

ICAO State Action Plan on CO₂ Emissions Reduction Activities in Sweden

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Author	Max Ohlsson
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1 COMMON INTRODUCTORY SECTION FOR EUROPEAN STATES' ACTION PLANS FOR CO₂ EMISSIONS REDUCTIONS

- a) Sweden is a member of the European Union and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States¹ 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 environmental concerns represent a potential constraint on the future development of the international aviation sector. Together they fully support ICAO's on-going efforts to address the full range of these concerns, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.
- c) Sweden, like all of ECAC's forty-four 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.
- d) Sweden recognises the value of each State preparing and submitting to ICAO an updated State action plan for CO₂ 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.
- e) In that context, it is the intention that all ECAC States submit to ICAO an Action plan. This is the action plan of Sweden.
- f) Sweden shares the view of all ECAC States that a comprehensive approach to reducing aviation CO₂ emissions is necessary, and that this should include:
 - 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 low-carbon, sustainable alternative fuels, including research and operational initiatives undertaken jointly with stakeholders,

¹ 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, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, Ukraine, and the United Kingdom

- 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 the Atlantic Initiative for the Reduction of Emissions (AIRE) in cooperation with the US FAA, 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 global goals. This sustainable growth becomes possible through the purchase of carbon units that foster emission reductions in other sectors of the economy, where abatement costs are lower than within the aviation sector.
- g) In Europe, many of the actions which are undertaken within the framework of this comprehensive approach are in practice taken collectively, throughout Europe, most of them led by the European Union. They are reported in Section 1 of this Action Plan, where the involvement of Sweden is described, as well as that of other stakeholders.
- h) In Sweden, a number of actions are undertaken at the national level, including those by stakeholders. These national actions are reported in Section 2 of this Plan.
- i) In relation to European actions, it is important to note that:
 - i. 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 to 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.
 - ii. Acting together, the ECAC States have undertaken 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, ETS).

1.1 Introduction - Current state of aviation in Sweden

Sweden is located in the north of Europe and is the third largest country in Western Europe with an area of 450 000 km². More than half of Sweden's area consists of forests, 10 % of mountains and approximately 8 % is cultivated land, lakes and rivers. The longest distance from the most northern point to the most south is 1 574 km and the longest east-west distance is 499 km². In size, Sweden is almost comparable to e.g. Spain and France.

Sweden has 10.2 million inhabitants, where 21 % of the population in Sweden are younger than 18 years old and about 19 % have passed the retirement age of 65.

Sweden has a population density of almost 25 inhabitants per square kilometers with the population mostly concentrated to the southern half of the country. Approximately 85 % of the Swedish population live in urban areas.³

Airports in Sweden

Today, there are 43 instrument flight rules (IFR) aerodromes in Sweden, and 38 of these are operated with commercial air traffic. Of the 38 with commercial air traffic there are 26 owned by municipalities, 10 are state-owned (by Swedavia) and two have other ownership structures e.g. limited liabilities. Swedavia AB⁴ was established in 2010 as a state owned company for airport operations.⁵

² www.sweden.se

³ <http://www.scb.se/>

⁴ www.swedavia.se/

⁵ Swedavia owns: 1) Stockholm-Arlanda, 2) Göteborg-Landvetter, 3) Malmö-Sturup, 4) Bromma-Airport, 5) Luleå-Airport, 6) Umeå-Airport, 7) Åre-Östersund Airport, 8) Visby Airport, 9) Ronneby Airport, 10) Kiruna Airport

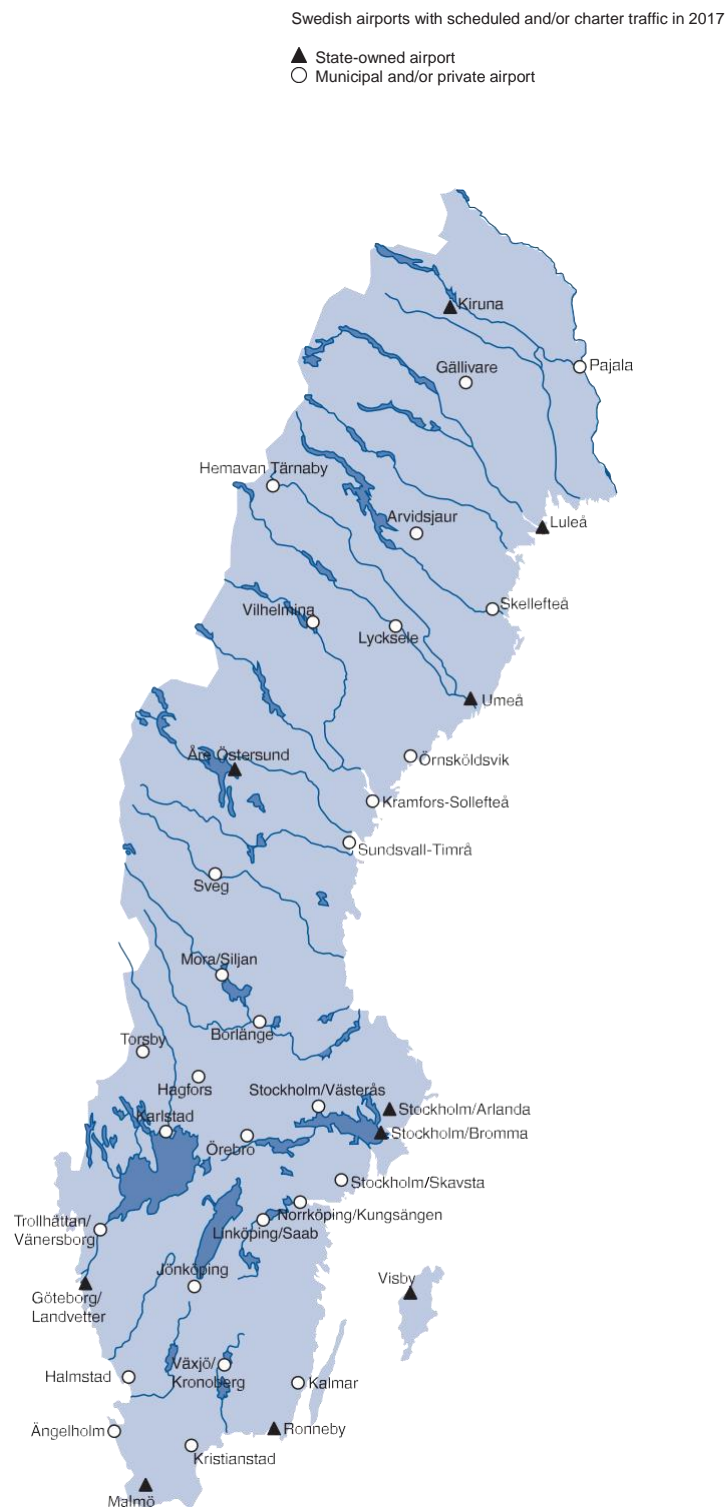
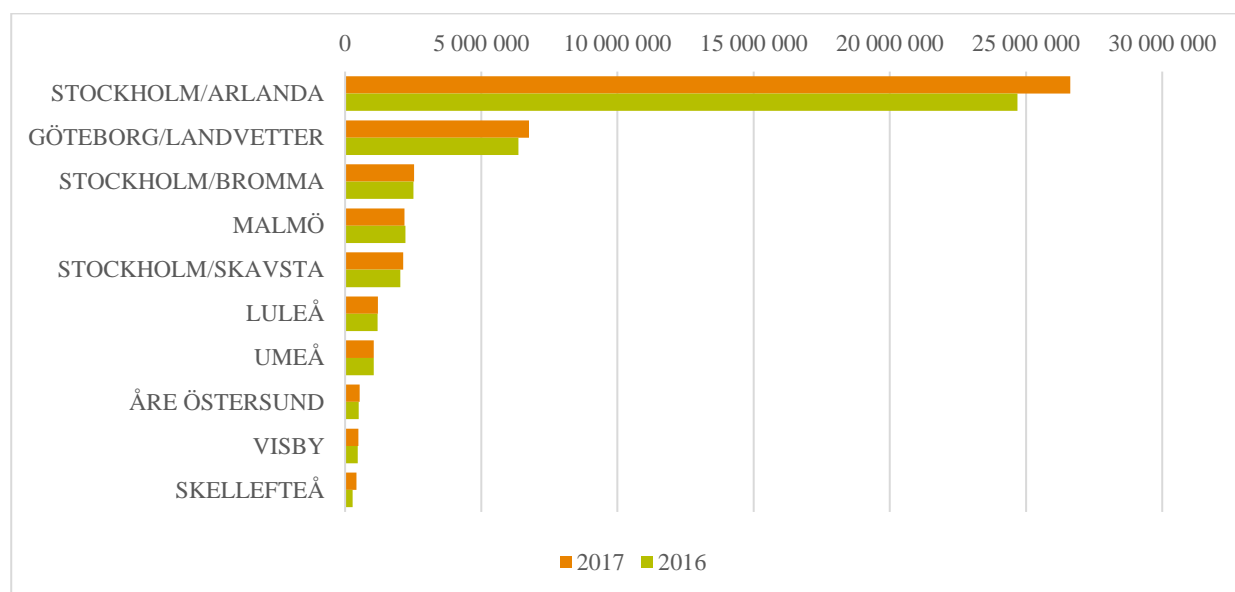


Figure 1. Swedish Airports 2017.

Top 10 airports regarding passengers

The largest aerodromes based upon departing and arriving passengers can be seen in figure 2 and 3. Approximately 26,6 million passengers travelled to or from Stockholm/Arlanda in 2017 and approximately 6,8 million to or from the second largest airport Göteborg/Landvetter. Eight of the airports among the “top 10 airports” are owned by Swedavia except Stockholm/Skavsta, which is privately owned and Skellefteå, owned by the municipality.

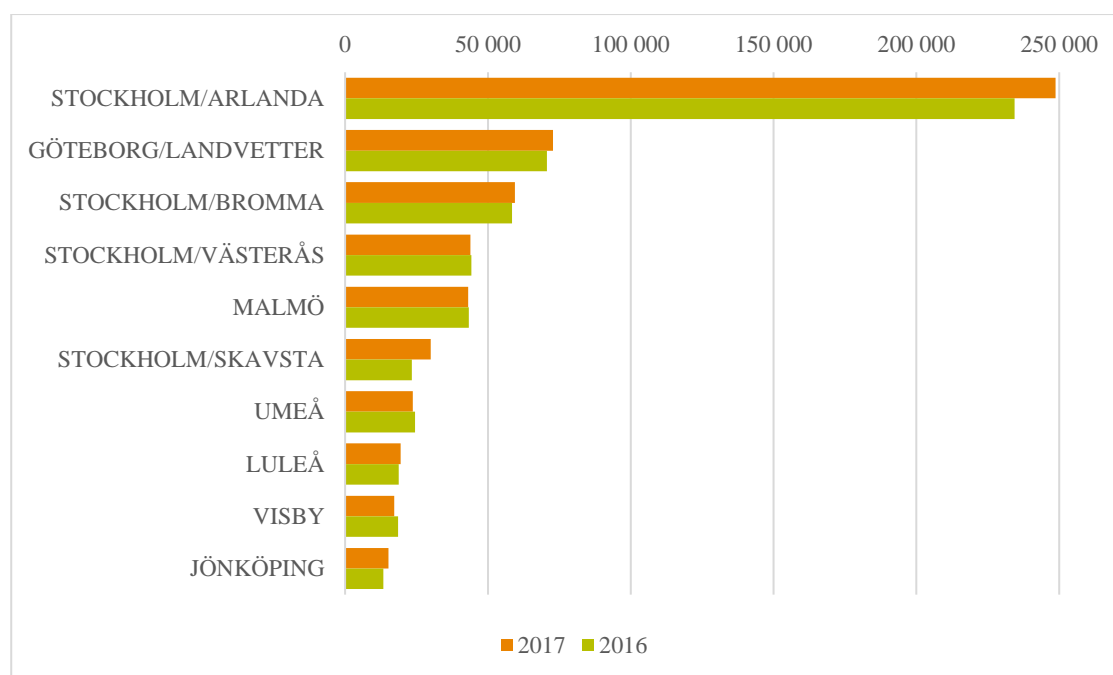


Airport	2016	2017
STOCKHOLM/ARLANDA	24 682 243	26 623 602
GÖTEBORG/LANDVETTER	6 369 397	6 751 805
STOCKHOLM/BROMMA	2 503 961	2 532 403
MALMÖ	2 217 854	2 183 862
STOCKHOLM/SKAVSTA	2 028 059	2 129 631
LULEÅ	1 197 014	1 202 932
UMEÅ	1 057 373	1 052 824
ÅRE ÖSTERSUND	495 228	529 823
VISBY	463 687	490 131
SKELLEFTEÅ	280 926	421 649

Figure 2 and 3. Number of scheduled and non-scheduled passengers at the top 10 airports 2016 and 2017

Top 10 airports regarding movements

The top 10 airports in terms of movements can be seen in figure 3 and 4. At e.g. Stockholm/Arlanda were more than 248 000 movements registered and at Göteborg/Landvetter were almost 73 000 movements registered in 2017. Among the top 10 airports in relation to movements, seven are owned by Swedavia, one is a private airport (Stockholm/Skavsta) and two are municipal airports (Stockholm/Västerås and Jönköping)



Airport	2016	2017
STOCKHOLM/ARLANDA	234 356	248 776
GÖTEBORG/LANDVETTER	70 678	72 791
STOCKHOLM/BROMMA	58 433	59 449
STOCKHOLM/VÄSTERÅS	44 174	43 894
MALMÖ	43 262	43 124
STOCKHOLM/SKAVSTA	23 413	30 017
UMEÅ	24 523	23 686
LULEÅ	18 750	19 442
VISBY	18 536	17 233
JÖNKÖPING	13 413	15 135

Figure 3 and 4. Number of movements at the top 10 airports 2016 and 2017

Airport's market shares 2017

In 2017, 93,9 % of the passengers arrived or departed at one of the top 10 Swedish airports (figure 5). Most passengers arrived or departed at Stockholm/Arlanda (57 %), Göteborg/Landvetter (17 %) and Stockholm/Bromma (6 %). 88 per cent of all passengers arrived or departed at the Swedavia airports in 2017.

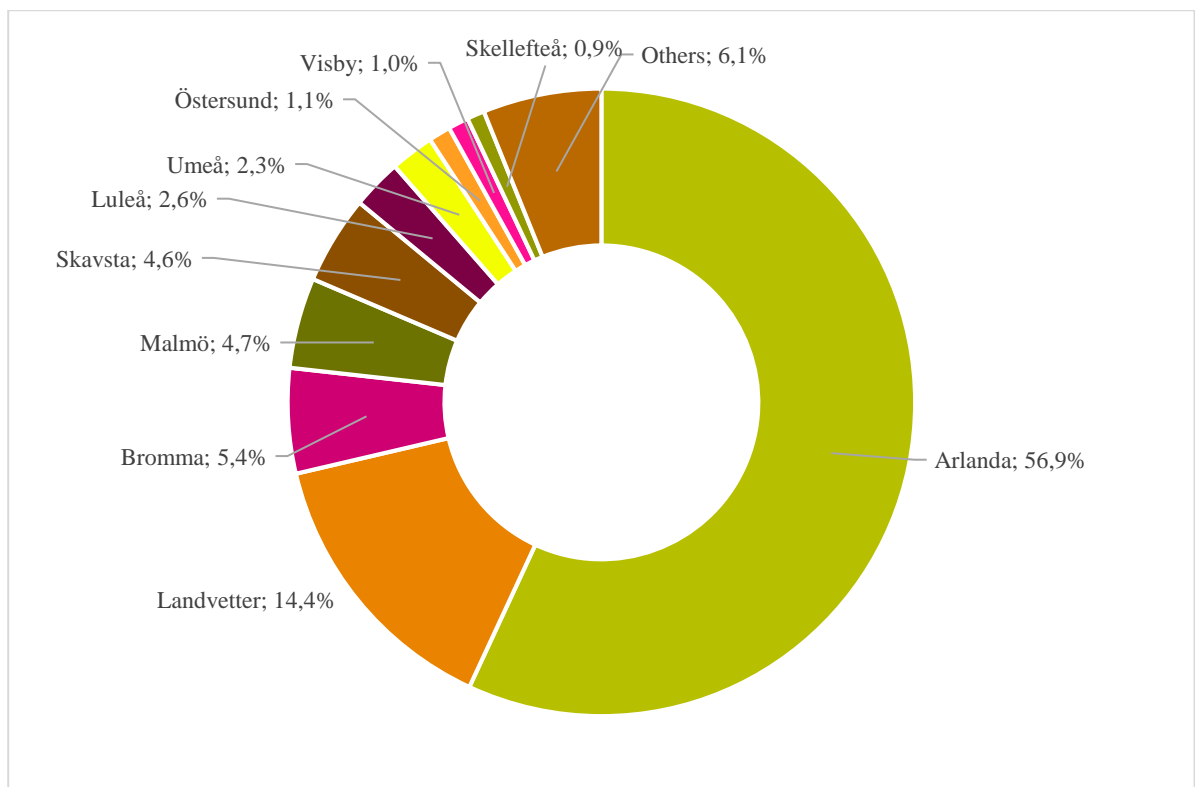


Figure 5. Airport's market shares 2017

Air Navigation Services

LFV (a public enterprise) has 1000 employees that operate air navigation services for civil and military customers at 20 locations in Sweden⁶. Until September 2010, LFV was the only provider of air navigation services in Sweden but today the air traffic services market is partially exposed to competition. The company Aviation Capacity Resources AB (ACR) operate air navigation services at 15 locations in Sweden⁷. The state owned airports

⁶ www.lfv.se

⁷ www.acr-sweden.se

are exempt from competition for air navigation services after a decision from the Swedish parliament mid-June 2014.

Another provider is NUAC HB⁸. NUAC HB started to provide operational support, to the ATCCs in Copenhagen, Stockholm and Malmö in January 2011. The company administrates the Danish/Swedish Functional Airspace Block (FAB) and from mid-2012, NUAC HB manages the en route operations from Naviair and LFV and acts as an ANS provider delivering Air Traffic Management (ATM) in the Danish/Swedish FAB⁹.

Passengers departed

In 2017, almost 23,7 million passengers departed from Swedish airports, an all-time high number. Departing passengers increased by 6 percent between 2016 and 2017. The vast majority of the increase came from international departure passengers.

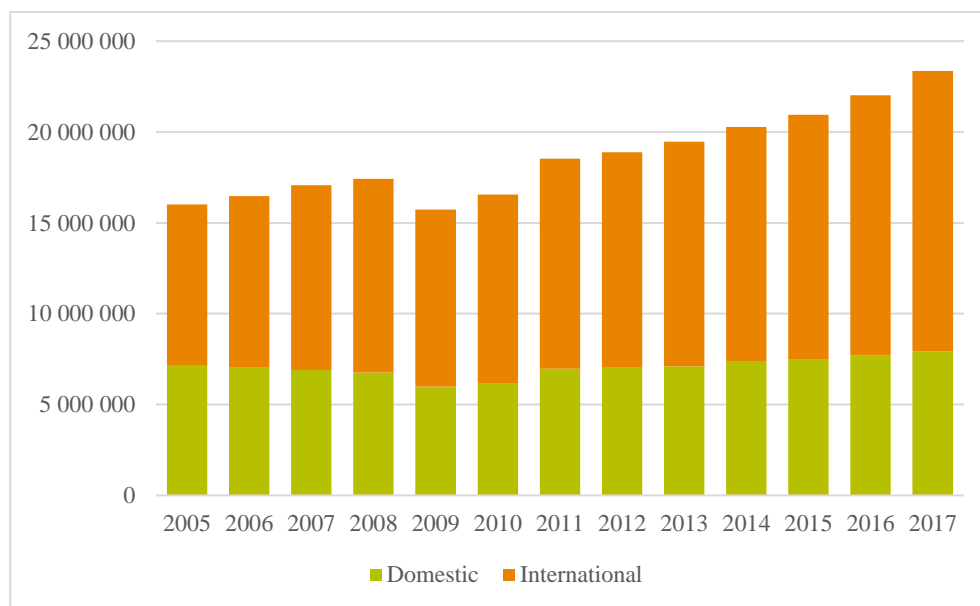


Figure 5. Number of international and domestic departing passengers in scheduled and non-scheduled traffic at Swedish airports 2005-2017

Movements

In 2017, 762 000 IFR-movements (international and domestic) were recorded in Swedish airspace. It is an all-time high level recorded. The

⁸ NUAC HB is a joint subsidiary owned by Danish Naviair and Swedish LFV

⁹ www.nuac.eu

growth was about 4.9 % in 2017 compared to 2016. Overflights amount to about 42 per cent of the movements 2017, a proportion that have not changed since 2005, see figure 6.

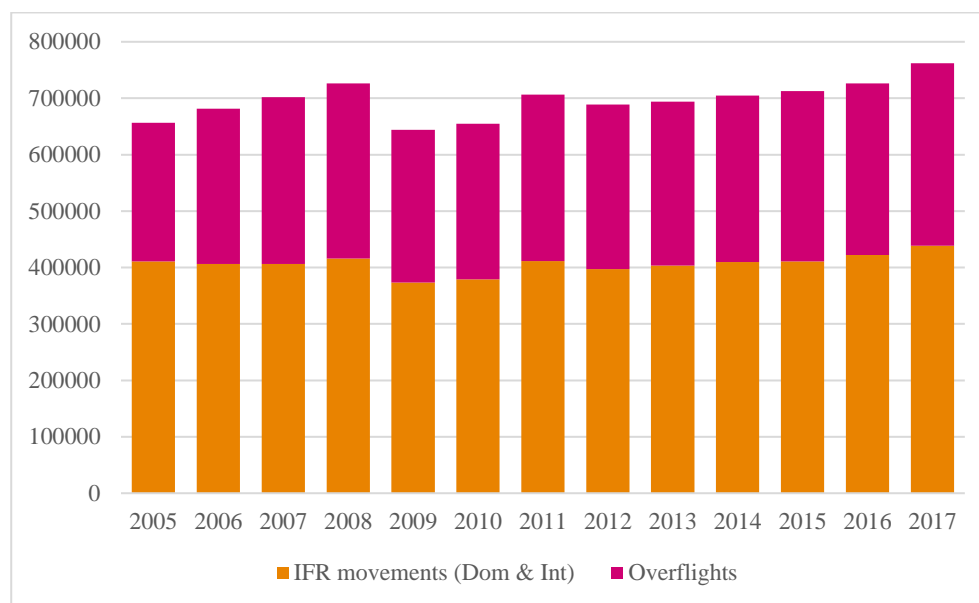


Figure 6. Number of international and domestic IFT-movements at Swedish airports 2005-2017

Freight and mail

In total, 163 000 tonnes freight and mail arrived or departed at the Swedish airports in 2017. This is an increase of 8 percent compared to 2016. See figure 7. The all-time high number were recorded in 2007, when 240 000 tonnes freight and mail arrived or departed. It is freight that has fluctuated over the years, whereas mail has been rather stable.

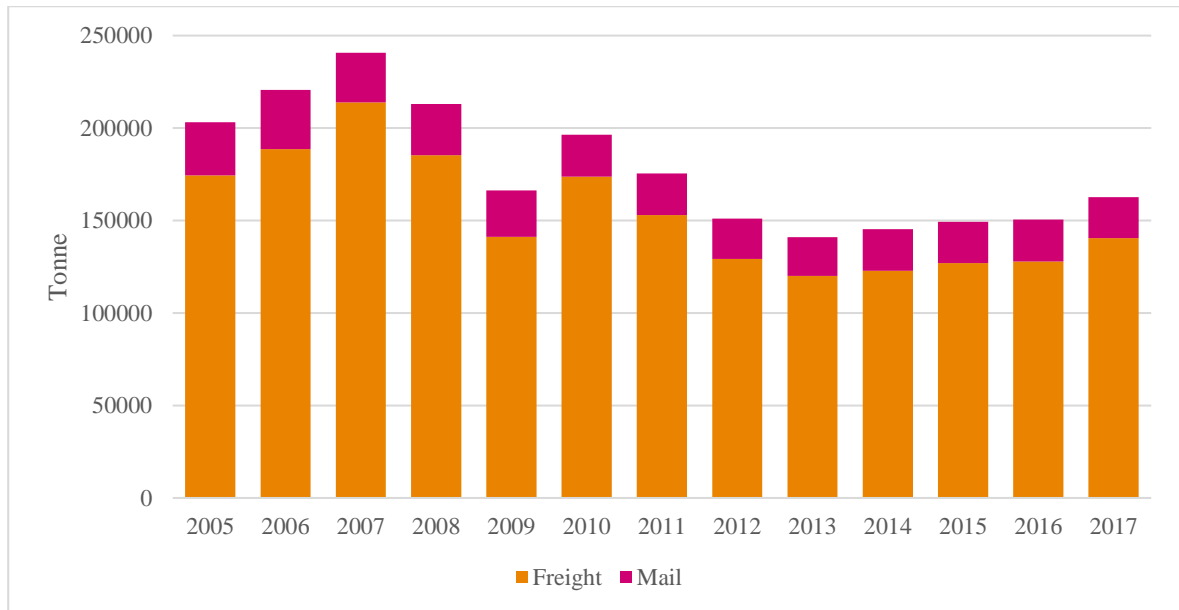


Figure 7. Freight and mail in tonnes loaded and unloaded at Swedish airports 2005- 2017

Air operators /Aircrafts - operating licenses

Operating licenses are categorized in category A and B. *Category A* includes aircraft carriers with aircraft maximum take-off weight of 10 tonnes or more and/or 20 seats or more. Within category A there are 12 operating licenses granted in Sweden.

Aircraft carriers with aircraft with maximum take-off weight of less than 10 tonnes and/or less than 20 seats are included in *category B*. Within category B there are 17 operating licenses granted in Sweden. Among these are 4 corporations operating with airplanes, 12 operating with helicopters and one is operating with both airplanes and helicopters.

In 2018, Sweden had 3 020 Swedish registered aircraft (compared to 3 077 in 2013). Of these were 1617 airworthy (1 795 in 2013).

Airlines operating in Sweden and market shares based on number of passengers

Concerning domestic air traffic, Scandinavian Airlines Systems (SAS), obtained 45 % of the market shares in 2017, followed by BraFlyg (previous Malmö Aviation and Braathens Aviation) with a 30 % market share, and Norwegian with 21 %. Worth noting is that NextJet went bankrupt in May 2018, which held a 3.5 % market share in 2017.

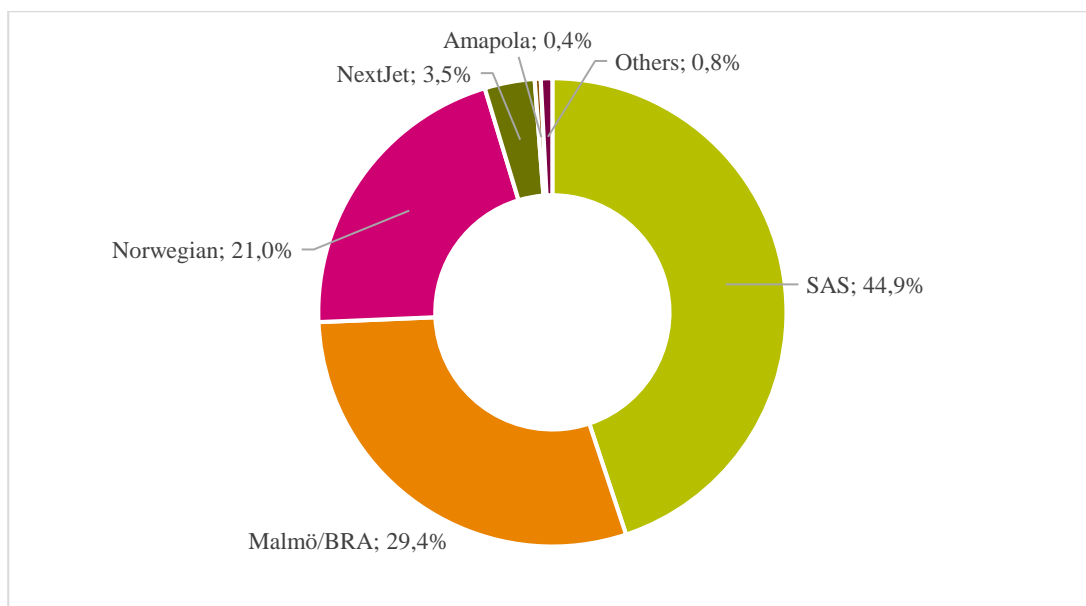


Figure 8. Domestic market shares related to passengers, 2017

For international air traffic, SAS obtained 25 % of the market shares in 2017, while Norwegian had 18 % and Ryanair almost 7 %, see figure 9.

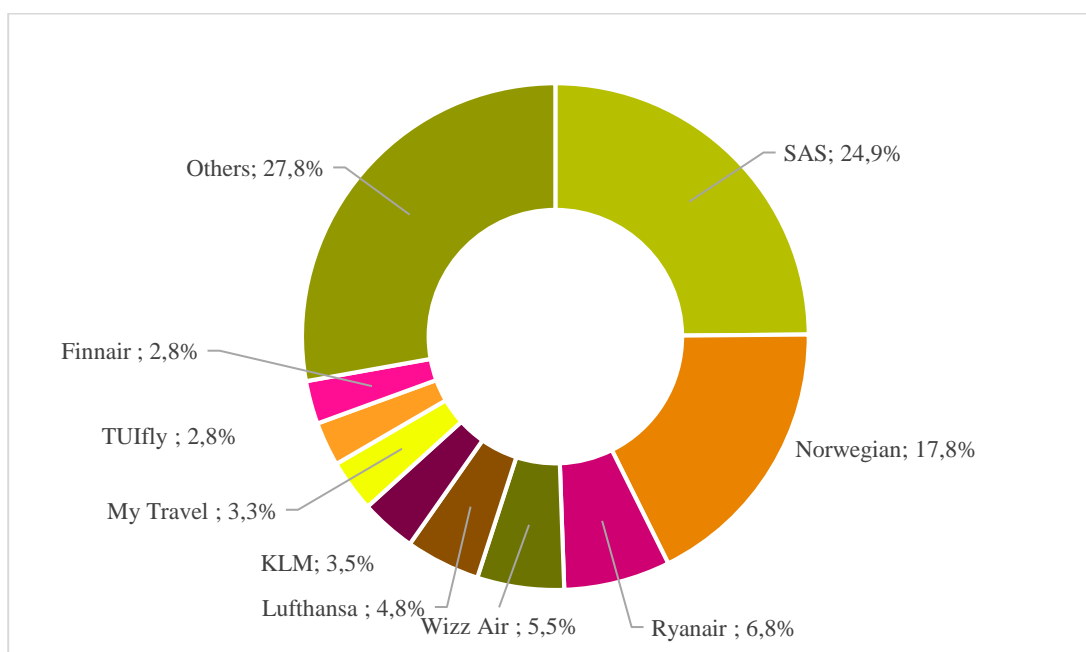


Figure 9. International market shares related to passengers, 2017

Emissions Data

The Swedish emissions data are taken from Sweden's National Inventory Report 2016, submitted under the United Nations Framework Convention Climate Change (Source Swedish EPA).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Domestic Aviation	659	620	603	589	492	476	524	515	517	516	536	544
International Aviation	1927	1996	2187	2453	2083	2105	2269	2163	2237	2266	2366	2525

Figure 10: CO₂ emissions (1000 metric ton) reported by Sweden

Emissions of CO₂ from domestic aviation in Sweden have declined with 18 % in 2016 compared to 2005. For flights from Sweden to the first destination in another country (in accordance with IPCC definition of International Flights) CO₂ between 2005 and 2016 have risen with 31 %. Furthermore, if the year of 1990 is compared to 2016 CO₂ emissions from domestic aviation have declined with 20%, whereas for international aviation CO₂ emissions have risen 77 %.

2 Section 1: ECAC/EU common Section for European State Action Plans

2.1 Executive Summary

The European Section of this action plan, which is common to all European State action plans, presents a summary of the actions taken collectively in the 44 States of the European Civil Aviation Conference (ECAC) to reduce CO₂ emissions from the aviation system against a background of increased travel and transport.

For over a century, Europe has led the development of new technology, monitoring its impacts and developing new innovations to better meet societies developing needs and concerns. From the dawn of aviation, governments and industry across the region have invested heavily to understand and mitigate the environmental impacts of aviation, initially focusing on noise, then adding air quality and more recently the emissions affecting the global climate and CO₂ from fuel burn in particular. This is all taking place in a sector ever striving to improve safety and security whilst also reducing operating costs and improving fuel efficiency.

Some of these mitigating actions have domestic beginnings that stretch to international aviation whilst others are part of centralised cross-cutting funding such as through the EU Research Framework programmes. The aviation sector has also benefitted from large bespoke programmes such as the EU's Single European Sky ATM Research Initiative (SESAR). This has a vision stretching to 2050, which may turn utopian dreams of flight with seamless end-to-end co-ordination, optimised for efficiency, with minimal environmental impacts and complete safety into reality.

The European common section also includes new innovations being tried and tested in a range of demonstration trials to reduce fuel burn and CO₂ emissions at different stages of different flights, airports or routes. These might not be contributing to measured benefits in day-to-day operations yet, but Europe can anticipate a stream of future implementation actions and additional CO₂ savings.

Aircraft related technology

European members have worked together to best support progress in the ICAO Committee on Aviation Environmental Protection (CAEP). This contribution of resources, analytical capability and leadership has undoubtedly facilitated leaps in global certification standards that has helped drive the markets demand for technology improvements. Developing what became the 2016 ICAO CO₂ standards for newly built aircraft relied on contributions from many across the ECAC States. Airlines now have confidence that fuel efficient aircraft are future proof which may even have generated orders for manufacturers and demonstrates a virtuous circle that efficiency sells. Solutions and technology improvements have already started to go into service and are helping to support demand for ever more ambitious research.

Environmental improvements across the ECAC States is knowledge lead and at the forefront of this is the Clean Sky EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough “clean technologies”. This activity recognises and exploits the interaction between environmental, social and competitiveness aspects with sustainable economic growth. Funding and its motivation is critical to research and the public private partnership model of the EU Framework Programmes underpins much that will contribute to this and future CO₂ action plans across the ECAC region. Evaluations of the work so far under the JTI alone estimate aircraft CO₂ reductions of 32% which, aggregated over the future life of those products, amount to 6bn tonnes of CO₂.

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.

Alternative fuels

ECAC States are embracing the introduction of sustainable alternative aviation fuels but recognise the many challenges between the current situation and their widespread availability or use. It has been proven fit for purpose and the distribution system has demonstrated its capacity to handle sustainable alternative fuels. Recent actions have focussed on preparing the legal base for recognising a minimum reduction in greenhouse gas emissions and market share targets for such fuels in the transport sector. The greatest challenge to overcome is economic scalability of the production of sustainable fuel and the future actions of the ECAC states are preparing the building blocks towards that goal. The European Commission has proposed specific measures and sub-quotas to promote innovation and the deployment of more advanced sustainable fuels as well as additional incentives to use such fuels in aviation. Public private partnership in the European Advanced Biofuels Flight-path is also continuing to bring down the commercial barriers. In that framework, Europe is progressing towards a 2 million tonne goal for the consumption of sustainably produced paraffinic biofuels by 2020. Europe has progressed from demonstration flights to sustainable biofuel being made available through the hydrant fuelling infrastructure, but recognises that continued action will be required to enable a more large-scale introduction.

Improved Air Traffic Management

The European Union’s Single European Sky (SES) policy aims to transform Air Traffic Management in Europe, tripling capacity, halving ATM costs with 10 times the safety and 10% less environmental impact. Progress is well underway on the road map to achieve these ambitious goals through commitment and investment in the research and technology. Validated

ATM solutions alone are capable of 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 cost. Steps 2 and 3 of the overall SES plan for the future will deploy 'Trajectory-based Operation' and 'Performance-based Operations' respectively. 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.

Economic/Market Based Measures (MBMs)

ECAC members 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 31 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 CO₂ emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO₂ emissions.

ECAC States, through the Bratislava declaration, have expressed their intention to voluntarily participate in CORSIA from its pilot phase and encourage other States to do likewise and join CORSIA. Subject to preserving the environmental integrity and effectiveness it is expected that the EU ETS legislation will be adapted to implement the CORSIA. A future world with a globally implemented CORSIA aimed at carbon neutral growth of international aviation would significantly reduce emissions.

ECAC Scenarios for Traffic and CO₂ Emissions

Aviation traffic continues to grow, develop and diversify in many ways across the ECAC states. Whilst the focus of available data relates to passenger traffic, similar issues and comparable outcomes might be anticipated for cargo traffic both as belly hold freight or in dedicated freighters. Analysis by EUROCONTROL and EASA has 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 CO₂ emissions of aviation have been estimated for both a theoretical baseline scenario (without any mitigation action) and a scenario with implemented mitigation measures that are presented in this action plan. Results are visualised in the below figure.

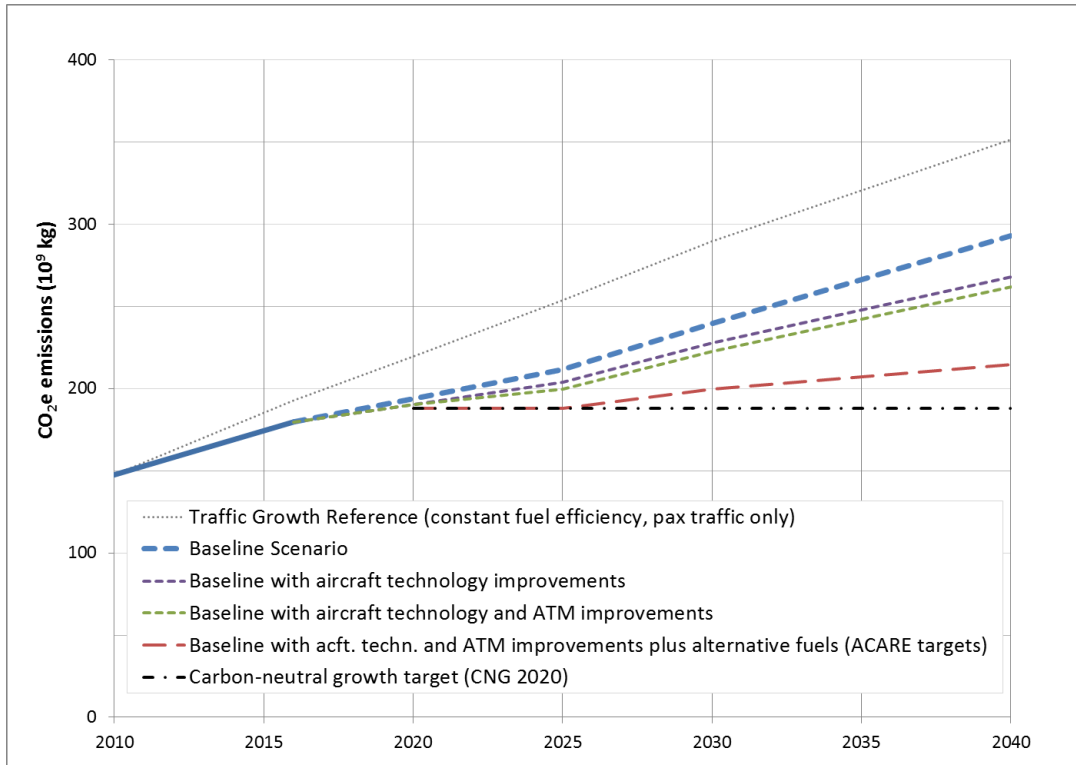
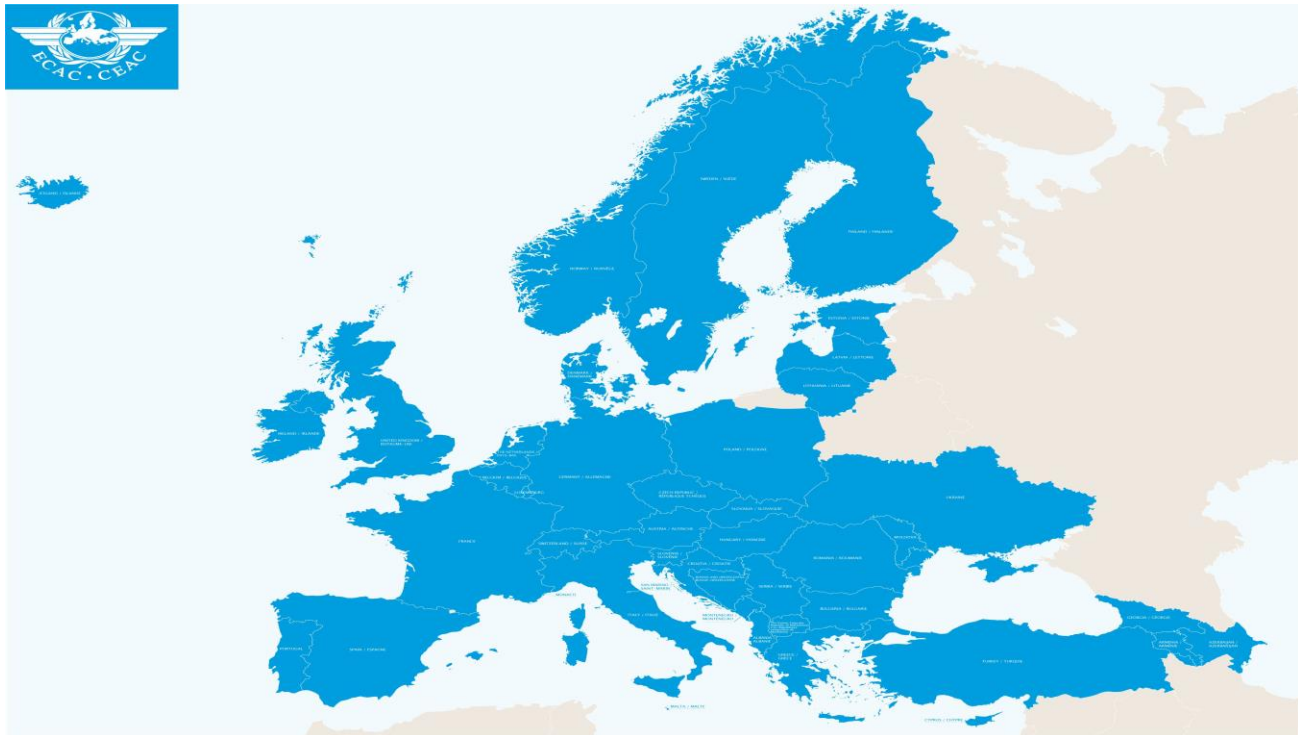


Figure 1 Equivalent CO₂ emissions forecast for the baseline and implemented measures scenarios

Under the baseline assumptions of traffic growth and fleet rollover with 2010 technology, CO₂ emissions would almost double for flights departing ECAC airports. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 8.5% reduction of fuel consumption and CO₂ emissions in 2040 compared to the baseline. Whilst the data to model the benefits of ATM improvements and sustainable alternative fuels may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall fuel efficiency, including the effects of new aircraft types and ATM-related measures, is projected to improve by 24% between 2010 and 2040. The potential of sustainable aviation fuels to reduce CO₂ emissions on a lifecycle basis is reflected in Figure 1. Market-based measures and their effects have not been simulated in detail, but will help reach the goal of carbon-neutral growth. 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 CO₂ emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2016) and forecasts (for 2020, 2030 and 2040) 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,
- its associated CO₂ emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of “Regulation and Growth”, while corresponding fuel consumption and CO₂ emissions assume the technology level of the year 2010 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, alternative 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. In the 20 year forecasts published by EUROCONTROL the scenario called ‘Regulation and Growth’ is constructed as the ‘most likely’ or ‘baseline’ scenario for traffic, most closely following the current trends. It 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 characterizing 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 1 presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year 2016 serves as the baseline year of the 20-year forecast results¹⁰ updated in 2018 by EUROCONTROL and presented here. Historical data for the year 2010 are also shown later for reference.

¹⁰ Challenges of Growth 2018: Flight forecast, EUROCONTROL September 2018 (to be published)

Table 1. Summary characteristics of EUROCONTROL scenarios:

	<i>Global Growth</i>	<i>Regulation and Growth</i>	<i>Fragmenting World</i>
2023 traffic growth	High ↗	Base →	Low ↘
Passenger			
Demographics (Population)	Aging UN Medium-fertility variant	Aging UN Medium-fertility variant	Aging 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 ↗ Pt-to-pt: N-Atlant. ↗↗	Hubs: Mid-East ↗↗ Europe&Turkey ↗ Pt-to-pt: N-Atlant. ↗	No change →
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

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 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 (ICAO¹¹). 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 data warehouse used by EUROCONTROL, including the actual flight distance and the cruise altitude by airport pair. These calculations were made for 98% of the passenger flights; the remaining flights in the flight plans had information missing. Determination of the fuel burn and CO₂ emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample. Fuel burn and CO₂ 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. While historical traffic data is used for the year 2016, the baseline fuel burn and emissions in 2016 and the forecast years (until 2040) are modelled in a simplified approach on the basis of the historical/forecasted traffic and assume the technology level of the year 2010.

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 CO₂ emissions of European aviation in the absence of mitigation actions.

Table 2. Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres ¹² RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported ¹³ FTKT (billion)	Total Revenue Tonne Kilometres ^{14,14} RTK (billion)
2010	4.6	1,218	0.20	45.4	167.2
2016	5.2	1,601	0.21	45.3	205.4

¹¹ ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016.

¹² Calculated based on 98% of the passenger traffic.

¹³ Includes passenger and freight transport (on all-cargo and passenger flights).

¹⁴ A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

2020	5.6	1,825	0.25	49.4	231.9
2030	7.0	2,406	0.35	63.8	304.4
2040	8.4	2,919	0.45	79.4	371.2

Table 3. Fuel burn and CO₂ 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	37.98	120.00	0.0310	0.310
2016	46.28	146.26	0.0287	0.287
2020	49.95	157.85	0.0274	0.274
2030	61.75	195.13	0.0256	0.256
2040	75.44	238.38	0.0259	0.259

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

Figure 2. Forecasted traffic until 2040 (assumed both for the baseline and implemented measures scenarios)

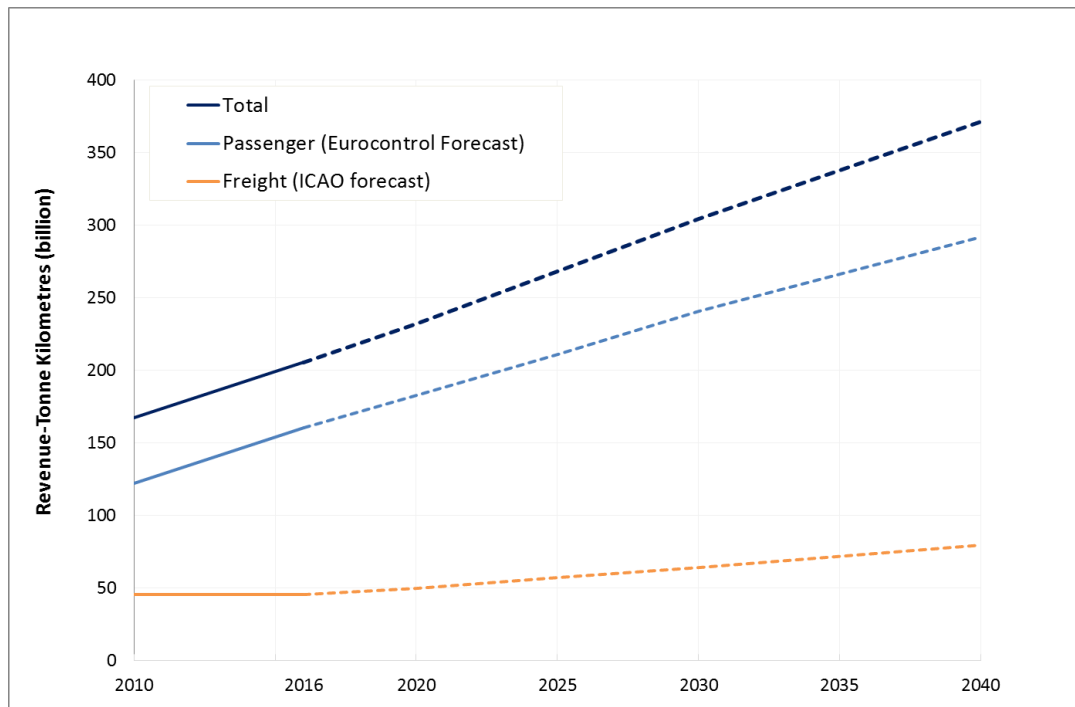
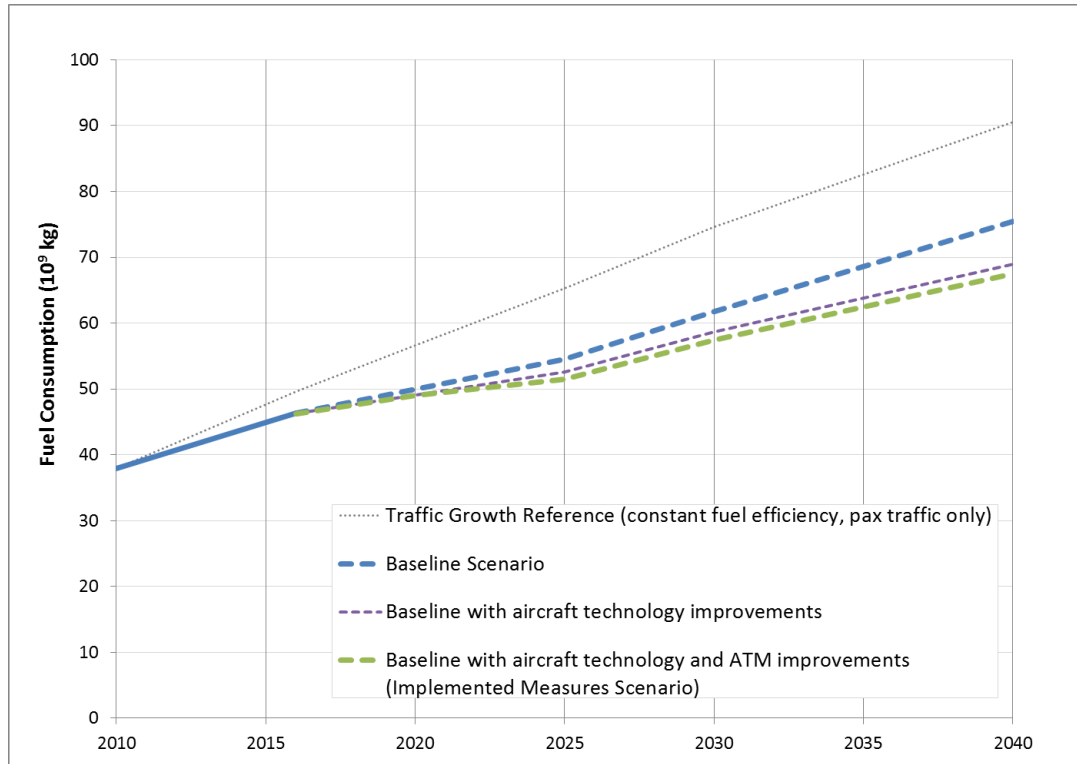


Figure 3. Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports)



2.2.2 ECAC Scenario with Implemented Measures, Estimated Benefits of Measures

In order to improve 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. EUROCONTROL's 'Regulation and Growth' scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development, improvements in ATM/operations and alternative fuels are considered here for a projection of fuel consumption and CO₂ emissions up to the year 2040.

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 (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of the Aircraft Assignment Tool is performed year by year, allowing the determination of the amount of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 0.96% per annum is assumed to aircraft deliveries during the last 10 years of the forecast (2030-2040). This rate of improvement corresponds to the 'medium' fuel technology scenario used by CAEP to generate the fuel trends for the Assembly.

The effects of **improved ATM efficiency** are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. Regarding SESAR effects, baseline deployment improvements of 0.2% in terms of fuel efficiency are assumed to be included in the base year fuel consumption for 2010. This improvement is assumed to rise to 0.3% in 2016 while additional improvements of 2.06% are targeted for the time period from 2025 onwards¹⁵. Further non-SESAR related fuel savings have been estimated to amount to 1.2% until the year 2010, and are already included in the baseline calculations¹⁶.

Regarding the **introduction of sustainable alternative fuels**, the European ACARE roadmap targets described in section B chapter 2.1 of this document are assumed for the implemented measures case. These targets include an increase of alternative fuel quantities to 2% of aviation's total fuel consumption in the year 2020, rising linearly to 25% in 2035 and 40% in 2050. An average 60% reduction of lifecycle CO₂ emissions compared to crude-oil based JET fuel was assumed for sustainable aviation fuels, which is in line with requirements from Article 17 of the EU's Renewable Energy Directive (Directive 2009/28/EC)¹⁷. The resulting emission savings are shown in Table 6 and Figure 4 in units of equivalent CO₂ emissions on a well-to-wake basis. Well-to-wake emissions include all GHG emissions throughout the fuel lifecycle, including emissions from feedstock extraction or cultivation (including land-use change), feedstock processing and transportation, fuel production at conversion facilities as well as distribution and combustion¹⁸.

For simplicity, effects of **market-based measures** including the EU Emissions Trading Scheme (ETS) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) on aviation's CO₂ emissions have not been modelled explicitly in the top-down assessment

¹⁵ See SESAR1 D72 "Updated Performance Assessment in 2016" document, November 2016, project B05, project manager: ENAIRE.

¹⁶ See SESAR1 D107 "Updated Step 1 validation targets – aligned with dataset 13", project B.04.01, December 2014, project manager: NATS.

¹⁷ According to article 17 of the EU RED (Directive 2009/28/EC), GHG emission savings of at least 60% are required for biofuels produced in new installations in which production started on or after 1 January 2017.

¹⁸ Well-to-wake CO₂e emissions of fossil-based JET fuel are calculated by assuming an emission index of 3.88 kg CO₂e per kg fuel (see DIN e.V., "Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)", German version EN 16258:2012), which is in accordance with 89 g CO₂e per MJ suggested by ICAO CAEP AFTF.

of the implemented measures scenario presented here. CORSIA aims for carbon-neutral growth (CNG) of aviation, and this target is therefore shown in Figure 4¹⁹.

Tables 4-6 and Figures 3-4 summarize the results for the scenario with implemented measures. It should be noted that Table 4 shows direct combustion emissions of CO₂ (assuming 3.16 kg CO₂ per kg fuel), whereas Table 6 and Figure 4 present equivalent CO₂ emissions on a well-to-wake basis. More detailed tabulated results are found in Appendix A.

Table 4. 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)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	0.0310	0.310
2016	46.24	146.11	0.0286	0.286
2020	49.03	154.93	0.0245	0.245
2030	57.38	181.33	0.0242	0.242
2040	67.50	213.30	0.0237	0.237

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

Table 5. Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

Period	Average annual fuel efficiency improvement (%)
2010-2016	-1.36%
2016-2020	-1.40%
2020-2030	-1.11%
2030-2040	-0.21%

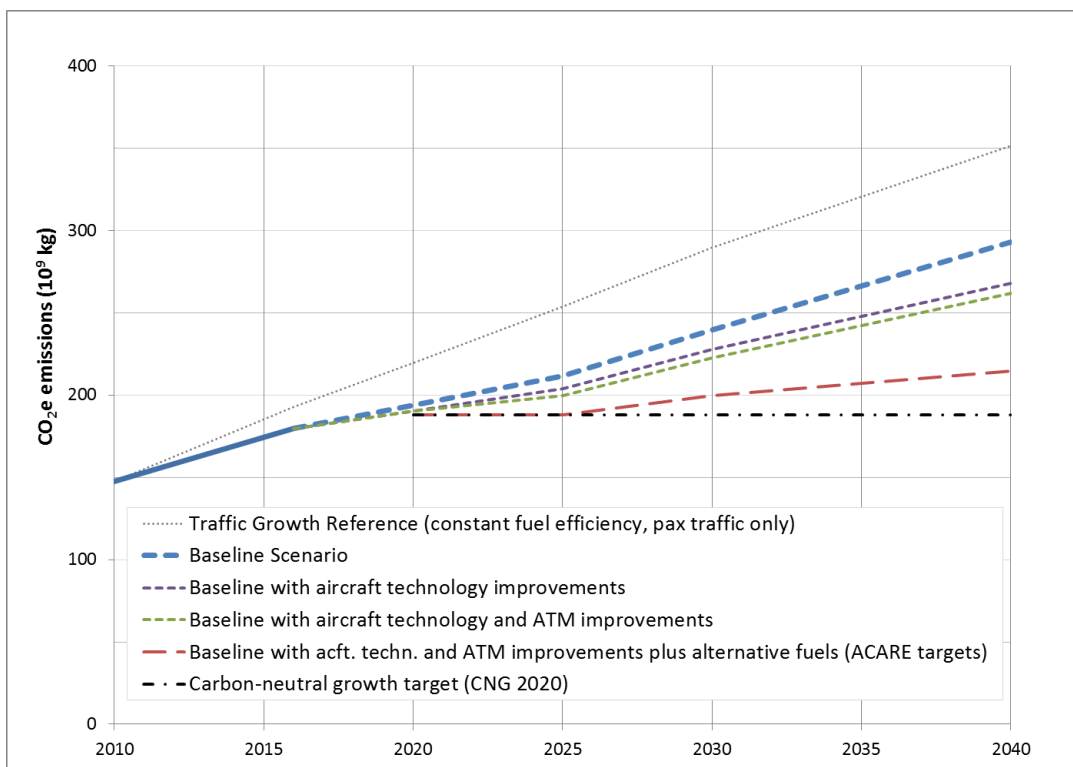
¹⁹ Note that in a strict sense the CORSIA target of CNG is aimed to be achieved globally (and hence not necessarily in each world region).

Table 6. Equivalent (well-to-wake) CO₂e emissions forecasts for the scenarios described in this chapter

Year	Well-to-wake CO ₂ e emissions (10 ⁹ kg)				% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario			
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	Acft. techn. and ATM improvements + alternative fuels	
2010	147.3				NA
2016	179.6	179.6	179.4	179.4	-0.1%
2020	193.8	190.4	190.2	187.9	-3.0%
2030	239.6	227.6	222.6	199.5	-16.7%
2040	292.7	267.7	261.9	214.8	-26.6%

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 alternative fuels.

Figure 4. Equivalent (well-to-wake) CO₂ emissions forecast for the baseline and implemented measures scenarios



As shown in Figures 3-4, the impact of improved aircraft technology indicates an overall 8.5% reduction of fuel consumption and CO₂ emissions in 2040 compared to the baseline scenario. Whilst the data to model the benefits of ATM improvements and sustainable alternative fuels shown in Figure 4 may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall fuel efficiency, including the effects of new aircraft types and ATM-related measures, is projected to improve by 24% between 2010 and 2040.

Under the currently assumed aircraft and ATM improvement scenarios, the rate of fuel efficiency improvement is expected to slow down progressively until 2040. Aircraft technology and ATM improvements alone will not be sufficient to meet the post-2020 carbon neutral growth objective of aviation, nor will the use of alternative fuels even if Europe's ambitious targets for alternative fuels are met. This confirms that additional action, particularly market-based measures, are required to fill the gap.

2.3 Section B: Actions Taken Collectively Throughout Europe



2.3.1 AIRCRAFT-RELATED TECHNOLOGY DEVELOPMENT

2.3.1.1 Aircraft emissions standards (Europe's contribution to the development of the aeroplane CO₂ standard in CAEP)

European Member States fully supported the work achieved in ICAO's Committee on Aviation Environmental Protection (CAEP), which resulted in an agreement on the new aeroplane CO₂ Standard at CAEP/10 meeting in February 2016, applicable to new aeroplane type designs from 2020 and to aeroplane type designs that are already in-production in 2023. Europe significantly contributed to this task, notably through the European Aviation Safety Agency (EASA) which co-led the CO₂ Task Group within CAEP's Working Group 3, and which provided extensive technical and analytical support.

The assessment of the benefits provided by this measure in terms of reduction in European emissions is not provided in this action plan. Nonetheless, elements of assessment of the overall contribution of the CO₂ standard towards the global aspirational goals are available in CAEP.

2.3.1.2 Research and development

Clean Sky is an EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough "clean technologies" for air transport globally. By accelerating their deployment, the JTI will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.

Joint Technology Initiatives are specific large-scale EU research projects created by the European Commission within the 7th Framework Programme (FP7) and continued within the Horizon 2020 Framework Programme. Set up as a Public Private Partnership between the European Commission and the European aeronautical industry, Clean Sky pulls together the research and technology resources of the European Union in a coherent programme that contributes significantly to the 'greening' of global aviation.

The first Clean Sky programme (**Clean Sky 1** - 2011-2017) has a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry. It aims to develop environmental friendly technologies impacting all flying-segments of commercial aviation. The objectives are to reduce aircraft CO₂ emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

What has the current JTI achieved so far?

*It is estimated that Clean Sky resulted in a reduction of aviation CO₂ emissions by more than 32% with respect to baseline levels (in 2000), which represents an **aggregate of up to 6 billion tonnes of CO₂ over the next 35 years***

This was followed up with a second programme (**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 RTD efforts under Clean Sky 2 are:

- **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 key new 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.

In addition, the **Technology Evaluator** 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). More details on Clean Sky can be found at the following link:

<http://www.cleansky.eu/>

2.3.2 Alternative Fuels

2.3.2.1 European Advanced Biofuels Flightpath

Within the European Union, Directive 2009/28/EC on the promotion of the use of energy from renewable sources ("the Renewable Energy Directive" – RED) established mandatory targets to be achieved by 2020 for a 20% overall share of renewable energy in the EU and a 10% share for renewable energy in the transport sector. Furthermore, sustainability criteria for biofuels to be counted towards that target were established²⁰. Directive 2009/28/EC of the European Parliament and of the Council of 23/04/2009 on the promotion of the use of energy from renewable sources, details in its Article 17 that *'with effect from 1 January 2017, the greenhouse gas emission saving from the use of biofuels and bioliquids taken into account for the purposes referred to in points (a), (b) and (c) of paragraph 1 shall be at least 50 %. From 1 January 2018 that greenhouse gas emission saving shall be at least 60 % for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017'*.

In November 30, 2016, the European Commission (EC) presented a proposal to the EU Council and the European Parliament for a recast of the Renewable Energy Directive for 2030.

To promote the deployment and development of low carbon fuels, such as advanced biofuels, it is proposed to introduce after 2020 an obligation requiring fuel suppliers to sell a gradually increasing share of renewable and low-emission fuels, including advanced biofuels and renewable electricity (at least 1.5% in 2021 increasing to at least 6.8% by 2030).

To promote innovation the obligation includes a specific sub-quota for advanced biofuels, increasing from 0.5% in 2021 to at least 3.6% in 2030. Advanced biofuels are defined as biofuels that are based on a list of feedstocks; mostly lignocellulosic material, wastes and residues.

Aviation and marine sectors are explicitly covered in the proposal. In fact, it is proposed that advanced alternative fuels used for aviation and

²⁰ Directive 2009/28/EC of the European Parliament and of the Council of 23/04/2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Article 17 Sustainability criteria for biofuels and bioliquids, at pp. EU Official Journal L140/36-L140/38

maritime sectors can be counted 1.2 times towards the 6.8% renewable energy mandate. This would provide an additional incentive to develop and deploy alternative fuels in the aviation sector.

In February 2009, the European Commission's Directorate General for Energy and Transport initiated the SWAFEA (Sustainable Ways for Alternative Fuels and Energy for Aviation) study to investigate the feasibility and the impact of the use of alternative fuels in aviation.

The SWAFEA final report was published in July 2011²¹. It provides a comprehensive analysis on the prospects for alternative fuels in aviation, including an integrated analysis of the technical feasibility, environmental sustainability (based on the sustainability criteria of the EU Directive on renewable energy²²) and economic aspects. It includes a number of recommendations on the steps that should be taken to promote the take-up of sustainable biofuels for aviation in Europe.

In March 2011, the European Commission published a White Paper on transport²³. In the context of an overall goal of achieving a reduction of at least 60% in greenhouse gas emissions from transport by 2050 with respect to 1990, the White Paper established a goal of low-carbon sustainable fuels in aviation reaching 40% by 2050.

ACARE Roadmap targets regarding share alternative sustainable fuels:

Aviation to use:

- **at minimum 2%** sustainable alternative fuels **in 2020**;
- **at minimum 25%** sustainable alternative fuels **in 2035**;
- **at minimum 40%** sustainable alternative fuels **in 2050**

Source: ACARE Strategic Research and Innovation Agenda, Volume 2

As a first step towards delivering this goal, 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 aims to speed up the commercialisation of aviation

²¹http://www.icao.int/environmental-protection/GFAAF/Documents/SW_WP9_D.9.1%20Final%20report_released%20July2011.pdf

²² Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

²³ Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM (2011) 144 final

biofuels in Europe, with the objective of achieving the commercialisation of sustainably produced paraffinic biofuels in the aviation sector by reaching an aggregated 2 million tonnes consumption by 2020.

This initiative is a shared and voluntary commitment by its members to support and promote the production, storage and distribution of sustainably produced drop-in biofuels for use in aviation. It also targets establishing appropriate financial mechanisms to support the construction of industrial "first of a kind" advanced biofuel production plants. The Biofuels Flight path is explained in a technical paper, which sets out in more detail the challenges and required actions²⁴.

More specifically, the initiative focuses on the following:

1. Facilitating the development of standards for drop-in biofuels and their certification for use in commercial aircraft,
2. Working together across the full supply chain to further develop worldwide accepted sustainability certification frameworks,
3. Agree biofuel take-off arrangements over a defined period of time and at a reasonable cost,
4. Promote appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector,
5. Establish financing structures to facilitate the realisation of 2nd Generation biofuel projects,
6. Accelerate targeted research and innovation for advanced biofuel technologies, and especially algae, and
7. Take concrete actions to inform the European citizen of the benefits of replacing kerosene with certified sustainable biofuels.

When the Flightpath 2020 initiative began in 2010, only one production pathway was approved for aviation use; renewable kerosene had only been produced at very small scale and only a handful of test and demonstration flights had been conducted using it. Since then, worldwide technical and operational progress in the industry has been remarkable. Four different pathways for the production of renewable kerosene are now approved and several more are expected to be certified soon. A significant number of flights using renewable kerosene have been conducted, most of them revenue flights carrying passengers. Production has been demonstrated at up to industrial scale for some of the pathways. Distribution of renewable kerosene through an airport hydrant system was also demonstrated in Oslo in 2015.

In 2016 the European commission tendered support and secretariat functions for the Flightpath 2020, which had so far depended on the initiative of the individual members. This €1.5m tender was won by a consortium run by SENASA, which started the work supporting the Flightpath at the end of 2016.

²⁴https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf

Performed flights using bio-kerosene

IATA: 2000 flights worldwide using bio-kerosene blends performed by 22 airlines between June 2011 and December 2015

Lufthansa: 1 189 Frankfurt-Hamburg flights using 800 tonnes of bio-kerosene (during 6 months period June - December 2011)

KLM: a series of 200 Amsterdam-Paris flights from September 2011 to December 2014, 26 flights New York-Amsterdam in 2013, and 20 flights Amsterdam-Aruba in 2014 using bio-kerosene

Air France: A series of 50 Paris – Toulouse flights evaluating SIP kerosene in 2014/2015

Since late 2015, bio kerosene is regularly available as a fuel blend at Oslo airport. Total throughput so far can be approximatively estimated at 2000 tonnes. Attribution to individual flights is no longer possible except on an accounting basis as the fuel is commingled in the normal hydrant fuelling infrastructure of the airport.

Production (EU)

Neste (Finland): by batches

- Frankfurt-Hamburg (6 months) 1 189 flights operated by Lufthansa: 800 tonnes of bio-kerosene

- Itaka: €10m EU funding (2012-2015): ca. 1 000 tonnes

Biorefly: €13.7m EU funding: 2000 tonnes per year – BioChemtex (Italy)

BSFJ Swedish Biofuels: €27.8m EU funding (2014-2019)

2.3.2.2 Research and Development projects on alternative fuels in aviation

In the time frame 2011-2016, 3 projects have been funded by the FP7 Research and Innovation program of the EU.

ITAKA: €10m EU funding (2012-2015) with the aim of assessing the potential of a specific crop (camelina) for providing jet fuel. The project aims entailed testing the whole chain from field to fly and assessing the potential beyond the data gathered in lab experiments, gathering experiences on related certification, distribution and economic aspects. For a feedstock, ITAKA targeted European camelina oil and used cooking oil in order to meet a minimum of 60% GHG emissions savings compared to the fossil fuel jetA1.

SOLAR-JET: This project has demonstrated the possibility of producing jet-fuel from CO₂ and water. This was done by coupling a two-step solar thermochemical cycle based on non-stoichiometric ceria redox reactions with the Fischer-Tropsch process. This successful demonstration is further complemented by assessments of the chemical suitability of the solar kerosene, identification of technological gaps, and determination of the technological and economical potentials.

Core-JetFuel: €1.2m EU funding (2013-2017) this action evaluated the research and innovation "landscape" in order to develop and implement a strategy for sharing information, for coordinating initiatives, projects and results and to identify needs in research, standardisation, innovation/deployment and policy measures at European level. Bottlenecks of research and innovation will be identified and, where appropriate, recommendations for the European Commission will be made with respect to the priorities in the funding strategy. The consortium covers the entire alternative fuel production chain in four domains: Feedstock and sustainability; conversion technologies and radical concepts; technical compatibility, certification and deployment; policies, incentives and regulation. CORE-Jet Fuel ensures cooperation with other European, international and national initiatives and with the key stakeholders. The expected benefits are enhanced knowledge amongst decision makers, support for maintaining coherent research policies and the promotion of a better understanding of future investments in aviation fuel research and innovation.

In 2015, the European Commission launched projects under the Horizon 2020 research programme with production capacities of the order of several thousand tonnes per year.

In addition, in 2013 the Commission tendered the **HBBA study** (High Biofuel Blends in Aviation). This study analysed in detail the blending behaviour of fossil kerosene with bio kerosene produced by the various pathways either already approved or undergoing the technical approval process. It also analysed the impact of bio kerosene on various types of aircraft fuel seals, plus the effect of different bio-kerosenes on aircraft emissions. The final report on this research was published in early 2017 and is available at:

https://ec.europa.eu/energy/sites/ener/files/documents/final_report_for_publication.pdf



2.3.3 Improved Air Traffic Management and Infrastructure Use

2.3.3.1 The EU's Single European Sky Initiative and SESAR

SESAR Project

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 larger volumes of flights in a safer, more cost-efficient and environmental friendly manner.

The initial SES aims with respect to the 2005 performance were to:

- Triple capacity of ATM systems,
- Reduce ATM costs by 50%,
- Increase safety by a factor of 10, and
- Reduce the environmental impact by 10% per flight.

SESAR, the technology pillar of the Single European Sky, contributes to the Single Sky's performance targets by defining, developing, validating

and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner.

Guided by the European ATM Master Plan, the SESAR Joint Undertaking (JU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe’s air traffic management system and deliver benefits to Europe and its citizens. The SESAR JU research programme has been split into 2 phases, SESAR 1 (from 2008 to 2016) and SESAR 2020 (starting in 2016). It is delivering 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.

Concerning the environmental impact, the estimated potential total fuel and CO₂ emission savings per flight are depicted below by flight segment:

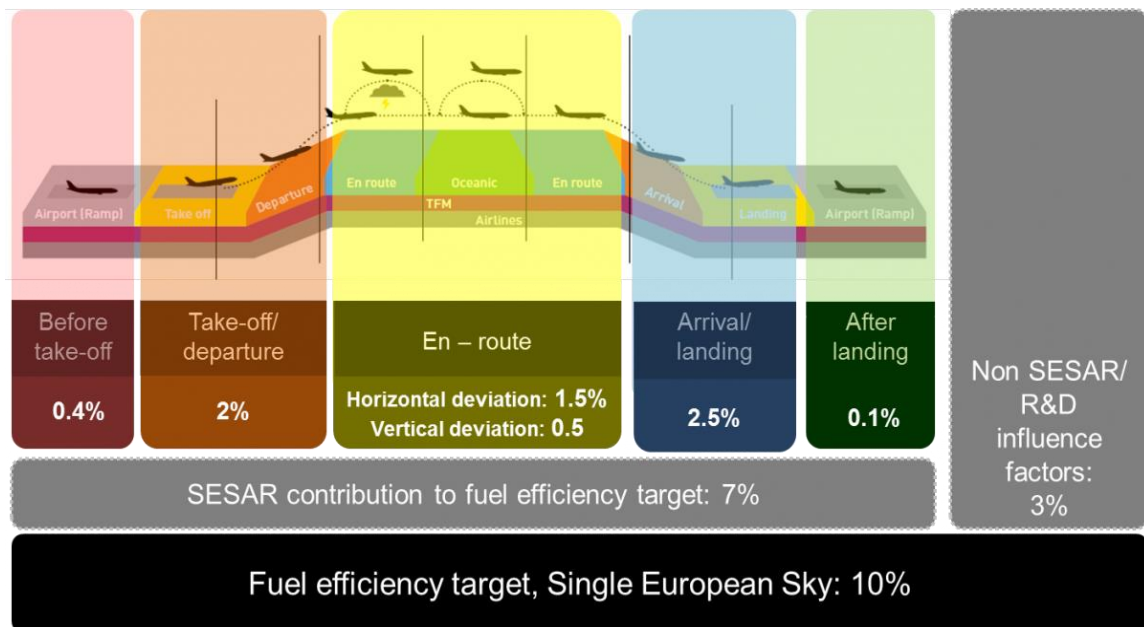


Figure 5.

By the end of SESAR 1, the validation exercises conducted showed that the solutions identified could provide by 2024 (as compared to the 2005 baseline) 2.36% reduction per flight in gate-to-gate greenhouse gas emissions.

SESAR Research Projects (environmental focus)

During SESAR 1, environmental aspects were mainly addressed under two types of project: Environmental research projects, which were considered as a transversal activity and therefore primarily supported the projects validating the SESAR solutions, and secondly SESAR validation and

demonstration projects, which were pre-implementation activities. Environment aspects, in particular fuel efficiency, were also a core objective of approximately 80% of SESAR 1's primary projects.

Environmental Research Projects:

The four Environmental research projects have been completed:

- Project 16.03.01 dealt with the "Development of the Environment validation framework (Models and Tools)";
- Project 16.03.02 addressed the "Development of environmental metrics";
- Project 16.03.03 dealt with the "Development of a framework to establish interdependencies and trade-off with other performance areas";
- Project 16.03.07 considered "Future regulatory scenarios and risks".

In the context of Project 16.03.01, a first version of the IMPACT tool was developed by EUROCONTROL providing SESAR primary projects with the means to conduct fuel efficiency, aircraft emissions and noise assessments, from a web-based platform, using the same aircraft performance assumptions. IMPACT successfully passed the verification and validation process of the ICAO Committee on Aviation Environmental Protection Modelling and Database Group CAEP. Project 16.06.03 also ensured the continuous development/maintenance of other tools covering aircraft greenhouse gas (GHG) assessment (AEM), and local air quality issues (Open-ALAQ5). It should be noted that these tools 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.

In the context of Project 16.03.02, a set of metrics for assessing GHG emissions, noise, and airport local air quality were documented. The metrics identified by Project 16.03.02 will be gradually implemented in IMPACT.

Project 16.03.03 produced a comprehensive analysis of the issues related to environmental impact interdependencies and trade-offs.

Project 16.03.07 conducted a review of the then current environmental regulatory measures as applicable to ATM and SESAR deployment, and another report presenting an analysis of environmental regulatory and physical risk scenarios in the form of user guidance. It identifies both those concept of operations and Key Performance Areas which are most likely to be affected by these risks and the future operational solutions that can contribute to mitigating them. It also provides a gap analysis identifying knowledge gaps or uncertainties which require further monitoring, research or analysis.

Project 16.06.03, was the SESAR Environment support and coordination project which ensured the coordination and facilitation of all the

Environmental research project activities whilst supporting the SESAR/AIRE/DEMO projects in the application of the material produced by the research projects. In particular, this project delivered an Environment Impact Assessment methodology providing guidance on how to conduct an assessment, which metrics to use, and dos and don'ts for each type of validation exercise with a specific emphasis on flight trials.

The above-mentioned SESAR 1 environmental project deliverables constitute the reference material that SESAR2020 should be using.

SESAR 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 CO₂ 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).

A total of 15 767 flight trials were conducted under AIRE, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3 150 kg of CO₂), 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. More information can be found at <http://www.sesarju.eu>

A key feature leading to the success of AIRE is that it focused strongly on operational and procedural techniques rather than new technologies. AIRE trials used technology that was already in place, but until the relevant AIRE project came along, air traffic controllers and other users hadn't necessarily thought deeply about how to make the best operational use of that technology. For example, because of the AIRE initiative and the good cooperation between NAV Portugal and FAA, in New York and St Maria oceanic airspace lateral separation optimisation is given for any flight that requests it.

Specific trials were carried for the following improvement areas/solutions as part of the AIRE initiative:

- a. Use of GDL/DMAN systems (pre-departure sequencing system / Departure Manager) in Amsterdam, Paris and Zurich,
- b. Issue of Target-Off Block time (TOBT), calculation of variable taxiout time and issue of Target-Start-up Arrival Time (TSAT) in Vienna,
- c. Continuous Descent Operations (CDOs or CDAs) in Amsterdam, Brussels, Cologne, Madrid, New York, Paris, Prague, Pointe-à-Pitre, Toulouse, and Zurich,

- d. CDOs in Stockholm, Gothenburg, Riga, La Palma; Budapest and Palma de Majorca airports using RNP-AR procedures,
- e. Lateral and vertical flight profile changes in the NAT taking benefit of the implementation of Automatic Dependent Surveillance-Broadcast (ADS-B) surveillance in the North Atlantic,
- f. Calculation of Estimated Times of Arrival (ETA) allowing time based operations in Amsterdam,
- g. Precision Area Navigation - Global Navigation Satellite System (RNAV GNSS) Approaches in Sweden,
- h. Free route in Lisbon and Casablanca, over Germany, Belgium, Luxembourg, Netherlands in the EURO-SAM corridor, France, and Italy,
- i. Global information sharing and exchange of actual position and updated meteorological data between the ATM system and Airline AOCs for the vertical and lateral optimisation of oceanic flights using a new interface.

The **AIRE 1** campaign (2008-2009) demonstrated, with 1,152 trials performed, that significant savings can already be achieved using existing technology. CO₂ savings per flight ranged from 90kg to 1,250kg and the accumulated savings during the trials were equivalent to 400 tonnes of CO₂. This first set of trials represented not only substantial improvements for the greening of air transport, but generated further motivation and commitment of the teams involved creating momentum to continue to make progress on reducing aviation emissions.

Table 7: Summary of AIRE 1 projects

Domain	Location	Trials performed	CO ₂ benefit/flight
Surface	Paris, France	353	190-1 200 kg
Terminal	Paris, France	82	100-1 250 kg
	Stockholm, Sweden	11	450-950 kg
	Madrid, Spain	620	250-800 kg
Oceanic	Santa Maria, Portugal	48	90-650 kg
	Reykjavik, Iceland	48	250-1 050 kg
	Total	1 152	

The **AIRE 2** campaign (2010-2011) showed a doubling in demand for projects and a high transition rate from R&D to day-to-day operations. 18 projects involving 40 airlines, airports, ANSPs and industry partners were

conducted in which surface, terminal, oceanic and gate-to-gate operations were tackled. 9 416 flight trials took place. Table 8 summarises AIRE 2 projects operational aims and results.

CDOs were demonstrated in busy and complex TMAs although some operational measures to maintain safety, efficiency, and capacity at an acceptable level had to be developed.

Table 8: Summary of AIRE 2 projects

Project name	Location	Operation	Objective	CO ₂ and Noise benefits per flight (kg)	Number of flights
CDM at Vienna Airport	Austria	CDM notably pre-departure sequence	CO ₂ & Ground Operational efficiency	54	208
Greener airport operations under <u>adverse conditions</u>	France	CDM notably pre-departure sequence	CO ₂ & Ground Operational efficiency	79	1 800
B3	Belgium	CDO in a complex radar vectoring environment	Noise & CO ₂	160-315; -2dB (between 10 to 25 Nm from touchdown)	3 094
DoWo - Down Wind Optimisation	France	Green STAR & Green IA in busy TMA	CO ₂	158-315	219
REACT-CR	Czech republic	CDO	CO ₂	205-302	204
Flight Trials for less CO ₂ emission during transition from en-route to final approach	Germany	Arrival vertical profile optimisation in high density traffic	CO ₂	110-650	362
RETA-CDA2	Spain	CDO from ToD	CO ₂	250-800	210

DORIS	Spain	Oceanic: Flight optimisation with ATC coordination & Data link (ACARS, FANS CPDLC)	CO ₂	3 134	110
ONATAP	Portugal	Free and Direct Routes	CO ₂	526	999
ENGAGE	UK	Optimisation of cruise altitude and/or Mach number	CO ₂	1 310	23
RlongSM (Reduced longitudinal Separation Minima)	UK	Optimisation of cruise altitude profiles	CO ₂	441	533
Gate to gate Green Shuttle	France	Optimisation of cruise altitude profile & CDO from ToD	CO ₂	788	221
Transatlantic green flight PPTP	France	Optimisation of oceanic trajectory (vertical and lateral) & approach	CO ₂	2 090+ 1 050	93
Greener Wave	Switzerland	Optimisation of holding time through 4D slot allocation	CO ₂	504	1 700
VINGA	Sweden	CDO from ToD with RNP STAR and RNP AR.	CO ₂ & noise	70-285; negligible change to noise contours	189
AIRE Green Connections	Sweden	Optimised arrivals and approaches based on	CO ₂ & noise	220	25

		RNP AR & Data link. 4D trajectory exercise			
Trajectory based night time	The Netherlands	CDO with pre-planning	CO ₂ + noise	TBC	124
A380 Transatlantic Green Flights	France	Optimisation of taxiing and cruise altitude profile	CO ₂	1 200+ 1 900	19
				Total	9 416

The AIRE 3 campaign comprised 9 projects (2012-2014) and 5199 trials summarised in table 9.

Table 9: Summary of AIRE 3 projects

Project name	Location	Operation	Number of Trials	Benefits per flight
AMBER	Riga International Airport	Turboprop aircraft to fly tailored Required Navigation Performance – Authorisation Required (RNP-AR) approaches together with Continuous Descent Operations (CDO),	124	230 kg reduction in CO ₂ emissions per approach; A reduction in noise impact of 0.6 decibels (dBA).
CANARIAS	La Palma and Lanzarote airports	CCDs and CDOs	8	Area Navigation-Standard Terminal Arrival Route (RNAV STAR) and RNP-AR approaches 34-38 NM and 292-313 kg of fuel for La Palma and 14 NM and 100 kg of

				fuel for Lanzarote saved.
OPTA-IN	Palma de Mallorca Airport	CDOs	101	Potential reduction of 7-12% in fuel burn and related CO ₂ emissions
REACT plus	Budapest Airport	CDOs and CCOs	4 113	102 kg of fuel conserved during each CDO
ENGAGE Phase II	North Atlantic – between Canada & Europe	Optimisation of cruise altitude and/or Mach number	210	200-400 litres of fuel savings; An average of 1-2% of fuel burn
SATISFIED	EUR-SAM Oceanic corridor	Free routing	165	1.58 t CO ₂ emissions
SMART	Lisbon flight information region (FIR), New York Oceanic and Santa Maria FIR	Oceanic: Flight optimisation	250	3.13 t CO ₂ per flight
WE-FREE	Paris CDG, Venice, Verona, Milano Linate, Pisa, Bologna, Torino, Genoa airports	Free routing	128	693 kg CO ₂ for CDG-Roma Fiumicino; 504 kg CO ₂ for CDG Milano Linate
MAGGO	Santa Maria FIR and TMA	Several enablers	100	The MAGGO project couldn't be concluded

2.3.3.2 SESAR2020 Environmental Performance Assessment

SESAR2020 builds upon the expectations of SESAR1 and of the deployment baseline.

It is estimated that around 50.0m MT of fuel per year will be burned by 2025, ECAC wide, by around 10m flights. The SESAR2020 Fuel Saving Ambition (10%) equate to 500kg per flight or around 1.6 t CO₂ per flight, including:

- SESAR2020 Fuel Saving target for Solutions (6.8%) = 340kg/flight or 1 t CO₂/flight,
- SESAR 1 Fuel Saving performance (1.8%) = 90kg/flight or 283kg of CO₂/flight,
- SESAR Deployment Baseline Fuel Saving performance (0.2%) = 10kg/flight or 31kg of CO₂/flight,
- Non-SESAR ATM improvements (1.2%) = 60kg/flight or 189Kg of CO₂/flight.

It has to be noted that, while the SESAR 1 baseline was 2005, the SESAR2020 baseline is 2012.

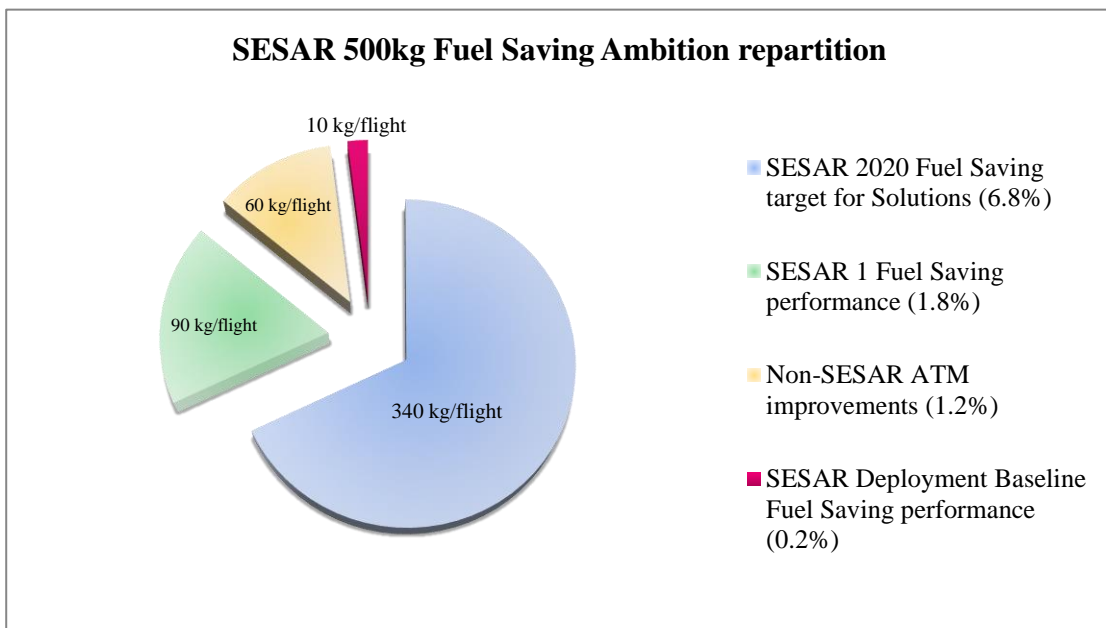


Figure 6.

SESAR2020 has put in place a methodology that should allow a close monitoring of the expected fuel saving performance of each Solution, and of the overall programme. But, at this point of the SESAR2020 programme, it is too early to assess with a good level of confidence the gap between the expected fuel-saving benefit of each SESAR Solution and its demonstrated potential from the results of the validation exercises.

However, 30 out of the 85 SESAR2020 Solutions have the potential to generate fuel savings. Table 10 provides the Top 10 Solutions with the biggest expected fuel saving potential:

Table 10: Summary of SESAR2020 projects offering the greatest potential fuel savings

Solution	Short description + Fuel saving rational	Operational environment (OE/ Sub-OEs) benefitting
<p>PJ.07-01 Airspace User Processes for Trajectory Definition</p>	<p>This Solution refers to the development of processes related to the Flight Operation Centre (FOC) aimed at managing and updating the shared business trajectory, and fully integrating FOCs in the ATM Network processes. These processes respond to the need to accommodate individual airspace users' business needs and priorities without compromising the performance of the overall ATM system or the performance of other stakeholders. This will also ensure continuity in the Collaborative Decision Making process throughout the trajectory lifecycle.</p> <p>The benefits will come through anticipation and choice of the optimal route and reduction of vertical inefficiencies, which will reduce costs and fuel burn. No real impact on airport is expected.</p>	<p>Mainly for: Terminal Very High Complexity En-route Very High Complexity</p> <p>Some benefit but much lower for: Terminal High, Medium, Low Complexity En-route High, Medium Complexity</p>
<p>PJ.10-01C Collaborative Control</p>	<p>This Solution refers to coordination by exception rather than coordination by procedure and is facilitated by advanced controller tools, reducing the need for coordination agreements, fewer boundary constraints and the ability to combine sectors into multisector planner teams.</p> <p>The existence of clear procedures for collaborative control reduces the need for coordination and results in a more streamlined method of operation close to a sector boundary. This may bring a reduction in the number of level-offs and, thus, bring a partial improvement in fuel efficiency.</p>	<p>Mainly for: Terminal Very High Complexity En-route Very High Complexity</p> <p>Some benefit but much lower for: Terminal High, Medium, Low Complexity En Route High, Medium Complexity</p>
<p>PJ.10-02b</p>	<p>This Solution aims to further improve the quality of services of separation management</p>	<p>Mainly for:</p>

<p>Advanced Separation Management</p>	<p>in the en-route and TMA operational environments by introducing automation mechanisms and integrating additional information (ATC intent, aircraft intent).</p> <p>Controller tools will enable earlier and more precise detection and resolution of conflicts. This will reduce the need for vectoring and enable de-confliction actions to be taken earlier and through the usage of closed clearances. Those will be managed more proactively on-board, and benefit fuel efficiency. Clearances issued by the ATCOs may, in some situations, take into account aircraft derived data related to airline preferences, bringing an improvement in fuel efficiency.</p>	<p>Terminal Very High Complexity</p> <p>En-route Very High Complexity</p> <p>Some benefit but much lower:</p> <p>Terminal High, Medium, Low Complexity</p> <p>En-route High, Medium Complexity</p>
<p>PJ.09-03 Collaborative Network Management Functions</p>	<p>This Solution allows for network management based on transparency, performance targets and agreed control mechanisms. The work enables a real-time visualisation of the evolving Airport Operation Plan (AOP) and Network Operating Plan (NOP) planning environment (such as demand pattern and capacity bottlenecks) to support airspace user and local planning activities.</p> <p>Thanks to this Solution, the increased efficiency of the performance of the system due to more optimised trajectory with airlines preference will result in fuel burn reductions.</p>	<p>Mainly for:</p> <p>En-route Very High Complexity</p> <p>Some benefit but much lower for:</p> <p>Terminal very High, High, Medium Complexity</p> <p>En-route High, Medium Complexity</p> <p>Airport very large, large, medium</p>
<p>PJ.01-02 Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA</p>	<p>This Solution brings near real time traffic management to the TMA, taking advantage of predicted demand information provided by arrival and departure management systems from one or multiple airports. This will allow the identification and resolution of complex interacting traffic flows in the TMA and on the runway, through the use of AMAN and DMAN flow adjustments and ground holdings.</p> <p>Traffic optimisation obtained thanks to this Solution will reduce the need for tactical interventions and will result in more efficient flights, and increased flight efficiency will save fuel.</p>	<p>Mainly for:</p> <p>Terminal Very High Complexity</p> <p>En-route Very High Complexity</p> <p>Some benefit but much lower for:</p> <p>Terminal very High, High, Medium, Low Complexity</p> <p>En-route High, Medium Complexity</p>

<p>PJ2-01 Wake turbulence separation optimization</p>	<p>This Solution refers to the use of downlinked information from aircraft to predict wake vortex and determine appropriate wake-vortex minima dynamically, thereby optimising runway delivery.</p> <p>Wake turbulence separation optimization should reduce airborne delays due to arrival capacity limitations linked to wake separations.</p> <p>For major airports that are today constrained in peak hours, the use of:</p> <ul style="list-style-type: none"> - optimised wake category scheme or pairwise separations can either be translated into added capacity (as described above) or additional resilience in case of perturbation. - time based separation will reduce the effect of a headwind on the arrival flow rate and thus increase the predictability of the scheduling process. <p>On less constrained airports, significant improvement can also be observed by employing reduced separation applied on a time based separation basis in the specific runway configuration or wind conditions responsible for a large part of the airport delay.</p> <p>This increases the flexibility for Controllers to manage the arrival traffic due to the separation minima reduction.</p> <p>The weather dependant reduction of wake separation, considering the allowable increase of throughput, is expected to be a major mitigation of delay and to provide for an increase in the flexibility for Controllers to manage the arrival traffic due to the reduction in the required wake separations.</p> <p>The reduction of delay will generate fuel saving.</p>	<p>Mainly for:</p> <p>Airports and TMAs with High and Medium complexity.</p> <ul style="list-style-type: none"> • Any runway configuration. • Airports with mainly strong headwinds. • Capacity constrained airports or airports with observed delay.
<p>PJ.09-02 Integrated local DCB processes</p>	<p>This Solution sees the seamless integration of local network management with extended air traffic control planning and arrival management activities in short-term and execution phases. The work will improve the efficiency of ATM resource management, as</p>	<p>Mainly for:</p> <p>Airport Very large</p> <p>Some benefit but much lower for: Terminal very</p>

	<p>well as the effectiveness of complexity resolutions by closing the gap between local network management and extended ATC planning.</p> <p>The increased efficiency of the performance of the system due to more optimised trajectory with airlines preference will result in fuel burn reductions.</p>	<p>High, High, Medium Complexity</p> <p>En-route very High, High, Medium Complexity</p> <p>Airport large, medium</p>
<p>PJ.01-03 Dynamic and Enhanced Routes and Airspace</p>	<p>This Solution brings together vertical and lateral profile issues in both the en-route and TMA phases of flight, with a view to creating an end-to-end optimised profile and ensuring transition between free route and fixed route airspace. The Solution will be supported by new controller tools and enhanced airborne functionalities.</p> <p>Significant fuel efficiency benefits are expected from Continuous Descent (CDO) / Continuous Climb Operations (CCO) in high density operations.</p> <p>CDO / CCO permit closer correlation of the actual with optimal vertical profile, to take into account the preference of the Airspace User for the most efficient climb / descent profile for the flight. Implementation of enhanced conformance monitoring / alerting by both ground and airborne systems reduce the likelihood of ATCO intervention in the climb / descent, so reducing the potential for tactical level offs.</p>	<p>Mainly for: Terminal Very High Complexity</p> <p>Some benefit but much lower for: Terminal High, Medium Complexity</p>
<p>PJ.02-08 Traffic optimisation on single and multiple runway airports</p>	<p>This Solution refers to a system that enables tower and approach controllers to optimise runway operations arrival and/or departure spacing and make the best use of minimum separations, runway occupancy, runway capacity and airport capacity.</p> <p>Imbalances known more than 3 hours ahead allow to re-planning inbound traffic from the originating airport or reconsider Airport Transit View (ATV) on behalf of airlines reducing delays due to airport constraints up to 20%. Planning runway closures or runway changes in the optimum periods of the day will minimize the time spent re-routing air and ground traffic during the execution phase. Sharing this information with the different actors will provide the NOP with more accurate</p>	<p>Mainly for: Terminal Very High Complexity</p> <ul style="list-style-type: none"> • Single and Multiple runways • Preferably Congested large and medium size airports

	<p>forecasts for arrival and departure time in order to coordinate the subsequent target times.</p> <p>There should be some fuel gains as a direct consequence of improved predictability, both for departures and arrivals (less variability ==> less patch stretching, holdings ...).</p>	
<p>PJ.08-01 Management of Dynamic Airspace configurations</p>	<p>This Solution refers to the development of the process, procedures and tools related to Dynamic Airspace Configuration (DAC), supporting Dynamic Mobile Areas of Type 1 and Type 2. It consists of the activation of Airspace configurations through an integrated collaborative decision making process, at national, sub-regional and regional levels; a seamless and coordinated approach to airspace configuration, from planning to execution phases, allowing the Network to continuously adapt to demand pattern changes in a free route environment) and ATC sector configurations adapted to dynamic TMA boundaries and both fixed and dynamic elements.</p> <p>This solution increased efficiency enabling optimised flight trajectories and profiles with the end result being reduced fuel burn, noise and CO₂ emissions.</p> <p>Advanced Airspace Management should decrease Airspace Users fuel consumption and reduce flight time.</p> <p>Optimised trajectory and a more direct route as a result of enhanced situation awareness through real airspace status update and seamless civil-military coordination by AFUA application.</p>	<p>Mainly for: En-route Very High Complexity</p> <p>Some benefit but much lower for: En-route High, Medium Complexity</p>



2.3.4 ECONOMIC/MARKET-BASED MEASURES

ECAC members 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 31 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 CO₂ emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO₂ emissions.

2.3.4.1 The EU Emissions Trading System

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. It operates in 31 countries: the 28 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS is the first and so far the biggest international system capping greenhouse gas emissions; it currently covers half of the EU's CO₂ emissions, encompassing those from around 12 000 power stations and industrial plants in 31 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 has recently been revised in line with the European Council Conclusions of October 2014²⁵ 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% domestic reduction of greenhouse gases compared to 1990²⁶.

The EU ETS began operation in 2005; 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. Aircraft Operators are entitled to free allocation based on an efficiency benchmark, but this might 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.

By 30th April each year, companies, including aircraft operators, have to surrender allowances to cover their emissions from the previous calendar year. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or sell them to another company that is short of allowances. The flexibility that trading brings ensures that emissions are cut where it costs least to do so. The number of allowances reduces over time so that total emissions fall.

²⁵ <http://www.consilium.europa.eu/en/meetings/european-council/2014/10/23-24/>

²⁶ 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>

As regards aviation, legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council²⁷. The 2006 proposal to include aviation in the EU ETS, in line with the resolution of the 2004 ICAO Assembly deciding not to develop a global measure but to favour the inclusion of aviation in open regional systems, was accompanied by a detailed impact assessment²⁸. After careful analysis of the different options, it was concluded that this was the most cost-efficient and environmentally effective option for addressing aviation emissions.

In October 2013, the Assembly of the International Civil Aviation Organisation (ICAO) decided to develop a global market-based mechanism (MBM) for international aviation emissions. Following this agreement the EU decided to limit the scope of the EU ETS to flights between airports located in the European Economic Area (EEA) for the period 2013-2016 (Regulation 421/2014), and to carry out a new revision in the light of the outcome of the 2016 ICAO Assembly. The temporary limitation follows on from the April 2013 'stop the clock' decision²⁹ adopted to promote progress on global action at the 2013 ICAO Assembly.

The European Commission assessed the outcome of the 39th ICAO Assembly and, in that light, made a new legislative proposal on the scope of the EU ETS. Following the EU legislative process, this Regulation was adopted in December 2017³⁰.

The legislation maintains the scope of the EU ETS for aviation limited to intra-EEA flights. It foresees that once there is clarity on the nature and content of the legal instruments adopted by ICAO for the implementation of CORSIA, as well as about the intentions of other states regarding its implementation, 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. This should be accompanied, where appropriate, by a proposal to the European Parliament and to the Council to revise the EU ETS Directive that is consistent with the Union economy-wide greenhouse gas

²⁷ 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>

²⁸ http://ec.europa.eu/clima/policies/transport/aviation/documentation_en.htm

²⁹ 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>

³⁰ 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

emission reduction commitment for 2030 with the aim of preserving the environmental integrity and effectiveness of Union climate action.

The Regulation also sets out the basis for the implementation of CORSIA. It provides for European legislation on the monitoring, reporting and verification rules that avoid any distortion of competition for the purpose of implementing CORSIA in European Union law. This will be undertaken through a delegated act under the EU ETS Directive.

The EU ETS has been effectively implemented over recent years on intra-EEA flights, and has ensured a level playing field with a very high level of compliance³¹. It will continue to be a central element of the EU policy to address aviation CO₂ emissions in the coming years.

The complete, consistent, transparent and accurate monitoring, reporting and verification of greenhouse gas emissions remains fundamental for the effective operation of the EU ETS. Aviation operators, verifiers and competent authorities have already gained wide experience with monitoring and reporting; detailed rules are prescribed by Regulations (EU) N°600/2012³² and 601/2012.³³

The EU legislation establishes exemptions and simplifications to avoid excessive administrative burden for the smallest operators of aircraft. Since the EU ETS for aviation took effect in 2012 a *de minimis* exemption for commercial operators – with either fewer than 243 flights per period for three consecutive four-month periods or flights with total annual emissions lower than 10 000 tonnes CO₂ per year applies. This means that many aircraft operators from developing countries are exempted from the EU ETS. Indeed, over 90 States have no commercial aircraft operators included in the scope of the EU ETS. In addition, from 2013 flights by non-commercial aircraft operators with total annual emissions lower than 1 000 tonnes CO₂ per year are excluded from the EU ETS. A further administrative simplification applies to small aircraft operators emitting less than 25 000 tonnes of CO₂ per year, who can choose to use the small emitters' tool rather than independent verification of their emissions. In addition, small emitter aircraft operators can use the simplified reporting procedures under the existing legislation. The recent amendment to extend the intra-EEA scope after 2016 includes a new

³¹ Report on the functioning of the European carbon market, COM(2017) 693 final, https://ec.europa.eu/commission/sites/beta.../report-functioning-carbon-market_en.pdf

³² Commission Regulation (EU) No 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0600&from=EN>

³³ Regulation (EU) No 601/2012 of the European Parliament and of the Council of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012R0601>

simplification, allowing aircraft operators emitting less than 3 000 tCO₂ per year on intra-EEA flights to use the small emitters' tool.

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 consider options available in order to provide for optimal interaction between the EU scheme and that country's measures. In such a case, flights arriving from the third country could be excluded from the scope of the EU ETS. This will be the case between the EU and Switzerland following the agreement to link their respective emissions trading systems, which was signed on 23rd November 2017. The EU therefore encourages other countries to adopt measures of their own and is ready to engage in bilateral discussions with any country that has done so. The legislation also makes it clear that if there is agreement on global measures, the EU shall consider whether amendments to the EU legislation regarding aviation under the EU ETS are necessary.

Impact on fuel consumption and/or CO₂ emissions

The environmental outcome of an emissions trading system is determined by the emissions cap. Aircraft operators are able to use allowances from outside the aviation sector to cover their emissions. The absolute level of CO₂ emissions from the aviation sector itself can exceed the number of allowances allocated to it, as the increase is offset by CO₂ emissions reductions in other sectors of the economy covered by the EU ETS.

With the inclusion of intra-European flights in the EU ETS it has delivered around 100 MT of CO₂ reductions/offsets between 2012 and 2018. The total amount of annual allowances to be issued will be around 38 million, whilst verified CO₂ emissions from aviation activities carried out between aerodromes located in the EEA has fluctuated between 53.5 MT CO₂ in 2013 and 61MT in 2016. This means that the EU ETS is now contributing more than 23 MT CO₂ of emission reductions annually³⁴, or around 100 MT CO₂ over 2012-2018, partly within the sector (airlines reduce their emissions to avoid paying for additional units) or in other sectors (airlines purchase units from other ETS sectors, which would have to reduce their emissions consistently). While some reductions are likely to be within the aviation sector, encouraged by the EU ETS's economic incentive for limiting emissions or use of aviation biofuels, the majority of reductions are expected to occur in other sectors.

³⁴ Report on the functioning of the European carbon market, COM(2017) 693 final, https://ec.europa.eu/commission/sites/beta.../report-functioning-carbon-market_en.pdf

Putting a price on greenhouse gas emissions is important to harness market forces and achieve cost-effective emission reductions. In parallel to providing a carbon price which incentivises emission reductions, the EU ETS also supports the reduction of greenhouse gas emissions through €2.1bn fund for the deployment of innovative renewables and carbon capture and storage. This funding has been raised from the sale of 300 million emission allowances from the New Entrants' Reserve of the third phase of the EU ETS. This includes over €900m for supporting bioenergy projects, including advanced biofuels.

In addition, through Member States' use of EU ETS auction revenue in 2015, over €3.5bn has been reported by them as being used to address climate change. The purposes for which revenues from allowances should be used encompass mitigation of greenhouse gas emissions and adaptation to the inevitable impacts of climate change in the EU and third countries. These will reduce emissions through: low-emission transport; funding research and development, including in particular in the field of aeronautics and air transport; providing contributions to the Global Energy Efficiency and Renewable Energy Fund, and measures to avoid deforestation.

In terms of its contribution towards the ICAO global goals, the states implementing the EU ETS have delivered, in "net" terms, a reduction of around 100 MT of aviation CO₂ emissions over 2012-2018 for the scope that is covered, and this reduction 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 31 individual 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.

Table 11: Summary of estimated EU-ETS emission reductions

<i>Estimated emissions reductions resulting from the EU-ETS</i>	
<i>Year</i>	<i>Reduction in CO₂ emissions</i>
<i>2012-2018</i>	<i>100 MT</i>

The table presents projected benefits of the EU-ETS based on the current scope (intra-European flights).

2.3.4.2 The Carbon Offsetting and Reduction Scheme for International Aviation

In October 2016, the Assembly of ICAO confirmed the objective of targeting CO₂-neutral growth as of 2020, and for this purpose to introduce a global market-based measure for compensating CO₂ emissions above that level, namely Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The corresponding resolution is A39-3: Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme.

According to the Assembly Resolution, the average level of CO₂ emissions from international aviation covered by the scheme between 2019 and 2020 represents the basis for carbon neutral growth from 2020, against which emissions in future years are compared. In any year from 2021 when international aviation CO₂ emissions covered by the scheme exceed the average baseline emissions of 2019 and 2020, this difference represents the sector's offsetting requirements for that year.

CORSIA is divided into 3 phases³⁵: There is a pilot phase (2021-2023), a first phase (2024-2026) and a second phase (2027-2035). During CORSIA's pilot phase and the first phase, participation from states is voluntary. The second phase applies to all ICAO Member States.



CORSIA Implementation Plan Brochure (© ICAO)

Exempted are States with individual share of international aviation activities in RTKs, in year 2018 below 0.5 per cent of total RTKs and States that are not part of the list of States that account for 90 per cent of total RTKs when sorted from the highest to the lowest amount of individual RTKs. Additionally Least Developed Countries (LDCs), Small Island

³⁵ Further information on <https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx>

Developing States (SIDS) and Landlocked Developing Countries are exempted as well.

CORSIA operates on a route-based approach. The offsetting obligations of CORSIA shall apply to all aircraft operators on the same route between States, both of which are included in the CORSIA. Exempted are a) emissions from aircraft operators emitting less than 10 000 tCO₂ emissions from international aviation per year, b) emissions from aircraft whose Maximum Take Off Mass (MTOM) is less than 5 700 kg, and c) emissions from humanitarian, medical and firefighting operations.

According to the "Bratislava Declaration" from September 3rd 2016 the Directors General of Civil Aviation Authorities of the 44 ECAC Member States declared their intention to implement CORSIA from the start of the pilot phase, provided certain conditions were met. 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 CO₂ emissions from air transport and to achieving overall carbon neutral growth.



2.3.5 EU Initiatives in Third Countries

Multilateral Projects

At the end of 2013 the European Commission launched a project with a total budget of €6.5 million under the name "*Capacity building for CO₂ mitigation from international aviation*". The 42-month project, implemented by the ICAO, boosts less developed countries' ability to track, manage and reduce their aviation emissions. In line with the call from the 2013 ICAO Assembly, beneficiary countries will submit meaningful State action plans for reducing aviation emissions. They then and received assistance to establish emissions inventories and pilot new ways of reducing fuel consumption. Through the wide range of activities in these countries, the project contributes to international, regional and national efforts to address growing emissions from international aviation. The beneficiary countries are the following:

Africa: Burkina Faso, Kenya and Economic Community of Central African States (ECCAS) Member States: Angola, Burundi, Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome and Principe.

Caribbean: Dominican Republic and Trinidad and Tobago.

Preceding the ICAO Assembly of October 2016 sealing the decision to create a global MBM scheme, a declaration of intent was signed between Transport Commissioner Violeta Bulc and ICAO Secretary General Dr Fang Liu, announcing their common intention to continue cooperation to address climate change towards the implementation of the ICAO Global Market Based Measures. On adoption of a decision by the ICAO Assembly on a GMBM, the parties intended to jointly examine the most effective mechanisms to upgrade the existing support mechanism and also to continue similar assistance, including cooperation and knowledge sharing with other international organisations, with the aim of starting in 2019.

The "Capacity building for CO₂ mitigation from international aviation" has been of enormous value to the beneficiary countries. A second project has been initiated by the European Commission aimed at assisting a new set of countries on their way to implementing the CORSIA. Further details will be published upon signature of the contract with the different parties.

Additionally, initiatives providing ASEAN Member States with technical assistance on implementing CORSIA have been initiated in 2018 and will possibly be extended further in 2019. The ARISE plus project dedicates an activity under result 3 - '*strengthened national capabilities of individual ASEAN Members States and aligned measures with ICAO SARPs*'. To achieve this, the project will support workshops in 2018 on capacity building and technical assistance, especially for the development or enhancement of actions plans. This will provide a genuine opportunity to pave the way for the effective implementation of further potential assistance and foster States readiness for their first national aviation emission report at the end of 2019.

EASA is also implementing Aviation Partnership Projects (APPs) in China, South Asia and Latin America (including the Caribbean) as well as projects funded by DG NEAR and DG DEVCO in other regions. This can enable the EU to form a holistic view of progress on CORSIA implementation worldwide.

In terms of synergies, the South Asia and South East Asia environmental workshops could engage with key regional stakeholders (ICAO Asia Pacific office, regulatory authorities, airline operators, verification bodies), and thereby assess the level of readiness for CORSIA on wider scale in the Asia Pacific region. This preparatory work would help focus the

subsequent FPI CORSIA project and create economies of scale in order to maximise the benefits of the project, which needs to be implemented within an ambitious timescale.



2.3.6 SUPPORT TO VOLUNTARY ACTIONS

ACI Airport Carbon Accreditation

This is a certification programme for carbon management at airports, based on carbon mapping and management standards specifically designed for the airport industry. It was launched in 2009 by ACI EUROPE, the trade association for European airports.

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 CO₂ 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.

This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). It is also officially supported by the United Nations Environmental Programme (UNEP). The programme is overseen by an independent Advisory Board.

At the beginning of this reporting year (May 2016) there were 156 airports in the programme. Since then, a further 36 airports have joined and 3 have withdrawn, bringing the total number of airports at the end of this reporting year (May 2017) to 189 covering 38.1 % of global air passenger traffic.

In 2017, for the first time, airports outside Europe achieved the highest accreditation status: 1 airport in North America, 5 in Asia-Pacific and 1 in Africa have been recognised as carbon neutral. European airports doubled their pledge and set the bar at 100 European airports becoming carbon neutral by 2030 from the 34 currently assessed to be carbon neutral.

Airport Carbon Accreditation is a four-step programme, from carbon mapping to carbon neutrality. The four steps of certification are: Level 1 "Mapping", Level 2 "Reduction", Level 3 "Optimisation", and Level 3+ "Carbon Neutrality".

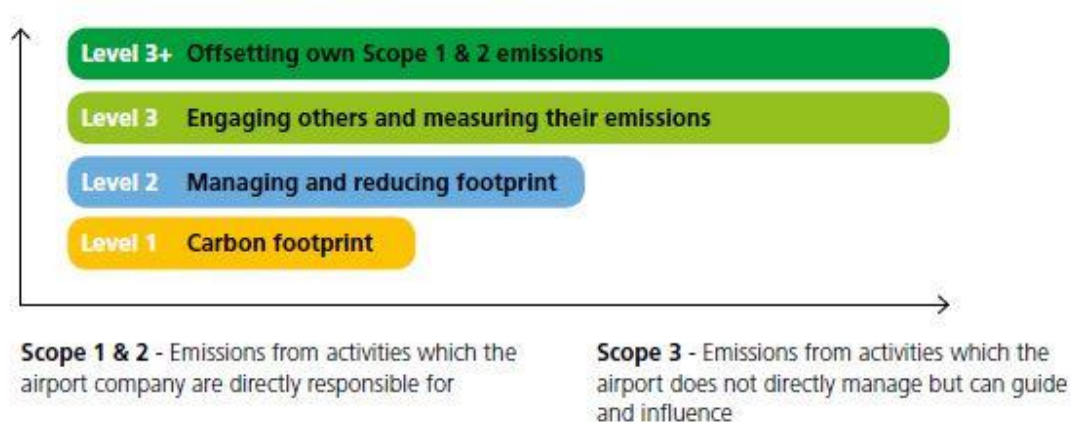


Figure 7: Four steps of Airport Carbon Accreditation

Levels of certification (ACA Annual Report 2016-2017)

One of its essential requirements is the verification by external and independent auditors of the data provided by airports. Aggregated data are included in the *Airport Carbon Accreditation* Annual Report thus ensuring transparent and accurate carbon reporting. At level 2 of the programme and above (Reduction, Optimisation and Carbon Neutrality), airport operators are required to demonstrate CO₂ reductions associated with the activities they control.

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 was maintained for the reporting year which ended with 116 airports in the programme. These airports account for 64.8% of European passenger traffic and 61% of all accredited airports in the programme this year.

Anticipated benefits:

The Administrator of the programme has been collecting CO₂ data from participating airports over the past five years. This has allowed the absolute CO₂ reduction from the participation in the programme to be quantified.

Table 12: Emissions reduction highlights for the European region

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

Table 13: Emissions offset for the European region

	2015-2016	2016-2017
Aggregate emissions offset, Level 3+ (tCO ₂)	222	252 218

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

Table 14: Summary of Emissions under airports direct control

Variable	2013 -2014		2014-2015	
	Emissions	Number of airports	Emissions	Number of airports

Aggregate carbon footprint for 'year 0' ³⁶ for emissions under airports' direct control (all airports)	2.04 MT CO ₂	85	2.09 MT CO ₂	92
Carbon footprint per passenger	2.01 kg CO ₂		1,89 kg CO ₂	
Aggregate reduction in emissions from sources under airports' direct control (Level 2 and above) ³⁷	87.4 ktonnes CO ₂	56	139 ktonnes CO ₂	71
Carbon footprint reduction per passenger	0.11 kg CO ₂		0.15 kg CO ₂	
Total carbon footprint for 'year 0' for emissions sources which an airport may guide or influence (level 3 and above) ³⁸	12.8 MT CO ₂	31	14.0 MT CO ₂	36
Aggregate reductions from emissions sources which an airport may guide or influence	224 ktonnes CO ₂		551 ktonnes CO ₂	
Total emissions offset (Level 3+)	181 ktonnes CO ₂	16	294 ktonnes CO ₂	20

Its 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 aircraft emissions in the LTO cycle are also covered. Thus, airlines can benefit from the gains

³⁶ 'Year 0' refers to the 12 month period for which an individual airport's carbon footprint refers to, which according to the Airport Carbon Accreditation requirements must have been within 12 months of the application date.

³⁷ This figure includes increases in CO₂ emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

³⁸ These emissions sources are those detailed in the guidance document, plus any other sources that an airport may wish to include.

made by more efficient airport operations to see a decrease in their emissions during the LTO cycle. This is consistent with the objective of including aviation in the EU ETS as of 1 January 2012 (Directive 2008/101/EC) and can support the efforts of airlines to reduce these emissions.

2.4 DETAILED RESULTS FOR ECAC SCENARIOS FROM SECTION A

2.4.1 BASELINE SCENARIO (technology freeze in 2010)

a) International passenger and cargo traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres ³⁹ RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported ⁴⁰ FTKT (billion)	Total Revenue Tonne Kilometres ^{42, 41} RTK (billion)
2010	4.6	1,218	0.20	45.4	167.2
2016	5.2	1,601	0.21	45.3	205.4
2020	5.6	1,825	0.25	49.4	231.9
2030	7.0	2,406	0.35	63.8	304.4
2040	8.4	2,919	0.45	79.4	371.2

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

b) Fuel consumption and CO₂ emissions of international passenger traffic departing from ECAC airports

Year	Fuel Consumption (10 ⁹ kg)	CO ₂ emissions (10 ⁹ kg)	Well-to-wake CO ₂ e emissions (10 ⁹ kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.28	146.26	179.6	0.0287	0.287
2020	49.95	157.85	193.8	0.0274	0.274
2030	61.75	195.13	239.6	0.0256	0.256
2040	75.44	238.38	292.7	0.0259	0.259

³⁹ Calculated based on 98% of the passenger traffic for which sufficient data is available.

⁴⁰ Includes passenger and freight transport (on all-cargo and passenger flights).

⁴¹ A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

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

2.4.2 IMPLEMENTED MEASURES SCENARIO

A) EFFECTS OF AIRCRAFT TECHNOLOGY IMPROVEMENT AFTER 2010

Fuel consumption and CO₂ emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2010 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	37.98	120.00	147.3	0.0310	0.310
2016	46.28	146.26	179.6	0.0286	0.286
2020	49.08	155.08	190.4	0.0270	0.245
2030	58.65	185.34	227.6	0.0247	0.247
2040	68.99	218.01	267.7	0.0242	0.242

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

B) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AFTER 2010

Fuel consumption and CO₂ emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2010:

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	37.98	120.00	147.3	0.0310	0.310
2016	46.24	146.11	179.4	0.0286	0.286
2020	49.03	154.93	190.2	0.0245	0.245
2030	57.38	181.33	222.6	0.0242	0.242
2040	67.50	213.30	261.9	0.0237	0.237

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

C) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AND ALTERNATIVE FUELS

Fuel consumption and CO₂ emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements as well as alternative fuel effects included:

Year	Fuel Consumption (10⁹ kg)	CO₂ emissions (10⁹ kg)	Well-to-wake CO₂e emissions (10⁹ kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.24	146.11	179.4	0.0286	0.286
2020	49.03	154.93	187.9	0.0245	0.245
2030	57.38	181.33	199.5	0.0242	0.242
2040	67.50	213.30	214.8	0.0237	0.237

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 alternative fuels.

3 NATIONAL ACTIONS IN SWEDEN

This section is complementary to the Supra-national actions described in section 1 above. In many cases, national activities and actions in Sweden that are described in this section are illustrations of how supra-national actions are implemented in Sweden. Many activities and projects that are intended to limit the emission of carbon dioxide from civil aviation in Sweden are based on extensive cooperation. The stakeholders involved are airports, air navigation services (ANS) providers, aircraft operators, research institutes and universities as well as central government and regional authorities and enterprises.

3.1 National initiatives

3.1.1 A national aviation strategy

In January 2017, the Swedish Government issued a national aviation strategy. The strategy provides a vision of the role of aviation in transportation in both the short-term and long-term future. The starting point are the national transport policy objectives and the goal of reaching the lowest rate of unemployment in the EU by 2020. The strategy points out accessibility domestically and internationally, the strengthening of Stockholm Arlanda Airport as a hub and a large airport, that the impact of aviation on climate and environment needs to decrease, an increase in export of Swedish services and goods. Sweden is to be in the forefront of increased aviation safety and that Sweden is to be a major player in research and innovation in the aviation industry.

3.1.2 Tax on air travel

From April 2018, a tax on aviation is applied on all Swedish airports and aircrafts approved for more than ten passengers. The tax rate differs on the final destination of the trip. For shorter trips, the tax rate is 60 SEK per passenger, for medium range trips the tax rate is 250 SEK per passenger and for longer trips the tax rate is 400 SEK per passenger. The full list of tax rates for different countries can be found on The Swedish Tax Agency's website.⁴²

3.1.3 Investigation on control means to promote the use of biofuels in aviation

A governmental investigation on sustainable biofuels in aviation has been issued. The investigation, issued in February 2018, will present proposals

⁴² Swedish Tax Agency,
<https://www.skatteverket.se/servicelankar/otherlanguages/inenglish/businessesandemployers/payingtaxesbusinesses/taxonairtravel/taxratepercountry.4.41f1c61d16193087d7f5472.html>

and regulations on how to promote biofuels in aviation. The investigation shall also investigate possible control means for reducing emissions caused by aviation and a reasonable rate of blending of biofuels in jet fuel considering pricing and availability of biofuels. The investigation intends to present its result in March 2019.

3.1.4 Research fund for research and development in bio-jet fuels

The Swedish Government has issued 100 MSEK between the years 2018 to 2020 to be issued to research and development within the area of bio-jet fuels. The Swedish Energy Agency is in charge of distributing these funds promoting more environmentally friendly jet fuels. The assignment also includes the establishing of an innovation cluster which gathers the full value chain of bio-jet fuels and to develop a united needs analysis in order to manage the transition to sustainable aviation.

3.1.5 A roadmap for carbon free competition

The initiative *Fossil Free Sweden* has released roadmaps for carbon free competition for different industries, including the aviation industry. This roadmap pinpoints necessary measurements needed for the aviation industry to become carbon free while maintaining competition. It presents the need for a fuel switch to more sustainable jet fuels, the need for extensive energy efficiency improvements and an increase in electrification.

An increase in production of sustainable jet fuels is essential while a market for the sustainable bio-jet fuels needs to emerge. The target is for all domestic aviation to be fossil free by 2030 and for all aircraft departing from Sweden to be fossil free by 2045.

The major suggestions are; to form a governmental investment support for bio-jet fuel producers, to issue public targets with stops in 2030 and 2045 including a long-term goal for electrification in aviation and to establish a governmental procurement for fossil free fuels needed for public flights within Sweden.

3.1.6 Strategic plan for converting the transport sector to fossil-free fuels

In April 2017, six Swedish government agencies issued a strategic plan for converting the transport sector to fossil-free fuels. The plan includes a separate plan for the aviation industry. This strategic document presents a number of possible measures to decrease the climate- and environmental impact of the aviation industry; an investigation into the possibilities for the EU ETS-system and CORSIA to turn the fast growing increase in emissions from international aviation, more ambitious targets within the EU-system of

performance plans, an investigation into the possibility of demanding flights to present its climate impact in sales and marketing of flights, information- and knowledge spreading efforts on more climate suitable travelling and transports, an investigation on control means to promote the use of biofuels in aviation (see above) and a review of governmental research funds toward aviation and to assess how they can be formed to focus more distinctly on fossil-free fuels.

3.2 Improved Air Traffic Management, Infrastructure Use and Operational Improvements

3.2.1 In-depth Investigation regarding the design of the Swedish airspace

The Swedish government have instructed LFV to carry out an in-depth study regarding the design of the Swedish airspace. The study should result in an airspace strategy that could provide the basis for the mission to carry out a review of the airspace.

The reporting of the assignment shall include a focus on airspace use and purpose of the change. LFV shall herewith make suggestions on what goals and key performance areas that could be ruling in the future change of Swedish airspace. The report should include at least aspects such as aviation safety, capacity, cost-effectiveness and environmental impact. The report should also include a description of how the introduction of unmanned aircraft, such as drones, affecting airspace capacity. LFV shall also report the balance between different airspace users' interests.⁴³

3.2.2 Extended Free Route Airspace – NEFRA and Borealis

The NEFRA Programme has been a cooperative effort by technical and operational experts from six air navigation service providers in neighbouring Danish/Swedish and North European FABs - Avinor, EANS, Finavia (now ANS Finland), LGS, LFV, and Naviair. It originated from regional FAB-wide FRA initiatives in DK/SE FAB and NEFAB, setting cross border free route operations as the ultimate goal for ensuring the most cost effective and fuel efficient flights in the whole area.

The final NEFRA's milestone was successfully accomplished on May 25th 2017 by connecting the Free Route Airspace (FRA) in Norway with the seamless FRA area already available across Denmark, Estonia, Finland, Latvia, and Sweden. This has expanded the area where aircraft operators can fly their preferred trajectories as if in one airspace, marking completion of the four-year Programme.

⁴³ <https://www.regeringen.se/regeringsuppdrag/2018/05/uppdrag-att-genomfora-en-fordjupad-studie-avseende-utformning-av-det-svenska-luftrummet/>

The activity has required number of upgrades of ATM functionalities enabling cross border FRA operations, and demanded for common flight planning procedures and training of air traffic controllers.

3.2.3 EcoFly - structured environmental co-operation between stakeholders

In EcoFly, LFV and Swedavia quarterly meet representatives from five airlines (SAS, Norwegian, BRA, TUI and Novair) in order to continuously analyse airspace, procedures and working methods for Pilots and Air Traffic Controllers to find common areas of improvements and environmental gains.

EcoFly is an important forum to gather knowledge and enhance the understanding between airlines, pilots, airports and LFV. The co-operation has also resulted in a lot of modifications to working methods at LFV, such as enhanced methods for providing predictability for approach planning, enabling CDO, providing distance-to-go during approach vectoring, more fuel efficient ways to use speed control etc.

3.2.4 Reduced and harmonised descent speeds

By reducing descent speed and descent angle, arriving flights can leave the cruise level somewhat earlier and thereby save fuel and reduce emissions. This can also make the descent- and speed profiles of the arriving traffic flow more harmonised, which in turn can make ATC sequencing more efficient. Actual fuel data and model calculations for both Airbus321 and Boeing737 show that a reduction of descent speed by 20 knots will save approximately 20 kg of fuel. In turn the flight will be extended by 45 seconds, but an increasing number of airlines want to make this trade-off between fuel and time by getting their pilots to use lower descent speed.

LFV is currently examining if it is possible to publish a harmonised descent speed for all airports in Sweden.

3.2.5 Pilot project – Environmental analysis of flight operations for Åre Östersund Airport

LFV conducts active environmental work, both in its own operations and by creating good opportunities for customers to reduce their environmental impact. To work for reduced carbon dioxide emissions are today a necessity, both from social and economic standpoints and to be an attractive partner, provider and employer.

Swedavia owns, operates and develops a network of Swedish airports. All of Swedavia's airports are climate-certified at the highest level of the Airport Carbon Accreditation (ACA) programme. Only 30 airports in Europe meet

the requirements at this level and a third of them are Swedavia airports. This is further described in section 4.5.1.

As the ANSP for Swedavia, LFV must meet the customers demand; optimize flight operations in order to reduce emissions. A pilot project was initiated 2016 by LFV together with Swedavia in which the environmental efficiency of the flight operations at Swedavia Åre Östersund Airport were studied in depth. The purpose of the survey was fourfold: provide a description of a baseline, identify areas where the environmental impact of air operations can be reduced, find possible solutions for the identified deficiencies and calculate the improvements in terms of CO₂ emissions.

The report also provided support for Åre Östersund Aiport in its relations with relevant stakeholders such as customers, environmental authorities and the local community. This pilot project also developed advanced ATM analysis methods that will be of great assistance when analyzing other airports.

As a result of the pilot project LFV conducted an environmental analysis of flight operations for Swedavia Umeå Airport during 2017.

3.2.6 Training Air Traffic Controllers in fuel management

In 2015-2017 LFV trained all controllers in a 2 hour program focusing on ATC-behavior and flight efficiency/environmental impact. The training included impact of air traffic noise, Swedish environmental legislation for airports, and what airlines are doing to increase flight efficiency (eg. using cost indexes). But the main focus was on how different solutions to operative situations will impact flight efficiency/fuel flow. Eg. the consequences of an off-track solution instead of a level off for departing traffic, the fuel impact of speed during descent, how controllers could provide maximum predictability for pilots in their planning for optimum top of descent. All data used was checked with the main Swedish airlines.

3.2.7 Co-operation on Swedavia's environmental processes

LFV assists Swedavia with Environmental Impact Assessments (EIA) and in the legal processes regarding new environmental permits for some of the major airports in Sweden. These processes comprise analysis on improvements and how leading edge technology can be used to reduce the environmental impact. As a result of this co-operation, Swedavia will for example introduce environmental optimized RNP AR-procedures to Arlanda in June 2018.

3.3 Measures taken from the airline-industry

The most powerful measure to minimize the climate impact of aviation readily available to operators today is to fly the newest and most

environmental friendly aircraft on the market. In Sweden there is an ongoing re-generation of the fleet as several operators are investing in new aircraft types with reduced environmental footprint.

Scandinavian Airlines (SAS) is ISO14001 certified and has set the goal to reduce flight emissions per passenger kilometer by 20 % in 2020 compared with 2010. This is primarily done by fleet renewal, fuel saving and usage of alternative sustainable jet fuel. SAS is currently in an ongoing fleet replacement process, where older B737NG and A320ceo-family aircraft are replaced with new A320neo. SAS will also introduce A350 from 2019 onwards on long haul flights. SAS also uses ATR72-600 and CRJ900 on shorter routes. In general, with the new aircraft, the fuel saving is estimated to be over 15-20 % compared to an equivalent sized aircraft resulting in sharply reducing CO₂ emissions.

Norwegian Air Shuttle ASA (Norwegian) has one of the youngest fleets in the world. With a fleet of nearly 150 planes the average fleet-age is only 3,7 years. The Boeing 787 emits some 20% less than its predecessors. Norwegian has furthermore ordered 100 Boeing 737 MAX entering into service starting this summer: the MAX consumes around 20% less fuel than the plane it replaces, the Boeing 737-800.

To support the corporate goal of Braathens Regional Airlines' (BRA) to achieve 100% fossil free domestic flying by 2030 the airline has invested in a new turboprop-fleet with the fuel-efficient ATR 72. The ATR 72 has the potential to reduce the emissions with approximately 30 % per passenger kilometer. Flying the ATR 72 also means that there is no "high altitude effect" as these aircrafts fly well below the critical levels. BRA's jet fleet is going to be renewed from 2020. The investment in new jet aircraft was delayed from 2018 to 2020 due to the uncertainty considering the effects of the new "Flygskatt" (Tax on aviation) would have on the domestic market.

Novair, fully owned by one of the largest tour operators in Scandinavia the Apollo group, took delivery of brand new A321neo aircraft in the summer of 2017, replacing A321ceo aircraft. This new technology enables more than 15% improved performance in fuel consumption per passenger compared to the aircraft that were replaced.

3.3.1 Improved air traffic management and infrastructure use

Aviation Capacity Resources AB (ACR) offers 'green approaches' at the airports where they provide services which empowers the operators and pilots to optimize their flight profiles towards higher environmental efficiency. Furthermore, the development of satellite based approach procedures at the airports contribute to shorter and faster approach procedures.

Novair has been involved in the European ATM modernization programme SESAR since 2009, acting as an Airspace User Expert. Special focus has been on Trajectory Based Operations, Terminal Maneuvering Area aspects and measurement of ATM efficiency in terms of fuel consumption. Ongoing activities are currently in place with active engagement in large scale European validation activities, to enable future Trajectory Based Operations, seen as a key enabler for a future Single European Sky.

3.3.2 Alternative fuels

The introduction of alternative fuels is another powerful way for airlines to reduce aviation's impact on the environment. Biofuels, for example, have the potential to reduce overall carbon emissions by between 40 to 80 per cent, depending on how they are produced and which feedstocks they come from. Biofuel refers to fuel made from renewable organic raw materials, such as waste and residue or plant oils. The plants used in the production of biofuel absorb carbon dioxide, which is released back into the atmosphere when the biofuel combusts.

Fossil Free Sweden was initiated by the Swedish government ahead of the COP21 climate change conference in Paris in 2015 as the United Nations launched an Action Agenda, to show how enterprises, cities, municipalities and organizations contribute to climate efforts.

The ambition is to make Sweden one of the first fossil free welfare countries in the world. Not only because it is our responsibility to future generations, but because it makes economic sense. To achieve this, all actors in society must work actively to reduce emissions. Within the framework of Fossil Free Sweden, the Swedish Aviation Industry has produced a roadmap how Swedish aviation could become completely 100% fossil free by 2045, and domestic fossil free flying already by 2030.

The following are examples of specific measures taken by the operators support the transitioning to biofuels:

- BRA has for example launched several initiatives to help kick-start the domestic demand for bio fuel. BRA enables their customers to reduce the environmental footprint by adding bio-fuel to their trip, either in a separate agreement (corporate product) or while booking their flight directly on the on the web. They also make it possible for their loyalty program members to change their “award points” to biofuel. In cooperation with Halmstad City Airport and Air BP, they also co-finance the blending with 5 % biofuel on an annual basis at Halmstad City Airport.

- SAS contribution and efforts to accelerate the commercialization of alternative sustainable jet fuels is extensive through participation in a large number of projects and corporations on the biofuel topic. SAS currently use alternative sustainable jet fuel on flights from Oslo and Bergen. SAS plans to use biofuels from a number of Swedish airports during 2018.

These initiatives are taken to show realistic and possible ways forward, showing decision makers and investors that there is a demand for bigger scale production of bio fuel from local raw material. In the future, the Swedish aviation industry hope that political decisions will enable the necessary investments to give the market access to locally produced bio fuel to a competitive price instead of penalizing the industry with taxes or other measures with little or no positive effect on the environment.

The efficiency of the measures taken by the industry is proven. BRA for example reports that the combination of an upgraded fleet and access to bio fuel has shown a reduction of the fossil emissions of by 65 % on a test flight that was performed in February 2017 between Bromma and Umeå.

3.3.3 More efficient operations

Technological improvements are not the only means to reduce emissions. Better planning of operations is also a key factor when trying to find a way towards cleaner aviation. This is also a priority for the Swedish aviation industry.

ACR has for example implemented procedures and instructions to its controllers to always give clearance to the aircraft to follow that nearest/shortest route that the traffic allows.

SAS is working actively with fuel saving activities which includes almost all operations. The activities range from all types of efficiency enhancements incorporated in the flight procedures in the daily operation to modification of existing aircraft, for example with upgraded engines and lighter interior. If SAS is not in direct control of the process itself they work through stakeholder collaboration with for example airports and air navigations service providers to ensure the process.

BRA uses a palette of measures to be as efficient as possible in every step of the flight operations, such as flying on the right level, optimal speed and asking for the shortest possible route. Weight reducing measures, such as “paperless cockpit”, which saves tons of paper and fuel, have also been implemented in the last years.

Another leading example is Novair which is working in multiple disciplines to enable sustainable growth in the aviation industry which includes a

continuous on-going internal fuel conservation programme to improve operating procedures, weight reduction and maintenance activities. Furthermore, Novair is working in various partnerships with other national stakeholders such as the Air Navigation Service Provider LFV and the airport operator Swedavia concerning improvement in airspace design and new instrument flight procedures. Among novelties stemming from this work is the implementation of new Performance Based Navigation (PBN) procedures, such as at Stockholm Arlanda Airport, where new curved arrival procedures will be implemented in the Swedish AIP by the end of June 2018, designed to avoid overflying noise sensitive areas near the airport and resulting in significant fuel savings and lesser CO₂ emissions.

As a member of the European Union, all Swedish operators implement the EU Emissions Trading Scheme (EU ETS) on their intra-EU routes.

3.3.4 Other measures from Airline-industry

The Swedish aviation industry works in every way to mitigate the environmental impact of its activities. These efforts go much further than what regulations require today as the industry is eager to speed up the development towards more environmentally friendly and economically sound aviation.

The development and introduction of electrical and hybrid aircraft is fully supported and the industry follows and invests in this development with great interest. SAS, for example, supports projects connected to the development of aircrafts with increased or fully usage of electricity for propulsion. Several short and medium range domestic routes in Sweden should be optimal for introducing this new aircraft technology once it is available on the market.

Other measures, such as CO₂-compensation is offered by most airlines and airport operators. Specifically, SAS offer its customers to upgrade their fuel consumption to biofuel or offset the CO₂-emissions through CO₂-compensation.

In 2009, BRA was the first commercial airline to be certified ISO14001 in 2009, at the time under the names Malmö Aviation and Sverigeflyg. Today, BRA is certified ISO 14001:2015. BRA has furthermore adopted a companywide sustainability policy since they want to actively contribute to the fulfillment of the UN's goals for sustainable development.

3.4 Other measures

3.4.1 European Airport carbon Accreditation (Swedavia)

The Airport Carbon Accreditation Scheme is described in chapter 2.3.6. The scheme was launched in June 2009. Stockholm/Arlanda Airport was the first airport accredited at the highest level in the European Airport Carbon Accreditation (ACA) program 2009.

Since then, all the Swedavia airports have been certified. That means that as of June 2018, the Swedish airport operator Swedavia owns and operates ten of the total of 39 airports in world with the highest level of certification 3+. 30 of these are located in Europe.⁴⁴ Certification at ACA's highest level (3+, Neutrality) means that the net carbon dioxide emissions over an entire year are zero. The airport must also give an account of its own fossil carbon dioxide emissions as well as emission sources that the airport can influence. All emission sources are verified by an independent auditor. Not only must the airport reduce its own emissions, it also requires third party engagement in carbon footprint reduction.

By 2020, Swedavia will have zero emissions from CO₂ from their own operations. Swedavia therefore actively supports the development of renewable jet fuels in the Nordic countries and the access to bio jet fuels at Swedavia's airports in Sweden.

One of the most important activities for Swedavia in 2016 was continued investment in the development and increased use of renewable aviation fuel throughout the air travel industry. Swedavia was the first company in the world to purchase aviation biofuel equivalent to the amount used by its employees' air travel for official business for one year. The Fly Green Fund, an economic association in which Swedavia is a partner, was entrusted with the task, and the first fuel was delivered in December 2016. The total investment of ten million SEK will be divided, depending on the final price of the fuel, between fuel purchases and support for research and development in projects leading to large-scale production in the Nordic countries. So far, airlines have shown only limited interest in Swedavia's efforts to cover part of the additional cost of renewable fuel for airlines. One of the challenges in 2017 was to contribute to the establishment of a pilot facility for producing sufficient biofuel volumes in order to establish large-scale Nordic production in the long term. However, as mentioned in chapter 3.1.3, a government investigation has started looking into the challenge. In April 2018, a digital arena was launched by SAS, Swedavia and Research

⁴⁴ <http://www.airportcarbonaccreditation.org/airport/participants/europe.html>

Institute of Sweden (RISE), where different initiatives shall collaborate in order to accelerate the production of biofuels.⁴⁵

3.4.2 Nordic Initiative for Sustainable Aviation (NISA)

NISA is a Nordic association working to promote and develop a more sustainable aviation industry, with a specific focus on alternative sustainable fuels for the aviation sector. The goal of NISA is to accelerate the development and the commercialization of sustainable aviation fuels. This is achieved by organizing activities, strengthening the cooperation across the value chain and by focusing on opportunities in the Nordic region. The actors behind the initiative are the Nordic airports, Nordic airlines and their organizations, and the aviation authorities. The initiative is also supported by aircraft manufacturers Airbus and Boeing.

3.4.3 Actions at regional level

For Sweden's regional airports, a joint decision taken at the Annual General Meeting in April 2017, agreed that the airports will contribute to reaching the goal of a fossil-free domestic air travel until 2030. For this, cooperation between most regional airports is now starting. The overall goal is to be able to:

- Offer 5% fossil-free refueling of aviation fuel by 2018
- Offer 50% fossil-free refueling of aviation fuel 2025
- Offer 100% fossil-free refueling of aviation fuel 2030
- Participate in regional environmental goals aimed at 100% fossil-free region

With the joint environmental efforts of the regional airports, the entire aviation industry in Sweden has embraced the ambition to completely switch to fossil-free biofuels and create a climate-neutral aviation.

The regional airports' commitment to a fossil-free flight also facilitates regional and local initiatives already in place to create a domestic biofuel production in Sweden. The ambition of Swedish regional airports is that Sweden's first biofuel plant will be established in connection with some of our regional airports.⁴⁶

⁴⁵ <https://www.bioflygarena.com/>

⁴⁶ <https://www.flygplatser.se/de-regionala-flygplatsernas-miljoarbete/>

4 LIST OF ABBREVIATIONS

- ACARE** – Advisory Council for Research and Innovation in Europe
- ACARS** – Aircraft Communications Addressing and Reporting System
- ACA** – Airport Carbon Accreditation
- ACC** – Area Control Centres
- ACCAPEG** – Aviation and Climate Change Action Plan Expert Group
- ACI** – Airports Council International
- APER TG** - Action Plans for Emissions Reduction Task Group of the ECAC/EU Aviation and Environment Working Group (EAEG)
- EAER** – European Aviation Environmental Report
- AEM** – Advanced Emission Model
- AFTF** – Alternative Fuels Task Force (of ICAO CAEP)
- AIRE** – The Atlantic Interoperability Initiative to Reduce Emissions
- ANS** – Air Navigation Service
- ATC** – Air Traffic Control
- ATM** – Air Traffic Management
- BAU** – Business as Usual
- CAEP** – Committee on Aviation Environmental Protection
- CCD** – Continuous Climb Departures
- CDA** – Continuous Descent Approach
- CDM** - Collaborative Decision Making
- CDA** – Continuous Descent Approach
- CDO** - Continuous Descent Operations
- CNG** – Carbon neutral growth
- CORSIA** - Carbon Offsetting and Reduction Scheme for International Aviation
- CPDLC** – Controller-Pilot Data Link Communications
- 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

FAB – Functional Airspace Block
FANS – Future Air Navigation System
FP7 - 7th Framework Programme
GHG – Greenhouse Gas
GMBM – Global Market-based Measure
Green STAR – Standard Arrival
Green IA – Initial Approach
HVO – Hydro-treated Vegetable Oil
ICAO – International Civil Aviation Organisation
IFR – Instrumental Flight Rules
4.1.1 IPCC – **Intergovernmental Panel on Climate Change**
IPR – Intellectual Property Right
JTI – Joint Technology Initiative
LTO cycle – Landing/Take-off Cycle
MBM – Market-based Measure
MT – Million tonnes
OFA - Operational Focus Area
RED – Renewable Energy Directive
RNAV – Area Navigation
RNP AR – Required Navigation Performance Authorization Required
RNP STAR – Required Navigation Performance Standard Arrival
RPAS – Remotely Piloted Aircraft
RPK – Revenue Passenger Kilometre
RTK – Revenue Tonne Kilometre
RTD – Research and Innovation
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
SWAFEA – Sustainable Ways for Alternative Fuels and Energy for Aviation
SWIM – System Wide Information Management
TMA - Terminal Manoeuvring Area
ToD – Top of Descent

UNEP – United Nations Environmental Programme