State Action Plan of Finland

International Aviation CO_2 Emissions

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International Aviation CO_2 Emissions

Liikenteen turvallisuusvirasto (Trafi)
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ALKUSANAT

Lentoliikenteen kansainvälistä ympäristötyötä tehdään YK:n alaisen Kansainvälisen siviili-ilmailujärjestön (ICAO) johdolla. Liikenteen turvallisuusvirasto (Trafi) oli Suomen ilmailuviranomaisena ICAOn yleiskokouksessa vuonna 2016 sopimassa siitä, että vuonna 2021 otetaan käyttöön maailmanlaajuinen kansainvälisen lentoliikenteen päästöjärjestelmä CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation). Uuden päästöjärjestelmän ja päästövähennyskeinojen avulla pyritään lentoliikenteessä hiilineutraaliin kasvuun vuodesta 2020 lähtien.

Vuonna 2013 ICAOn yleiskokouksessa sovittiin, että lentoliikenteen energiatehokkuutta parannetaan vuosittain kahdella prosentilla vuoteen 2050 saakka. Valtioiden tulee raportoida kansainvälisen lentoliikenteen CO_2-päästönsä ICAO:lle. Kunkin valtion on myös laadittava toimintasuunnitelma, jossa se linjaa toimensa ilmastonmuutoksen hillitsemiseksi lentoliikenteen osalta.

Suomen kansallinen toimintasuunnitelma

Suomen päivitetty toimintasuunnitelma (State Action Plan) annettiin tänään sähköisesti ICAOlle. Suomi laati suunnitelmansa EU / ECAC -valtioiden sopiman mallin mukaisesti, jossa on sekä ylikansallinen että kansallinen osuus. Ylikansallisen osuuden luonnosteli APER-työryhmä (Action Plans for Emissions Reduction Task Group). Kansallisia erityispiirteitä kuvaavan osuuden Trafi laati yhteistyössä suomalaisten lentoyhtiöiden, lentoasemien pitäjän ja lennonvarmistuspalveluiden tarjoajan sekä polttoaineen tuottajan kanssa. Suunnitelman kansallinen osuus käsittelee seuraavia aihealueita:

* Ilma-aluksiin liittyvä tekninen kehitys

* Kestävien vaihtoehtoisten polttoaineiden (biopolttoaineet) kehitys ja käyttöönotto

* Ilmatilanhallinnan ja infrastruktuurin optimointi ja parantaminen

* Tehokkaammat lento-operaatiot

* Markkinaperusteiset päästöjenvähennyskeinot

* Muut päästöjenvähennyskeinot

Vuonna 2015 Suomen toimintasuunnitelmaa työstänyttä työryhmää veti erityisasiantuntija Joonas Laukia Trafista, ja toimintasuunnitelman päivittämisestä vuosina 2016 ja 2018 vastasi erityisasiantuntija Tiia Jyräsalo Trafista. Päivittämiseen osallistuivat hallitussihteeri Janne Mänttäri liikenne- ja viestintäministeriöstä, johtava asiantuntija Kari Siekkinen ja johtava asiantuntija Katja Lohko-Soner Trafista, kestävän kehityksen johtaja Mikko Viinikainen ja ympäristöasiantuntijat Tuomo Linnanto ja Johanna Kara Finaviasta, Fuel Manager Hanna Salmi, Environmental Manager Outi Merilä ja kestävän kehityksen johtaja Kati Ihamäki Finnairista, Head of operations support Jarno Ruotsalainen Nordic Regional Airlinesista sekä Development Manager Virpi Kröger Nesteeltä.

Helsingissä 16.7.2018

Pekka Henttu

ilmailujohtaja

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1 Common Introductory Section for European States' Action Plans for CO_2 Emission Reductions

a) Finland 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 States[1] 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) Finland, 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) Finland 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 Finland.

f) Finland 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,

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.

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[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

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 Finland is described, as well as that of other stakeholders.

h) In Finland 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 Current state of aviation in Finland

1.1.1 General

Air transport is an important part of an efficient and well-functioning transport system and a key factor for competitiveness of Finland. Economic growth in Finland is based on export, but the country is located far from the market areas for our products. Logistically, Finland is an island; without air transport, it would not be able to perform swift overnight carriages or move goods to the larger market areas of Europe. Flying to Central Europe takes a couple of hours, while the travel time with other forms of transport is several days. A study conducted by Oxford Economics estimated that the aviation sector, together with closely connected industry sectors, produce 3.2% of Finland's GDP, and employ a total of 100 000 persons directly or indirectly.

1.1.2 Development of air transport in Finland

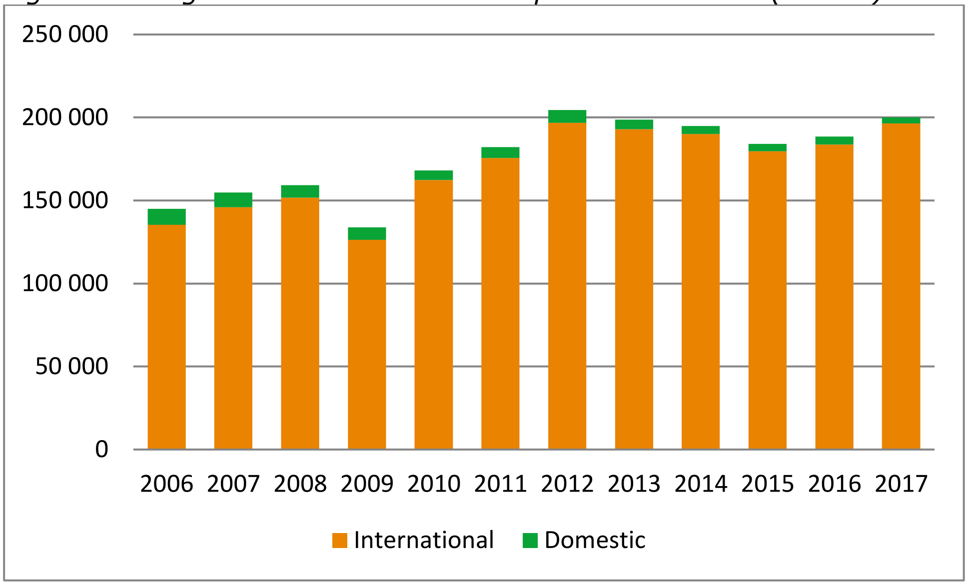
International air transport has grown rapidly in recent years. In Finland, domestic traffic has been declining, but international services have increased. At present, about 80% of air traffic is international. The long-term trend in air traffic is upward, although the economic recession also affected the figures in aviation. To meet the challenges of globalisation, Finland must continue to ensure connectivity with swift and efficient connections both within the country and abroad. Tourism will be a major factor in maintaining and developing domestic and international air transport in the future – according to an IATA study, 36% of foreign tourists arrive in Finland by plane. More than 80 % of Finland´s air passenger traffic and about 95% of air freight traffic passes through Helsinki Airport. A total of 22.7 million passengers and 199 982 tonnes of air freight went through Finnish airports in 2017. Even though only about 1 % of the total volume of imports and exports are carried by air freight, about 10 % of total value of foreign trade is carried by air. The volume of air freight is expected to grow in the near future. Due to the gateway position of Helsinki Airport (18.9 million passengers in 2017), Finland is able to offer and maintain an exceptionally wide range of destinations with regard to the size of the country (5.5 million inhabitants). Finland aims to further strengthen its position as a gateway between Europe and Asia.

Figure 1. Passenger traffic at Finnish airports 2006-2017.

Source: Statistics Finland, Finavia.

Tough competition, rapid changes in jet fuel prices and economic situation significantly affect airline operations. There are total of 13 commercial air carriers in Finland, out of which Finnair is still by far the largest. Market share of low-cost carriers has remained relatively small. New operators are however making continuous attempts to enter air traffic markets in Finland, and the market share of low-cost airlines is growing. Two largest Finnish airlines, Finnair and Nordic Regional Airlines, together with Norwegian, operate nearly all of the domestic traffic, and over 70 % of international traffic.

Figure 2. Freight and mail at Finnish airports 2006-2017 (tonnes).



Source: Statistics Finland, Finavia.

The airport network is dense in Finland: there are 24 airports within the airport network maintained by state-owned company Finavia Ltd and two independent airports maintained by municipalities (Seinäjoki and Mikkeli). The Finnish airport network maintained by Finavia operates cost-effectively in accordance with the network principle, and the network principle has helped to ensure that the level of services can be maintained. In Finland, the air transport sector carries the cost of its own infrastructure, and also largely finances the work of the civil aviation authority.

Air transport is largely regulated at an international level. The International Civil Aviation Organization ICAO traditionally plays an important role in the international co-operation and harmonisation of the sector. The EU is a key actor both in the regulation of the air transport market, flight safety issues and airspace management. In international and EU-level co-operation and regulation, Finland aims to make sure that our specific needs are taken into account, while at the same time seeking to ensure a high level of flight safety and environmental protection.

1.1.3 Environmentally sound air transport and emissions from Finnish aviation

The environmental impact is one of the major challenges facing the aviation sector. The air transport sector must bear responsibility for the reduction of emissions as a part of the overall transport system. Currently the CO_2 emissions from the domestic civil aviation compose approximately 1.5 % of Finland's total transport sector CO_2 emissions[2].

Finland supports aviation emissions trading as a tool to manage environmental impacts. The emissions trading scheme has strong support among stakeholders too. At EU level, aviation was included in the emissions trading scheme in year 2012. In addition to the emissions trading, Finland supports and welcomes the enormous efforts made by the ICAO with the contribution of the Committee on Aviation Environmental Protection (CAEP) in developing the global MBM scheme CORSIA. Finland also promotes more efficient use of airspace and modernisation

[2] Calculation is based on IPCC methodology, and this same data is reported to the EU and UNFCCC as a part of Finland's greenhouse gas inventory report.

of air carrier fleet to reduce environmental impacts. Moreover, Finland aims to introduce new and cleaner technology as well as intelligent transport solutions.

Domestic civil aviation consumes roughly 1.4 % of all energy used in transport sector in Finland (in 2016). Also the N_2O emissions from aviation are about 1.9 % of total transport sector N_2O emissions, and less for other greenhouse gases[3]. The CO_2 emissions reported to Finland under the EU Emissions Trading System for aviation were a total of 1 051 798 tonnes in 2017. It is expected that the emissions will grow in the future, although less than the volume of air traffic due to improving technology.

Table 1. CO_2 emissions from international aviation 1990-2016[4]

Year	CO_2 Emissions (kt CO_2)	Year	CO_2 Emissions (kt CO_2)
1990	1 008	2004	1 282
1991	948	2005	1 290
1992	838	2006	1 435
1993	788	2007	1 656
1994	829	2008	1 792
1995	897	2009	1 570
1996	960	2010	1 654
1997	998	2011	1 957
1998	1 022	2012	1 889
1999	1 094	2013	1 949
2000	1 063	2014	1 921
2001	1 090	2015	1 963
2002	1 078	2016	1 968
2003	1 114		

Source: Statistics Finland.

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 CO_2 emissions from the aviation system against a background of increased travel and transport.

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[3] Calculation is based on IPCC methodology, and this same data is reported to the EU and UNFCCC as a part of Finland's greenhouse gas inventory report.
[4] Calculation is based on IPCC methodology, and this same data is reported to the EU and UNFCCC as a part of Finland's greenhouse gas inventory report. Source: Statistics Finland, National Inventory Report (NIR) and standardized reporting tables, CRF-tables, Table10s2, International Bunkers Aviation https://www.stat.fi/tup/khkinv/khkaasut_raportointi_en.html

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 focussing on noise, then adding air quality and more recently the emissions affecting the global climate and CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 action plans across the ECAC region. Evaluations of the work so far under the JTI alone estimate aircraft CO_2 reductions of 32% which, aggregated over the future life of those products, amount to 6bn tonnes of CO_2.
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 CO_2 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 CO_2 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 CO_2 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 CO_2 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.

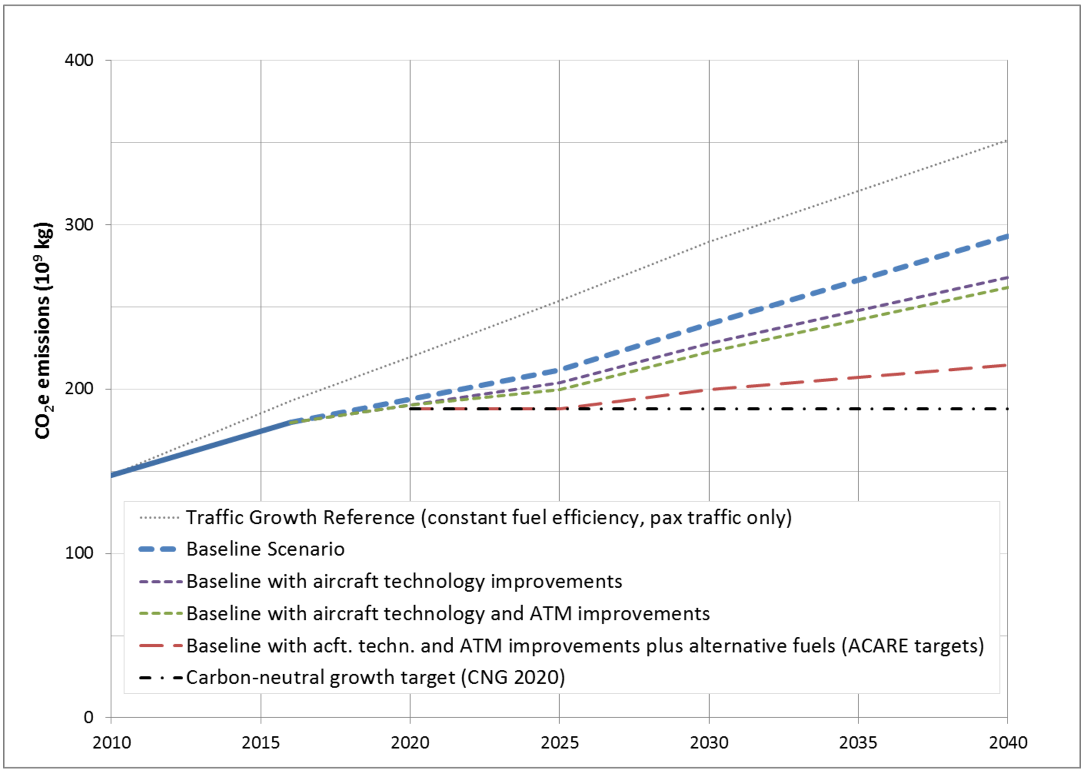
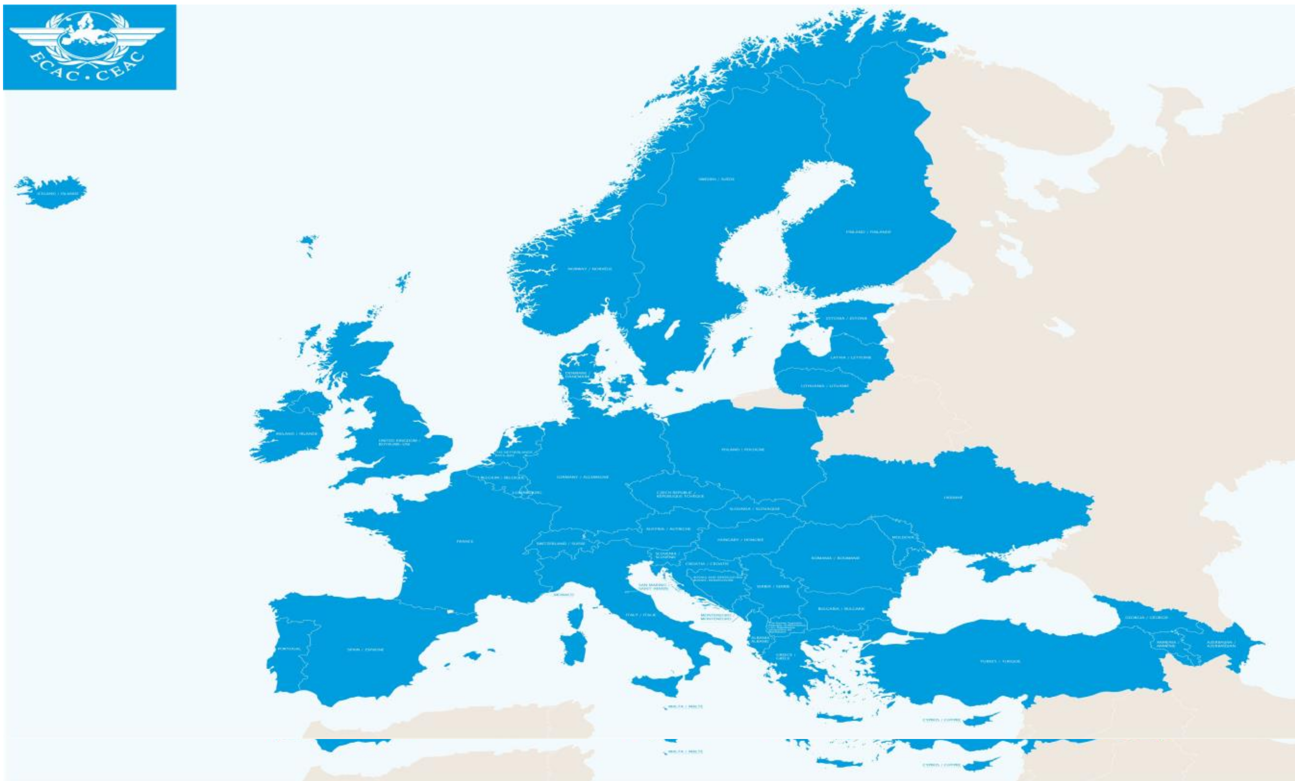


Figure 1 Equivalent CO_2 emissions forecast for the baseline and implemented measures scenarios

Under the baseline assumptions of traffic growth and fleet rollover with 2010 technology, CO_2 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 CO_2 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 CO_2 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 Section A: ECAC Baseline Scenario and Estimated Benefits of Implemented Measures

2.2.1 ECAC Baseline Scenario

The baseline scenario is intended to serve as a reference scenario for CO_2 emissions of European aviation <u>in the absence of any of the mitigation actions described later in this document</u>. 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 CO_2 emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of "Regulation and Growth", while corresponding fuel consumption and CO_2 emissions assume the technology level of the year 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 results[5] updated in 2018 by EUROCONTROL and presented here. Historical data for the year 2010 are also shown later for reference.

[5] Challenges of Growth 2018: Flight forecast, EUROCONTROL September 2018 (to be published)

Table 1. Summary characteristics of EUROCONTROL scenarios:

	Global Growth	*Regulation and Growth*	*Fragmenting World*
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 (ICAO[6]). 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 CO_2 emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample. Fuel burn and CO_2 emission results consider each aircraft's fuel burn in its ground and airborne phases of flight and are obtained by use of the EUROCONTROL IMPACT environmental model. 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 CO_2 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[7] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[8] FTKT (billion)	Total Revenue Tonne Kilometres[14,9] 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

[6] ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016.

[7] Calculated based on 98% of the passenger traffic.

[8] Includes passenger and freight transport (on all-cargo and passenger flights).

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

Table 3. Fuel burn and CO_2 emissions forecast for the baseline scenario

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	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)

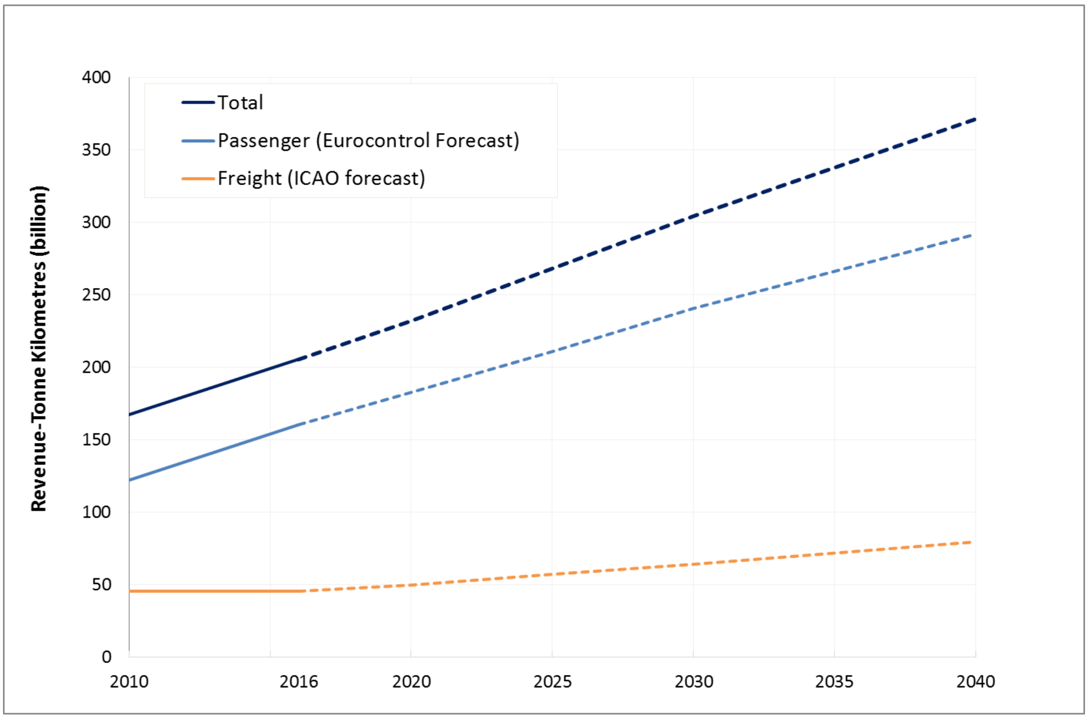
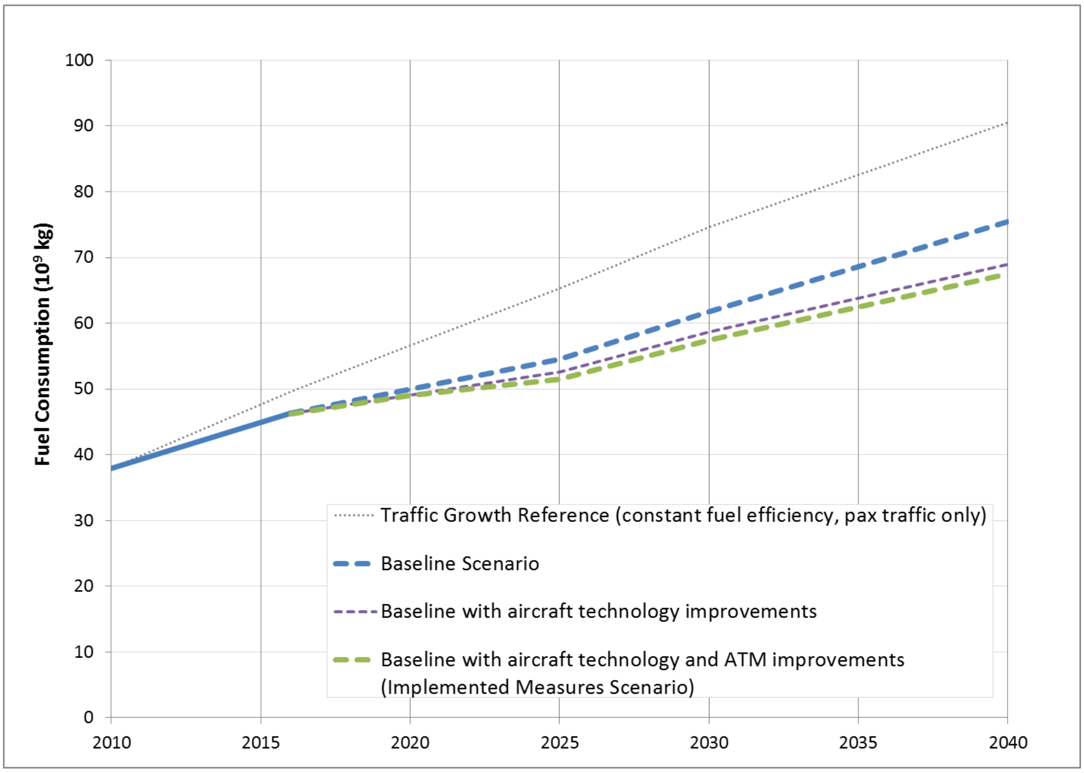


Figure 3. Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports)



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 CO_2 emissions up to the year 2040.

Effects of **improved aircraft technology** are captured by simulating fleet rollover 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 onwards[10]. 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 calculations[11].

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 CO_2 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)[12]. The resulting emission savings are shown in Table 6 and Figure 4 in units of equivalent CO_2 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 combustion[13].

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 CO_2 emissions have not been modelled explicitly in the top-down assessment of the implemented measures scenario presented here. CORSIA aims for carbon-neutral growth (CNG) of aviation, and this target is therefore shown in Figure 4[14].

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 CO_2 (assuming 3.16 kg CO_2 per kg fuel), whereas Table 6 and Figure 4 present equivalent CO_2 emissions on a well-to-wake basis. More detailed tabulated results are found in Appendix A.

Table 4. Fuel burn and CO_2 emissions forecast for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

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

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

[12] 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.

[13] Well-to-wake CO_2e emissions of fossil-based JET fuel are calculated by assuming an emission index of 3.88 kg CO_2e 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 CO_2e per MJ suggested by ICAO CAEP AFTF.

[14] 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).

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.				

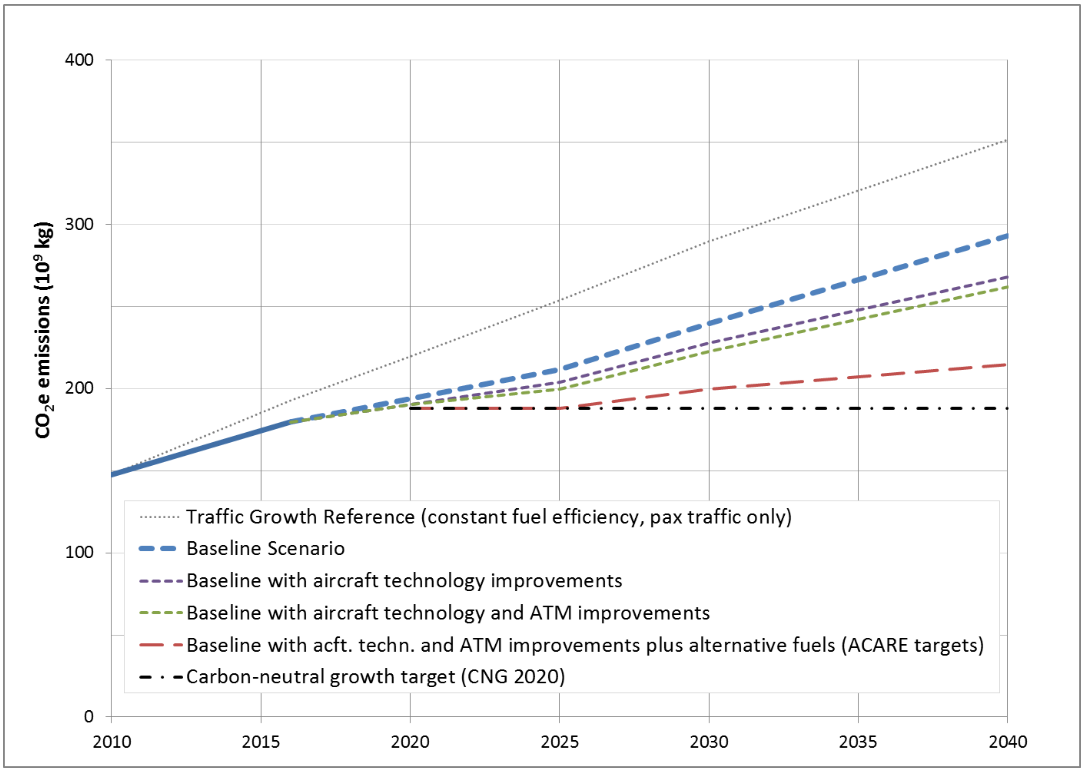
Table 5. Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

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

Table 6. Equivalent (well-to-wake) CO_2e emissions forecasts for the scenarios described in this chapter

Year	Well-to-wake CO_2e 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) CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 emissions by more than 32% with respect to baseline levels (in 2000), which represents an* ***aggregate of up to 6 billion tonnes of CO_2 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 established[15]. 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 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

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[15] 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

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 2011[16]. 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 energy[17]) 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 transport[18]. 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 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 actions[19].

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,

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

[17] 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

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

[19] https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf

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.

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 CO_2 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 CO_2 emission savings per flight are depicted below by flight segment:

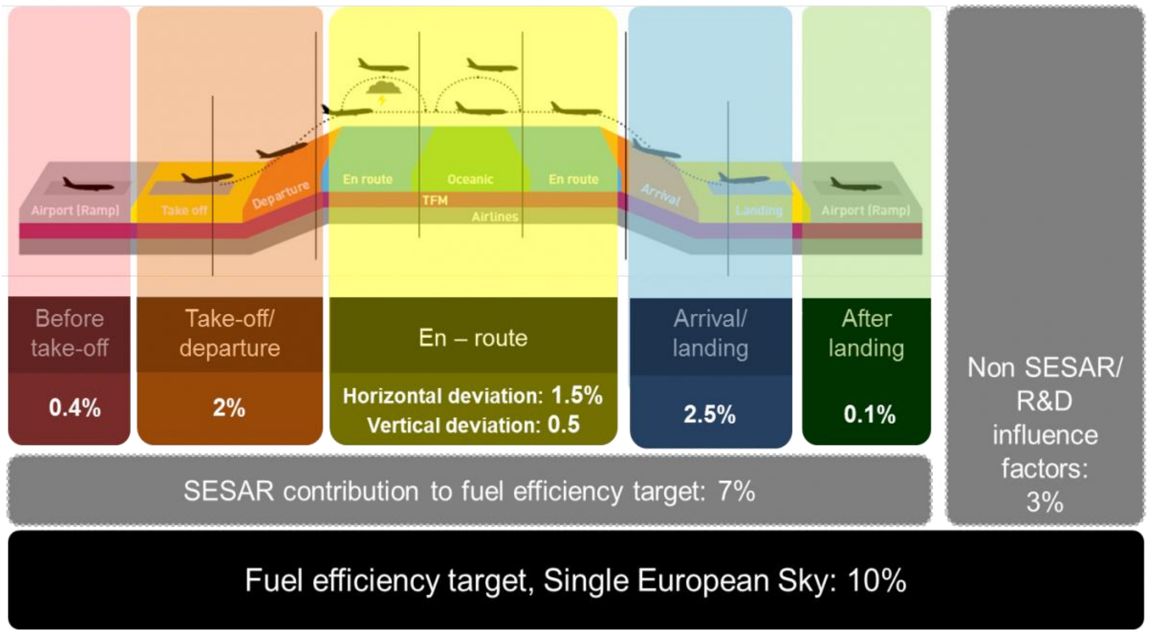

Figure 5.

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-ALAQS). 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 CO_2 emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 "green" projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE).

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 CO_2), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology. 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 operationally 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 (PRNAV 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. CO_2 savings per flight ranged from 90kg to 1,250kg and the accumulated savings during the trials were equivalent to 400 tonnes of CO_2. 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 adverse conditions	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 RNP AR & Data link. 4D trajectory exercise	CO_2 & noise	220	25
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 CO_2 per flight, including:

- SESAR2020 Fuel Saving target for Solutions (6.8%) = 340kg/flight or 1 t CO_2/flight,

- SESAR 1 Fuel Saving performance (1.8%) = 90kg/flight or 283kg of CO_2/flight,
- SESAR Deployment Baseline Fuel Saving performance (0.2%) = 10kg/flight or 31kg of CO_2/flight,
- Non-SESAR ATM improvements (1.2%) = 60kg/flight or 189Kg of CO_2/flight.

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

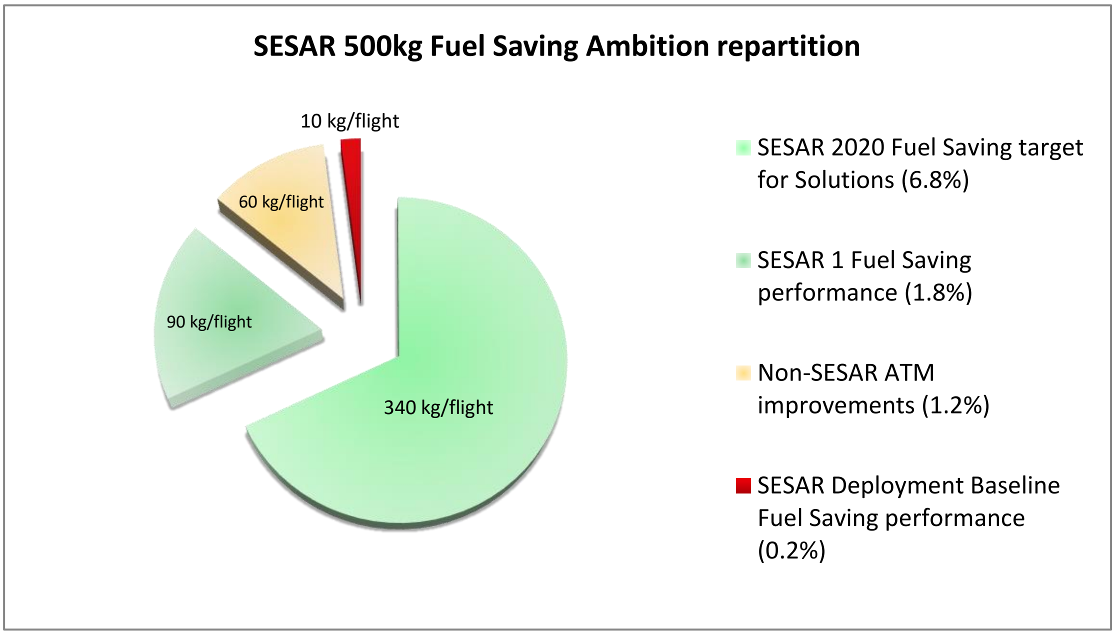

Figure 6.

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
PJ.07-01 Airspace User Processes for	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	Mainly for: Terminal Very High Complexity

Trajectory Definition	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. 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.	En-route Very High Complexity Some benefit but much lower for: Terminal High, Medium, Low Complexity En-route High, Medium Complexity
PJ.10-01C Collaborative Control	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. 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.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower for: Terminal High, Medium, Low Complexity En Route High, Medium Complexity
PJ.10-02b Advanced Separation Management	This Solution aims to further improve the quality of services of separation management in the en-route and TMA operational environments by introducing automation mechanisms and integrating additional information (ATC intent, aircraft intent). 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.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower: Terminal High, Medium, Low Complexity En-route High, Medium Complexity
PJ.09-03 Collaborative Network Management Functions	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.	Mainly for: En-route Very High Complexity Some benefit but much lower for:

	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.	Terminal very High, High, Medium Complexity En-route High, Medium Complexity Airport very large, large, medium
PJ.01-02 Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA	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. 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.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower for: Terminal very High, High, Medium, Low Complexity En-route High, Medium Complexity
PJ2-01 Wake turbulence separation optimization	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. Wake turbulence separation optimization should reduce airborne delays due to arrival capacity limitations linked to wake separations. For major airports that are today constrained in peak hours, the use of: - 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. 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. This increases the flexibility for Controllers to manage the arrival traffic due to the separation minima reduction.	Mainly for: Airports and TMAs with High and Medium complexity. • Any runway configuration. • Airports with mainly strong headwinds. • Capacity constrained airports or airports with observed delay.

	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. The reduction of delay will generate fuel saving.	
PJ.09-02 Integrated local DCB processes	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 well as the effectiveness of complexity resolutions by closing the gap between local network management and extended ATC planning. The increased efficiency of the performance of the system due to more optimised trajectory with airlines preference will result in fuel burn reductions.	Mainly for: Airport Very large Some benefit but much lower for: Terminal very High, High, Medium Complexity En-route very High, High, Medium Complexity Airport large, medium
PJ.01-03 Dynamic and Enhanced Routes and Airspace	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. Significant fuel efficiency benefits are expected from Continuous Descent (CDO) / Continuous Climb Operations (CCO) in high density operations. 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.	Mainly for: Terminal Very High Complexity Some benefit but much lower for: Terminal High, Medium Complexity
PJ.02-08 Traffic optimisation on single and multiple runway airports	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. Imbalances known more than 3 hours ahead allow to re-planning inbound traffic from the	Mainly for: Terminal Very High Complexity • Single and Multiple runways • Preferably Congested

	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 forecasts for arrival and departure time in order to coordinate the subsequent target times. There should be some fuel gains as a direct consequence of improved predictability, both for departures and arrivals (less variability ==> less patch stretching, holdings ...).	large and medium size airports
PJ.08-01 Management of Dynamic Airspace configurations	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. This solution increased efficiency enabling optimised flight trajectories and profiles with the end result being reduced fuel burn, noise and CO_2 emissions. Advanced Airspace Management should decrease Airspace Users fuel consumption and reduce flight time. 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.	Mainly for: En-route Very High Complexity Some benefit but much lower for: En-route High, Medium Complexity

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 CO_2 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 CO_2 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 CO_2 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 2014[20] 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 1990[21] .

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.

As regards aviation, legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[22]. 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 assessment[23]. 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

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

21 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

22 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

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

limitation follows on from the April 2013 'stop the clock' decision[24] 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 2017[25].

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 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 compliance[26]. It will continue to be a central element of the EU policy to address aviation CO_2 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°600/2012[27] and 601/2012.[28]

The EU legislation establishes exemptions and simplifications to avoid excessive administrative burden for the smallest operators of aircraft. Since the EU ETS for

24 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

25 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

26 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

27 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

28 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

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 CO_2 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 CO_2 per year are excluded from the EU ETS. A further administrative simplification applies to small aircraft operators emitting less than 25 000 tonnes of CO_2 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 simplification, allowing aircraft operators emitting less than 3 000 tCO_2 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 CO_2 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 CO_2 emissions from the aviation sector itself can exceed the number of allowances allocated to it, as the increase is offset by CO_2 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 CO_2 reductions/offsets between 2012 and 2018. The total amount of annual allowances to be issued will be around 38 million, whilst verified CO_2 emissions from aviation activities carried out between aerodromes located in the EEA has fluctuated between 53.5 MT CO_2 in 2013 and 61MT in 2016. This means that the EU ETS is now contributing more than 23 MT CO_2 of emission reductions annually[29], or around 100 MT CO_2 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

[29] 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

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.

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 CO_2 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

Estimated emissions reductions resulting from the EU-ETS	
Year	*Reduction in CO_2 emissions*
2012-2018	*100 MT*

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 CO_2-neutral growth as of 2020, and for this purpose to introduce a global market-based measure for compensating CO_2 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 CO_2 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 CO_2 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 phases[30]: 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 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 CORSA. Exempted are a) emissions form aircraft operators emitting less than 10 000 tCO_2 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 CO_2 emissions from air transport and to achieving overall carbon neutral growth.

[30] Further information on https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx

2.3.5 EU Initiatives in Third Counties

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 CO_2 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 CO_2 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 CO_2 emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party.

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".

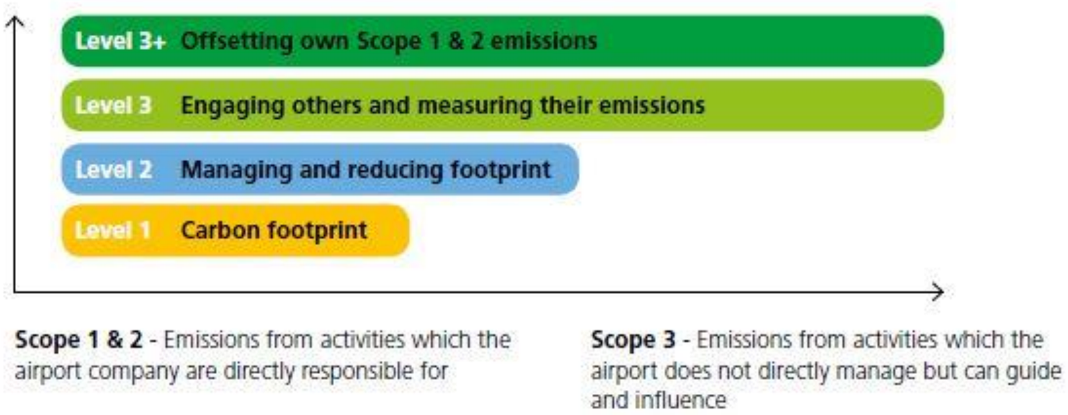

Figure 7: Four steps of Airport Carbon Accreditation

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 CO_2 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 CO_2 data from participating airports over the past five years. This has allowed the absolute CO_2 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'[31] 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)[32]	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	

[31] '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.

[32] This figure includes increases in CO_2 emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

Total carbon footprint for 'year 0' for emissions sources which an airport may guide or influence (level 3 and above)[33]	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 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[34] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[35] FTKT (billion)	Total Revenue Tonne Kilometres[42, 36] 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

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

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

[35] Includes passenger and freight transport (on all-cargo and passenger flights).

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

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 CO_2 emissions of international passenger traffic departing from ECAC airports

Year	Fuel Con-sumption (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	0.0287	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
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 CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2010 included:

Year	Fuel Con-sumption (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 CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2010:

Year	Fuel Con-sumption (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 CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements as well as alternative fuel effects included:

Year	Fuel Con-sumption (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	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 Section 2: National actions in Finland

In addition to the supranational actions introduced in Section 1 of this action plan, a number of actions are taken at a national level in Finland. This section introduces Finnish stakeholders' CO_2 reduction actions. Text in Section 2 describes selected actions, and estimated emissions reductions resulting from these actions are listed in Appendix I of this action plan.

Following stakeholders have contributed to this section: Finnish Ministry of Transport and Communications, Finnish Transport Safety Agency, Air Navigation Services Finland Oy, Finavia Corporation, Finnair Plc, Nordic Regional Airlines and Neste.

3.1 Aircraft-related technology development

Maintaining a modern fleet is one of the most important measures an airline can do for the benefit of environment, as each new generation of aircraft reduces fuel consumption approximately 25 per cent. According to IATA, the average age of the world's commercial aircraft is about 11 years. The average age of Finnair's fleet is about 9 years.

By the end of 2017, Finnair had eleven next-generation Airbus A350 XWB wide-body aircraft. The last Airbus A340 aircraft was phased out in 2017. In addition to providing a first-class travel experience, the new Airbus A350 XWB aircraft offer 20 per cent more cargo and passenger capacity than their predecessors. In addition to Airbus A35 XWB aircraft, Finnair added seven new Airbus A321 to its fleet in 2017.

3.2 **Alternative fuels**

The introduction of alternative fuels is an important way for airlines to reduce aviation's impact on 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.

In early 2012, the Ministry of Transport and Communications established a working group to study future clean transport fuel solutions (alternatives to fossil fuels) in all transport modes, including aviation. The group looked into possible future alternative fuels for the entire Finnish transport sector as well as their availability. The group also made suggestions for actions to be taken for the introduction of alternative fuels. The group gave its final report in May 2013. According to the study's recommendations, biokerosene should replace 40 per cent of the current aviation fuels by 2050.

Finnair first operated flights using biofuel in 2011 - second in the world after certification. On 23 September 2014, world leaders met in New York at the UN Climate Summit to discuss climate change. Finnair's flight from Helsinki to New York on the same day was operated using a more environmentally friendly biofuel mixture that was partly manufactured from used cooking oil. Finnair was the sole airline to take up the challenge from ICAO and IATA for the biofuel flights to New York.

Finnair is evaluating the possibility of establishing a biofuel hub at Helsinki Airport, Helsinki Green Hub. The company is part of a project led by the Finnish Ministry of Transport and Communications that also includes Finavia and Neste as partners. Renewable bio-based diesel has not yet received international approval for use as aviation fuel, but the approval process is underway. Finnair wants to find an ecologically, financially and socially sustainable fuel solution. The projects that are currently underway play a significant role in achieving this objective.

Finnair is also a member of the Nordic Initiative for Sustainable Aviation working group comprised of Nordic airlines, airport operators and government ministries who are working together with aircraft manufacturers to expedite the development of biofuel in the aviation industry. https://www.cleancluster.dk/nisa-members/
Group was active participant to a research by Nordic energy that produced an extensive report: Sustainable jet fuel for aviation, Nordic perspectives on the use of advanced sustainable jet fuel for aviation. This report presents an overview of the current state in the Nordic countries of the development process for the sustainable jet fuel and assesses the commercial potential for initiating and scaling up advanced sustainable jet fuel production in the region. http://norden.diva-portal.org/smash/get/diva2:956135/FULLTEXT01.pdf

Neste (NESTE, Nasdaq Helsinki) creates sustainable solutions for transport, business, and consumer needs. The company's wide range of renewable products enables its customers to reduce climate emissions. Neste is the world's largest producer of renewable diesel refined from waste and residues, introducing renewable solutions also to the aviation and plastics industries. Neste is also a technologically advanced refiner of high-quality oil products. The company wants to be a reliable partner with widely valued expertise, research, and sustainable operations. In 2017, Neste's revenue stood at EUR 13.2 billion. In 2018, Neste placed 2nd on the Global 100 list of the most sustainable companies in the world.

Neste produces both conventional and renewable jet fuel at its Porvoo refinery in Finland. The company is a global pioneer in renewable jet fuels and currently one of the only companies in the world capable of producing renewable jet fuel in industrial quantities. In addition to Neste refinery in Finland, also its refineries in Rotterdam and Singapore could be harnessed to produce Neste MY Renewable Jet Fuel in the future. The total renewable products annual production capacity is 2.6 million tonnes. The target is to increase the production to 4 million tonnes by year 2022.

Neste MY Renewable Jet Fuel is a pure hydrocarbon and therefore very similar to fossil-based aviation fuels. Neste Renewable Jet Fuel complies with ASTM D7566 (latest version) fuel standard specification. It is a drop-in fuel, and its use does not require any modifications to the aircraft, for example its engines. Quality is particularly important in the aviation sector, as aircraft fuel must have high energy content and be capable of being used in cold conditions. Conventional biodiesel and ethanol cannot meet these requirements.

Neste MY Renewable Jet Fuel is fully able to meet these very stringent quality standards. Its suitability for aviation use and high-level performance have been verified in a commercial test program consisting of over 1,000 commercial flights with Lufthansa, and at Oslo airport.

Neste and Genève Aéroport are pioneering together to make flying more sustainable by starting to decarbonize aviation towards fossil neutral growth. Genève Aéroport is planning the introduction of renewable jet fuel for aircraft operations from Geneva International Airport; the target shall be at least 1% (one percent) of the annual jet fuel consumption at Genève Aéroport shall be composed of renewable jet fuel starting late 2018.

Neste has committed itself to the European Aviation Biofuels Flightpath. The joint goal of the signatories is to promote the efficient adoption of biofuels by the aviation sector, as well as to ensure that aviation biofuels are produced sustainably and are suitable for use by aircraft flying on commercial routes.

Neste was a partner in the EU-supported ITAKA project (Initiative Towards sustAinable Kerosene for Aviation). The project's target was to support the development of aviation biofuels in an economically, socially and environmentally sustainable manner as well as improving the readiness of existing technology and infrastructures. This aim was achieved through a first of its kind collaborative project in the EU, developing a full value chain to produce sustainable drop-in fuel at large scale. Neste was a part of an international consortium working to promote the project's goals and has produced a quantity of Neste MY Renewable Jet Fuel for the project. During the year 2016, the fuel was available at Gardermoen airport in Oslo, Norway, where airlines KLM, Lufthansa, and SAS used it. First in World, renewable jet fuel was distributed via the airport's hydrant system.

BioPort Holland sustainable jet biofuel supply chain initiative was set up in 2013. Neste signed a Letter of Intent with the Dutch government, KLM, Schiphol Airport, SkyNRG and Port of Rotterdam to scale up production of sustainable renewable jet fuel in the Netherlands at Neste NEXBTL plant in Rotterdam.

Neste is also a member of aireg, the Aviation Initiative for Renewable Energy in Germany, which advances the development and deployment of renewable liquid fuels in aviation and aims to contribute to achieving aviation's ambitious CO_2 reduction goals. Neste has been an active member in developing ASTM standard specifications for renewable aviation fuel.

Neste MY Renewable Jet Fuel is based on the company’s NEXBTL technology, which can make very flexible use of a wide range of vegetable oils and waste- or residue-based raw materials. Neste’s procurement processes and systems are fine-tuned to ensure that all its renewable inputs are produced sustainably. Examples of Neste's waste and residue-based raw materials include animal and fish fats, used cooking oil and various residues generated during vegetable oil refining, such as palm fatty acid distillate

(PFAD) and technical corn oil. These raw materials accounted for roughly 80% of Neste's renewable inputs in 2017.

The production of fuels from waste-based feedstock is resource-efficient, and Neste already now has the capability to use 100% waste and residues. Neste is constantly searching for new waste-based raw materials of increasingly poorer quality.

Additionally, Neste produces renewable products from vegetable oils, mainly from crude palm oil. In all, Neste is already able to produce renewable diesel from more than ten different raw materials.

All of the company's renewable raw materials are sustainably produced and comply with both the requirements set out by legislation and the company's own stringent sustainability criteria. With regard to crude palm oil, Neste only uses certified feedstock.

Neste MY Renewable Jet Fuel can significantly reduce an aircraft’s greenhouse gas (GHG) emissions. Depending on the feedstock and logistics, the GHG emissions are significantly smaller compared to conventional jet fuel. For instance, in the 6 months test program carried out with Deutsche Lufthansa, the greenhouse-gas savings potential of Neste MY Renewable Jet Fuel was 60%, resulting in a reduction of 1500 tonnes in CO_2 emissions during the program. In addition to a smaller carbon footprint, the fuel also offers lower emissions of other pollutants. Neste MY Renewable Jet Fuel is less toxic than conventional jet fuel because it does not contain any aromatics. The sulphur content is also close to zero.

Neste’s aim is to increase commercial production of Neste MY Renewable Jet Fuel and generate growth as a supplier of this new fuel. In collaboration with the aircraft manufacturer Boeing, Neste now aims to amend the existing ASTM D7566 standard specification to cover a wider range of high quality renewable fuel in lower blend ratios than the current renewable jet fuel that can be blended to fossil jet up to 50%. This amendment is expected to improve the availability of the fuel. Currently renewable jet fuel can be produced as batch production at the Porvoo refinery in Finland. In the upcoming years, the intention is to scale up the production to significant volumes, produced on continuous basis.

Continuous industrial-scale production of both renewable diesel and renewable jet fuel at Neste’s refineries would, however, require some additional investments. In order to support the commercialization of renewable jet fuel globally, cooperation is required among all stakeholders. As a fuel producer, Neste supports targets of various projects and initiatives by actively participating various workgroups, and aims to develop common roadmaps with airlines, OEMs, and authorities.

In terms of Nordic co-operation, NISA (Nordic Initiative for Sustainable Aviation) has been established. NISA is an active Nordic association working to promote and develop a more sustainable aviation industry, with a specific focus on alternative sustainable fuels for the aviation sector.

To affect the development of sustainable biofuels and move intensions forward, NISA is required to co-ordinate initiatives at different maturity levels (R&D, approval, demonstration plants, airport integration), as well as involving different parts of the entire supply chain: investments into production facilities, feedstock, biofuels production, logistics, distribution, investors, demonstration plants, customer relationships, and the like. The initiatives of NISA are likely to positively affect a transition to cleantech development and contribute to the creation of jobs and knowhow within the area, thereby strengthening the market position for all the parties involved and society overall.
The goal of NISA is to accelerate the development and the commercialisation of sustainable aviation fuels. This is achieved by organising activities, strengthening the co-operation across the value chain and by focusing on opportunities in the Nordic region.

In addition to that, The Nordic Council of Ministers has launched a study of the climatic impact and commercial potential of using biofuels for aircraft. This Nordic approach will identify if there is potential for green growth in biofuels for aircraft, and the outcome of the efforts was presented at a conference in 2016. In addition to their positive climatic impact, biofuels for aircraft may also have significant commercial potential.

3.3 Improved air traffic management and infrastructure use

World's air traffic management system is a complicated patchwork of nation-based air traffic control systems. In Europe particularly that does not result in optimized flight paths due to various restrictions in airspace use. The Single European Sky, a pending initiative of the EU, aiming at improving the performance of air traffic management would consequently potentially save around 10 per cent in aircraft emissions almost immediately, as flight paths through Europe are rationalised, less fuel is consumed and more of passengers' valuable time is saved.

The infrastructure that determines the way airplanes land and the courses that they are allowed to use are crucial factors in fuel efficiency, and addressing them requires close cooperation with air traffic authorities in multiple countries.

Airport infrastructure is developed with a long-term approach. Finland aims to reduce aircraft noise and also invest in reducing other environmental nuisance at airports. Infrastructure for air traffic is relatively light in comparison with other transport sectors, leading to smaller infrastructural effects on environment.

3.3.1 International state level co-operation in air navigation service (ANS) to improve environmental efficiency and reduce emissions

Regulation (EC) No 1070/2009 of the European Parliament and of the Council requires EU Member States to set up functional airspace blocks. Under the regulation, Member States must by 4 December 2012 take all necessary measures in order to ensure the implementation of functional airspace blocks (FAB) with a view to achieving the required capacity and efficiency of the air traffic management network within the Single European Sky, maintaining a high level of safety and contributing to the overall performance of the air transport system and a reduced environmental impact.

NEFAB (North European Functional Airspace Block) is one of the nine functional airspace blocks in Europe established in response to the EU's Single European Sky initiative. NEFAB's airspace is composed of the following flight information regions (FIR) and upper information regions (UIR) of the North European airspace: Estonia, Finland, Latvia, Norway, and Bodø Oceanic. The contracting States are responsible for creating in this area a seamless airspace across their national borders and supervising the cooperation of air navigation service providers and other stakeholders in order to maintain safe and efficient airspace management, whilst respecting the sovereign interests of the contracting States.

NEFAB has set strategic objectives within the four key performance areas (safety, capacity, cost-efficiency, and environment) in line with the target setting of the Reference Period 2 for 2015-2019. The planned projects and activities are initiatives defined to ensure that the strategic objectives are met and user expectations fulfilled. Improved flight efficiency and better environmental performance is a must in the years to come. This results in a more systematic approach to environmental consequences of airspace management and airspace design solutions. Hence, within this strategic planning period until 2019, the focus is to a large extent on airspace and service provision where the benefit potential is considered to be the largest within this timeframe.

The benefits of the NEFAB area can be divided into two parts: Airspace Development and ATS (Air Traffic Services) provision that will give benefits to customers as well as business opportunities. NEFAB major achievement has been Free Route Airspace implementation in 2015. This allows airspace users to have shorter routings, which will reduce emissions and costs. Resulting from a more efficient airspace structure and more direct routes, the establishment of NEFAB is estimated to have positive impacts on the environment. It is estimated that the formation of the functional airspace block will reduce total flying time at the NEFAB area by about 6 200 hours annually by year 2015, and by 8 400 hours by 2020, in comparison with 2011. Respectively, fuel consumption will be 13 800 tonnes (2015) and 18 800 tonnes (2020) lower compared to 2011, leading to CO_2 reductions of 46 000 tonnes (2015) and 62 500 tonnes (2020).

3.3.2 International co-operation between air navigation service providers

The Borealis Alliance of nine (Finland, Latvia, Estonia, Norway, Sweden, Denmark, United Kingdom, Ireland and Iceland) European Air Navigation Service Providers (ANSPs) has launched of a programme to deliver seamless and integrated free route airspace across the whole of Northern Europe by 2020. This initiative benefits from the experiences gained by Free Route Airspace implementation in NEFAB and also in Danish-Swedish FAB. The Borealis Alliance members provide air traffic services for 3.5m flights a year, across 12.5 million km2 of north European airspace and between them form Europe's major transatlantic gateway.

Airlines and business aviation operators will in future be able to plan and take the most cost effective, fuel efficient and timely routes across the entire airspace managed by Borealis members rather than following pre-defined ‘routes’ within each member country’s airspace, saving time, money and fuel. The programme will create free route airspace extending from the eastern boundary of the North Atlantic to the western boundary of Russian airspace in the North of Europe.

The programme will build on work initiated through the three existing Functional Airspace Blocks (FABs) – the Danish-Swedish, UK-Ireland and North European FABs – and the North European Free Route Airspace (NEFRA) programme. 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. The NEFRA Free Route Airspace is voluntarily being expanded by the ANSPs to the particularly complex airspace of the UK in stages, starting from 2017. By 2021, the Borealis Alliance will create seamless Free Route Airspace enabling airlines to plan and fly their preferred routes across the whole of Northern Europe, saving significant time, fuel and therefore money. The interface with the oceanic airspace, beyond 2020, will also be considered as part of the programme to maximise the benefits for customers.

The key focus of the coming years are requirements set forth by the Single European Sky legislation and its Performance Scheme requirements, contribution to the Borealis Free Route Airspace Programme, arising competing markets, and enhanced business angle of the NEFAB Programme.

The NEFAB air navigation airspace providers will continue series of activities aimed to improve airspace and service performance in terms of cost efficiency, airspace efficiency for civil and military users, and reduced environmental impact.

The National Supervisory Authorities (NSAs) responsible for regulating civil aviation in nine North European States have agreed to work together to support a major Borealis programme delivering Free Route Airspace across Northern Europe, in what is a major step forward for the Single European Sky initiative.

The regulators of the nine ANSPs have established a working group to explore the best way to improve regulatory cooperation across all nine States for the Borealis Alliance Free Route Airspace programme and its subsequent projects.

While regulatory cooperation already takes place through existing mechanisms including bilateral agreements between States and the existing three Functional Airspace Blocks (FAB), today's commitment to explore a consistent regulatory approach for a programme of this scale, represents a significant step forward in regulatory cooperation.

3.3.3 ANS Finland provides an efficient airspace in Finland

According to a study carried out in February 2018, average horizontal en-route flight efficiency between city pairs in Finland was extremely good. The en-route part of the flights was on average 1.7% (0,5% better than in 2010) longer than the optimum trajectory, while at the same time the European reference level for en-route extensions is 5.2% on an average.

According to a study carried out in February 2018, average horizontal en-route flight efficiency of actual tracks between city pairs in Finland was extremely good. In 2017 the extension of en-route part of the flights was on average 1.2% (1,0% better than in 2010) longer than the optimum trajectory, while at the same time the European reference level for actual route en-route extensions is 2.7% on an average.

Finland's new airspace structure was introduced smoothly in November 2014. The reasons for the airspace reform include establishing the Single European Sky and the restructuring of the Finnish Defence Forces. The goal is to allocate an even more optimal departure, arrival, and flight path for all flights in Finnish airspace. The optimisation of flight routes will improve the efficient use of the airspace, shorten flight times in some cases, and reduce fuel consumption and therefore also emissions. At the same time, the operating conditions for recreational aviation improve as uncontrolled airspace grows.

The airspace reform was a prerequisite for the uniform airspace of the NEFAB area, Sweden, and Denmark to be implemented in 2015. In the long run, the goal of coordinating the airspace of different countries is to lower the costs for European airspace control.

The air navigation services of Finavia corporation was assigned to the new company Air Navigation Services Finland Oy (ANS Finland) in 1 April, 2017.

ANS Finland has actively promoted dynamic airspace management. The aim is to have temporary airspace reservations only when needed e.g. for military needs and improve military mission effectiveness. Dynamic airspace management is to minimize unnecessary airspace reservations so the airspace users can best use their preferred routes. By that, flight paths can be shortened and flight emissions reduced. This will be further improved with new tools using real time data exchange between civil and military. The concept has been successfully developed with stakeholders to meet their needs, including military.

3.3.4 Continuous descent operations

By using the continuous descent operations (CDO) technique, fuel burn, emissions and aircraft noise can be reduced. ANS Finland offers continuous descent operations at all its 22 airports. Between 2008-2012 Finavia Corporation (ANS functions was operated by Finavia those years) had a project to develop methods to improve knowledge about and performance of CDO with three major Finnish airlines (Finnair, SAS/Blue1 and Nordic Regional).

At Helsinki Airport, the percentage of CDOs during 2017 was 71% (+12% compared to 2013) of all approaches. Even during parallel runway operations, 67% (+16% compared to 2013) of the aircraft approaching a runway for which the procedure allows altitude to be adjusted according to the CDO technique were able to perform CDO. During night time (22 – 07) the proportion of CDO was 76% (+15% compared to 2013).

With good co-operation between air traffic control and airlines, CDO can be performed to all three runways at Helsinki Airport at all times except for the afternoon rush hour, when independent parallel operations are in use. Approximately 100 kg of fuel (which means 320 kg of CO_2) can be saved by performing CDO with a narrow body aircraft. The amount of CO_2 emissions savings by CDO is roughly 13 000 tonnes per year at Helsinki Airport.

ANS Finland is constantly developing arrival routes and procedures in co-operation with Finavia to allow more planes to perform CDOs. A code of conduct for continuous descent operations was produced and was handed out as a guideline for all the airlines. ANS Finland is continuously striving to achieve better results.

For example, good co-operation with air traffic control allows about 70 per cent of Finnair's landings to use a continuous descent approach, which requires significantly less fuel than the standard "stepped" approach.

In traditional stepped landings, pilots must repeatedly increase engine thrust to level off as they descend, which greatly increases emissions and noise around the airport. However, greener, quieter CDO landings are only possible with the well-developed, relatively uncongested infrastructure of airports such as Helsinki's.

3.4 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.

Finnair started a Fuel Efficiency Program in 2017, aiming to decrease CO_2 emissions (g/RTK) by 17% from year 2013 level until the end of 2020.

Fuel Efficiency Program covers various process improvements such as:

- Traffic Program adjustments to improve punctuality and thus decrease high Cost Index flying
- Decreasing weight carried on board; discretionary fuel, water and other operating weight
- Flight profile optimization using new / improved flight management tools
- Other operational issues such as HEL airport CDM and one engine-out taxiing
- Co-operation with Norra, Finnair's subsidiary operating regional flights.

Process improvement is data-intensive work, and modern data analysis tools are vital. Airbus A350 aircraft produces more data than its predecessors, thus providing more opportunities for process optimization than before.

3.5 Economic/market-based measures

As a member of the European Union, Finland is implementing the EU Emissions Trading System (EU ETS). See Section 1 for a detailed introduction to the scheme.

On 23 November 2017, the EU and Switzerland signed an agreement on the linking of their emissions trading systems. Once the agreement has entered into force, linking would result in the mutual recognition of EU and Swiss emission allowances. Finnish aircraft operators have provided their tonne-kilometre monitoring plan to the Swiss authorities and they will participate also to Swiss emissions trading system once linking has been finalized.

On 6 October 2016, the 39th session of the ICAO Assembly concluded with the adoption of a global market-based measure scheme to address CO_2 emissions from international aviation. The ICAO resolution creates an offsetting system for international aviation to cap aviation emissions at 2020 levels. The CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) agreement complements the other emission reduction measures used in aviation. Finland will voluntarily participate in CORSIA from its outset.

3.6 Regulatory measures/other

Finland's Air Transport Strategy[37] for years 2015-2030 outlines future directions also for environmental issues. In respect of CO_2 emissions, the strategy emphasizes the importance of a global solution to reduce aviation greenhouse gas emissions. Aviation is global business, and a global market-based-measure would guarantee environmental integrity and a level playing-field between airlines. In addition to this, the strategy underlines the importance of sustainable biofuels in reducing aviation emissions. Finland has a manufacturer that is capable of producing aviation biofuels in a large scale. Helsinki Airport could serve as a "biofuel hub" between Europe and Asia in the future – however, this requires finding solutions to the price gap between biofuels and fossil kerosene. Ministry of Transport and Communications, Finavia, Finnair and Neste are evaluating the possibility of establishing a biofuel hub at Helsinki Airport, Helsinki Green Hub.

3.7 Airport improvements

Finavia implemented Airport CDM (collaborative decision making) for Helsinki Airport in October 2012. The operating model is based on making communication between different operators at the airport smoother and more effective. CDM produces exact and current information about the take-offs and landings of aircraft, which improves the predictability of air traffic. As a result of CDM, idling and taxiing times at Helsinki Airport are now shorter. Until now, planes may have had to wait for their turn while taxiing, but more effective communication now allows them to wait at the gate with engines down. After receiving permission, the aircraft starts the engines, taxis to the runway and takes off without unnecessary idling. This has reduced fuel consumption and engine emissions at Helsinki Airport. The reduction of CO_2 emissions is approximately 2000 tonnes annually.

Other measures at the airports include:

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[37] The strategy is publicly available through the following link (in Finnish, abstract in English): http://urn.fi/URN:ISBN:978-952-243-441-8

- Helsinki Airport reached Level 3+ (carbon neutral) and the six Lapland Airports are at Level 2 (reduction) of the Airport Carbon Accreditation (ACA) programme of the Airports Council International (ACI). To reach carbon neutrality the airport has to show continuous reduction of emissions index and compensate the remaining emissions with emissions units purchased from carbon markets.

- A 124 kWp solar energy system was installed on the roof of the new south pier at Helsinki Airport in July 2017. The total output of this system and the system to be installed on the west pier (which is still under construction) will exceed 500 kWp. This means that it is among the ten largest production units in Finland.

- To reduce vehicle emissions, all apron buses at Helsinki Airport switched to renewable diesel fuel in July 2017. The new fuel (Neste MY) will reduce CO_2 emissions by as much as 90 per cent.

- The requirements laid out in the BREEAM environmental certification system for buildings are considered in the planning and implementation of the Helsinki Airport development programme. The objectives guide energy efficiency, activities during the construction stage and well-planned commissioning of the buildings. The airport development project currently under way (south and west pier as well as the Plaza) was granted the interim design-stage BREEAM certificate with an Excellent rating as the only Finnish construction project in 2017.

- In connection with runway renovation, LED technology was introduced as runway lighting at Oulu Airport. Lighting based on the same technology was also installed on the renovated runway 2 at Helsinki Airport. As a result, energy consumption will decrease by as much as 80 percent.

- Train connection to Helsinki Airport was opened in summer 2015. The railway has provided easier access to the airport services and flights from Helsinki Airport. The ring rail line connects Helsinki Airport to the national railway network and improves public transport in the Helsinki metropolitan area and reduces emissions.

3.8 Estimated emission reductions from selected measures[38]

Title	**Finnair Fuel Efficiency Programme**
Category	More Efficient Operations
Date of implementation	2017 onwards
Action	Improving fuel efficiency
Economic cost	Considerable

[38] Please note that the emission reductions listed here are for illustrative purposes only. They have already been taken into account at the European-level baseline scenario, presented in Section 1 of this Action Plan and cannot be added to the benefits presented in the European section.

List of stakeholders involved	Finnair, Norra, Finavia, ANS Finland, Eurocontrol
Reduction in CO_2 emissions	Approx. 60-70 000 tonnes of CO_2 annually, compared to g CO_2/RTK level in 2013

Title	**Reduced Use of APU**
Category	More Efficient Operations
Date of implementation	2011 onwards
Action	A reduction of slightly over 20 per cent in using APU in the Airbus 320 fleet
Economic cost	Low
List of stakeholders involved	Finnair
Reduction in CO_2 emissions	Approx. 3 500 tonnes of CO_2 annually

Title	**Replacing A340s with A350XWBs**
Category	Fleet Renewal
Date of implementation	2015–2023
Action	Finnair to phase out seven A340s by the end of 2017, replacing them with A350 XWB aircraft. Total number of Finnair A350 orders to be delivered by 2023 is currently 19.
Economic cost	High
List of stakeholders involved	Finnair
Reduction in CO_2 emissions	25% less when replacing A340

Title	**Reducing Aircraft Empty Weight**
Category	More Efficient Operations
Date of implementation	2012 – 2014

Action	Replacing containers used in narrow and wide body aircraft with light-weight composite containers
Economic cost	Medium
List of stakeholders involved	Finnair
Reduction in CO_2 emissions	Approx. 4 500 tonnes of CO_2

Title	**City-specific Taxi Fuel**
Category	More efficient operations
Date of implementation	May 2013
Action	City-specific taxi fuel implemented in flight planning system
Economic cost	Low
List of stakeholders involved	Nordic Regional Airlines
Reduction in CO_2 emissions	Approx. 315 tonnes of CO_2 annually

Title	**Reduction of Contingency Fuel**
Category	More efficient operations
Date of implementation	December 2014
Action	Reduced contingency fuel based on route-specific, statistical data. Reduced contingency fuel on flights where applicable.
Economic cost	Low
List of stakeholders involved	Nordic Regional Airlines
Reduction in CO_2 emissions	Approx. 190 tonnes of CO_2 annually

Title	**Center of Gravity Optimization**
Category	More efficient operations
Date of implementation	July 2013

Action	Center of gravity optimized to reduce fuel consumption
Economic cost	Low
List of stakeholders involved	Nordic Regional Airlines
Reduction in CO_2 emissions	Approx. 315 tonnes of CO_2 annually

Title	**New Software for operations**
Category	More efficient operations
Date of implementation	April 2014
Action	Introduction of software for calculating optimized and fuel efficient flight profiles (climb, cruise, descent)
Economic cost	Medium
List of stakeholders involved	Nordic Regional Airlines
Reduction in CO_2 emissions	Approx. 2 000 tonnes of CO_2 annually

Title	**Single Engine Taxi**
Category	More efficient operations
Date of implementation	2015
Action	Training to remind flight crew on the conditions for single engine taxi-in
Economic cost	Low
List of stakeholders involved	Nordic Regional Airlines
Reduction in CO_2 emissions	Approx. 160 tonnes of CO_2 annually

Title	**Continuous Descent Operations**
Category	Improved Air Traffic Management and Infrastructure Use
Date of implementation	Started in 2008, continuous
Action	Offering CDOs at all of Finavia's 21 airports

Economic cost	Medium
List of stakeholders involved	Finavia, ANS Finland, Airlines
Reduction in CO_2 emissions	Approx. 13 000 tonnes of CO_2 annually at Helsinki Airport

Title	**Airport Collaborative Decision Making (A-CDM)**
Category	Improved Air Traffic Management and Infrastructure Use
Date of implementation	Started in 2012, continuous
Action	Offering shorter taxiing times at Helsinki-Vantaa airport
Economic cost	Medium
List of stakeholders involved	Finavia, Airlines
Reduction in CO_2 emissions	Approx. 2 000 tonnes of CO_2 annually

Title	**NEFAB**
Category	Improved Air Traffic Management and Infrastructure Use
Date of implementation	2012
Action	More efficient airspace structure and more direct routes
Economic cost	High
List of stakeholders involved	Finavia, Trafi, Airlines
Reduction in CO_2 emissions	46 000 tonnes of CO_2 (by 2015) and 62 500 tonnes (by 2020)

Title	**Biokerosene to Replace Current Aviation Fuels**
Category	Alternative fuels
Date of implementation	By 2050

Action	Implementing EU level target of 40% sustainable biofuels in use for aviation by 2050. Also recommended by the working group established by the Ministry of Transportation and Communications.
Economic cost	Currently: high
List of stakeholders involved	All stakeholders
Reduction in CO_2 emissions	Significant

Title	**Helsinki Airport as a "Bio-hub"**
Category	Alternative fuels
Date of implementation	Continuous
Action	Continuous efforts to enable availability of sustainable aviation fuels at Helsinki airport.
Economic cost	High
List of stakeholders involved	All stakeholders
Reduction in CO_2 emissions	Significant, the use of NEXBTL renewable diesel has been proven to reduce greenhouse gas (GHG) emissions by 40–90% over the product's entire life cycle when compared to traditional, fossil fuel

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

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