ICAO State Action Plan on CO₂ emissions from aviation

Denmark

1st of October 2018
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a) Denmark is a member of the European Union” and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States1 of any European organisation dealing with civil aviation. It is currently composed of 44 Member States, and was created in 1955.

b) ECAC States share the view that environmental concerns represent a potential constraint on the future development of the international aviation sector, and 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) Denmark, 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) Denmark recognises the value of each State preparing and submitting to ICAO an updated State Action Plan for emissions reductions, as an important step towards the achievement of the global collective goals agreed at 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 Denmark.

f) Denmark shares the view of all ECAC States that a comprehensive approach to reducing aviation 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. the development and deployment of low-carbon sustainable alternative fuels, including research and operational initiatives undertaken jointly with stakeholders

iv. the optimisation and improvement 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

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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.
v. Market-based measures, which allow the sector to continue to grow in a sustainable and efficient manner, recognising that the measures at (i) to (iv) above cannot, even in aggregate, deliver in time the emissions reductions necessary to meet the global goals. This sustainable growth becomes possible through the purchase of carbon units that foster emissions 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 Denmark’s involvement in them is described, as well as that of stakeholders.

h) In Denmark 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 and 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 (thus for example research, ETS).
Introduction: Current state of aviation in Denmark

Basic facts
Denmark is a part of the Nordic Region in Europe, and has borders with Germany to the south. Denmark has an area of 43,000 km², and with 5.8 million inhabitants it is the smallest but also most densely populated country in the Nordic Region with 130 inhabitants per square kilometers. The country consists of the Jutland peninsula and over 400 islands, of which Zealand and Funen are the largest. The Capital of Denmark, Copenhagen, is situated on the east of Zealand. 85% of the population lives in cities.

Greenland and the Faroe Islands are part of the Kingdom of Denmark but have autonomous self-rule. Denmark is bound together by many roads, railways and ferry routes. Domestic flights play a minor, but important role in linking the various parts of the country together.

Airports in Denmark
Denmark has 9 public airports with more than 10,000 passengers per year. Copenhagen (København) Airport has the largest number of passengers, while Billund is the largest provincial airport.

Copenhagen Airport A/S is a shareholder company, of which the Danish state owns 39.2% of the shares. The other larger provincial airports are owned by the municipalities, except Roskilde Airport, which is owned by Copenhagen Airport A/S, and Bornholms (Rønne) Airport which is owned by the Danish state.

Major airports in Denmark.
The total number of passengers in the larger Danish airports has been increasing over the past years from around 24 million passengers in 2005 to around 35 million in 2017. The total quantity of cargo transported by airplane via Copenhagen and Billund (which are the most significant cargo airports) in the same period, has varied and amounted to 303,000 tons in 2017.

**Air operators in Denmark**

There are around 15 aviation operators with an EU license to operate aircrafts with an approved starting volume larger than 10 tons, more than 20 seats, or an annual turnover that exceeds 3 million euro. Moreover, there are two North Atlantic aviation companies (Atlantic Airways and Air Greenland), who have Danish concession to fly passengers, cargo, mail etc. The two largest companies measured by turnover in the last few years, are SAS Group and Thomas Cook Airlines Scandinavia A/S.

SAS Group operates as a Scandinavian airline with one AOC and consists of the companies SAS Danmark A/S, SAS Norge ASA and SAS Sverige AB, which respectively have Danish, Norwegian, and Swedish EU license. In June 2018 the Norwegian state sold its shares in SAS Group. Consequently Sweden and Denmark now own 29 % of the shares, and the rest is privately owned.

Thomas Cook Airlines Scandinavia is part of the global Thomas Cook Group Airlines.

**Air Traffic Services**

The provision of air traffic services in the Danish airspace is mainly provided by Naviair in the form of air traffic control service. Naviair is an independent public entity, who is designated to the task by the Danish Government.

In order to make the airspace independent of national borders, a Danish-Swedish Functional Airspace Block (FAB) was established in 2009. Same year, the Danish-Swedish company Nordic Unified Air Traffic Control (NUAC) was founded, which has undertaken the control of the air traffic from 2012. NUAC carries out integrated En Route area control services in the Danish-Swedish FAB as well as terminal control services at the three major terminal areas within the FAB, namely Stockholm, Malmö and Copenhagen.

**Danish domestic aviation**

The Danish provincial airports are placed with a short travel time to Copenhagen Airport. Currently, there are domestic routes between Copenhagen and respectively Aalborg, Aarhus, Karup, Billund, Bornholm, and Sønderborg, and also between Bornholm and respectively Billund and Sønderborg. In addition, there are flights between Copenhagen and Kangerlussuaq in Greenland, as well as between Danish airports and Vagar Airport on the Faroe Islands, which in Denmark are also considered as domestic routes.

Since 1993 domestic aviation has been liberalised and the market conditions, the number of departures and the pricing are determined by private operators.

The total number of domestic passengers in Denmark amounted to ca. 3,596,000 in 2017, which is around 10% of the total number of passengers in the Danish airports.
Danish international aviation

Danish international aviation is dominated by key players: SAS and Copenhagen Airport. SAS Group, as a joint Scandinavian airline, has a large number of routes in Europe and overseas. SAS Group is part of the Star Alliance, and in recent years has felt increasing competition from low fare airlines. One of the main hubs for the SAS Group is Copenhagen Airport.

Copenhagen Airport is by far the largest airport in Denmark with ca. 29 million passengers in 2017. In 2014 Copenhagen Airport A/S presented a master plan for the future, which prepares the airport for a growth up to 40 million passengers.

There are three airports with international departures in Jutland, e.g. Billund, Aalborg and Aarhus. Billund Airport had around 3.4 million international passengers in 2017.

International aviation also includes cargo transportation, which typically transports goods that are expensive, compact, and/or easily spoiled. Air cargo is an important component in the logistics included in import as well as export.

Charter flights are also included in international aviation. In 2017 approximately 1.2 million of the travellers from Danish airports were charter flight passengers.

The Development in Danish Aviation

The figure below shows the development of the total number of passengers at the Danish airports with more than 10,000 passengers per year, in the years 2005-2017.
Development of total number of passengers in major Danish airports 2005-2017.

The table below shows the total number of passengers at the Danish airports with more than 10.000 passengers, in 2017. Moreover, it is divided into domestic and international passengers, and their percentage of the total number of passengers distributed to domestic and international flights.

<table>
<thead>
<tr>
<th>Airports</th>
<th>Total</th>
<th>Total Domestic</th>
<th>% Domestic</th>
<th>% International</th>
</tr>
</thead>
<tbody>
<tr>
<td>København</td>
<td>29.178</td>
<td>1.847</td>
<td>6,3</td>
<td>93,7</td>
</tr>
<tr>
<td>Billund</td>
<td>3.382</td>
<td>162</td>
<td>4,8</td>
<td>95,2</td>
</tr>
<tr>
<td>Aalborg</td>
<td>1.501</td>
<td>865</td>
<td>57,6</td>
<td>42,4</td>
</tr>
<tr>
<td>Aarhus</td>
<td>373</td>
<td>192</td>
<td>51,5</td>
<td>48,5</td>
</tr>
<tr>
<td>Karup</td>
<td>146</td>
<td>140</td>
<td>95,9</td>
<td>4,1</td>
</tr>
<tr>
<td>Bornholm</td>
<td>263</td>
<td>256</td>
<td>97,3</td>
<td>2,7</td>
</tr>
<tr>
<td>Esbjerg</td>
<td>85</td>
<td>63</td>
<td>74,1</td>
<td>25,9</td>
</tr>
<tr>
<td>Sønderborg</td>
<td>63</td>
<td>59</td>
<td>93,7</td>
<td>6,3</td>
</tr>
<tr>
<td>Roskilde</td>
<td>18</td>
<td>12</td>
<td>66,7</td>
<td>33,3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35.009</strong></td>
<td><strong>3.596</strong></td>
<td><strong>10,3</strong></td>
<td><strong>89,7</strong></td>
</tr>
</tbody>
</table>

Number of passengers in the Danish airports, including domestic, in 2017 (x000)

Only the two largest airports, namely Copenhagen Airport and Billund, handle a significant amount of air cargo. The figure below shows the development in air cargo since 2008.

Air cargo at major Danish airports 2008-2017 (kg).
SECTION 1: ECAC/EU common section for European State Action Plans

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

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

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

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

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

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

The main efforts under Clean Sky 2 include demonstrating technologies: for both large and regional passenger aircraft, improved performance and versatility of new rotorcraft concepts, innovative airframe structures and materials, radical engine architectures, systems and controls and consideration of how we manage aircraft at the end of their useful life. This represents a rich stream of ideas and concepts that, with continued support, will mature and contribute to achieving the goals on limiting global climate change.

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

**Improved Air Traffic Management**
The European Union’s Single European Sky (SES) policy aims to transform Air Traffic Management in Europe, tripling capacity, halving ATM costs with 10 times the safety and 10% less environmental impact. Progress is well underway on the road map to achieve these ambitious goals through commitment and investment in the research and technology. Validated ATM solutions alone are capable of 21% more airspace capacity, 14% more airport capacity, a 40% reduction in accident risk, 2.8% less greenhouse emissions and a 6% reduction in flight cost. Steps 2 and 3 of the overall SES plan for the future will deploy ‘Trajectory-based Operation’ and ‘Performance-based Operations’ respectively. Much of the research to develop these solutions is underway and published results of the many earlier demonstration actions confirm the challenge but give us confidence that the goals will be achieved in the ECAC region with widespread potential to be replicated in other regions.
**Economic/Market Based Measures (MBMs)**

ECAC members have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The 31 EEA states in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap and trade approach to limit CO2 emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO2 emissions.

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

**ECAC Scenarios for Traffic and CO2 Emissions**

Aviation traffic continues to grow, develop and diversify in many ways across the ECAC states. Whilst the focus of available data relates to passenger traffic, similar issues and comparable outcomes might be anticipated for cargo traffic both as belly hold freight and in dedicated freighters. Analysis by EUROCONTROL and EASA has identified the most likely scenario of influences on future traffic and modelled these assumptions out to future years. On the basis of this traffic forecast, fuel consumption and CO2 emissions of aviation have been estimated for both a theoretical baseline scenario (without any mitigation action) and a scenario with implemented mitigation measures that are presented in this action plan. Results are visualised in the below figure.
Figure 1. Equivalent CO2 emissions forecast for the baseline and implemented measures scenarios.

Under the baseline assumptions of traffic growth and fleet rollover with 2010 technology, CO2 emissions would almost double for flights departing ECAC airports. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 8.5% reduction of fuel consumption and CO2 emissions in 2040 compared to the baseline. Whilst the data to model the benefits of ATM improvements and sustainable alternative fuels may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall fuel efficiency, including the effects of new aircraft types and ATM-related measures, is projected to improve by 24% between 2010 and 2040. The potential of sustainable aviation fuels to reduce CO2 emissions on a lifecycle basis is reflected in Figure 1. Market-based measures and their effects have not been simulated in detail, but will help reach the goal of carbon-neutral growth. As further developments in policy and technology are made, further analysis will improve the modelling of future emissions.
ECAC baseline scenario and estimated benefits of implemented measures

ECAC Baseline Scenario
The baseline scenario is intended to serve as a reference scenario for CO₂ emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2016) and forecasts (for 2020, 2030 and 2040) were provided by EUROCONTROL for this purpose:

- European air traffic (includes all commercial and international flights departing from ECAC airports, in number of flights, revenue passenger kilometres (RPK) and revenue tonne-kilometres (RTK)),
- its associated aggregated fuel consumption,
- its associated CO₂ emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of “Regulation and Growth”, while corresponding fuel consumption and CO₂ emissions assume the technology level of the year 2010 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, alternative fuels or market based measures).

Traffic Scenario “Regulation and Growth”
As in all forecasts produced by EUROCONTROL, various scenarios are built with a specific storyline and a mix of characteristics. The aim is to improve the understanding of factors that will influence future traffic growth and the risks that lie ahead. In the 20 year forecasts published by EUROCONTROL the scenario called ‘Regulation and Growth’ is constructed as the ‘most likely’ or ‘baseline’ scenario for traffic, most closely following the current trends. It considers a moderate economic growth, with some regulation particularly regarding the social and economic demands.
Amongst the models applied by EUROCONTROL for the forecast the passenger traffic sub-model is the most developed and is structured around five main group of factors that are taken into account:

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

Table 1 presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year 2016 serves as the baseline year of the 20-year forecast results\(^2\) updated in 2018 by EUROCONTROL and presented here. Historical data for the year 2010 are also shown later for reference.

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\(^2\) Challenges of Growth 2018: Flight forecast, EUROCONTROL September 2018 (to be published)
**Table 1. Summary characteristics of EUROCONTROL scenarios:**

<table>
<thead>
<tr>
<th>2023 traffic growth</th>
<th>Passenger Demographics (Population)</th>
<th>Routes and Destinations</th>
<th>Open Skies</th>
<th>High-speed rail (new &amp; improved connections)</th>
<th>Economic conditions</th>
<th>GDP growth</th>
<th>EU Enlargement</th>
<th>Free Trade</th>
<th>Price of travel</th>
<th>Operating cost</th>
<th>Price of CO\textsubscript{2} in Emission Trading Scheme</th>
<th>Price of oil/barrel</th>
<th>Change in other charges</th>
<th>Structure Network</th>
<th>Market Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stronger ➔</td>
<td>Moderate ➔</td>
<td>Weaker ➔ ➔ ➔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ➔</td>
<td>Aging UN Medium-fertility variant</td>
<td>Long-haul ➔</td>
<td>EU enlargement later + Far &amp; Middle-East</td>
<td>20 city-pairs faster implementation</td>
<td>Stronger ➔</td>
<td>Decreasing ➔ ➔</td>
<td>No change ➔</td>
<td></td>
<td>Decreasong ➔</td>
<td>Decreasing ➔</td>
<td>No change ➔</td>
<td>No change ➔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base ➔</td>
<td>Aging UN Medium-fertility variant</td>
<td>No Change ➔</td>
<td>EU enlargement Earliest</td>
<td>20 city-pairs</td>
<td>Moderate ➔</td>
<td>Decreasing ➔</td>
<td>No change ➔</td>
<td></td>
<td>Moderate ➔</td>
<td>Lowest ➔</td>
<td>Highest ➔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low ➔</td>
<td>Aging UN Zero-migration variant</td>
<td>Long-haul ➔</td>
<td>EU enlargement Latest</td>
<td>20 city-pairs later implementation.</td>
<td>Weaker ➔ ➔ ➔</td>
<td>No change ➔</td>
<td>No change ➔</td>
<td></td>
<td>Moderate ➔</td>
<td>Lowest ➔</td>
<td>Highest ➔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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\(^3\)). 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**

<table>
<thead>
<tr>
<th>Year</th>
<th>Passenger Traffic (IFR movements) (million)</th>
<th>Revenue Passenger Kilometres(^4) RPK (billion)</th>
<th>All-Cargo Traffic (IFR movements) (million)</th>
<th>Freight Tonne Kilometres transported(^5) FTKT (billion)</th>
<th>Total Revenue Tonne Kilometres(^6,6) RTK (billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>4.6</td>
<td>1,218</td>
<td>0.20</td>
<td>45.4</td>
<td>167.2</td>
</tr>
<tr>
<td>2016</td>
<td>5.2</td>
<td>1,601</td>
<td>0.21</td>
<td>45.3</td>
<td>205.4</td>
</tr>
<tr>
<td>2020</td>
<td>5.6</td>
<td>1,825</td>
<td>0.25</td>
<td>49.4</td>
<td>231.9</td>
</tr>
<tr>
<td>2030</td>
<td>7.0</td>
<td>2,406</td>
<td>0.35</td>
<td>63.8</td>
<td>304.4</td>
</tr>
<tr>
<td>2040</td>
<td>8.4</td>
<td>2,919</td>
<td>0.45</td>
<td>79.4</td>
<td>371.2</td>
</tr>
</tbody>
</table>

\(^3\) ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016.

\(^4\) Calculated based on 98% of the passenger traffic.

\(^5\) Includes passenger and freight transport (on all-cargo and passenger flights).

\(^6\) A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).
Table 3. Fuel burn and CO₂ emissions forecast for the baseline scenario

<table>
<thead>
<tr>
<th>Year</th>
<th>Fuel Consumption (10⁹ kg)</th>
<th>CO₂ emissions (10⁹ kg)</th>
<th>Fuel efficiency (kg/RTK)</th>
<th>Fuel efficiency (kg/RTK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37.98</td>
<td>120.00</td>
<td>0.0310</td>
<td>0.310</td>
</tr>
<tr>
<td>2016</td>
<td>46.28</td>
<td>146.26</td>
<td>0.0287</td>
<td>0.287</td>
</tr>
<tr>
<td>2020</td>
<td>49.95</td>
<td>157.85</td>
<td>0.0274</td>
<td>0.274</td>
</tr>
<tr>
<td>2030</td>
<td>61.75</td>
<td>195.13</td>
<td>0.0256</td>
<td>0.256</td>
</tr>
<tr>
<td>2040</td>
<td>75.44</td>
<td>238.38</td>
<td>0.0259</td>
<td>0.259</td>
</tr>
</tbody>
</table>

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)**

**ECAC Scenario with Implemented Measures, Estimated Benefits of Measures**

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

For reasons of simplicity, the scenario with implemented measures is based on the same traffic volumes as the baseline case, i.e. EUROCONTROL’s ‘Regulation and Growth’ scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development, improvements in ATM/operations and alternative fuels are considered here for a projection of fuel consumption and CO₂ emissions up to the year 2040.

Effects of **improved aircraft technology** are captured by simulating fleet roll-over and considering the fuel efficiency improvements of new aircraft types of the latest generation (e.g. Airbus A320NEO, Boeing 737MAX, Airbus A350XWB etc.). The simulated future fleet of aircraft has been generated using the Aircraft Assignment Tool (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of the Aircraft Assignment Tool is performed year by year, allowing the determination of the amount of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 0.96% per annum is assumed to aircraft deliveries during the last 10 years of the forecast (2030-2040). This rate of
improvement corresponds to the ‘medium’ fuel technology scenario used by CAEP to generate the fuel trends for the Assembly.

The effects of **improved ATM efficiency** are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. Regarding SESAR effects, baseline deployment improvements of 0.2% in terms of fuel efficiency are assumed to be included in the base year fuel consumption for 2010. This improvement is assumed to rise to 0.3% in 2016 while additional improvements of 2.06% are targeted for the time period from 2025 onwards. 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.

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). 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.

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.

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$_2$

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7 See SESAR1 D72 “Updated Performance Assessment in 2016” document, November 2016, project B05, project manager: ENAIRE.
8 See SESAR1 D107 “Updated Step 1 validation targets – aligned with dataset 13”, project B.04.01, December 2014, project manager: NATS.
9 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.
10 Well-to-wake CO2e emissions of fossil-based JET fuel are calculated by assuming an emission index of 3.88 kg CO2e per kg fuel (see DIN e.V., "Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)", German version EN 16258:2012), which is in accordance with 89 g CO2e per MJ suggested by ICAO CAEP AFTF.
11 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).
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)

<table>
<thead>
<tr>
<th>Year</th>
<th>Fuel Consumption (10$^9$ kg)</th>
<th>CO$_2$ emissions (10$^9$ kg)</th>
<th>Fuel efficiency (kg/RTK)</th>
<th>Fuel efficiency (kg/RTK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37.98</td>
<td>120.00</td>
<td>0.0310</td>
<td>0.310</td>
</tr>
<tr>
<td>2016</td>
<td>46.24</td>
<td>146.11</td>
<td>0.0286</td>
<td>0.286</td>
</tr>
<tr>
<td>2020</td>
<td>49.03</td>
<td>154.93</td>
<td>0.0245</td>
<td>0.245</td>
</tr>
<tr>
<td>2030</td>
<td>57.38</td>
<td>181.33</td>
<td>0.0242</td>
<td>0.242</td>
</tr>
<tr>
<td>2040</td>
<td>67.50</td>
<td>213.30</td>
<td>0.0237</td>
<td>0.237</td>
</tr>
</tbody>
</table>

*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)

<table>
<thead>
<tr>
<th>Period</th>
<th>Average annual fuel efficiency improvement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2016</td>
<td>-1.36%</td>
</tr>
<tr>
<td>2016-2020</td>
<td>-1.40%</td>
</tr>
<tr>
<td>2020-2030</td>
<td>-1.11%</td>
</tr>
<tr>
<td>2030-2040</td>
<td>-0.21%</td>
</tr>
</tbody>
</table>

**Table 6.** Equivalent (well-to-wake) CO$_2$e emissions forecasts for the scenarios described in this chapter

<table>
<thead>
<tr>
<th>Year</th>
<th>Well-to-wake CO$_2$e emissions (10$^9$ kg)</th>
<th>% improvement by Implemented Measures (full scope)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Baseline Scenario</strong></td>
<td><strong>Implemented Measures Scenario</strong></td>
</tr>
<tr>
<td></td>
<td>Aircraft techn. improvements only</td>
<td>Aircraft techn. and ATM improvements</td>
</tr>
<tr>
<td>2010</td>
<td>147.3</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>179.6</td>
<td>179.6</td>
</tr>
<tr>
<td>2020</td>
<td>193.8</td>
<td>190.4</td>
</tr>
<tr>
<td>2030</td>
<td>239.6</td>
<td>227.6</td>
</tr>
<tr>
<td>2040</td>
<td>292.7</td>
<td>267.7</td>
</tr>
</tbody>
</table>

*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.*
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.
Actions taken collectively throughout Europe

Aircraft related technology development

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

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

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

Research and development

Clean Sky is an EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough “clean technologies” for air transport globally. By accelerating their deployment, the JTI will contribute to Europe’s strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.
Joint Technology Initiatives are specific large-scale EU research projects created by the European Commission within the 7th Framework Programme (FP7) and continued within the Horizon 2020 Framework Programme. Set up as a Public Private Partnership between the European Commission and the European aeronautical industry, Clean Sky pulls together the research and technology resources of the European Union in a coherent programme that contributes significantly to the ‘greening’ of global aviation.

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

What has the current JTI achieved so far?

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

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

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

Main remaining areas for RTD efforts under Clean Sky 2 are:

- **Large Passenger Aircraft**: demonstration of best technologies to achieve the environmental goals whilst fulfilling future market needs and improving the competitiveness of future products.

- **Regional Aircraft**: demonstrating and validating key technologies that will enable a 90-seat class turboprop aircraft to deliver breakthrough economic and environmental performance and a superior passenger experience.

- **Fast Rotorcraft**: demonstrating new rotorcraft concepts (tilt-rotor and compound helicopters) technologies to deliver superior vehicle versatility and performance.

- **Airframe**: demonstrating the benefits of advanced and innovative airframe structures (like a more efficient wing with natural laminar flow, optimised control surfaces, control systems and embedded systems, highly integrated in metallic and
advanced composites structures). In addition, novel engine integration strategies and innovative fuselage structures will be investigated and tested.

- **Engines**: validating advanced and more radical engine architectures.

- **Systems**: demonstrating the advantages of applying new technologies in major areas such as power management, cockpit, wing, landing gear, to address the needs of a future generation of aircraft in terms of maturation, demonstration and Innovation.

- **Small Air Transport**: demonstrating the advantages of applying key technologies on small aircraft demonstrators to revitalise an important segment of the aeronautics sector that can bring key new mobility solutions.

- **Eco-Design**: coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship with intelligent Re-use, Recycling and advanced services.

In addition, the Technology Evaluator will continue to be upgraded to assess technological progress routinely and evaluate the performance potential of Clean Sky 2 technologies at both vehicle and aggregate levels (airports and air traffic systems). More details on Clean Sky can be found at the following link:


**Alternative fuels**

*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°. 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’.

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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 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\(^\text{13}\). 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\(^\text{14}\) 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\(^\text{15}\). 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.

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\(^{15}\) Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM (2011) 144 final
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\textsuperscript{16}.

More specifically, the initiative focuses on the following:

1. Facilitating the development of standards for drop-in biofuels and their certification for use in commercial aircraft,
2. Working together across the full supply chain to further develop worldwide accepted sustainability certification frameworks,
3. Agree biofuel take-off arrangements over a defined period of time and at a reasonable cost,
4. Promote appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector,
5. Establish financing structures to facilitate the realisation of 2\textsuperscript{nd} 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.

\textsuperscript{16} https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf
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


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
Research and Development projects on alternative fuels in aviation

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

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

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

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

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

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

Improved air traffic management and infrastructure use

The EU’s Single European Sky Initiative and SESAR

SESAR Project

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

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

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

SESAR, the technology pillar of the Single European Sky, contributes to the Single Sky’s performance targets by defining, developing, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner.
Guided by the European ATM Master Plan, the SESAR Joint Undertaking (JU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe’s air traffic management system and deliver benefits to Europe and its citizens. The SESAR JU research programme has been split into 2 phases, SESAR 1 (from 2008 to 2016) and SESAR 2020 (starting in 2016). It is delivering solutions in four key areas, namely airport operations, network operations, air traffic services and technology enablers.

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

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

**Figure 5.**

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

**SESAR Research Projects (environmental focus)**

During SESAR 1, environmental aspects were mainly addressed under two types of project: Environmental research projects, which were considered as a transversal activity and therefore primarily supported the projects validating the SESAR solutions, and secondly SESAR validation and demonstration projects, which were pre-implementation activities. Environment aspects, in particular fuel efficiency, were also a core objective of approximately 80% of SESAR 1’s primary projects.
Environmental Research Projects:

The four Environmental research projects have been completed:

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

In the context of Project 16.03.01, a first version of the IMPACT tool was developed by EUROCONTROL providing SESAR primary projects with the means to conduct fuel efficiency, aircraft emissions and noise assessments, from a web-based platform, using the same aircraft performance assumptions. IMPACT successfully passed the verification and validation process of the ICAO Committee on Aviation Environmental Protection Modelling and Database Group CAEP. Project 16.06.03 also ensured the continuous development/maintenance of other tools covering aircraft greenhouse gas (GHG) assessment (AEM), and local air quality issues (Open-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 CO₂ emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 “green” projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE).

A total of 15 767 flight trials were conducted under AIRE, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3 150 kg of CO₂), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology. More information can be found at [http://www.sesarju.eu](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\textsubscript{2} savings per flight ranged from 90kg to 1,250kg and the accumulated savings during the trials were equivalent to 400 tonnes of CO\textsubscript{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

<table>
<thead>
<tr>
<th>Domain</th>
<th>Location</th>
<th>Trials performed</th>
<th>CO\textsubscript{2} benefit/flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Paris, France</td>
<td>353</td>
<td>190-1 200 kg</td>
</tr>
<tr>
<td>Terminal</td>
<td>Paris, France</td>
<td>82</td>
<td>100-1 250 kg</td>
</tr>
<tr>
<td></td>
<td>Stockholm, Sweden</td>
<td>11</td>
<td>450-950 kg</td>
</tr>
<tr>
<td></td>
<td>Madrid, Spain</td>
<td>620</td>
<td>250-800 kg</td>
</tr>
<tr>
<td>Oceanic</td>
<td>Santa Maria, Portugal</td>
<td>48</td>
<td>90-650 kg</td>
</tr>
<tr>
<td></td>
<td>Reykjavik, Iceland</td>
<td>48</td>
<td>250-1 050 kg</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1 152</td>
<td></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Project name</th>
<th>Location</th>
<th>Operation</th>
<th>Objective</th>
<th>CO$_2$ and Noise benefits per flight (kg)</th>
<th>Number of flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDM at Vienna Airport</td>
<td>Austria</td>
<td>CDM notably pre-departure sequence</td>
<td>CO$_2$ &amp; Ground Operational efficiency</td>
<td>54</td>
<td>208</td>
</tr>
<tr>
<td>Greener airport operations under adverse conditions</td>
<td>France</td>
<td>CDM notably pre-departure sequence</td>
<td>CO$_2$ &amp; Ground Operational efficiency</td>
<td>79</td>
<td>1 800</td>
</tr>
<tr>
<td>B3</td>
<td>Belgium</td>
<td>CDO in a complex radar vectoring environment</td>
<td>Noise &amp; CO$_2$</td>
<td>160-315; -2dB (between 10 to 25 Nm from touchdown)</td>
<td>3 094</td>
</tr>
<tr>
<td>DoWo - Down Wind Optimisation</td>
<td>France</td>
<td>Green STAR &amp; Green IA in busy TMA</td>
<td>CO$_2$</td>
<td>158-315</td>
<td>219</td>
</tr>
<tr>
<td>REACT-CR</td>
<td>Czech republic</td>
<td>CDO</td>
<td>CO$_2$</td>
<td>205-302</td>
<td>204</td>
</tr>
<tr>
<td>Flight Trials for less CO$_2$ emission during transition from en-route to final approach</td>
<td>Germany</td>
<td>Arrival vertical profile optimisation in high density traffic</td>
<td>CO$_2$</td>
<td>110-650</td>
<td>362</td>
</tr>
<tr>
<td>RETA-CDA2</td>
<td>Spain</td>
<td>CDO from ToD</td>
<td>CO$_2$</td>
<td>250-800</td>
<td>210</td>
</tr>
<tr>
<td>DORIS</td>
<td>Spain</td>
<td>Oceanic: Flight optimisation with ATC coordination &amp; Data link (ACARS, FANS CPDLC)</td>
<td>CO$_2$</td>
<td>3 134</td>
<td>110</td>
</tr>
<tr>
<td><strong>ONATAP</strong></td>
<td>Portugal</td>
<td>Free and Direct Routes</td>
<td>CO₂</td>
<td>526</td>
<td>999</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>-----------------------------------------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>ENGAGE</strong></td>
<td>UK</td>
<td>Optimisation of cruise altitude and/or Mach number</td>
<td>CO₂</td>
<td>1 310</td>
<td>23</td>
</tr>
<tr>
<td><strong>RlongSM</strong></td>
<td>UK</td>
<td>Optimisation of cruise altitude profiles</td>
<td>CO₂</td>
<td>441</td>
<td>533</td>
</tr>
<tr>
<td>(Reduced longitudinal Separation Minima)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gate to gate</strong></td>
<td>France</td>
<td>Optimisation of cruise altitude profile &amp; CDO from ToD</td>
<td>CO₂</td>
<td>788</td>
<td>221</td>
</tr>
<tr>
<td>Green Shuttle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transatlantic</strong></td>
<td>France</td>
<td>Optimisation of oceanic trajectory (vertical and lateral) &amp; approach</td>
<td>CO₂</td>
<td>2 090+</td>
<td>93</td>
</tr>
<tr>
<td>green flight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPTP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Greener Wave</strong></td>
<td>Switzerland</td>
<td>Optimisation of holding time through 4D slot allocation</td>
<td>CO₂</td>
<td>504</td>
<td>1 700</td>
</tr>
<tr>
<td><strong>VINGA</strong></td>
<td>Sweden</td>
<td>CDO from ToD with RNP STAR and RNP AR.</td>
<td>CO₂ &amp; noise</td>
<td>70-285; negligible change to noise contours</td>
<td>189</td>
</tr>
<tr>
<td><strong>AIRE Green</strong></td>
<td>Sweden</td>
<td>Optimised arrivals and approaches based on RNP AR &amp; Data link. 4D trajectory exercise</td>
<td>CO₂ &amp; noise</td>
<td>220</td>
<td>25</td>
</tr>
<tr>
<td>Connections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trajectory based night time</td>
<td>The Netherlands</td>
<td>CDO with pre-planning</td>
<td>CO₂ + noise</td>
<td>TBC</td>
<td>124</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>-------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>A380 Transatlantic Green Flights</td>
<td>France</td>
<td>Optimisation of taxiing and cruise altitude profile</td>
<td>CO₂</td>
<td>1 200+ 1 900</td>
<td>19</td>
</tr>
</tbody>
</table>

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

**Table 9: Summary of AIRE 3 projects**

<table>
<thead>
<tr>
<th>Project name</th>
<th>Location</th>
<th>Operation</th>
<th>Number of Trials</th>
<th>Benefits per flight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMBER</strong></td>
<td>Riga International Airport</td>
<td>Turboprop aircraft to fly tailored Required Navigation Performance – Authorisation Required (RNP-AR) approaches together with Continuous Descent Operations (CDO),</td>
<td>124</td>
<td>230 kg reduction in CO₂ emissions per approach; A reduction in noise impact of 0.6 decibels (dBA).</td>
</tr>
<tr>
<td><strong>CANARIAS</strong></td>
<td>La Palma and Lanzarote airports</td>
<td>CCDs and CDOs</td>
<td>8</td>
<td>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.</td>
</tr>
<tr>
<td><strong>OPTA-IN</strong></td>
<td>Palma de Mallorca Airport</td>
<td>CDOs</td>
<td>101</td>
<td>Potential reduction of 7-12% in fuel burn and related CO₂ emissions</td>
</tr>
<tr>
<td><strong>REACT plus</strong></td>
<td>Budapest Airport</td>
<td>CDOs and CCOs</td>
<td>4 113</td>
<td>102 kg of fuel conserved during each CDO</td>
</tr>
<tr>
<td><strong>ENGAGE Phase II</strong></td>
<td>North Atlantic – between Canada &amp; Europe</td>
<td>Optimisation of cruise altitude and/or Mach number</td>
<td>210</td>
<td>200-400 litres of fuel savings; An average of 1-2% of fuel burn</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------</td>
<td>--------------------------------------------------</td>
<td>----</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>SATISFIED</strong></td>
<td>EUR-SAM Oceanic corridor</td>
<td>Free routing</td>
<td>165</td>
<td>1.58 t CO₂ emissions</td>
</tr>
<tr>
<td><strong>SMART</strong></td>
<td>Lisbon flight information region (FIR), New York Oceanic and Santa Maria FIR</td>
<td>Oceanic: Flight optimisation</td>
<td>250</td>
<td>3.13 t CO₂ per flight</td>
</tr>
<tr>
<td><strong>WE-FREE</strong></td>
<td>Paris CDG, Venice, Verona, Milano Linate, Pisa, Bologna, Torino, Genoa airports</td>
<td>Free routing</td>
<td>128</td>
<td>693 kg CO₂ for CDG-Roma Fiumicino; 504 kg CO₂ for CDG Milano Linate</td>
</tr>
<tr>
<td><strong>MAGGO</strong></td>
<td>Santa Maria FIR and TMA</td>
<td>Several enablers</td>
<td>100</td>
<td>The MAGGO project couldn’t be concluded</td>
</tr>
</tbody>
</table>

**SESAR2020 Environmental Performance Assessment**

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

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

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

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

<table>
<thead>
<tr>
<th>Solution</th>
<th>Short description + Fuel saving rational</th>
<th>Operational environment (OE/ Sub-OEs) benefitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJ.07-01</td>
<td>This Solution refers to the development of processes related to the Flight Operation Centre (FOC) aimed at managing and updating the shared business trajectory, and fully integrating FOCs in the ATM Network processes. These processes respond to the need to accommodate individual airspace users’ business needs and priorities without compromising the performance of the overall ATM system or the performance of other stakeholders. This will also ensure continuity in the Collaborative Decision Making process throughout the trajectory lifecycle. The benefits will come through anticipation and choice of the optimal route and reduction of vertical inefficiencies, which will reduce</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
costs and fuel burn. No real impact on airport is expected.

<p>| 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 for: 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. 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. | Mainly for: En-route Very High Complexity Some benefit but much lower for: Terminal very High, High, Medium Complexity En-route High, Medium Complexity Airport very large, large, medium |</p>
<table>
<thead>
<tr>
<th>PJ.01-02</th>
<th>Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PJ2-01</th>
<th>Wake turbulence separation optimization</th>
</tr>
</thead>
</table>
| 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. 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. | 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. |
| 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 Complexity |
| 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 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. | Mainly for: Terminal Very High Complexity • Single and Multiple runways • Preferably Congested large and medium size airports |
Sharing this information with the different actors will provide the NOP with more accurate forecasts for arrival and departure times 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 ...).

| PJ.08-01 Management of Dynamic Airspace configurations | Mainly for:  
En-route Very High Complexity  
Some benefit but much lower for:  
En-route High, Medium Complexity |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>This solution increased efficiency enabling optimised flight trajectories and profiles with the end result being reduced fuel burn, noise and CO₂ 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.</td>
</tr>
</tbody>
</table>
Economic/market-based measures

ECAC members have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The 31 EEA states in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap and trade approach to limit CO₂ emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO₂ emissions.

The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is the cornerstone of the European Union’s policy to tackle climate change, and a key tool for reducing greenhouse gas emissions cost-effectively, including from the aviation sector. It operates in 31 countries: the 28 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS is the first and so far the biggest international system capping greenhouse gas emissions; it currently covers half of the EU’s CO₂ emissions, encompassing those from around 12 000 power stations and industrial plants in 31 countries, and, under its current scope, around 500 commercial and non-commercial aircraft operators that fly between airports in the European Economic Area (EEA). The EU ETS Directive has recently been revised in line with the European Council Conclusions of October 2014¹⁷ 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\textsuperscript{18}.

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 30\textsuperscript{th} 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\textsuperscript{19}. 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\textsuperscript{20}. 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

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\textsuperscript{20} http://ec.europa.eu/clima/policies/transport/aviation/documentation_en.htm
the 2016 ICAO Assembly. The temporary limitation follows on from the April 2013 'stop the clock' decision\(^{21}\) 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\(^{22}\).

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\(^{23}\). 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\(^{24}\) and 601/2012\(^{25}\).

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


took effect in 2012 a *de minimis* exemption for commercial operators – with either fewer than 243 flights per period for three consecutive four-month periods or flights with total annual emissions lower than 10 000 tonnes CO₂ per year applies. This means that many aircraft operators from developing countries are exempted from the EU ETS. Indeed, over 90 States have no commercial aircraft operators included in the scope of the EU ETS. In addition, from 2013 flights by non-commercial aircraft operators with total annual emissions lower than 1 000 tonnes CO₂ per year are excluded from the EU ETS. A further administrative simplification applies to small aircraft operators emitting less than 25 000 tonnes of CO₂ per year, who can choose to use the small emitters' tool rather than independent verification of their emissions. In addition, small emitter aircraft operators can use the simplified reporting procedures under the existing legislation. The recent amendment to extend the intra-EEA scope after 2016 includes a new simplification, allowing aircraft operators emitting less than 3 000 tCO₂ per year on intra-EEA flights to use the small emitters' tool.

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

*Impact on fuel consumption and/or CO₂ emissions*

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

With the inclusion of intra-European flights in the EU ETS it has delivered around 100 MT of CO₂ reductions/offsets between 2012 and 2018. The total amount of annual allowances to be issued will be around 38 million, whilst verified CO₂ emissions from aviation activities carried out between aerodromes located in the EEA has fluctuated between 53.5 MT CO₂ in 2013 and 61MT in 2016. This means that the EU ETS is now contributing more than 23 MT CO₂ of emission reductions annually²⁶, or around 100 MT CO₂ over 2012-2018, partly within the sector (airlines reduce their emissions to avoid paying for additional units) or in other sectors (airlines purchase units from other ETS sectors, which would have to reduce their emissions consistently). While some reductions are likely to be within the aviation sector,

encouraged by the EU ETS’s economic incentive for limiting emissions or use of aviation biofuels, the majority of reductions are expected to occur in other sectors.

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**

<table>
<thead>
<tr>
<th>Year</th>
<th>Reduction in CO$_2$ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-2018</td>
<td>100 MT</td>
</tr>
</tbody>
</table>

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

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\textsubscript{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\textsubscript{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\textsuperscript{27}: 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.

\textit{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 from aircraft operators emitting less than 10 000 tCO\textsubscript{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 3\textsuperscript{rd} 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\textsubscript{2} emissions from air transport and to achieving overall carbon neutral growth.

\textsuperscript{27} Further information on https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx
EU initiatives in third countries

Multilateral projects
At the end of 2013 the European Commission launched a project with a total budget of €6.5 million under the name "Capacity building for CO₂ mitigation from international aviation". The 42-month project, implemented by the ICAO, boosts less developed countries' ability to track, manage and reduce their aviation emissions. In line with the call from the 2013 ICAO Assembly, beneficiary countries will submit meaningful State action plans for reducing aviation emissions. They then 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)

Caribbean: Dominican Republic and Trinidad and Tobago.

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

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

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

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

In terms of synergies, the South Asia and South East Asia environmental workshops could engage with key regional stakeholders (ICAO Asia Pacific office, regulatory authorities, airline operators, verification bodies), and thereby assess the level of readiness for CORSIA on wider scale in the Asia Pacific region. This preparatory work would help focus the subsequent FPI CORSIA project and create economies of scale in order to maximise the benefits of the project, which needs to be implemented within an ambitious timescale.
Support to voluntary actions

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

The underlying aim of the programme is to encourage and enable airports to implement best practice carbon and energy management processes and to gain public recognition of their achievements. It requires airports to measure their CO₂ emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party.

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

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

In 2017, for the first time, airports outside Europe achieved the highest accreditation status: 1 airport in North America, 5 in Asia-Pacific and 1 in Africa have been recognised as carbon neutral. European airports doubled their pledge and set the bar at 100 European airports becoming carbon neutral by 2030 from the 34 currently assessed to be carbon neutral.
Airport Carbon Accreditation is a four-step programme, from carbon mapping to carbon neutrality. The four steps of certification are: Level 1 “Mapping”, Level 2 “Reduction”, Level 3 “Optimisation”, and Level 3+ “Carbon Neutrality”.

**Figure 7: Four steps of Airport Carbon Accreditation**

**Levels of certification (ACA Annual Report 2016-2017)**

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

For historical reasons European airports remain at the forefront of airport actions to voluntarily mitigate and reduce their impact on climate change. The strong growth momentum was maintained for the reporting year which ended with 116 airports in the programme. These airports account for 64.8% of European passenger traffic and 61% of all accredited airports in the programme this year.

**Anticipated benefits:**

The Administrator of the programme has been collecting CO₂ data from participating airports over the past five years. This has allowed the absolute CO₂ reduction from the participation in the programme to be quantified.
Table 12: Emissions reduction highlights for the European region

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total aggregate scope 1 &amp; 2 reduction (ktCO₂)</td>
<td>51.7</td>
<td>54.6</td>
<td>48.7</td>
<td>140</td>
<td>130</td>
<td>169</td>
<td>156</td>
<td>155</td>
</tr>
<tr>
<td>Total aggregate scope 3 reduction (ktCO₂)</td>
<td>360</td>
<td>675</td>
<td>366</td>
<td>30.2</td>
<td>224</td>
<td>551</td>
<td>142</td>
<td>899</td>
</tr>
</tbody>
</table>

Table 13: Emissions offset for the European region

<table>
<thead>
<tr>
<th>Aggregate emissions offset, Level 3+ (tCO₂)</th>
<th>2015-2016</th>
<th>2016-2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>222</td>
<td>252</td>
<td>218</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emissions</td>
<td>Number of airports</td>
</tr>
<tr>
<td>Aggregate carbon footprint for ‘year 0’² for emissions under airports’ direct control (all airports)</td>
<td>22.04 MT CO₂</td>
<td>85</td>
</tr>
<tr>
<td>Carbon footprint per passenger</td>
<td>2.01 kg CO₂</td>
<td>1,89 kg CO₂</td>
</tr>
</tbody>
</table>

² ‘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.
| Aggregate reduction in emissions from sources under airports’ direct control (Level 2 and above)$^{29}$ | 87.4 ktonnes CO$_2$ | 56 | 139 ktonnes CO$_2$ | 71 |
| Carbon footprint reduction per passenger | 0.11 kg CO$_2$ | 0.15 kg CO$_2$ |
| Total carbon footprint for ‘year 0’ for emissions sources which an airport may guide or influence (level 3 and above)$^{30}$ | 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.

$^{29}$ This figure includes increases in CO$_2$ emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

$^{30}$ These emissions sources are those detailed in the guidance document, plus any other sources that an airport may wish to include.
APPENDIX A –

Detailed results for ECAC Scenarios from Section A

Baseline scenario (technology freeze in 2010)

a) International passenger and cargo traffic departing from ECAC airports

<table>
<thead>
<tr>
<th>Year</th>
<th>Passenger Traffic (IFR movements) (million)</th>
<th>Revenue Passenger Kilometres(^{31}) RPK (billion)</th>
<th>All-Cargo Traffic (IFR movements) (million)</th>
<th>Freight Tonne Kilometres transported(^{32}) FTKT (billion)</th>
<th>Total Revenue Tonne Kilometres(^{33}) RTK (billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>4.6</td>
<td>1,218</td>
<td>0.20</td>
<td>45.4</td>
<td>167.2</td>
</tr>
<tr>
<td>2016</td>
<td>5.2</td>
<td>1,601</td>
<td>0.21</td>
<td>45.3</td>
<td>205.4</td>
</tr>
<tr>
<td>2020</td>
<td>5.6</td>
<td>1,825</td>
<td>0.25</td>
<td>49.4</td>
<td>231.9</td>
</tr>
<tr>
<td>2030</td>
<td>7.0</td>
<td>2,406</td>
<td>0.35</td>
<td>63.8</td>
<td>304.4</td>
</tr>
<tr>
<td>2040</td>
<td>8.4</td>
<td>2,919</td>
<td>0.45</td>
<td>79.4</td>
<td>371.2</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Fuel Consumption ((10^9\text{ kg}))</th>
<th>CO(_2) emissions ((10^9\text{ kg}))</th>
<th>Well-to-wake CO(_2)(_e) emissions ((10^9\text{ kg}))</th>
<th>Fuel efficiency ((\text{kg/RPK}))</th>
<th>Fuel efficiency ((\text{kg/RTK}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37.98</td>
<td>120.00</td>
<td>147.3</td>
<td>0.0310</td>
<td>0.310</td>
</tr>
<tr>
<td>2016</td>
<td>46.28</td>
<td>146.26</td>
<td>179.6</td>
<td>0.0287</td>
<td>0.287</td>
</tr>
<tr>
<td>2020</td>
<td>49.95</td>
<td>157.85</td>
<td>193.8</td>
<td>0.0274</td>
<td>0.274</td>
</tr>
<tr>
<td>2030</td>
<td>61.75</td>
<td>195.13</td>
<td>239.6</td>
<td>0.0256</td>
<td>0.256</td>
</tr>
<tr>
<td>2040</td>
<td>75.44</td>
<td>238.38</td>
<td>292.7</td>
<td>0.0259</td>
<td>0.259</td>
</tr>
</tbody>
</table>

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

\(^{31}\) Calculated based on 98% of the passenger traffic for which sufficient data is available.

\(^{32}\) Includes passenger and freight transport (on all-cargo and passenger flights).

\(^{33}\) A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).
Implemented measures scenario

Effects of aircraft technology improvement after 2010

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Fuel Consumption (10⁹ kg)</th>
<th>CO₂ emissions (10⁹ kg)</th>
<th>Well-to-wake CO₂e emissions (10⁹ kg)</th>
<th>Fuel efficiency (kg/RPK)</th>
<th>Fuel efficiency (kg/RTK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37.98</td>
<td>120.00</td>
<td>147.3</td>
<td>0.0310</td>
<td>0.310</td>
</tr>
<tr>
<td>2016</td>
<td>46.28</td>
<td>146.26</td>
<td>179.6</td>
<td>0.0286</td>
<td>0.286</td>
</tr>
<tr>
<td>2020</td>
<td>49.08</td>
<td>155.08</td>
<td>190.4</td>
<td>0.0270</td>
<td>0.245</td>
</tr>
<tr>
<td>2030</td>
<td>58.65</td>
<td>185.34</td>
<td>227.6</td>
<td>0.0247</td>
<td>0.247</td>
</tr>
<tr>
<td>2040</td>
<td>68.99</td>
<td>218.01</td>
<td>267.7</td>
<td>0.0242</td>
<td>0.242</td>
</tr>
</tbody>
</table>

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

Effects of aircraft technology and ATM improvements after 2010

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Fuel Consumption (10⁹ kg)</th>
<th>CO₂ emissions (10⁹ kg)</th>
<th>Well-to-wake CO₂e emissions (10⁹ kg)</th>
<th>Fuel efficiency (kg/RPK)</th>
<th>Fuel efficiency (kg/RTK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37.98</td>
<td>120.00</td>
<td>147.3</td>
<td>0.0310</td>
<td>0.310</td>
</tr>
<tr>
<td>2016</td>
<td>46.24</td>
<td>146.11</td>
<td>179.4</td>
<td>0.0286</td>
<td>0.286</td>
</tr>
<tr>
<td>2020</td>
<td>49.03</td>
<td>154.93</td>
<td>190.2</td>
<td>0.0245</td>
<td>0.245</td>
</tr>
<tr>
<td>2030</td>
<td>57.38</td>
<td>181.33</td>
<td>222.6</td>
<td>0.0242</td>
<td>0.242</td>
</tr>
<tr>
<td>2040</td>
<td>67.50</td>
<td>213.30</td>
<td>261.9</td>
<td>0.0237</td>
<td>0.237</td>
</tr>
</tbody>
</table>

For reasons of data availability, results shown in this table do not include cargo/freight traffic.
Effects of aircraft technology and ATM improvements and alternative fuels

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

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

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.
SECTION 2: National actions in Denmark

Aircraft related technology

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

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

Please note that this information about SAS is valid for the whole of SAS and is submitted in the Action Plans for Sweden as well.

Thomas Cook Airlines
Thomas Cook Airlines Scandinavia is part of the global Thomas Cook Group Airlines. The group has a dedicated goal to reduce emissions from aircraft operations by 12 % by 2020, against a baseline year of 2008. The group has replaced older aircraft with new A321’s with sharklets in recent years. Only new A321 versions are used as single-aisle aircraft in Scandinavia. The Thomas Cook Group is currently expecting to replace older long haul aircraft with new ones in 2019-2022. The new aircraft will be more fuel efficient than the current fleet.

A replacement of the fleet will contribute to achieving the goal to reduce the CO2-footprint from flight operations. The experience so far is that the new A321 are above expectations regarding fuel efficiency. The saving in fuel has been close to 8 %, where the expectations were 3-4 %.

Sustainable aviation fuels
SAS, Danish Aviation, Copenhagen Airport A/S and others have engaged in NISA (Nordic Initiative for Sustainable Aviation) which is a Nordic association of major airlines, airports, aviation-related organizations, authorities and the aircraft manufacturers Airbus and Boeing. The purpose of NISA is to facilitate and accelerate the development and the commercialization of sustainable aviation fuels by organizing activities, strengthening the cooperation across the value chain and by focusing on opportunities in the Nordic region.

Several of NISA’s members have been involved in deliveries and promotional flights with the blend in of biofuel, and in agreements on the establishment of biofuel airports. The plan is that these airports should be able to deliver a limited but continuous blend in of biofuel for the airlines who are interested and willing to sign and pay extra for the deliveries.
Danish Aviation and the Danish Transport Authority in cooperation with NISA commissioned in 2014 a study of Danish achievements and opportunities on the issue “Sustainable Fuels for Aviation”. The scope of the study was to screen potential technologies and feedstock, with the aim of identifying opportunities for a production and supply chain for sustainable fuels for commercial (and potentially military) aviation in Denmark. The report concludes that there are available sustainable biomaterials in Denmark and that the technologies are in principle available. It was a key recommendation that sustainable fuel for aviation is a priority in a national energy plan. The report suggests that further cooperation in e.g. a Nordic context would improve the possibilities of making the development, the production and the sale of sustainable jet fuel competitive.

Not least because of this, the Danish Energy Agency in cooperation with other Nordic climate and transport authorities and with NISA has initiated a Nordic study entitled "Nordic perspectives on the use of advanced sustainable jet fuel for aviation." The project's timeframe is mid-2015 to mid-2016th. The purpose of the study was to assess to what extent the use of advanced sustainable jet fuel may contribute to GHG mitigation in the sector and assess the commercial potential for initiating and scaling up production at a Nordic level, making use of Nordic know-how, feedstock and production facilities, and identify barriers and steps to take to remove the barriers.

The study was funded by the Nordic Council of Ministers / Nordic Energy Research (NER) and the project management was carried out by the Danish Energy Agency.

The study found it important to explore the possibilities to make specific targets for the share of renewable energy sources (RES) in aviation on all levels, to promote public-private partnership between the aviation sector, jet fuel producers, universities and other public entities, in order to increase transparency and lower the risk in investing in sustainable business models. Policy makers should explore possibilities for establishing a mechanism for producers of sustainable jet fuels, in order to secure transition investment capital. The study also pointed out to organize the individual technologies and their developers in collaboration around specific production pathways throughout the value chain, and to explore and stimulate possibilities for co-processing with existing facilities, especially oil refineries.

With these topics as inspirational inputs and agenda topics, NISA and NER organized a Sustainable Aviation Fuel conference autumn 2017. The Organizers concluded the conference by presenting a draft for a message to the governments in the Nordic countries with elements for a political framework and the urgent need for an action plan:

1. Include aviation in National Energy Plans for EU (winter package) /RED II
2. Encourage corporate, private and public use of sustainable jet fuels (a Nordic Fly Green Fund?)
3. Include sustainable jet fuel in public procurement with sustainability criteria (military and public entities)
   Explore opportunities public-private partnerships to establish fund, grant, pilot/demo plants a.m.
4. Consider introducing pan-Nordic blend in requirements similar to the emerging Norwegian blend-in plan
5. Evaluate (Nordic) market opportunities, could be a pre-qualification- or tender process, procurement requirements
6. High priority to negotiations on aviation- and climate issues in international bodies

Since the above recommendations, the government in Norway has chosen to introduce a national plan for blending sustainable aviation fuel. The government in Sweden has introduced a tax on flights in and out of Sweden as well as initiated an analysis of the conditions and possibilities for a fossil-free domestic aviation.

In Denmark, sustainable jet fuel is not yet on the political agenda, but several research institutions are working on possible solutions. NISA collaborates with researchers and developers to promote both a Danish priority and a Nordic cooperation on sustainable aviation fuel. This has so far resulted in a collaboration with Nordic Energy Research (NER) and Danish Technological University on a forthcoming Workshop late autumn 2018 focusing on research, development and updated knowledge and dialogue on possible solutions. Researchers, developers, producers, politicians, authorities and investors are invited to present and discuss future opportunities with actors from the aviation industry.

Air Traffic Services: Naviair

The control of the air traffic in the Danish airspace is largely executed by Naviair, who is designated by the Danish Government.

Improved ATM and infrastructure use

Naviair’s primary approaches to reduction of greenhouse gas emissions are done through:

- short routes, continuous flights towards the destination and fuel saving flight levels
- fuel saving approach to Danish airports
- minimum of on ground waiting time with engines running through efficient traffic management at the airports
- green departures, Continuous Climb Operations (CCO), wherever possible – with continuous climb to cruising level
- partnership in the world’s first satellite-based global air traffic surveillance system which increases fuel savings and optimizes flight path efficiency

Among others, Naviair analyses and works with development of climate-friendly traffic concepts within Free Route Airspace (FRA), Continuous Climb Operations (CCOs), Continuous Descent Operations (CDO) as well as Required Navigation Performance (RNP).

PBN Approaches and Departures for Copenhagen Kastrup Airport

Copenhagen Airport and Naviair will implement PBN STARs and SIDs for all runways in Kastrup Airports in 2020. The design and validation activities already conducted indicates that the PBN procedures will lead to:

- Average reduction of flying time of 60 seconds for all departures without continuous climb potentials.
- Increased situational awareness, enabling pilots to better determine optimum Top of Descend point.
• Steeper approach patterns, in particular higher altitudes at downwind and less level flight at low level.

**DK/SE FAB and NUAC**

In 2009, Danish and Swedish airspace became one joint Danish-Swedish Functional Airspace Block (DK-SE FAB). Also in 2009 a joint company, NUAC (Nordic Unified Air traffic Control) was established by Naviair and Swedish LFV. NUAC is the first - and so far the only - fully integrated ANSP in Europe, operating the traffic control across national airspaces. NUAC is owned by Naviair (50 %) and LFV (50 %).

In 2011 Naviair and LFV introduced Free Route Airspace (FRA) in the DK-SE FAB. FRA benefits customers in the most cost-efficient way of their preference, increasing fuel saving and reducing flying time. FRA in the DK-SE FAB reduces CO$_2$ emissions with 40.000 ton annually according to simulations done by Eurocontrol.

Since 2012 NUAC has been responsible – on behalf of Naviair and LFV - for providing integrated en-route area control services in the Danish-Swedish Functional Airspace Block from three control centres in Copenhagen, Malmö and Stockholm. Besides securing harmonisation and streamlining of traffic control, the objective of NUAC is to reduce fuel consumption with flights in DK/SE FAB, reducing the emission of environmentally damaging gases.

**Extended free airspace: the NEFRA Programme and the Borealis Alliance**

LFV and Naviair have agreed on developing the NEFRA Programme started in May 2013. The NEFRA Programme is a programme to connect the existing FRA in the DK-SE FAB with the planned FRA in NEFAB states (Estonia, Finland, Latvia and Norway) seamlessly from late 2015. The Programme will benefit the customers to plan their flights through NEFAB and DK-SE FAB in the most cost-efficient way of their preference, without any requirements to cross the state or FAB borders at predefined points as it is today.

Nuair is part of the Borealis Alliance (including Norway, Estonia, Finland, Iceland, Ireland, Sweden, Latvia, UK and Denmark). It is planned to extend NEFRA to cover the full Borealis Alliance airspace from 2018.

**Aireon**

Today, radar coverage is inconsistent outside of most densely populated areas and over oceanic areas. Currently, no surveillance system provides 100 % global coverage and that presents challenges. Naviair is co-owner of Aireon LLC, the developer of the world’s first satellite-based global air traffic surveillance system (Global flight tracking), enabling - for the first time ever - a truly global, pole-to-pole aircraft tracking and surveillance capability from 2017.

Aireon expects its real-time global monitoring data to have a positive economic impact on air operations - increasing fuel savings, optimizing flight path efficiency and improving safety. All of which results in the eco-benefit of substantially reduced greenhouse gas emissions. For example with the Aireon real-time flight tracking it will be possible to reduce separation for the North Atlantic air traffic. This will - according to estimation based on Iridium-commissioned independent studies - lead to fuel savings worth USD 6-8 billion and following substantially reductions in greenhouse gas emissions.

**Other tangible climate initiatives**

Use of Continuous Climb Departures (CCD) by departure from Copenhagen Airport saves the environment from emissions of approximately 32,000 tonnes of CO$_2$ annually and the airlines fuel consumption of
approximately 10,000 tonnes annually. The concept means that more than 95 per cent of departing flights are given permission to deviate from the Standard Instrument Departure (SID) procedure. Instead, they use Naviair’s offer for CCO, where aircraft are given permission to climb directly to their preferred cruising level and head directly for their destination as quickly as possible during the departure procedure.

Naviair is also improving the possibility of using Continuous Descent Operations (CDO) at Copenhagen Airport. In periods with low traffic density, it is possible to use CDO. In 2009 more gentle level restrictions at approach into Copenhagen Airport were introduced, this means that the airlines can complete an approximate CDO.

**Market based measures - MBM**

Denmark is part of the EU, and thus participates in the EU Emissions Trading Scheme (EU ETS). Denmark has a clear preference for a global scheme for MBM. Denmark considers this the best way to achieve substantial reductions in CO₂ emissions and to avoid distortion of competition.

**Ground related activities**

*Copenhagen Airport*

Copenhagen Airports A/S (CPH) operates Copenhagen Airport, the airport with the highest number of passengers in Denmark (29.2 million in 2017). As a part of the international and national aviation sector, and with a strong growth strategy, CPH gives its active work with CO₂- and energy management high priority. In 2017, CPH updated its Corporate Responsibility (CR) strategy. Under the focus areas of People, Planet and Position, CPH has chosen to focus on 11 particular themes. These represent areas that will receive particular attention and be given extra priority in the coming years.

Under the Planet vision statement *“We have a responsibility to protect our climate and environment, and responsibility is an integral part of our business. We work purposefully and innovatively every day to develop sustainable solutions so that we can also contribute to creating a good environment for future generations”*, the airports CO₂ emissions is one of the 11 themes of special focus. The objective for this theme is:

*“Our long-term vision is to be carbon-neutral. As an airport in growth, it is our view that we have a special responsibility to reduce our CO₂ emissions. Reducing our climate impact is an important and integral part of our actions, so every day we are working on innovative solutions that will optimise our energy consumption.”*

Under this objective, CPH has set a number of specific targets in order to reduce emissions:
1. Energy consumption  
2016: 109 kWh/m²  
2023: Max. 90 kWh/m²  

2. Increase share of renewable energy  
2016: 0.24%  
2023: Min. 10%  

3. Maintain ACA accreditation at min. level 3  
2016: Level 3  
2023: Level 3  

4. CO₂ per pax  
2016: 1 kg per pax  
2023: Max 0.75 kg CO₂ per pax  

In 2014, CPH achieved an “Airport Carbon Accreditation” as the first airport in Denmark. CPH entered the accreditation scheme directly at level 3, “Optimization” as the first airport in the scheme’s history. Since then CPH has renewed the accreditation yearly – the newest renewal being from June 2018:

In short this means that CPH must:

- Update the carbon footprint for scope 1, 2 and 3 for Copenhagen Airport year-on-year.
- Maintain a functional CO₂ reduction policy for scope 1 and 2 and show improvements
- Engage in an active dialogue with partners in all three scopes about ways to reduce the carbon footprint

At the same time, CPH is pursuing a growth strategy. Achieving the CO₂- and energy targets require initiatives that aim to reduce energy consumption from the operation of existing buildings and infrastructure and initiatives that aim to ensure that new buildings and infrastructure are planned with an effective energy performance.

Some of the results, CPH has achieved in this context, are:
- ATES (Aquifer Thermal Energy Storage) has been installed. The groundwater cooling system is used for cooling of terminal buildings in the summer period and heating in the winter period.
- Adjusting the voltage control at transformer stations within the airport premises.
- Improving general indoor and outdoor lighting (e.g. by changing to LED technology).
- Exchanging runway and taxiway lighting to LED technology.
- Installing solar cells.
- Increased use of second-quality water to cool server rooms.
- CPH has changed some of its fleet of cars from diesel to natural gas and electric.
- In 2017, CPH made energy savings of 6.88 GWh, thus reaching our 2020 target three years early. Since 2013, we have made total energy savings of 23.6 GWh, compared with a target of 17.0 GWh.
- CPH received Energiforum Denmark's Energy and Environmental Award 2017.

For CPH, emissions from aircraft are the largest source of CO₂-emissions in scope 3. CPH has no direct control over these emissions, but aim to engage with and guide their stakeholders in order to continuously improve the sustainability of aviation.

Some of CPHs activities in this context are:
- CPH recommends single engine taxiing in the AIP for Copenhagen Airport.
- CPH recommends full stop of main engines as soon as the aircraft has been parked.
- CPH has strict rules for use of APUs (5 minutes after “on-block” and 5 minutes before ETD).
- CPH is founding member of the association Nordic Initiative for Sustainable Aviation (NISA), which aims to accelerate the development and the commercialization of sustainable aviation fuels within the Nordic region.
- CPH has implemented A-CDM.
- CPH is collaborating with Naviair on implementation of PBN for Copenhagen Airport.

Regarding other CO₂-emissions than aircraft in scope 3, some of the activities, CPH engage in, are:
- Defining requirements and setting targets for “green equipment” in Copenhagen Airport.
- Enforcing a rule of maximum idling time for vehicles engines of 1 minute.
- Public transportation to the airport. More than 60% of local departing passengers use public transportation (metro, train and buses) to the airport.
- Usage of groundwater for cooling of buildings.
“Green taxi” concept is incorporated in our Taxi Management System

**Billund Airport**
The second largest airport in Denmark, Billund, has an environmental policy which states the airport to be environmentally conscious and among the leaders with environmental solutions.

Billund Airport is also part of the Danish regional environmental network, Green Network, with environmental reporting requirements equivalent to an environmental ISO certification.

Billund Airport is in the final phase of a process of optimizing the procedure for departure, and is in contact with authorities with a view to change the starting position for medium jet aircraft. This will result in a reduction in the need for taxiing and fuel consumption.

Also a limit has been set to the use of APU to 5 minutes after “on-block”, and 5 minutes before take-off.

Furthermore Billund Airport has implemented or plan to implement a variety of actions mainly focused on ground installations:

- Usage of electric GPU instead of diesel GPU
- Replacement of vehicles powered by diesel to vehicles powered by electricity
- Replacement of traditional lights with LED
- Minimizing the duration of engine testing
- Planting of fast-growing willow trees used for CO2-neutral heating
- Heating of aircraft with district heating
- Usage of groundwater for cooling of buildings
- Landside transport to the airport by improving public transportation and carpooling.
SECTION 3: Emissions Data

The Danish emissions data have been calculated by the Danish Centre for Environment and Energy, Aarhus University. The data are based on all flights inside the state of Denmark and all flights out of Denmark, irrespective of the nationality of the air carrier. The data are in [ktonnes/year].

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Conclusion

This action plan provides an overview of the actions undertaken by the Kingdom of Denmark and Danish stakeholders – either alone or in collaboration with others such as the European Union – in order to mitigate the effects of aviation’s contribution to climate change. This Action Plan was finalized on the 1st of October 2018, and shall be considered as subject to update after that date.