018, "Stichting Duurzaam Vliegen" was established as a representative party for General Aviation. Their ambition is to reduce greenhouse gas emissions by 15% by 2030 compared to 1990 and to be able to fly emission-free by 2050.

Dutch Caribbean

For the Caribbean part of the Kingdom, two initiatives are highlighted: the Bonaire Air Ambulance and the Dutch Caribbean Cooperation of Airports (DCCA).

Bonaire Air Ambulance is responsible for healthcare transport on the islands. For optimal use, certain care is only available on one of the islands which makes reliable transport between them crucial. To become independent from airlines, Air Ambulance would like to acquire their fleet and they are investigating the feasibility of having electric or hybrid-electric aircraft. Their ambition can be a catalyst for new techniques to create a new ecosystem.

Dutch Caribbean Cooperation of Airports (DCCA) is an initiative of airports, established in 2021. Their objective is to improve the individual airports on several key elements, such as sustainability. One of their efforts is focused on improving connectivity between islands, aiming for a sustainable (electric), reliable and affordable public transport-like air connection.

Electric flight between the ABC islands

In 2019, about 150,000 passengers travelled by air between the islands and mostly between the airports of Curaçao and Aruba and Curaçao and Bonaire (Figure 33). Constant and reliable demand for travel is observed between the islands, both for business and private purposes. For many inhabitants, air transport is not only an important means of transportation, but it is often the only modality available.

Most aircraft movements are carried out by 9 and 19 seat aircraft operated by Divi Divi Air and EZ Air. The point-to-point character of the connectivity and at the same time the short distances make this very suitable for the introduction of electric aircraft. The inter-island connections have great potential to be replaced by electric 9 and 19 seaters once the necessary infrastructure is there.

Figure 33 - Overview of the ABC-islands and the distances between the islands

For the implementation of electric and thus zero-emission flight between the islands, a reliable and sustainable provision of renewable (green) energy is essential including sufficient infrastructure at airports. All the islands have made a good start with setting up renewable energy production facilities. However, there is still a lot of unused potential, for both wind and solar power. For the transition to zero-emission flight, it is essential that the transition to renewable energy generation keeps pace with developments in aviation.

A three-phase implementation of electric flight between the ABC islands is outlined below. The transition is intended to take off in 2026 and run up to 2035.

Phase 1 – Start of electric flights

In 2026, it is expected that the first commercial electric aircraft will have its commercial entry into service. Therefore, 2026 is chosen as a starting year. Three 9-seat electric aircraft will be flying the ABC routes.

Phase 2 – 50% electric flights

The ambition is that 50% of the flights will be carried out by electric aircraft in 2030 as compared to 2019 traffic. Therefore, three 19-seaters will be added. The pool of electric aircraft will be of three 9-seaters and three 19-seaters in phase 2.

Phase 3 – 100% electric flights

Ultimately, in 2035, all air movements between the islands as per 2019 will be electric. Another three 9-seaters and three 19-seaters will be incorporated. The total pool of electric aircraft will be six 9-seaters and six 19-seaters in phase 3.

The islands of Sint Eustatius, Sint Maarten and Saba are located even more closely together but there is little passenger traffic between these islands. Hence, electric flights make technical sense but market conditions are different compared to the ABC islands. The distance between the two groups of islands is around 800 km, which is less realistic for electric aviation at this moment.

3.4.2. Innovation strategy

The future will bring new modes of transport and new incumbents for mobility and online platforms will start to emerge offering Mobility as a Service (MaaS). In a short amount of time, these incumbents could play an important role in the aviation sector. Innovation offers chances and opportunities for the Dutch (aviation)industry as well. Therefore, to facilitate innovations the government is setting up an innovation strategy.

Drones and unmanned aircraft such as flying cars offer opportunities for businesses and may result in useful applications. Vertical take-off and landing could for instance reduce the negative effects of conventional flying. The government actively facilitates possibilities for testing and experimenting with (un)manned aircraft and other new technologies to make these new applications and services possible. Innovation for conventional commercial aircraft designs, powertrains and fuels is part of the innovation strategy as shown in Figure 34. However, this needs to be as safe as possible while also paying attention to (noise) pollution. The four different public values are therefore central: safety, sustainability, quality of life and connectivity as elaborated in the Civil Aviation Policy Memorandum (Rijksoverheid, 2020a).

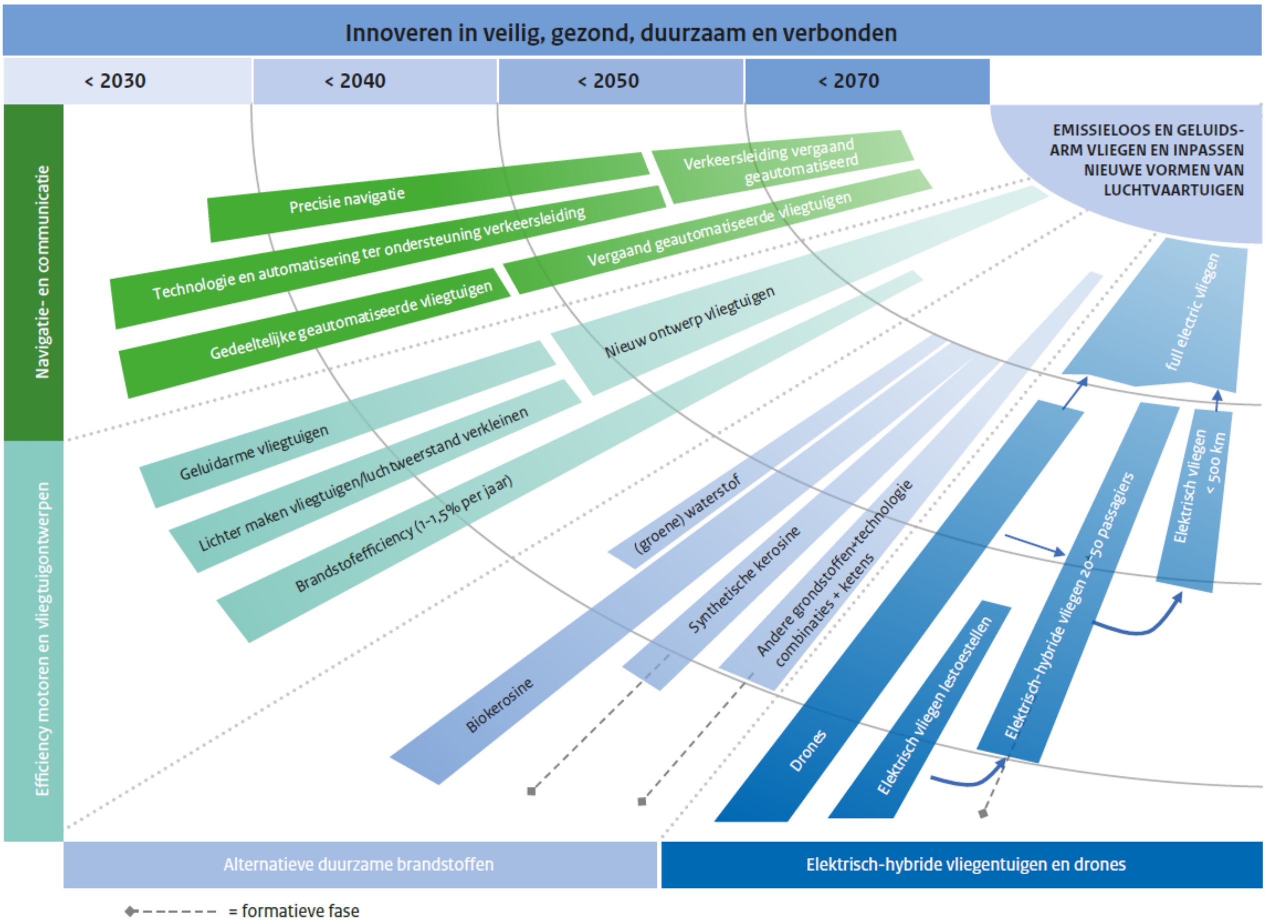

Figure 34 – Transformation roadmap for innovation (Rijksoverheid, 2020a)

3.4.3. Financial instruments for technologies and innovations

Financing strategy

Sustainable aviation requires financial support to accelerate innovations to reduce climate impact. The government has set up a strategy for the financial instruments to support the development of innovations that contribute. The financing strategy includes different instruments: grants, loans, guarantees and fiscal discounts. The government has the ambition to further expand these financial instruments. Part of the total EUR 400 million increased revenue from the aviation ticket tax will be allocated (indirectly) to sustainable aviation and to reduce negative effects on the environment (see section 3.8.3).

Different instruments are in place to stimulate sustainable aviation. Examples are the Tax relief schemes for environmentally friendly investment (Vamil and MIA), InvestNL and the PPS Allowance for R&D[74]. Besides the financial strategy, there are also some examples of specific aviation-related incentives to accelerate the development of innovative aircraft technologies: the Research & Development Mobility sectors (RDM) and TSH Aircraft manufacturing industry[75]. As part of the financing strategy, the National Growth Fund proposal ("Aviation in Transition", initiated by the sector) is discussed below in further detail.

National Growth Fund: Aviation in Transition proposal

In 2020 the government announced a new National Growth Fund (*Groeifonds)* with a budget of EUR 20 billion over five years (Rijksoverheid, 2021b). A group of aerospace and aviation industry representatives has developed a proposal for this fund called Aviation in Transition. The Ministry of Infrastructure and Water Management supported this proposal and submitted it to the secretariat of the National Growth Fund in November 2021. The new coalition government announced in December 2021 that it will continue to put efforts in the National Growth Fund by investing in projects aimed at knowledge development, research, development and innovation. This strengthens the economic value of the Dutch economy and ensures growth in the long term.

The Aviation in Transition program is an integrated approach. The implementation of promising research and innovations is accelerated through the removal of bottlenecks and the creation of a new open innovation infrastructure through:

- Realisation of first-of-a-kind pilot facilities for synthetic aviation fuel;
- Development of sustainable ultra-efficient demonstration aircraft with breakthrough technology for hydrogen propulsion, materials and systems;
- Establishment of a testing ground with loading and refuelling infrastructure and field laboratories at Dutch airports for the entire aviation chain;
- New and promising research will continue to feed the innovation infrastructure.

The total financial volume of the Aviation in Transition programme amounts to EUR 1,019 million. The requested contribution from the National Growth Fund (EUR 504 million) is expected to be recovered 4.5 times over the period 2020-2050. With the Aviation in Transition ecosystem proposal, the Dutch aviation sector hopes to ensure it is ready for future national and international obligations, while also turning this obligation into an opportunity to make the most of this emerging market from an economic perspective.

In addition, many innovations that make aviation more sustainable will also enable Dutch airports to further improve the quality of the working, living and everyday environment

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74 MIA-Vamil: Introduction to MIA and Vamil - January 2014.pdf (rvo.nl), InvestNL Invest-NL, PPS Allowance for R&D PPS-toeslag Onderzoek en Innovatie | RVO.nl | Rijksdienst
75 RDM R&D subsidy scheme mobility sector (RDM) | Business.gov.nl, TSH TSH Vliegtuigmaakindustrie | RVO.nl | Rijksdienst

at and around airports, by increasing the benefits (employment, regional business climate) while reducing the burdens (environmental quality such as noise and air pollution). This is expected to garner an even stronger proposition to attract companies and capital to the Netherlands, which in turn will contribute to innovation and new business.

3.5. Airspace design and infrastructure (operational improvements)

The Sustainable Aviation Table has initiated an action programme on operations to identify what operational improvements are worthwhile to act on starting today. Together with (inter)national stakeholders, multiple measures have been identified on a national level which also requires European and international cooperation to achieve the CO_2 reduction targets. These are primarily: aircraft performance, accurate planning information, route optimization, fuel policies & standards and weight reduction. Airspace optimization and ATM modernisation are measures in the longer term.

Dutch Airspace Redesign Programme

In 2018, the Netherlands started a joint civil-military program for redesigning its airspace. The Dutch Airspace Redesign Programme (DARP) is essential to accommodate the reduction of noise impact, the impact of CO_2 emissions and the long-term growth of civil and military air traffic and (future) innovations in aviation. The Ministry of Infrastructure and Water Management, the Ministry of Defence, the Air Navigation Service Providers (ANSP's), Royal Airforce, Air Traffic Control the Netherlands (*Luchtverkeersleiding Nederland)* LVNL and Maastricht Upper Area Control Centre (MUAC) work together in redesigning the Dutch airspace. International alignment and cooperation are inherently part of DARP (Rijksoverheid, 2021c).

The programme aims to reduce noise pollution and CO_2 emissions as much as possible. However, there are often trade-offs between these public interests when aircraft have to emit more emissions due to longer routes when avoiding residential areas. The government has decided to give priority to noise abatement up to 6,000 feet and to CO_2 reduction above 6,000 feet (Rijksoverheid, 2021d).

The Minister of Infrastructure and Water Management and the State Secretary of Defence published the draft Preferential Decision for the DARP in January 2021. It is supported by a Strategic Environmental Impact Assessment.

3.6. Market-based measures

As a member of the European Union, the Netherlands fully complies with the EU ETS directive. Together with the other 43 ECAC member states, the Netherlands is also participating on a voluntary basis in CORSIA. The Dutch Emissions Authority (Nederlandse Emissieautoriteit, NEa) is the independent national body responsible for implementing and monitoring both the EU ETS and CORSIA in the Netherlands and consolidated reporting to the respective international bodies (European Commission and ICAO).

3.7. Zero emission ground operations

This section outlines the measures taken by airports in the European part of the kingdom to reduce the emissions from ground operations. The reduction of carbon emissions caused by ground-based operations at Dutch airports is one of the ambitions outlined in the action programme on hybrid-electric aviation (*Actieprogramma Hybride Elektrisch Vliegen*, AHEV), see Figure 29. The ambition for ground-based operations is to become entirely emission-free in 2030 (Rijksoverheid, 2020a).

In the short term (up to 2025) tests and experiments for electrical taxiing and adjusting charging and energy infrastructure are conducted. In the long-term (2026-2029) ground operations will become zero-emission, including baggage-handling and sustainable taxiing to reduce CO2 emissions and improve air quality at and around airports by 2030. Currently, an instrument is being developed in collaboration with the sector to track progress towards this target as part of the action programme on targets and monitoring.

The Royal Schiphol Group (responsible for over 90% of aviation activities in the Netherlands) is working on a 'Most sustainable airports' roadmap (Royal Schiphol Group, 2020; Royal Schiphol Group, 2021b; CBS, 2021). The roadmap states that:

- All new vehicles will be zero emissions, including Ground Support Equipment (GSE) on airside. The airports invest in additional charging facilities (RSG has currently 750 available on airside) for electrically powered equipment. KLM's ambition is to have zero emissions from ground operations by 2030. Therefore, KLM has invested in the electrification of ground equipment. Some 62 percent of KLM's ground equipment is now electric.
- The usage of fixed power units at the platform will be promoted when available.
- Single-Engine Taxiing (SET) and sustainable taxiing operations (using TaxiBot or WheelTug for instance) will be increased to reduce fuel consumption. Currently, feasibility studies are being undertaken (Royal Schiphol Group, 2021b).
- 'Older' buildings will be renovated and new buildings will be at least energy-neutral.
- Energy efficiency will be increased, more solar power produced and the power grid will be strengthened.
- Smart and clean mobility to and from the airport will be increased by investing in public transport, bike infrastructure and electric car-sharing.

Tests have been conducted at Schiphol with the use of electric taxi equipment. Maastricht Aachen Airport (MAA) is also working on similar initiatives to reduce its CO_2 emissions such as platform and runway LED lighting systems, the electrification of GSE (such as the usage of e-GPUs and zero-emission vehicles), more energy-efficient systems and buildings by using green electricity (solar panels and green energy contracts instead of natural gas) and (autonomous) electrical baggage and cargo handling (NLR, 2020). Groningen Airport Eelde is investing in charging facilities for aircraft and conducts research to facilitate air taxis such as eVTOL's (Electric Vertical Take-off and Landing) and other forms of Advanced Air Mobility (AAM) (Groningen Airport, 2021)

3.8. Additional measures

This section details complementary policies which have an indirect effect on aviation CO_2 emissions. These are awareness and consumer behavior, promoting alternative modalities and taxes and levies.

3.8.1. Awareness and consumer behaviour

The Sustainable Aviation Table includes an action programme on awareness and behavioural change. The government wants to inform society objectively about the CO_2 emissions of air travel and what measures travellers and employees can take to reduce their carbon footprint. The action programme on awareness and consumer behaviour assumes that:

- Travelers have limited knowledge about how they can reduce or compensate for the negative effects on the climate of their air travel behaviour.
- Increased knowledge ensures more desired behaviour to reduce or compensate for the negative effects on the climate.

The Netherlands Institute for Transport Policy Analysis (*Kennisinstituut voor Mobiliteitsbeleid,* KiM) has conducted research that forms the base for this action programme (Netherlands Institute for Transport Policy Analysis, 2019). The outcome of this research is a set of ten interventions for consumer behaviour to reduce CO_2 emissions of aviation, focused on travellers flying to holiday destinations or Visiting Friends or Relatives (VFR).

The government itself has signed the Dutch sustainability mobility pledge *Coalitie Anders Reizen* (Anders Reizen, 2021). As have many other large employers in the Netherlands, aiming to reduce CO_2 emissions from travel by civil servants by 50% in 2030 compared to 2016.

3.8.2. Promoting alternative modalities

The Netherlands wants to make train travel in Europe more attractive in terms of travel time and consumer price to become a sustainable substitution for short-haul flights. A reduction of aircraft movements reduces CO_2 emissions, negative effects on the environment around airports and less congestion of airspace. Policies are aimed at improving international train connections up to 700 kilometres. Fourteen percent of aircraft movements departing from Schiphol are flights to these destinations. The action-oriented agenda Air-Rail is conducted in cooperation with the aviation sector to realise this substitution (Rijksoverheid, 2020e). The government expects that from 2025 an additional 2 million passengers per year will reach their destination via international railways. In the period between 2030-2050 this could further increase to over 15 million passengers. This is approximately 100.000 flights being substituted, or 20% of the aircraft movements at Amsterdam Airport Schiphol at this moment. It is important to note that airport capacity that becomes available by substituting short flights with trains may be used for long-haul flights and thus may lead to an increase in CO_2 emissions.

3.8.3. Taxes and levies

Taxes and levies on aviation can serve various purposes: fiscal greening, internalisation of costs and reducing CO_2 emissions from aviation. Research shows that, given the same destination, aviation costs are more internalised than train or bus costs. However, taxes and levies for travel by aircraft, train and bus are lower than the actual external and infrastructure costs (CE Delft, 2019).

For climate policy on aviation, it is important that costs for the aviation sector contribute as much as possible to achieving the climate targets. As described earlier the government’s main focus is on measures that contribute directly to CO_2 emissions reduction in the aviation sector.

Nevertheless, a flight tax contributes to greener taxation and ensures that aviation pricing better reflects the costs of aviation to society. An aviation tax of EUR 7.845 was introduced on the 1st of January 2021. Due to indexation, as of the 1st of January 2022, a ticket tax of EUR 7.947 applies to all departing passengers (flight ticket tax). Transit passengers and cargo are exempted.

The new coalition government intends to increase revenues from the aviation tax by EUR 400 million a year, twice the current amount (not accounting for COVID-19). Part of these increased revenues will be used to finance national innovation projects that contribute to increased sustainability in aviation and the reduction of negative effects on the environment such as noise(pollution) around airports.

Additionally, the Netherlands supports the European Commission’s proposals for a levy on kerosene. The government’s efforts in this field are focused on reducing the possibilities of carbon leakage to non-EU hubs.

Appendix A: detailed results for ECAC scenarios

BASELINE SCENARIO

a) Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[76] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[77] FTKT (billion)	Total Revenue Tonne Kilometres[78] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

Note that the traffic scenario shown in the table is assumed for both the baseline and implemented measures scenarios.

b) Fuel burn and CO_2 emissions forecast for the baseline scenario

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

76 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

77 Includes passenger and freight transport (on all-cargo and passenger flights).

78 A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

IMPLEMENTED MEASURES SCENARIO

EFFECTS OF AIRCRAFT TECHNOLOGY IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included:

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[79] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[80] FTKT (billion)	Total Revenue Tonne Kilometres[81] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2019:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	46.16	145.86	179.09	0.0217	0.217
2040	51.06	161.35	198.12	0.0196	0.196
2050	53.18	168.05	206.33	0.0182	0.182
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

79 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

80 Includes passenger and freight transport (on all-cargo and passenger flights).

81 A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

c) Equivalent (well-to-wake) CO_2e emissions forecasts for the scenarios described in this common section

Year	Well-to-wake CO_2e emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
		Implemented Measures Scenario		
	Baseline Scenario	Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	143.38			NA
2019	201.80			NA
2030	196.8	191.5	179.1	-9%
2040	242.0	220.1	198.1	-18%
2050	269.3	229.3	206.3	-23%

For reasons of data availability, results shown in this table do not include cargo/freight traffic.

Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.

Appendix B: note on the methods to account for the CO_2 emissions attributed to international flights

Background

The present note addresses recommendations on the methodologies to account the CO_2 emissions, for the guidance on the development of the common European approach for ECAC States to follow, in view of the submission to ICAO of their updated State Action Plans for CO_2 Emissions Reduction (APER).

The ECAC APER guidance shall be established on the basis of the ICAO 9988 Guidance on the Development of States' Action Plans on CO_2 Emissions Reduction Activities document (3rd edition). One of its objectives is to define a common approach for accounting CO_2 emissions of international flights: two different methods are proposed for CO_2 accounting, namely ICAO and IPCC. Because of their intrinsic definitions, it is expected that these two different approaches induce both accounting differences, and practical issues, and furthermore, two ways to target the CO_2 Emissions Reduction Activities, and to define the action plans, de facto.

As the objective of the definition of the common section of the ECAC APER guidance consists into determining a common approach for all the foreseen activities, including CO_2 accounting and monitoring, the ECAC APER Task Group required to assess the details of each methods and to propose recommendations in this present note.

Accounting methods

The ICAO Doc 9988 document 3rd edition defines the two CO_2 accounting methods (§3.2):

a) ICAO: each State reports the CO_2 emissions from the international flights operated by aircraft registered in the State (State of Registry).
b) IPCC: each State reports the CO_2 emissions from the international flights departing from all aerodromes located in the State or its territories (State of Origin).

The international flights concern aircraft movements from a country to another country. Each method determines the country assignment of the movement.

Method	ICAO	IPCC
Definition	The ICAO methodology is based on the State of nationality of the airline, and defines an "international" flight as one undertaken to or from an airport located in a State other than the airline's home State, i.e. each State reports only on the international activity of its own commercial air-carriers.	The IPCC methodology defines international aviation as flights departing from one country and arriving in another, i.e. each State report to IPCCs in respect of all flights departing from their territory, irrespective of the nationality of the operator.
Use in projects	CORSIA/ETS (partially)	IPCC EAER UNFCCC

Comparisons: flown distance and number of operations

The comparison of the number of operations and flown distance of 2019, aggregated at ECAC or State levels provide a good indication of the possible differences for CO_2 accounting.

At the ECAC area level, the relative difference between the ICAO and IPCC methods, is -0.66% for operations number and + 0.26% on flown distance (Source EUROCONTROL/CRCO). This is explained by the fact that movements of the operators registered outside the ECAC area member states are not counted in.

The table hereafter lists the countries for which the relative differences of counting the number of operations or flown distance is more than 50% or less than -50% (Source EUROCONTROL/CRCO).

DEPARTURE COUNTRY	(ICAO – IPCC) % difference number of operations	(ICAO – IPCC) % difference number of flown distance
ALBANIA	-71.04%	-75.34%
ARMENIA	-80.76%	-84.64%
AUSTRIA	114.51%	104.81%
BOSNIA AND HERZEGOVINA	-83.45%	-80.73%
CROATIA	-52.08%	-65.54%
CYPRUS	-84.06%	-92.75%
DENMARK	-68.07%	-53.81%
ESTONIA	-67.93%	-53.48%
FAROE ISLANDS	*-100.00%*	*-100.00%*
GEORGIA	-68.62%	-66.45%
GREECE	-58.26%	-65.83%
HUNGARY	213.95%	245.36%
IRELAND	509.31%	478.00%
ITALY	-71.45%	-63.90%
LIECHTENSTEIN	2100.00%	8572.91%
LITHUANIA	-78.83%	-65.95%
LUXEMBOURG	55.29%	54.05%
NORTH MACEDONIA	-98.69%	-98.90%
MALTA	97.00%	125.78%
MONACO	100.17%	708.97%
SLOVAKIA	-73.46%	-72.30%

The previous table highlights the possible relative differences for a country-by-country approach:

- High differences for low-cost origin countries (Ireland, Austria, Hungary) as all the movements exceed the departures capacity: nb operations ICAO >> nb operations IPCC
    - Example: Ireland (Ryanair), Austria (EasyJet), Hungary (Wizzair)
- High differences for business jet country locations: nb operations ICAO > nb operations IPCC
    - Example: Monaco, Malta, Liechtenstein
- Difference for countries with lot of low-cost departures: nb operations ICAO < nb operations IPCC
    - Example: Greece, Italy

Impact on the action plan definitions

The choice of the method entails two significantly different approaches. The ICAO approach would bring the focus on the capability of a State to manage the emissions evolution of only its own "flag carriers". A State having a significant aviation activity operated by non-flag carriers would therefore not be able to reflect in the plan its possible policy on the evolution of its overall aviation activity. Also, if the State flag carriers have an important aviation activity between third countries, this would become a "responsibility" of the State in terms of emissions reduction plans.

The IPCC method, on the contrary, brings the focus on the management of the emissions reductions for the State related aviation activity, integrating the State's policy in terms of evolution and importance of the aviation business for it and national plans to reduce emissions (e.g., promotion of operations with more fuel-efficient aircraft).

Allowing States to use the ICAO or the IPCC method has the risk of under estimation for some as well as double counting for others if consolidating the States action plans.

It is also worth noting that the IPCC method actually allows consolidating and correlating the data with the CORSIA reporting. Indeed, under CORSIA emissions are reported by States aggregated at country pair level with no info on the operator. If all States were reporting action plans based on the IPCC approach aggregating at country pair level, this info can be consolidated and correlated with the CORSIA reported one. The ICAO method for the action plans would not allow this.

Impact on the baseline definition (ECAC)

The selection of the ICAO/IPCC method also affects the definition and estimation of the CO_2 emissions of the international flights at the ECAC level.

The Base year dataset and the forecasts dataset that EUROCONTROL shall define and assess (at the ECAC level), are based on the IPCC. The ICAO method cannot be used for such assessments.

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