

EUROCONTROL Aviation Outlook 2050

Main Report

April 2022





**Foreword by the
Director General of
EUROCONTROL**

Aviation has been hit hard by the COVID19 pandemic and, even after traffic has recovered to 2019 levels, we can expect slower growth than previously forecast. However, growth will return and we need to prepare for significantly higher levels of traffic in the decades to come.

Long-term forecasts are never easy to produce but are vital for an industry such as aviation where long-term investment is required. This includes Air Traffic Management (ATM) systems, airports, airframes and also new types of aircraft and infrastructure that are being developed to make aviation more sustainable.

For the first time, this report includes estimates of net CO₂ emissions, it provides a real insight into how aviation can move towards the target of net zero by 2050. This challenging objective is achievable but it will not be easy – requiring coordinated action by aircraft manufacturers, airlines, airports, fuel companies, ANSPs and, crucially, governments and regulators.

Although Sustainable Aviation Fuel (SAF) is the largest contributor to achieving net zero by 2050 (41% in our base scenario), our view is other measures (e.g. Market-Based Measures) will continue to very significant role (32% in our base scenario). This is higher than other forecasts have suggested to date.

Even though aviation is only responsible for just over 2% of global CO₂ emissions, we need to play our part in improving sustainability. This report provides a clear idea of what that means in practice.

Eamonn Brennan

April 2022

DISCLAIMER: This report was prepared before the start of the invasion of Ukraine by Russia. At the point of publication, the impact on traffic (flights and emissions) is currently high for some States adjacent to Belarus, Russia and Ukraine. However, the overall impact to the full European network remains relatively small. The main focus in this report is air traffic development by 2050.

30-YEAR FORECAST 2022-2050

16 MILLION FLIGHTS BY 2050

(RANGE: 13.2-19.6 MILLION)

UP 44% ON 2019

- **10-YEAR LAG SINCE PREVIOUS LONG-TERM FORECAST (2018).**
- **MIDDLE-EAST & ASIA/PACIFIC: MOST DYNAMIC FLOWS WITH ECAC BY 2050.**

NET ZERO CO₂ TO BE ACHIEVED BY CUTTING 279 MILLION TONNES WITH:

- (17%) MORE EFFICIENT CONVENTIONAL AIRCRAFT.
- (2%) ELECTRIC & HYDROGEN POWERED AIRCRAFT.
- (8%) BETTER ATM AND AIRLINE OPERATIONS.
- (41%) SUSTAINABLE AVIATION FUEL.
- (32%) OTHER MEASURES.

MAIN CHALLENGES:

- LONG-HAUL MAIN SOURCE OF CO₂ EMISSIONS.
- NET ZERO CO₂ IN 2050 ACHIEVABLE BUT VERY CHALLENGING.
- FOCUS ON ATM EFFICIENCY (SES) ESSENTIAL AND SHOULD HAPPEN NOW.
- GREATER USE OF SAF: MAIN DRIVER TO DECARBONISE AVIATION BY 2050.

EUROCONTROL Aviation Outlook 2050

Flights and CO₂ forecasts

EXECUTIVE SUMMARY

This EUROCONTROL Aviation Outlook looks out to 2050, much further than previous forecasts and in line with aviation's objective of achieving net zero CO₂ emissions by that date.

It takes into account the impact of the COVID-19 pandemic and, even after aviation has recovered to pre-pandemic levels, it expects growth to be slower than previously forecasted. The impacts of the 2022 Russian invasion of Ukraine on aviation have not been specifically included in this report. However, even if geopolitical tensions look set to remain, it is more on a medium-term horizon than on a long-term one.

The most-likely scenario shows 16 million flights in 2050. Other possible scenarios (resulting in 19.6 million flights and 13.2 million flights by 2050) are also discussed.

the aviation market. This is the first time that we have published an integrated forecast of flights and CO₂.

The principal ways by which aviation will become more sustainable (and their respective relative contribution in 2050 to the 'most likely' scenario) are:

- Evolutionary improvements to aircraft and engines, making them more efficient (17%),
- Revolutionary new aircraft technologies, such as the deployment of electric and hydrogen-powered aircraft, together with the required infrastructure (2%),
- More efficient flights, thanks to operational improvements such as improved air traffic management and aircraft operations (8%),
- Gradually increasing use of sustainable aviation fuels (SAF, 41%).

ECAC	IFR Flights						
	2019		2050			2050/2019	
	Total (million)	Avg. daily (thousands)	Total (million)	Avg. daily (thousands)	Extra flights/day (thousands)	Total growth	AAGR
High scenario	11.1	30.4	19.6	53.6	23.2	+76%	+1.8%
Base scenario			16.0	43.7	13.4	+44%	+1.2%
Low scenario			13.2	36.2	5.8	+19%	+0.6%

The most-likely flight forecast is 10 years behind the previous EUROCONTROL long-term forecast, putting it between the two lower-growth scenarios of the "Challenges of Growth" study from 2018.

This report also reflects the fact that, while airport capacity in Europe still constrains growth to some degree, sustainability is expected to become a more significant factor influencing the future of

The range of scenarios reflects the fact that, if aviation is stronger, then it is better able to invest in more efficient technologies. However even in our most ambitious *High* scenario, 2050 is too soon to have completed the introduction of many revolutionary new aircraft, complete with their fuelling and charging infrastructure. It also reflects the fact that those technologies still seem likely to be best for shorter rather than longer-haul travel. The CO₂ improvements by then, therefore, remain

modest (2%-3% in 2050): industry and regulators will need to find ways to boost investment to improve on this. As other studies have found, the final step to reaching net zero CO₂ therefore needs 'out of sector' measures such as carbon capture.

No single solution will enable aviation to achieve net zero CO₂, but in all three scenarios here, it is the scaling up of the production, distribution and use of SAF that makes the largest contribution in the long term, with operational improvements helping more immediately. This report will be complemented by EUROCONTROL Objective

Skygreen, looking in much more detail at the elements leading to cutting CO₂ emissions by 55% by 2030 compared to 1990 levels.

Aviation can do, and is doing, much to achieve its 2050 target of net zero CO₂. In our scenarios, lower growth goes together with lower investment, resulting in worse CO₂ performance. The most sustainable outcomes require the aviation industry to work with governments to ensure that the right investments and suitable regulations can be and are being made, within aviation and beyond.

Although SAF is the largest contributor to achieving net zero by 2050 (41% in our base scenario), our view is that Market-Based Measures will continue to play a very significant role (32% in our base scenario). That is higher than other forecasts have suggested to date.

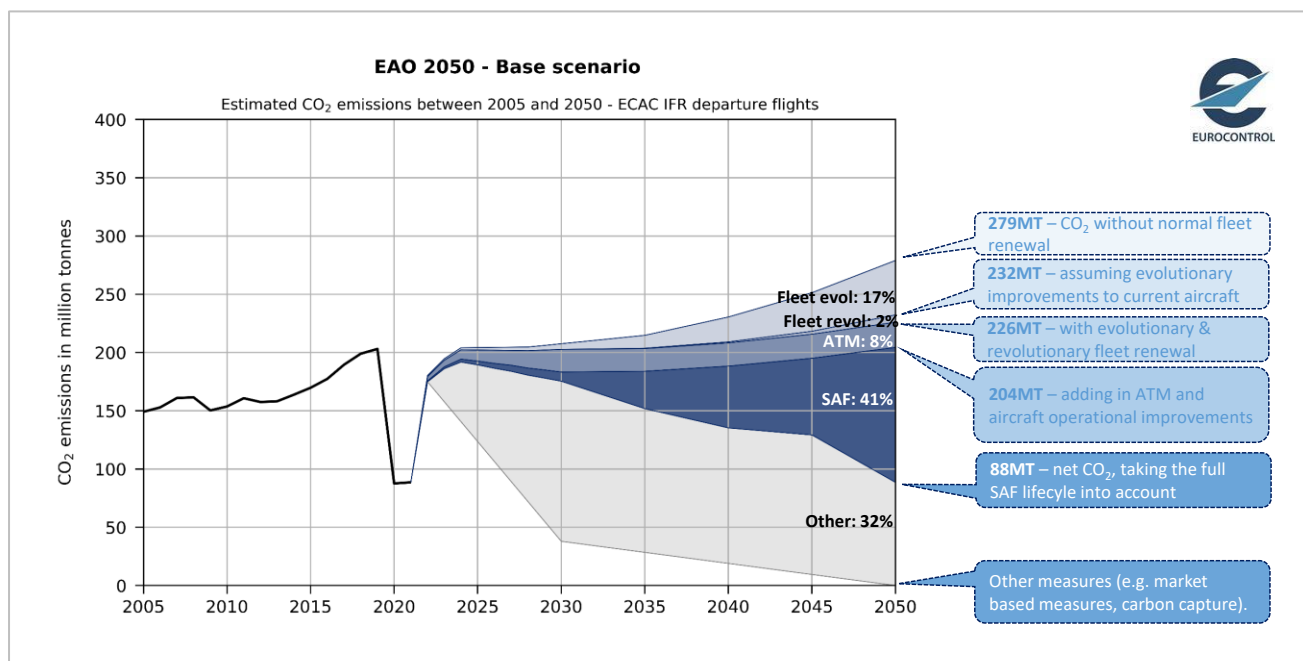


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1. SETTING THE SCENE

Aviation policy is increasingly focused on sustainability and, in particular, on how aviation can contribute to meeting the 2050 climate targets. This “EUROCONTROL Aviation Outlook 2050” aims to support these discussions with forecasts of both flights and CO₂ emissions for Europe. The Outlook is the successor to the “Challenges of Growth” studies (see Ref. 1, 2).

1.1 Three scenarios for the future

What aviation will be like in 2050 is most definitely uncertain. But that is not the same as being entirely unknown. 2050 will be heavily influenced by technology and policies that are already in place or in development, whether that means the supply of sustainable aviation fuels (SAF), hydrogen or electric-powered aircraft or market-based measures, or something else.

This EUROCONTROL Aviation Outlook uses scenarios: different stories about the future, about the possible speed, intensity and success of such developments in technology and policy. These scenarios provide a structured approach to uncertainty, each with qualitatively-different outcomes, but aiming to cover a wider range of the many possible futures. The range of scenarios guides users to anticipate the implications of future events, helping them prepare for change and uncertainty (see Figure 19). The effects of the 2022 Russian invasion of Ukraine highlight the need to consider a number of issues related to the oil price and the economic cycle. On the other hand, a number of significant past events have proven to be of relatively short to medium-term impact, emphasising the limited relevance of such events to a long-term forecast. The three scenarios are:

High scenario: this high-growth scenario in flight terms is characterised by strong economic growth in a globalised world, with intense investment in technology supporting sustainable aviation growth.

Base scenario: This ‘most-likely’ scenario is characterised by moderate economic growth, with regulation reflecting environmental, social and economic concerns to address aviation sustainability. This scenario follows both the current trends, and what are seen as the most

likely trends into the future.

Low scenario: This low-growth scenario in flight terms is characterised by slower economic growth, higher fuel, SAF and carbon prices, more limited investment in new technology (or later than in the other scenarios). Air travel actors have to adapt to environmental and potential trade constraints, taking a more “inwards” perspective. European travellers are likely to travel and consume more locally. This scenario encompasses assumptions where energy prices would be particularly high and a severe economic downturn might happen over a 30-year period.

HOW IS THE COVID-19 IMPACT MODELLED?

The COVID-19 crisis had and still has a dramatic impact on European aviation; this impact is primarily captured through the STATFOR seven-year flight forecast covering the 2021-2027 period (see Ref. 3). The 30-year forecast picks up from the end of the 7-year forecast in 2027. In other words, the COVID impact is captured and the EUROCONTROL Aviation Outlook to 2050 is looking beyond COVID.

HOW IS THE INVASION OF UKRAINE IMPACT MODELLED?

The scenarios consider the effects of different level of economic growth patterns (Low-Base-High) and prices (oil, jet fuel). If the Russian invasion of Ukraine and the related energy price inflation have a larger impact in the short to medium run, the impact on European aviation growth is expected to be captured in the long run.

For this 30-year forecast report, the storylines and the underlying assumptions have significantly changed from the previous 20-year forecast in “Challenges of Growth” (see Ref. 1) considering a detailed analysis of the fleet forecast and innovative projects (see Section 4).

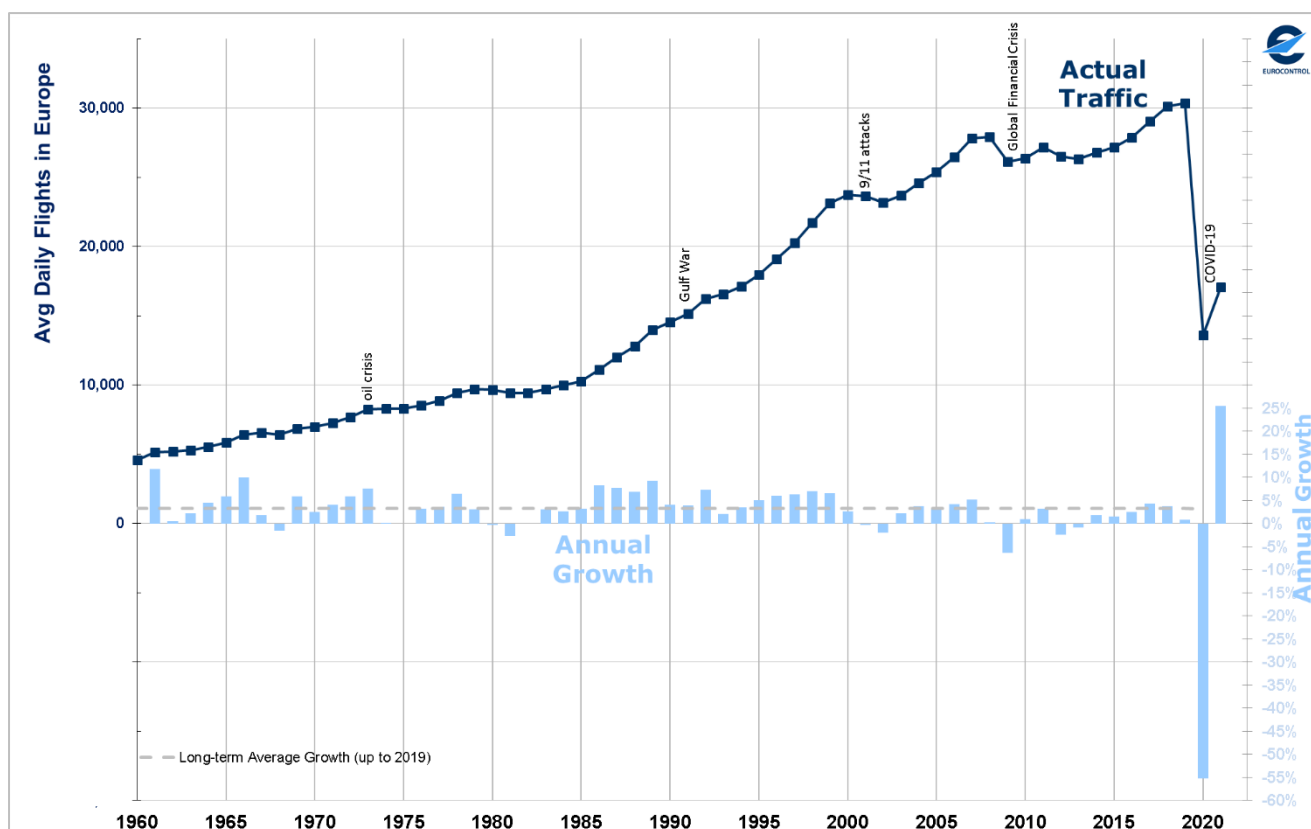
1.2 Flight growth trends to date

Our industry is cyclical, and the most recent upswing has ground rapidly to a halt. Looking 30 years ahead, to handle both these cyclical patterns, and uncertainty in the underlying trend, we detail some assumptions behind EUROCONTROL’s aviation outlook scenarios.

Flights in Europe¹ recorded a rapid expansion over the 20-year period 1988-2007 (traffic doubled from around 5 million to 10 million flights a year), thanks to the expansion of the single market and related trade, the development of low-cost carriers and overall economic expansion. Of course, some years were less positive than others (e.g. early 2000s), but overall, flights were averaging 4% growth per year.

surrounding Brexit, and other events such as the Boeing 737 MAX grounding or the aftermath of bankruptcies of important airlines in the region. Besides this, the COVID-19 outbreak started in China towards the end of 2019. Nevertheless, with 11.1 million flights, 2019 recorded the highest number of flights in European skies.

Figure 1. Annual flight growth rates in Europe settled down over the last decade, before COVID-19 hit.



THE END OF A CYCLE?

The last 15 years were notably marked by a double-dip recession, as a severe worldwide economic crisis (a.k.a. global financial crisis) which started in 2007-2008 in the United States, ultimately contributed to the Eurozone crisis (2009-2012), leading to a multi-year debt crisis.

Traffic levels in Europe did not recover to 2007 levels (10 million flights) before 2016. Both 2017 and 2018 recorded solid annual growth rates of around 4%.

Then, in 2019, European flight growth rates eroded (+0.9%) due to a deteriorating situation in major European economies, trade tensions between the great powers, uncertainty

Since the start of 2020, COVID-19 has become 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 reduced traffic in 2020: flight movements declined by 55% compared to 2019 at European level. The situation was slightly better in 2021, as health measures and vaccination campaigns eased the travel restrictions for some periods. In 2021, flight growth posted a 25% increase on 2020 (i.e. a 44% decline compared to 2019). That being said, new COVID variants continued to disrupt a large number of economic sectors in Europe, and that is still the case in early 2022.

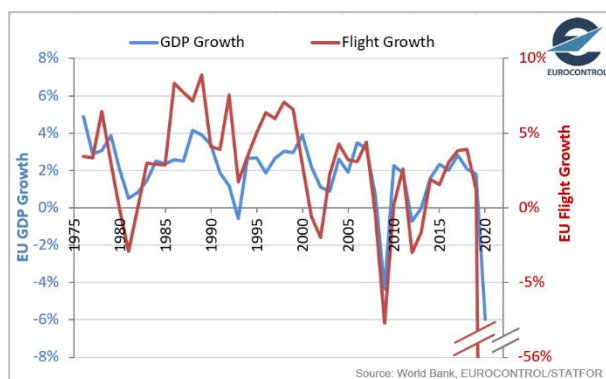
Figure 1 shows the development of the number of flights in Europe. Historical annual growth rates

¹ Unless otherwise specified, hereinafter 'Europe' means the 'ECAC region'.

were averaging 4% over the 1960-2009 period, but had slackened to circa 3% when including the global financial crisis impact (1960-2019).

In the long run, economic growth (measured by the Gross Domestic Product, GDP) remains the most important factor that influences the growth in demand for air travel. Figure 2 shows that, from year to year, demand for air travel followed the economic cycles of growth and decline. In addition, the figure shows a slowing down of economic growth rates, a deceleration which has been observed in flight growth as well. While the correlation between flight and economic growth is distorted in 2020 and 2021, the relationship is expected to be restored in future years; however, it is also clear from the graph that the same amount of GDP growth now drives less flight growth, as the market has matured.

Figure 2. Correlation between IFR flights growth (red line) and GDP growth (blue line) in Europe (1975-2020). The elasticity coefficient in Europe has reduced over the years.



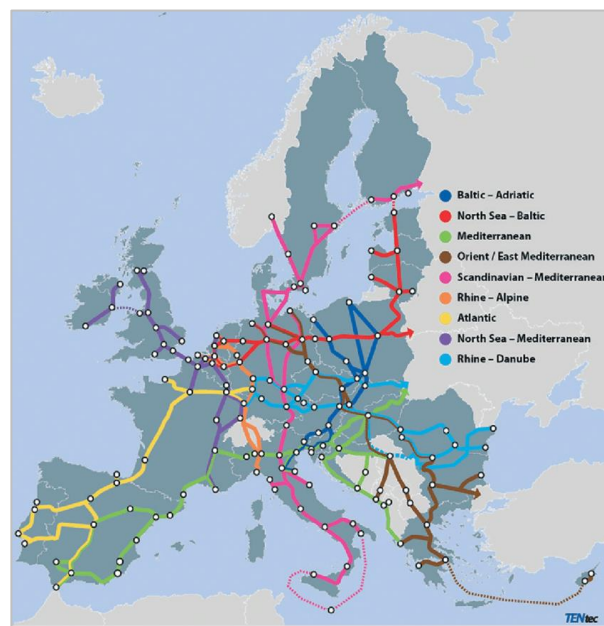
RECENT CHANGES

New high-speed rail lines and faster connections on existing lines (will) have an impact on the passenger choice between air and rail.

Over the recent years, we have observed an acceleration of the decline of short-haul flights, in particular domestic traffic. This decline of domestic traffic started many years ago for most European states.

This continuing decline can often be associated with a shift to other transport modes, such as in France with the development of the high-speed train network, but the decline of domestic flights has accelerated in 2019 following the growing pressure on environment impacting travel decisions for some traditional air travelers.

Figure 3: Nine TEN-T core network corridors: state of play and development needs. Source: European Commission 2017.



The impact is in particular visible for northern European States, for example Sweden whose domestic traffic declined by -9.3% in 2019, and represented one of the greatest changes to the Network in ECAC.

Other states also saw their internal traffic decline such as UK (-2.6%), Germany (-1%) and Turkey (-12.6%) for which the cause is also a combination of economic factors including high inflation, weak currency and widening trade deficits in Turkey.

The impact of recent events (invasion of Ukraine by Russia) has not been included in this long-term forecast. However, the assumptions of the low scenario potentially include lower economic growth development or geopolitical tensions between states.

Future development of high-speed rail network is considered in this forecast, as well as the development of night trains (see Section 2).

2. FLIGHT FORECAST TO 2050

Flight growth in Europe has lost 10 years compared to the previous long-term forecast, although the geographic balance has shifted a little. In the most-likely forecast there will be 16 million flights in Europe in 2050, 44% more than 2019. That is an average growth of 1.2% per year.

OVERALL RESULTS

Each scenario paints a picture of a different future with a different pattern of growth. Focusing on the ECAC region, covering the zone between Iceland and Azerbaijan, we observe the following:

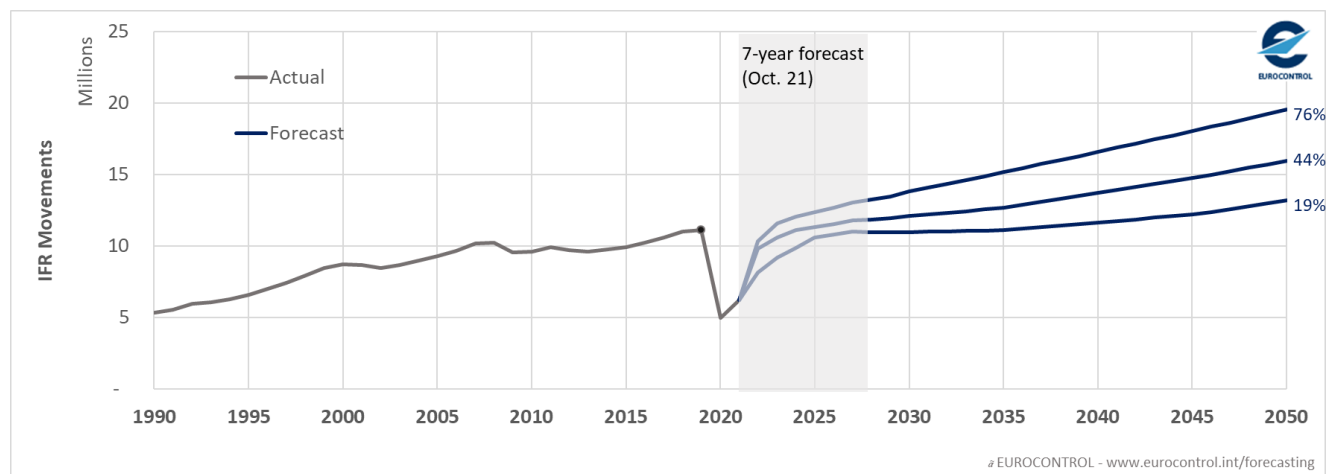
In the most-likely *Base* scenario, the forecast is for 16 million flights in Europe in 2050, 44% more than in 2019 – an average growth of 1.2% per year. Growth will be slower over the first 15 years (0.8%), catching up from the COVID-19 outbreak. It will then accelerate over the last 15 years (1.6%) as, even if the markets become more mature, and economic growth slightly decelerates, people still want to fly in increasing numbers. Europe remains a significant hub at the crossroads of the world's regions. Exchanges within Europe and between Europe and the rest of the world continue to be stimulated by trade, tourism and business, albeit

with greater sustainability concerns. A staggered blending mandate and availability of SAF progressively expands from 2035 onwards. The price of travel increases but people still want to fly. Moreover, airport capacity constraints are less problematic in this forecast, as the COVID-19 outbreak delayed airport congestion.

Comparing with the previous long-term forecast “Challenges of Growth” published in 2018 (see Ref. 1) for Europe, in which the most-likely scenario was expected to pass the 16 million flights bar in 2040, we now see a lag of ten years as our most-likely scenario is now expected to reach this bar in 2050.

In the *Low* scenario, some factors are hindering traffic growth: the prices of conventional fuel, SAF and CO₂ allowances are high, making the price of travel higher; economic development is slower. Flight demand is weaker so the industry is less able to invest in fleet renewal. Only a limited number of revolutionary fleet projects can be developed and at a later stage compared to other scenarios. Flight growth develops more slowly in this scenario with 13.2 million flights by 2050, 19% more than in 2019 – an average growth of 0.6% per year. Flight levels will only get back to 2019 (pre-COVID levels)

Figure 4. Flight Forecast for Europe, with total growth between 2019 and 2050.



ECAC	IFR Flights						
	2019		2050			2050/2019	
	Total (million)	Avg. daily (thousands)	Total (million)	Avg. daily (thousands)	Extra flights/day (thousands)	Total growth	AAGR
High scenario	11.1	30.4	19.6	53.6	23.2	+76%	+1.8%
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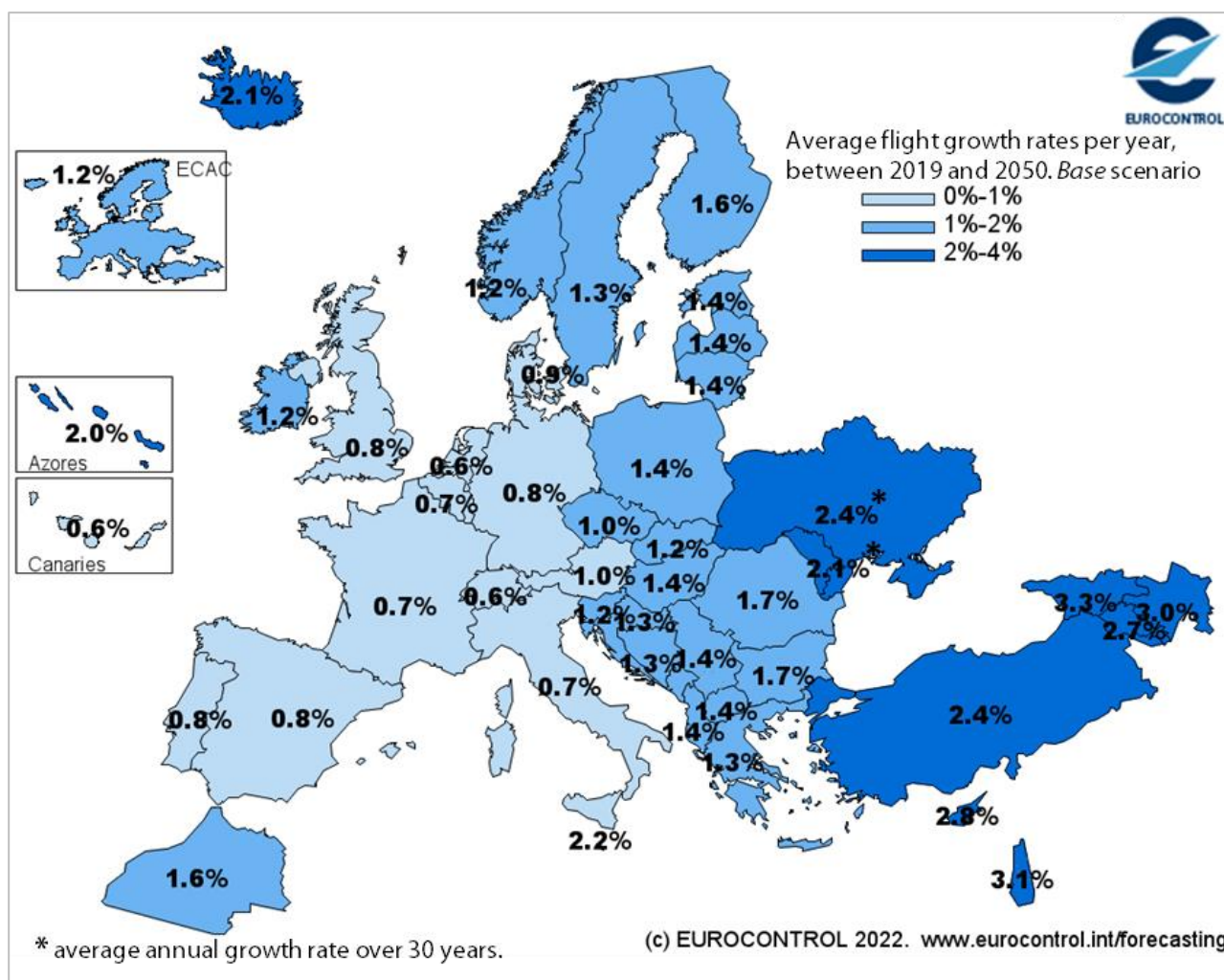
by 2034 (flat growth on average over the first 15 years) and flights will then slowly grow at an average rate of 1.2% over the last 15 years.

In the *High* scenario, the most ambitious scenario, high flight growth comes from sustained economic growth, a high propensity to fly, and

DETAILS WITHIN EUROPE

Growth will not be uniform across Europe. As shown in Figure 5, States in Eastern Europe will grow more quickly than Western ones (the latter is true for each scenario). Focusing on the *Base* scenario, we see growth across Europe, ranging

Figure 5. Average annual flight growth rates in the *Base* scenario over the next 30 years.



relatively lower prices of SAF and conventional fuel (compared to other scenarios). A wide range of new fleet projects are implemented between 2030 and 2050 (electric, hybrid-electric, hydrogen). This scenario records 19.6 million flights in 2050 in Europe, 76% more than in 2019. The average annual growth rate is 1.8% with earlier years (2019-2034) seeing an average rate of 2%, and the later years, a rate of 1.7% per year (2035-2050). This decelerating trend can be explained by multiple factors including market maturity, larger aircraft, and capacity constraints at airports.

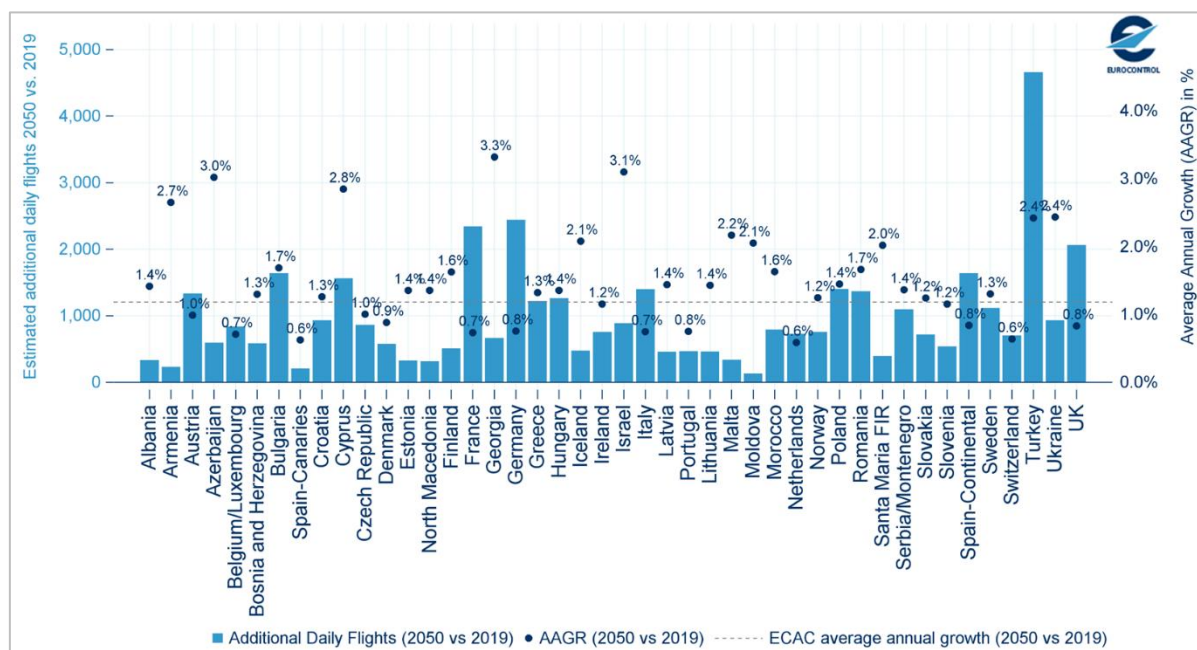
from 20% in the Netherlands to 175% in Georgia. In general, the most rapid growth (in percentage terms) is for countries in southern and eastern Europe with annual growth rates above 1.2%. In part, this reflects a lower current level of flights than for countries in the north and west and thus a higher potential for growth.

The exception is Turkey, which already has high traffic volumes but is still forecast to increase at 2.4% a year. In the most-likely scenario, this will add 4,660 flights a day and means it is set to more than double its daily traffic (+109%) by 2050, see Figure 6.

As shown in Figure 6, France and Germany, which each had² around 9,300 flights per day, will add around 2,300 flights and 2,400 flights per day respectively. Overall, four airspaces (Turkey, France, Germany and UK) will add more than 2,000 flights a day in the most-likely scenario (seventeen in the *High* scenario and just one in the *Low* scenario).

As mentioned in the table of Figure 4, the number of flights on the busiest days in a year is typically 20% above the average number of daily flights. This means that, in the *High* scenario, the number of flights on peak days could reach up to 65,000 movements.

Figure 6. Average Annual Growth rate in 2050 and extra flights a day through airspace³, Base scenario.



AIRPORT CAPACITY CONSTRAINTS

A key feature of EUROCONTROL forecasts is that they consider airport capacity constraints. In practice, flight growth is capped by the maximum capacity available at several airports across Europe. Airports were mostly focused on their short to medium-term plans because of the COVID-19 pandemic. Since the previous long-term forecast, 40 airports (out of 92) have revised their plans downwards and seven upwards. Overall, though, the total increase in capacity by 2040 has declined from 3.7 million flights in our previous forecast to only a few flights in this forecast (the two lines of the *Base* scenario are largely superimposed in Figure 7). This change in the airports' view reflects the high level of uncertainty and the new challenges that airports are facing due to the COVID-19 pandemic.

Based on these latest plans from airports, less than half a million flights will not be accommodated in

the most-likely scenario because of a lack of capacity at those airports.

As shown in Figure 7, without this 'capacity gap', the number of flights would be about 3% higher than our forecast. The capacity gap is wider in the *High* scenario, with 2.7 million flights unaccommodated, in other words 12% of the demand would not be fulfilled. At the other end, there is no capacity gap in the *Low* scenario. The size of this capacity gap has considerably reduced compared to our previous forecast (see Ref. 1), as the impact of the COVID-19 outbreak has delayed flight growth by approximately 10 years in the most-likely scenario. Whereas flight growth has lost ten years, the capacity gap would now be fifteen years behind for the *Base* scenario forecast as compared to the previous forecast (see Ref. 1).

Indeed, half a million flights were expected to be unaccommodated in 2035; and now in 2050 for the most-likely scenario.

² In 2019

³ 'Country' here corresponds to a flight information region (e.g. Montenegro and Serbia are combined).

Figure 7. Demand exceeds capacity by less than half a million flights in 2050 across the network in the base scenario, climbing to 2.7 million (12%) in the high-growth scenario

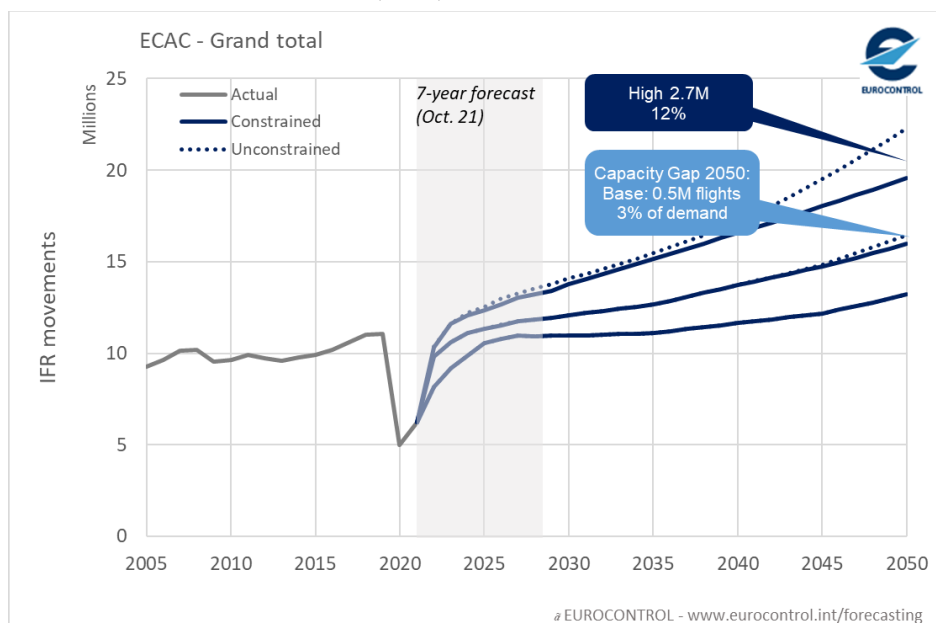


Figure 8 summarises where there is more demand for flights than there is capacity in 2050. Airports in Germany, Hungary, Netherlands, Norway and Spain will see less than 100,000 flights unaccommodated (each) in the most-likely scenario. Airports in Turkey will see a gap of more than 200,000 flights in the same scenario. The challenge is now reduced to a number of airports in six different States in the most-likely scenario, compared to seventeen in the previous forecast (see Ref. 1).

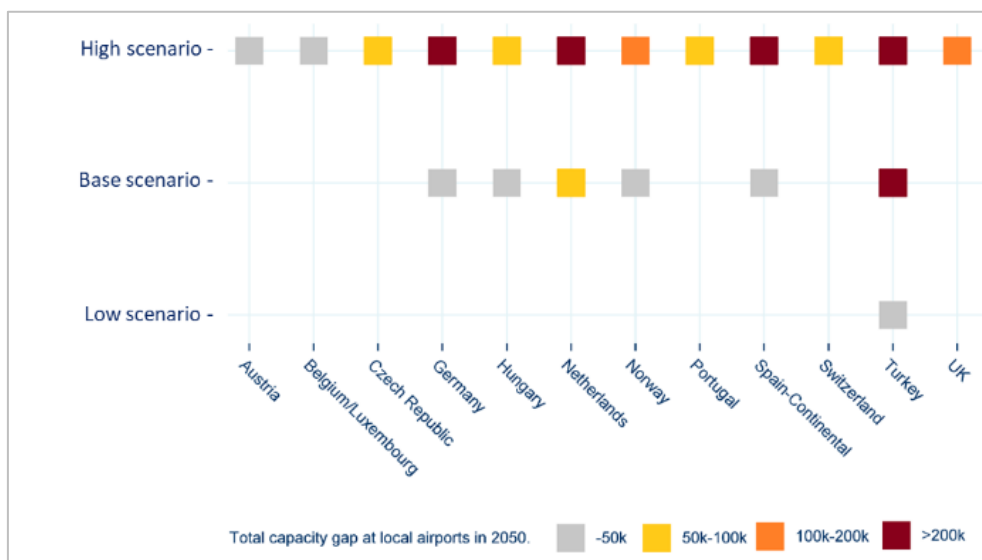
France, Greece, Ireland, Italy and Poland no longer appear in the *Base* scenario. Some airports in

France and Italy anticipate that more capacity (compared to the previous forecast) could be made available from 2035.

Other airports have neither changed nor reduced their plans, but flight growth has slowed down after COVID-19, so that airport capacity constraints are not necessarily “limiting” demand as they used to.

However, Turkey remains highly constrained, in all three scenarios, as in the previous forecast, in spite of heavy investments in capacity, as growth of this rapidly-maturing market is widely spread around its airports.

Figure 8. In the most-likely, *Base* scenario, there is a capacity gap at airports in six countries, down from seventeen in the previous long-term forecast



MARKET SEGMENTS

The distribution of traffic per market segment⁴ is expected to remain relatively stable over the next 30 years (Figure 10). All-cargo, accounting for the smallest share of traffic in 2019 (amongst the three market segments shown here) will see the highest increase in all scenarios. The segment will benefit from the strong economic growth in the Middle East and Asia/Pacific regions.

Passenger flights will grow by 1.8% per year in the *High* scenario (Figure 9), maintaining a 90% share of flights throughout the next 30 years. The passenger segment will have a slight reduction of market share (2 pp) in the remaining two scenarios. We discuss numbers of passengers in the next section.

Business aviation is expected to grow at an average rate of 1.4% per year between 2019 and 2050 in the most-likely scenario.

Its growth rate over the period does not vary significantly per scenario. The segment will be particularly affected by airport capacity constraints at the end of the horizon on the *High* scenario.

Figure 10: Distribution of flights per Business Aviation, All-Cargo and Passenger Market Segments.

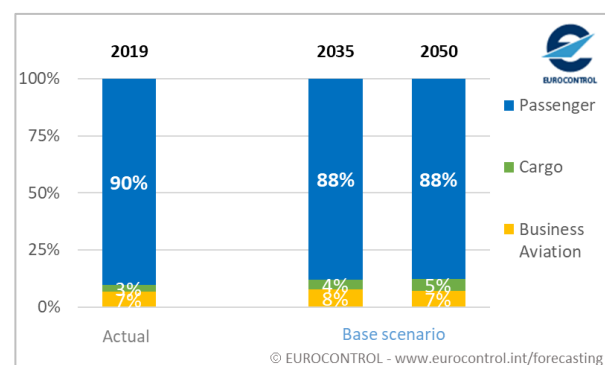


Figure 9: Average Annual Growth rates per market segment based on all European IFR movements between 2019 and 2050

Average annual growth rate 2050/2019 (%)			
IFR flights	Passenger	Business Aviation	All-cargo
<i>High scenario</i>	1.8%	1.4%	3.0%
<i>Base scenario</i>	1.1%	1.4%	2.9%
<i>Low scenario</i>	0.4%	1.1%	2.0%

PASSENGER FORECAST

The passenger market segment accounts for by far the greatest share (Figure 10) of flights. This segment is classically looked at in terms of number of passengers or revenue passenger kilometres (RPK). In 2019, while passenger flights increased by 1.2% in Europe, the number of passengers at Europe's airports grew by 7.6% in RPK terms (compared to 2018). The amplified magnitude of the passenger rates (RPK) compared to the flights is partly due to the general trend in longer flights and larger aircraft, as well as an increase in load factors. More recently, passenger flights decreased by 61% in 2020 due to the COVID-19 outbreak and the corresponding RPK collapsed (-74% compared to 2019).

Based on Eurostat data at airport pair level, together with an analysis of the Eurostat flows and

of the data from EUROCONTROL, an estimated number of passengers on board have been derived. In 2019, the number of passengers in ECAC is estimated at 1.32 billion in our statistics⁵. By 2050, the number of passengers in ECAC is expected to reach 1.88 billion in the *Base* scenario, corresponding to an average growth rate of 1.2% per year, or 1.6% p.a. in RPK terms.

In the *High* scenario, the number of passengers in ECAC is expected to grow to 2.23 billion in 2050, corresponding to an average annual growth rate of 1.7% between 2019 and 2050.

In the *Low* scenario, the number of passengers in ECAC in 2050 is expected to remain comparable to 2019.

⁴ For the purpose of this report the passenger market segment includes flights from Traditional Scheduled, Low-Cost and Charter airlines. STATFOR Doc 683 08/04/2022

⁵ Departing passengers traffic only.

HIGH SPEED TRAIN AND NIGHT TRAINS IMPACT

The high-speed train (HST) travel times have been updated for this forecast, as future projects will have an impact on the air travel demand. A review of the current status of future projects has been done; the principal source being specialised websites for rail industry professionals (UIC) and dedicated HST projects websites (e.g. railbaltica.org).

Given the length of the forecast horizon and the growing environmental concerns that push to transfer from air travel to alternative modes, an optimistic approach with a number of projects covering 66 city-pairs in the *High* scenario and 56 city-pairs in the remaining scenarios has been considered (the previous long-term forecast only considered 21 city-pairs).

If the benefits of travel time can play an obvious part in the case of high-speed train, slower train links have also been considered that could gain market share in the longer term. The focus was put on night trains, which can easily operate on the existing track network. Based on other dedicated websites (e.g. interrail.eu), 29 city-pairs were identified as plausible candidates. A constant impact has been assumed for every line in terms of passengers: 10% of the market share from air to rail in the *High* scenario, 6% in the *Base* scenario and no impact in the *Low* scenario (as limited investments are made in this latter scenario).

Due to more passengers opting for high-speed train and night train instead of travelling by air, the unconstrained⁶ demand for flights (in principal short-haul) is expected to be reduced by less than 1% in Europe by 2050 in the most-likely scenario, with similar impact on the other scenarios. The high-speed train network and night train offer do not develop in all parts of Europe to the same extent.

Even if the train networks are cross-border, the States with more projects in the pipeline are likely to see a stronger reduction in demand for flights by 2050, such as Sweden (-8.5% in the most-likely scenario), UK (-1.5%), France (-1.3%), Spain (-0.8%), Portugal (-3%) and Austria (-2.6%).

ECAC AND OTHER REGIONS

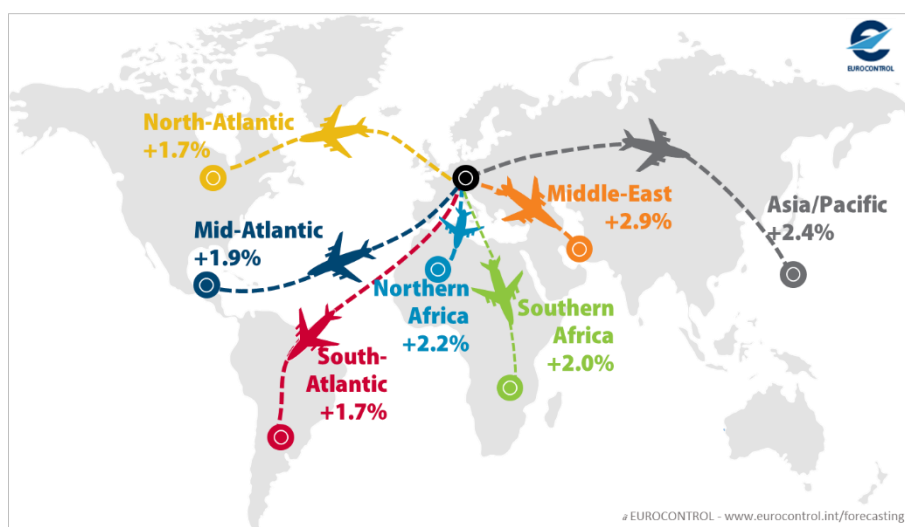
Figure 11 shows that the Middle East and Asia/Pacific regions will be the most dynamic partners by 2050: the average annual growth rate for flights departing ECAC to these regions is likely to be respectively 2.9% and 2.4% per year in the *Base* scenario.

More mature markets will record moderate growth; for example, the North Atlantic is expected to grow at an average rate of 1.7% per year.

Middle East arrivals and departures will become the busiest external flow by 2050, taking the position of the North Atlantic in all three scenarios. In the *High* and *Base* scenarios, the traffic to/from that region is set to exceed one million flights.

China and India will be the countries adding more flights on the Asia/Pacific flows with annual growth of 2.1% and 3.1% (*Base* scenario). As for the Middle East flows, Israel and the United Arab Emirates will be the main traffic generators by 2050, with annual growth of 3.2% and 2.8% throughout the forecast period in the most likely scenario.

Figure 11: Average Annual Flight Growth Rates from Europe (ECAC) to World regions 2019-2050 - Base scenario.



⁶ A fair comparison implies to compare the forecasts before the capacity constraints.

3. CO₂ EMISSIONS FORECAST TO 2050

Our three scenarios include assumptions about how aviation rises to the sustainability challenge: through improvements to existing aircraft and engines, but also by making radical changes in aircraft design and propulsion. This includes large-scale switching to use of sustainable aviation fuels (SAF, see Section 4.3), consistent with and indeed sometimes exceeding the proportions of SAF currently foreseen in EU “Fit for 55” regulations. These assumptions differ significantly between scenarios. For example, in the *High* scenario, investment both within aviation and beyond pays off with SAF more widely available and cheaper, and new aircraft types available sooner. In the *Low* scenario, weaker aviation growth means that airlines and manufacturers are less able to invest in overhauling the fleet.

These assumptions affect the price of flying, and hence demand. This has already been taken into account in the flight forecast just described. But they also allow us to estimate the net CO₂ emissions from those flights.

For this forecast, we focus on how new aircraft types and the switch from kerosene to SAF together reduce the CO₂ emissions from flying. There will also be fuel efficiency improvements and CO₂ savings from improvements in air traffic management and aircraft operations (see EUROCONTROL Objective Skygreen, Ref. 4).

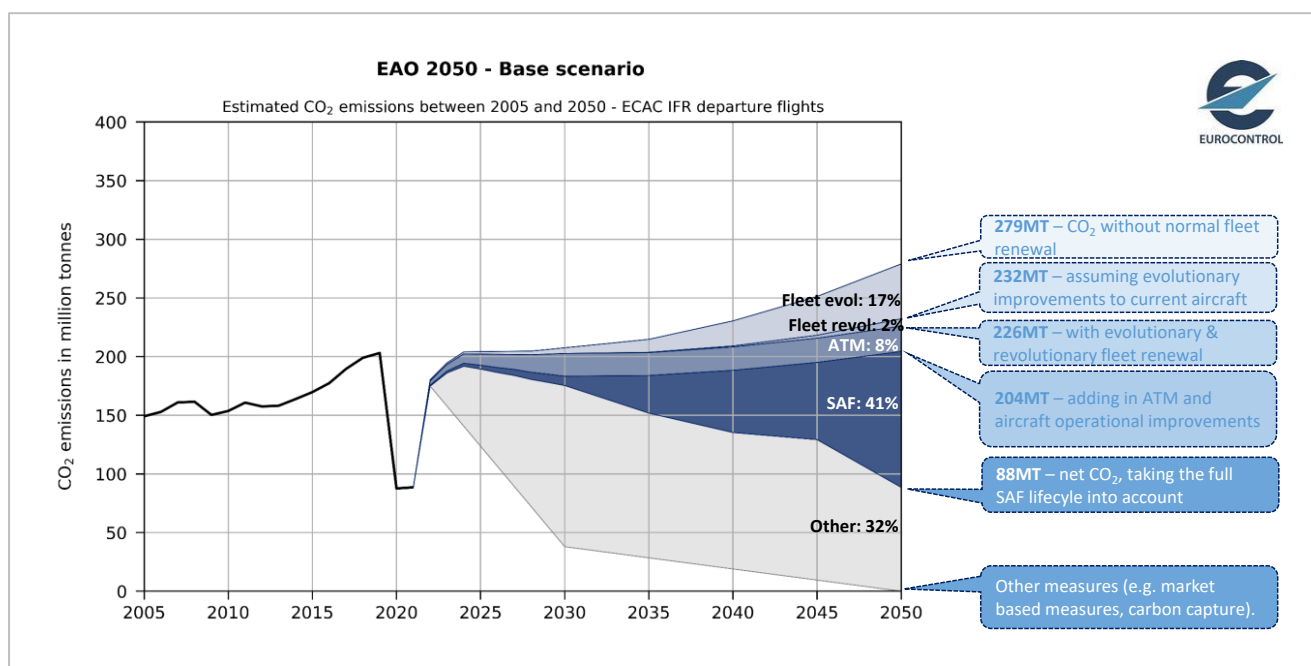
On this basis, Figures 12 to 14 show the CO₂ forecast⁷ for the three scenarios only addressing departing flights, estimated for the entire trajectories. The figure show clearly the impact of being able to invest in renewing the fleet, in that the three scenarios change places by 2050.

In the most-likely *Base* scenario (Fig 12), net CO₂ emissions fall to around 40% lower than 2005 levels by 2050. The majority of these savings are obtained by the use of SAF. New aircraft types do come into service and deliver CO₂ savings, with electric propulsion over some distances, and hydrogen over slightly longer distances, but they are still relatively new and not a dominant part of the fleet by 2050 (see Section 4).

The *Low* scenario (Fig 13) has the fewest flights in 2050. Net CO₂ is reduced at around 46% lower than 2005, the highest of the three scenarios. Less SAF is available, and it is more expensive due to demand from other sectors. Higher ticket prices have reduced demand, but there is less scope for radical re-shaping of the fleet.

The *High* scenario (Fig 14) shows more than twice as many flights in 2050 than in 2005, but net CO₂ is significantly reduced by around 65% compared to of 2005 volumes. In addition to widespread use of SAF, this scenario sees wider and earlier adoption of new aircraft types, although even then by 2050 the changes to the fleet are only partly revolutionary, and part evolutionary (see Fig 18).

Figure 12. By 2050, CO₂ emissions, net of SAF, fleet and operational improvements, are reduced by about 41% compared to 2005 in the *Base* scenario.



⁷ As is normal with CO₂ forecasts, we report emissions for all flights departing airports in the region, here ECAC airports. This therefore excludes arrivals from out-of-area and overflights.

Figure 13. By 2050, CO₂ emissions, net of SAF, fleet and operational improvements, are reduced by about 65% compared to 2005 in the **High** scenario.

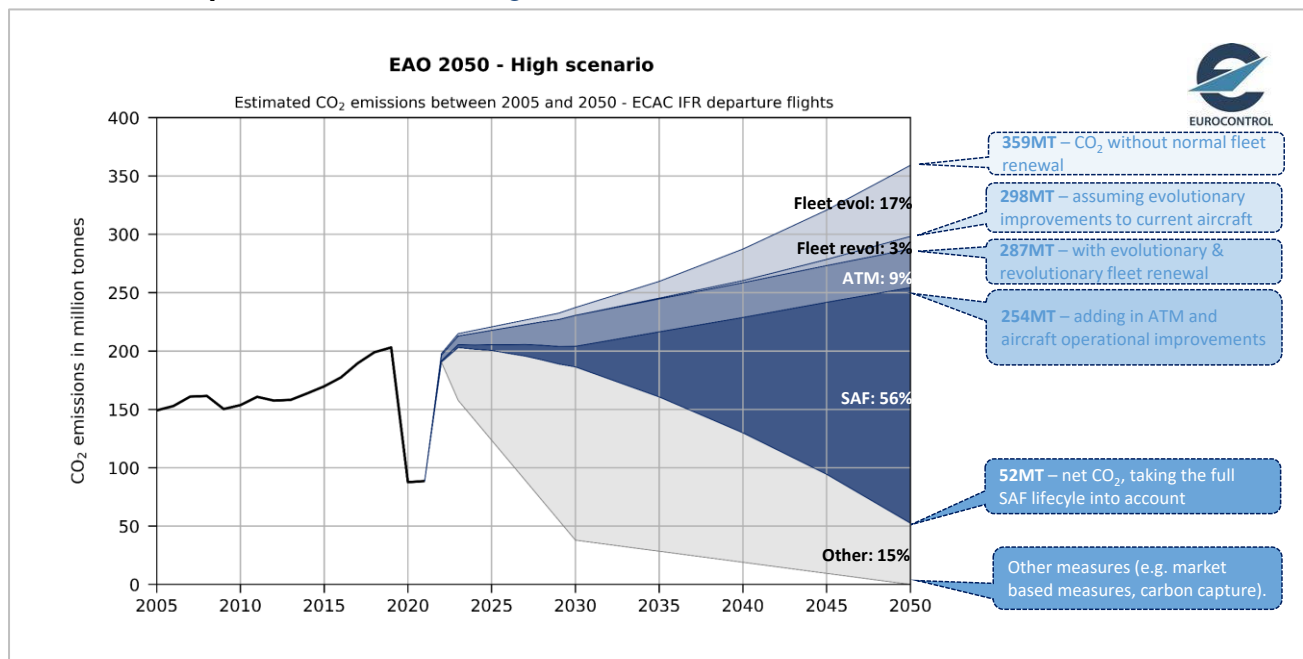


Figure 14. By 2050, CO₂ emissions, net of SAF, fleet and operational improvements, are reduced by about 46% compared to 2005 in the **Low** scenario.

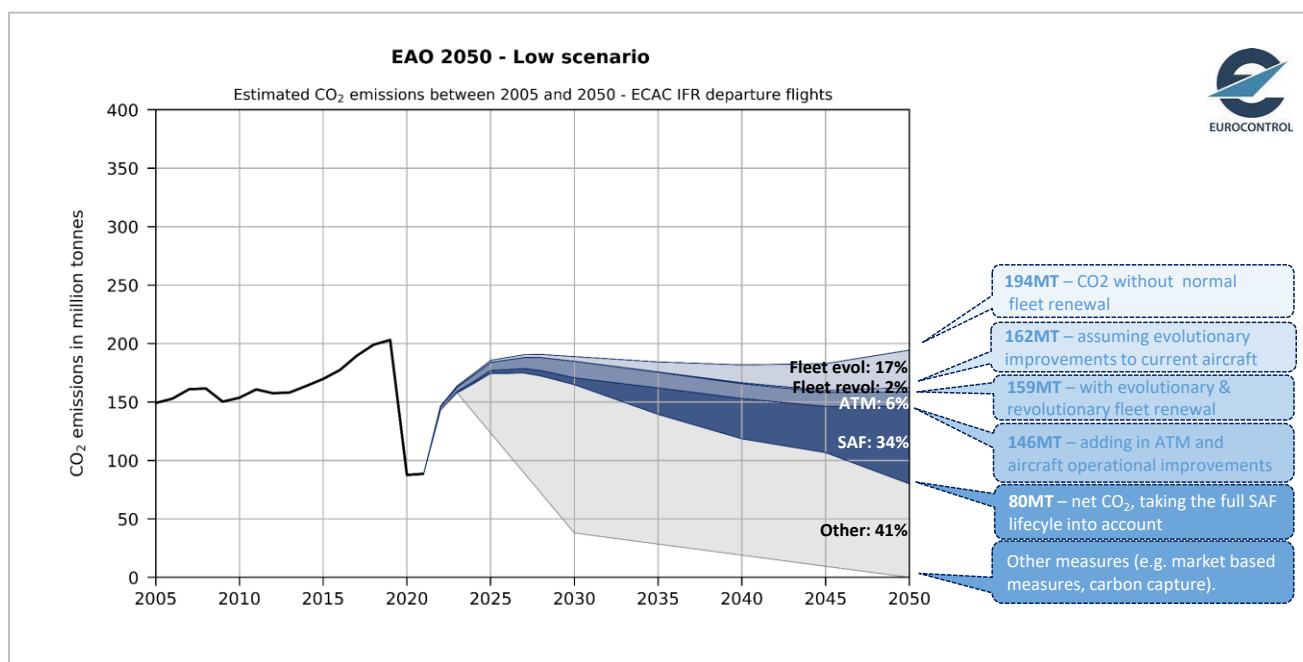


Figure 15 summarises the results for each of the 3 scenarios. It shows the relative share of each means to decarbonise aviation as well as the relative stability of the share of fleet evolution and fleet revolution across the 3 scenarios. It also shows the critical importance of SAF which is by

far the main means contributing to reaching net zero CO₂ emissions. In all our scenarios, market-based measures will still be needed in 2050 to fully decarbonise aviation.

It is therefore critical to use all possible means to develop SAF fuels.

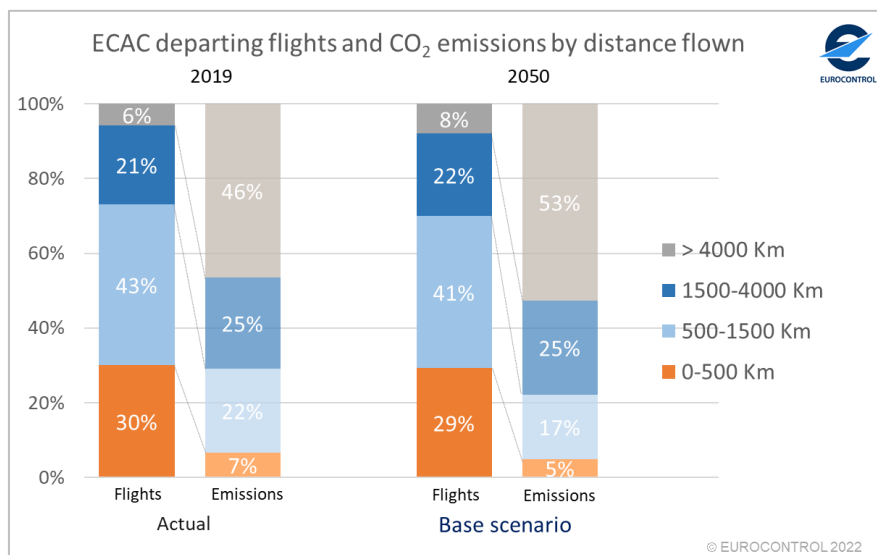
Figure 15. Summary of net zero CO₂ results for each scenario.

Net zero CO ₂ can be achieved by 2050 via the following:	Low Scenario	Base Scenario	High Scenario
Required CO ₂ reduction for Net zero	194MT	279MT	359MT
Fleet evolution: More efficient conventional aircraft	17%	17%	17%
Fleet revolution: Electric & hydrogen powered aircraft	2%	2%	3%
ATM: Better air traffic management and airline operations	6%	8%	9%
Sustainable Aviation Fuels	34%	41%	56%
Other measures: Market-based measures, carbon capture	41%	32%	15%

We have reported in a [data snapshot](#) how a small minority of flights, those over 4,000km, are responsible for around half of CO₂ emissions. All three scenarios forecast that the share of long-haul flights will increase by 2050. Over this time horizon, it will remain difficult to substitute for long-haul flying, so the CO₂ efficiency of SAF will be key.

Over shorter distances, there are substitutes; we discuss high-speed rail and night trains, for example, in Section 2. Even with substitute travel modes, the *Low* scenario actually forecasts an increasing share of very short-haul flights (less than 500km) driven, in part, by the arrival of electric aircraft with fewer seats, hence increasing frequencies, but not increasing the share of CO₂.

Figure 16. Long-haul continues to be the source of the majority of CO₂ emissions timeline in the all scenario (including the base).



4. KEY FACTORS FOR THE MOVE TOWARDS SUSTAINABILITY BY 2050

A variety of approaches to reducing the emissions effects of aviation have been identified, ranging from new fuel sources (biofuels or power-to-liquid fuels, collectively referred to as sustainable aviation fuels or SAF; hydrogen in fuel cells or directly combusted; battery electric; or hybrid-electric) as well as operational measures and policy measures. For short-haul flights, 9 and 19-seat aircraft will start paving the way for sustainable aviation in the 2025-30 timeframe, while new propulsion technology, hybrid-electric or hydrogen, could serve slightly longer segments of air travel in the *Base* scenario by the 2040 timeframe. These fleet and fuel-related improvements are discussed further in this section.

Over the next ten years, aviation expects to unlock the potential of Unmanned Aircraft Systems (drones operating as IFR) and supersonic aircraft. However, these future projects have not been included in this forecast.

4.1 Fleet and technology development

The development and deployment of new and more efficient aircraft are key to reduce CO₂ emissions induced by the aviation industry. The successful roll-out of these more efficient aircraft is conditioned on four elements:

1. The successful development of the necessary technologies to equip the revolutionary new type of aircraft (batteries with high energy density, H₂ efficient storage, new engines, new design),
2. A certification process for the new types of

technologies likely to be deployed on the new types of aircraft (H₂, hybrid electric, full electric),

3. The industrialisation of an efficient and cost-effective production process and the availability at airports of these three additional sources of aircraft energies,
4. An efficient production process supported by a sustainable supply chain and the availability of ad hoc financial conditions to support airlines to deploy more efficient aircraft in their fleets.

We consider that a proactive fleet renewal effort is key to achieve significant CO₂ emissions reduction.



We make the assumption that by 2050, in the *High* scenario, 12 types of aircraft will be rolled out from 2025 to 2050. We based this on the review of the different aircraft projects currently in progress, the analysis of the technology progress and their availability. We also benefited from the insights of various stakeholders in the aircraft manufacturing industry. These assumptions are developed below.

NEW TYPES OF AIRCRAFT

Figure 17 presents the new projects considered in

Figure 17. New types of aircraft - Entry Into Service Year timeline per scenario.

New type of aircraft	Size	Technology	Range	Aircraft segment	2025	2030	2035	2040	2045	2050
Electric aircraft (2 versions)	9 19	Revolutionary	Very short Short	Turboprop	●	●	✱			
Turboprop with regional jet specificities / capabilities	70	Evolutionary	Short & Medium	Turboprop		●				
Turboprop with regional jet specificities / capabilities	90	Evolutionary	Short & Medium	Turboprop		●	●			
Hybrid electric	30-40	Revolutionary	Very short & Short	Turboprop		●	●	✱		
Conventional aircraft (re-engined and upgraded)	170	Evolutionary	Medium & Long	Single aisle		●				
Wide body aircraft (re-engined and upgraded)	300	Evolutionary	Long	Wide body		●	●	✱		
Regional jet (re-engined and new aircraft design)	145	Evolutionary	Medium	Regional jet			●	✱		
Electric regional aircraft	100	Revolutionary	Short	Regional jet			●	●		
Hybrid electric (H ₂ fuel cells)	70	Revolutionary	Short	Turboprop			●			
Hybrid electric H ₂	200	Revolutionary	Medium	Single aisle			●	●	✱	
Blended wing body H ₂ aircraft	140	Revolutionary	Medium	Single aisle			●	●	✱	
New version of the A220	150	Evolutionary	Medium & Long	Regional jet				●		

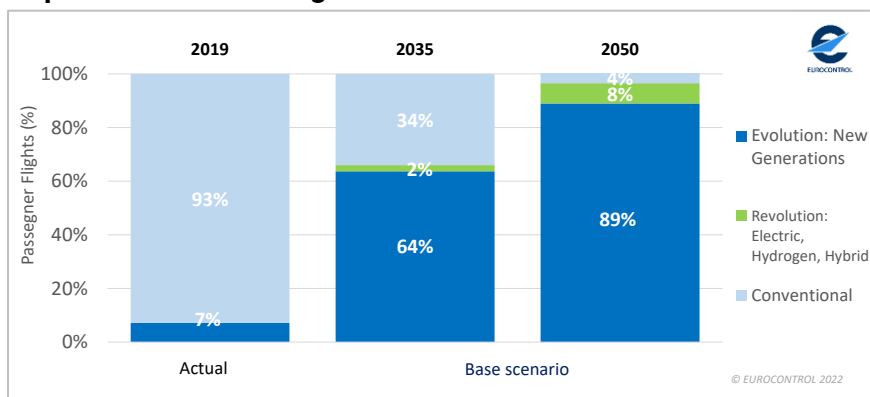
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the forecast, both evolutionary and revolutionary, that will come on top of the conventional fleet and aircraft programmes currently available on the market.

From 2025 to 2035

We first expect that six types of aircraft will take off in these ten years. These aircraft are divided into two categories, the *revolutionary* types of new aircraft and the *evolutionary* ones. The first revolutionary ones to be rolled out are nine-seater electric aircraft in 2025 followed by a nineteen-seater version in 2030⁸ and a 30-to-40 seater hybrid-electric aircraft (also in 2030). A new electric regional jet may follow, setting new

Figure 18. Forecast mix of aircraft in future years, based on the expected number of flights



standards of energy efficiency thanks to its conception (but with a limited range). The successful roll-out of these three new types of aircraft is heavily reliant on progress made on battery energy density and on access to battery raw materials.

More efficient conventional aircraft will be also rolled out such as two different turboprops with regional jet characteristics and capabilities, new wide-body aircraft potentially replacing current A350 or B787, and new single aisle aircraft. We expect the last two aircraft to achieve around 15% fuel efficiency improvement compared to the previous generation of aircraft.

From 2035 to 2050

During this period, we expect six new types of aircraft to enter into the airline fleet. Amongst these six aircraft, two are the evolution of a conventional narrow-body aircraft to achieve improved efficiency but the four other ones are *revolutionary* new types of aircraft.

One hydrogen hybrid-electric single-aisle aircraft

and two hydrogen aircraft (coming from both the current concepts developed by Airbus and the Universal Hydrogen conversion kits). Figure 18 summarises how these expectations affect the mix of aircraft in the fleet, for each scenario in 2035 and 2050.

4.2 Operational improvements

Operational improvements cover air traffic management (ATM) and aircraft operations. In the short to medium term, operational measures improving aircraft fuel efficiency are key and can be considered “low hanging fruit” in the route to net zero carbon emissions. They include optimising flight efficiency (e.g. flying more fuel efficient trajectories), introducing specific operational measures that reduce fuel burn (reduce holding and taxi times), and minimising fuel burn in aircraft operations in all phases of flight (e.g. through better aircraft weight management and optimising fuel management practices). In the medium term, SESAR 3 and the Digital European Sky input will help to deliver these benefits.

All the details related to optimised flight trajectories from 2021 to 2030 can be found in EUROCONTROL Objective Skygreen (See Ref. 4).

4.3 Sustainable Aviation Fuel

Sustainable aviation fuels are the most promising pathway to decarbonisation. Unlike other pathways, SAF, being a 'drop-in' type of fuel, can be used without changes to aircraft and airport infrastructure and can be the leading edge of how we travel for all distances (short to long-haul).

While electric and hydrogen systems have the potential to be ‘true-zero’ carbon solutions, usage of SAF has no bearing upon exhaust CO₂ emissions⁹. The CO₂ savings estimates come when the full lifecycle is taken into account (net CO₂). SAFs vary in their saving, but a typical value is an 80% reduction compared to fossil-based aviation fuel.

The faster that production and use are scaled up, the faster aviation decarbonises. In that context, the European Commission’s ‘Fit for 55’ (see Ref. 5) climate package, integrating the ReFuelEU

⁸ Eviation Alice, Aura Aero ERA aircraft, Heart Aerospace.

⁹ Although SAF can also reduce NOx emissions – this is outside the scope of this study.

Aviation proposal, is an instrumental booster for the uptake of SAF. This outlook considers that the EC's proposal, i.e. a blending obligation commencing from 2025 at 2% SAF, gradually increasing to 63% in 2050 and including a sub-obligation for synthetic aviation fuels starting in 2030 with 0.7% and progressively getting to 28% of e-fuels in 2050, will apply to the *Base* scenario. The *Low* scenario considers a less proactive approach with 1.6% in 2025, 4% in 2030 and 50% blending in 2050. Finally, the *High* scenario considers that there is sufficient feedstock and potential production capacity in Europe to meet 10% of all demand in 2030, commencing from 2.8% in 2025 and reaching 88% in 2050.

SAF costs considerably more to produce than fossil jet fuel. Due to high price pressure, currently low SAF demand and policy uncertainty, although the proposed blending mandate gives guarantee that there should be a market, there is a great deal of uncertainty about SAF costs. Uncertainty in cost has been quantified by the use of ranges of cost for the different technology pathways considering cost of feedstock and availability, capital investments and costs driven by the cost of green hydrogen production as well as carbon capture.

More details related to blending, production outlook, costs and net savings can be found in EUROCONTROL Objective Skygreen (see Ref. 4).

4.4 Market-based measures

Market-based measures (MBM) ensure or incentivise the reduction of aviation emissions, either directly or indirectly. They are complementary, in that they cover the gap when other measures (such as the new aircraft technology and SAF, just described) would not permit the targets to be met. MBM allow, or require, aircraft operators to balance some of their CO₂ emissions by paying for CO₂ savings elsewhere.

This forecasting exercise accounted for the various effect of the measures envisaged such as the latest EU proposal from the "Fit for 55 Package" (see Ref. 5) and the current ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Here we describe two major market-based measures: the EU's ETS and CORSIA.

EU EMISSIONS TRADING SYSTEM (EU ETS)

The EU ETS applies to flights operating within the

European Economic Area (EEA: EU27, Iceland, Liechtenstein, Norway), both domestic and international. The revision of the ETS directive¹⁰ defines the ETS and CORSIA implementation mechanisms under the umbrella of the EU Green Deal, with the aim of achieving at least a 55% net reduction in greenhouse gas emissions by 2030.

The revised directive is expected to tighten the existing rules: accelerating the reduction of availability of ETS allowances from 2.2% to 4.2%; and reducing the allowances provided for free to aircraft operators by 25% every year from 2024, leaving no free allowances for aviation from 2027.

CORSIA

ICAO's CORSIA aims to stabilise CO₂ emissions at 2019 levels. It applies from 2019 until 2035, with reporting-only in 2019 and 2020, and offsetting of emissions above the baseline from 2021. It covers international civil aviation emissions between ICAO Member States (excluding domestic). It is likely that the EU will exempt airlines of CORSIA offsetting where ETS applies.

Further details related to ETS and CORSIA implementation can be found in EUROCONTROL Objective Skygreen (see Ref. 4).

In the forecast, we combine these market-based measures costs (Section 4.4) together with SAF prices (Section 4.3) and jet fuel prices to get estimates of future total fuel prices. Depending on the scenarios, the prices range from [€550-€1,100] per tonne in 2025 to [€1,000-€1,500] per tonne in 2050.

4.5 Net zero CO₂ emissions by 2050

Increasingly large sections of the aviation industry are committing to the ambitious goal of net zero CO₂ emissions from flights by 2050 (see Ref. 6, 7) in light of the Paris Agreement. In particular, European states, European aviation and regulators are also committing to and planning for net zero. As recently as February 2022, and following the EU Aviation Summit on decarbonising the air transport sector, the European Commission, the 27 EU Member States, and 10 other ECAC Member States reaffirmed their commitment for achieving carbon neutrality in the air transport sector by 2050 (the "Toulouse Declaration"). The "Destination 2050" report (see Ref. 7) describes one route to net zero by 2050 as estimated by the European aviation industry.

¹⁰ Commission proposal COM (2021) 551.

This EUROCONTROL Aviation Outlook addresses a broad range of potential futures through three scenarios for European aviation. Each includes in-sector innovation that reduces net CO₂ emissions: new versions of current aircraft and engines; revolutionary changes in aircraft type and propulsion, electric, hybrid-electric and hydrogen (Section 4.1); improvements to air traffic management and aircraft operations (Section 4.2); and the switch to sustainable fuels (Section 4.3). As Destination 2050 found, these get us much of the way to net zero, but not all of the way.

The remaining step involves out-of-sector initiatives, or market-based measures (Section 4.4). This means purchasing out-of-sector reductions in CO₂ which, by 2050, will increasingly mean carbon capture.

In the *High* scenario, those remaining measures need to cover 17 million tonnes of CO₂, similar to Destination 2050. In the *Base* scenario, the need is around 40 million tonnes.

There are other differences between this EUROCONTROL Aviation Outlook and “Destination 2050”. For example, even the *High* scenario sees more modest CO₂ reductions from hydrogen aircraft by 2050. The *High* scenario is an ambitious scenario building on aircraft and propulsion projects that we see in development. But in 2050 the hydrogen and electric powered aircraft in our scenarios have relatively short range, while most CO₂ emissions are in long-haul (Figure 16). Perhaps future technologies, beyond SAF, will be able to meet the long-haul need, but that goes beyond this Outlook.

5. CONCLUSIONS

Mostly because of COVID-19 and the resulting downturn, flight growth in Europe will have lost 10 years compared to our previous long-term forecast: in the most-likely scenario there will be 16 million flights in Europe in 2050, 44% more than in 2019, or an average growth of +1.2% per year. Other possible scenarios surrounding the most-likely (19.6 million flights and 13.2 million flights by 2050) are also discussed.

We forecast that a small minority of flights, those over 4,000km, remain responsible for around half of CO₂ emissions, and in all scenarios the share of long-haul flights increases by 2050. Over shorter distances, there are substitutes; we discuss high-speed rail and night trains, for example, in Section 2. However at this time horizon, it will remain difficult to substitute for long-haul flying, so the CO₂ efficiency of SAF will be key.

The EUROCONTROL Aviation Outlook to 2050 scenarios reflect the fact that, if aviation is stronger, then it is better able to invest in more efficient technologies. It also reflects the fact that those technologies (including electric and hydrogen-powered aircraft) still seem likely to be

best for shorter haul, rather than longer-haul, travel. CO₂ improvements by 2050 from revolutionary aircraft changes, therefore, remain modest (2% to 3% in 2050); industry and regulators will need to find ways to boost investment to improve on this. As other studies have found, the final step to reaching net zero CO₂ therefore needs ‘out of sector’ measures such as carbon capture.

No single solution will enable aviation to achieve net zero CO₂, but in all scenarios here it is the scaling up of the production, distribution and use of SAF that makes the major contribution in the long term, with operational improvements helping more immediately.

The most sustainable outcomes require the aviation industry to work with governments to ensure that the right investments and suitable regulations can be and are being made, within aviation and beyond.

This report will be complemented by the EUROCONTROL Objective Skygreen report, which looks in much more detail at the elements leading to cutting emissions by 55% by 2030 compared to 1990 levels.

A. Input assumptions

To structure the uncertainty surrounding the possible outlook in the long term, some scenarios have been defined, with qualitatively-different representations of the many possible futures. Each scenario follows a specific path of events and developments that then drives the flight forecast.

These scenarios are characterised by specific assumptions expressed in the figures. Main assumptions are reproduced in Figure 19.

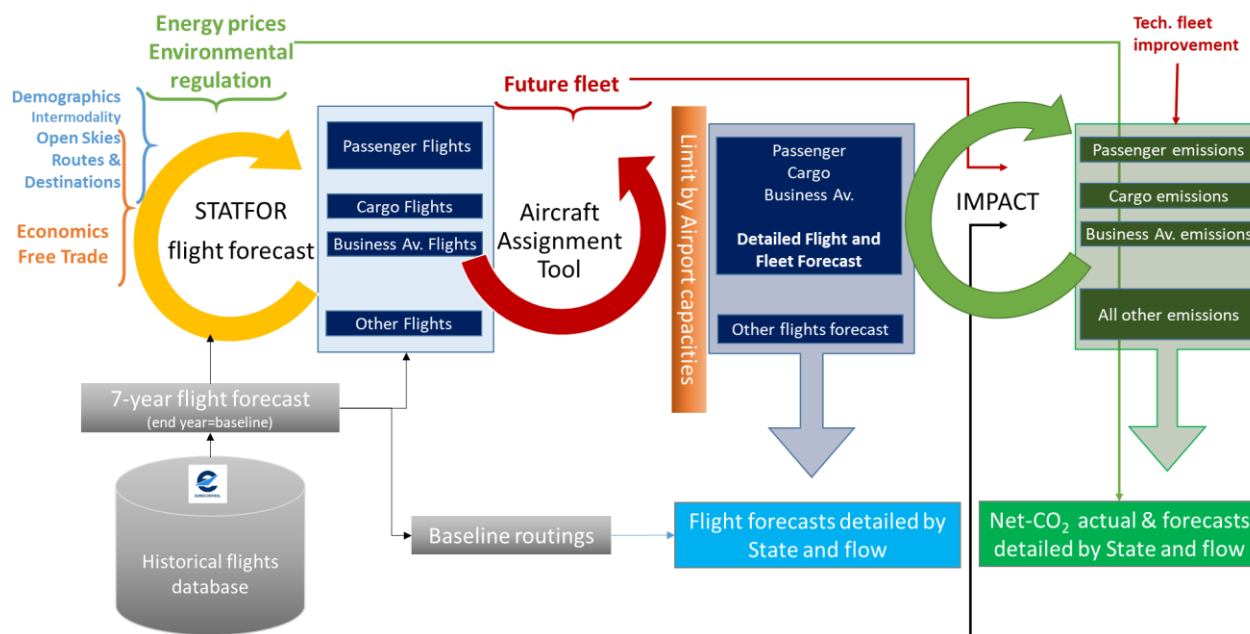
Figure 19. Summary of the input assumptions per scenario.

	High scenario	Base scenario	Low scenario
(EUROCONTROL 7-year forecast dated Oct. 2021): 2027 baseline	High ↗	Base →	Low ↘
Passenger			
Demographics (Population)	Aging	Aging	Aging
Routes and Destinations (summary)	UN Medium-fertility variant	UN Medium-fertility variant	UN Zero-migration variant
	Less short-haul (High-Speed Trains and Night Trains).	Maintained short-haul (High-Speed Train projects implementation delayed 2 years compared to plans and lower impact of Night Trains).	More short-haul (High-Speed Train projects implementation delayed 5 years, no Night Trains).
	High-speed rail (new & improved connections)	66 city-pairs, <i>implementation as planned</i> , with projects in Morocco and Poland	56 city-pairs, <i>implementation slightly behind plans (+2yr)</i>
Economic conditions			
GDP growth	Stronger ↗	Moderate → (baseline OE)	Weaker ↘↘
Free Trade	Global	Global	No additional benefits
Price of travel (2025/2050)			
Price of CO2 allowances	Low/High (63€/ 125€)	Moderate/Moderate (68€/120€)	High/Low (72€/115€)
Price of oil/barrel (jet fuel)	Low (59€/91€)	Moderate (60€/96€)	High (113€/168€)
Price of SAF	Low (942€/1000€)	Moderate (1162€/1155€)	High (1380€/1374€)
Change in other charges	noise: no change	noise: no change	noise: no change
	security: no change	security: no change	security: no change
(airline) Operating cost	Decreasing ↘↘	Decreasing ↘	slight increase ↗
Structure Network			
Long Haul, Medium Haul, Short Haul	Hubs: Europe (major hubs)↘, Turkey↗, Middle East ↗↗	Hubs: Middle East ↗↗ Europe&Turkey ↗	No change →
	Point-to-Point: N. Atlantic ↘	Point-to-Point: N. Atlantic ↗, European secondary airports ↗	
		N. Atlantic (major European hubs) ↘	
Market Structure			
Growth and replacement	Assumptions based on EUROCONTROL assumptions and CIRIUM fleet forecast (new programmes detailed below)		
Conventional (re-engining)	2 TP (drop-in up to 2045, then switch to non drop-in fuel), 3 Regional Jets (RJ), 4 Single Aisle (SA), 5 Twin-Aisle (TA)		
Electric - Hybrid - H2 (new build) ~"non drop-in fuel"	Earliest (as announced): small e-TP 9/29/35 seats by 2025/2030 + Electric RJ 100 seats + HybridElectric SA 200 seats + H2 project 140 seats + Hybrid Elec TP, all by 2035 + Electric/H2 TP 70/90 seats by 2045	A bit later (shifted 5 yrs): small e-TP 9/29/35 seats from 2030/2033/2035 + electric RJ 100 seats from 2040 + HybridElectric SA 200 seats by 2037 + H2 aircraft 140 seats by 2040	Later: small e-TP 9/29/35 seats by 2035/2040 + HybridElectric SA 200 seats by 2040 + H2 (Airbus) 140 seats by 2045
Retirement	Retirement curves varied by market segment classes (ie: All-cargo, Business Aviation and Passenger sub-classes), derived from historical trends over the past 50 years		
Availability of SAF			
Fuel mix	10% SAF - 90% Jet by 2030 49% SAF - 51% Jet by 2040 88% SAF - 12% Jet by 2050	5% SAF- 95% Jet by 2030 32% SAF - 68% Jet by 2040 63% SAF - 37% Jet by 2050	4% SAF- 96% Jet by 2030 26% SAF - 74% Jet by 2040 50% SAF - 50% Jet by 2050

B. Methodology

The EUROCONTROL Aviation Outlook uses a method relying on a model of economic and industry developments to grow airport-pair demand from the 7-year flight forecast 2021-2027 (October 2021, Ref.3) further into the future. An aircraft fleet forecast, in line with the initial flight forecast, is modelled for the main market segments using the Aircraft Assignment Tool. A final flight forecast is then derived, adjusted to take account of the effects of future airport capacity constraints. The flight forecast is then used by the IMPACT environmental modelling tool to forecast fuel burn and CO₂ emissions (Figure 20).

Figure 20. The flight forecast feeds the fleet forecasting tool, which is handed over to the emission modelling tool (IMPACT).



C. References

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- 6 [WAYPOINT 2050](#), International Air Transport Association (IATA) 1st edition September 2020.
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