The Future of Airports

A Vision of 2040 and 2070

Topic No. 10: Sustainability and Airport-Citizens

White Paper

ENAC Alumni – Airport Think Tank

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Foreword

In February 2019, ENAC Alumni – the alumni association of the National University of Civil Aviation (ENAC) – organized a day of discussion and education on the current and future challenges in air transportation: **The State of the Air ("Les Etats de l'Air")**. This event, held at the headquarter of the French General Directorate for Civil Aviation (DGAC), was part of a broader effort to fulfill some of our primary missions toward our 24,000 members: to maintain their knowledge up to date, to provide them platforms where to express and exchange ideas, and to promote excellence in aviation & space.

In addition to master classes on Airports, Aircraft and Systems, Design & Certification, Airline Operations, Air Traffic Management, Aircraft Maintenance, Pilots & Flight Operations, Safety & Compliance, and Entrepreneurship, **the State of the Air** featured a series of roundtables bringing together key leaders of the industry in the sectors of air transportation, tourism and general aviation who presented their vision of the future.

Following the large success of the State of the Air, and considering the dedication and expertise of our alumni, it has been decided to take the momentum and invite our think tanks to launch projects on the future of aviation. These think tanks reflect the diversity and excellence of our alumni community: air traffic management, airline operations, airports, digital innovation, and sustainable development.

The Airport Think Tank chaired by Gaël Le Bris is one of the most active of our research groups. The Future of Airports is an important study that brings a significant value added to help us foresee future challenges and prepare our industry for the changes to come. The participants of The Future of Airports have provided remarkable work. The output of the working sessions and the research findings are being released as white papers and other practice-ready materials that will be shared and brought to decision makers and leaders of both the public and private sectors worldwide. I am confident that the outcome of this Think Tank will be a huge move forward for the promotion and recognition of the ENAC Alumni.

Marc Houalla, President of ENAC Alumni

Introduction

From March 2019 to April 2020, the Airport Think Tank of ENAC Alumni conducted a research project on the long-term future of the airport industry: "The Future of Airports". The project involved thought aviation leaders from diverse backgrounds and affiliations who looked at the trends and potentially disruptive changes, emerging transformational innovations, their impact on practice and their challenges for air transportation, and the needs in research, education, and policies for anticipating and facilitating these changes.

The future of airports cannot be envisioned without considering the future of our societies. At the 2040 and 2070 horizons of our study, we will count more fellow human beings than ever. Overall, we will be wealthier and more educated, and have a longer life expectancy. However, we will all face increased impacts from climate change that will put pressure on resources and communities, and might increase inequalities. We will have different social expectations. How can aviation address these new paradigms and continue to provide mobility?

First and foremost, we shall never forget that safety always comes first. As we are making air transportation increasingly automated and connected, we shall remember that our top priority must be to safeguard life, health, and property, and to promote the public welfare.

Human-induced climate change is the most formidable threat to our civilization. Transportation must become greener if we want to sustain the development of our societies without degrading our well-being and endangering public health at a horizon increasingly visible. Aviation shall keep pioneering green policies.

As aviation professionals, we are on the front line to tackle the fundamental issues arising and still continue to interconnect people and move freight. Aviation shall remain a world of opportunities and "create and preserve friendship and understanding among the nations and peoples of the world" as stated in the Convention of Chicago of 1947.

By 2040 and 2070, it is likely that unforeseeable groundbreaking technological innovations, scientific discoveries, and social and political changes will occur and deeply impact our world. When reading these pages, remember that we conducted our work and prepared these materials with our eyes of 2019.

We are all part of this future, and we can make a difference individually if we make ethical and sustainable decisions. Aviator and writer Antoine de Saint-Exupéry said that when it comes to the future, "it is not about foreseeing it, but about making it possible". Let's make a bright aviation future possible together.

Gaël Le Bris, Chair of the Airport Think Tank of ENAC Alumni

Topic No. 10: Sustainability and Airport-Citizens

The Negative Externalities of Aviation

Like any human activity, air transportation has negative externalities. Aircraft noise has been the first airport-related issue to be recognized as so. Programs and activities aiming at reducing the number of people affected by noise have had significant effects since the 1970s in several countries. However, according to ICAO, the footprint of the 55 dB DNL noise contour[a] from 315 commercial service airports representing 80% of the global traffic could double if no progress is made on aircraft technology. The 2015 footprint represents 14,400 km^2 and 30 million people. Advanced but achievable technological improvement could stabilize this accrued noise exposure to its 2015 level and even reduce it. While the aircraft and engine design industries are working on such improvements, airports and governments also have a strong role to play for reducing this footprint, enhancing the insulation of the most exposed homes, and lowering the number of residents within this contour on the long-term. ICAO's standards and recommended practices (SARPs) on aircraft noise at airports include the framework for aircraft type noise certification expressed in the Assembly Resolution A39-1 of 2016[1]. It also includes the guidance developed through the "Balanced Approach to aircraft noise management" (Doc 9829) which is based on four main levers: Reduction at source, land use planning and management with policies and guidance provided in several documents[2,3,4], operational improvements such as noise abatement procedures[5,6] including the Noise Abatement Departure Procedures (NADP)[7] and the Continuous Descent and Climb Operations (CDO & CCO)[8,9], and operating restrictions including noise charges on the noisiest aircraft types[10,11]. This Balanced Approach analysis is specific to each airport geography, traffic, and conditions and a social and economic analysis must be undertaken for each measure envisaged.

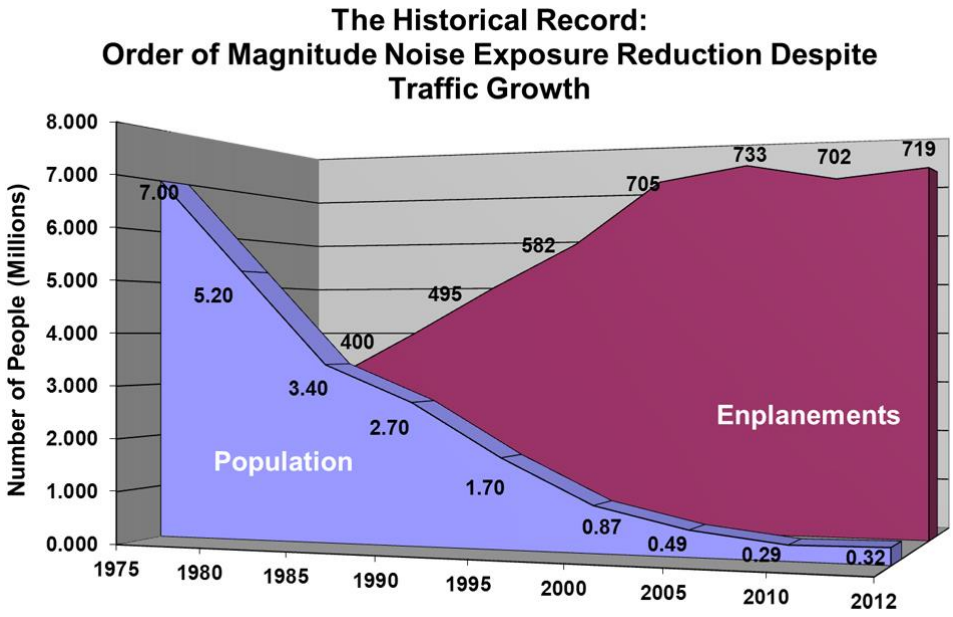

Figure 10-1 - Evolution of the Population Living Within 65 dB DNL Contours in the United States
Source: U.S. Federal Aviation Administration

[a] The Day-Night average sound Level (Ldn or DNL) is the average noise level over a 24-hour period. The noise level measurements between the hours of 10PM and 7AM are increased by 10 dB before averaging. This noise is weighted to consider the decrease in community background noise of 10 dB during this period.

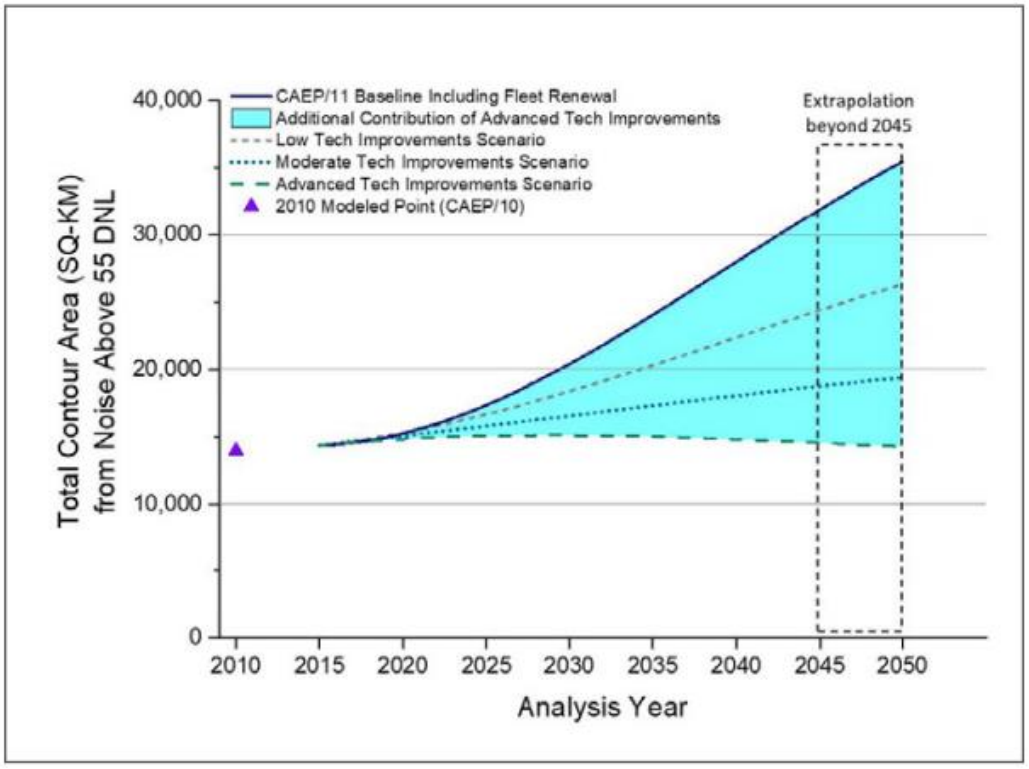

Figure 10-2 - Total Aircraft Noise Contour Area Above 55 dB DNL for 315 Airports (2010-2050)
Source: ICAO

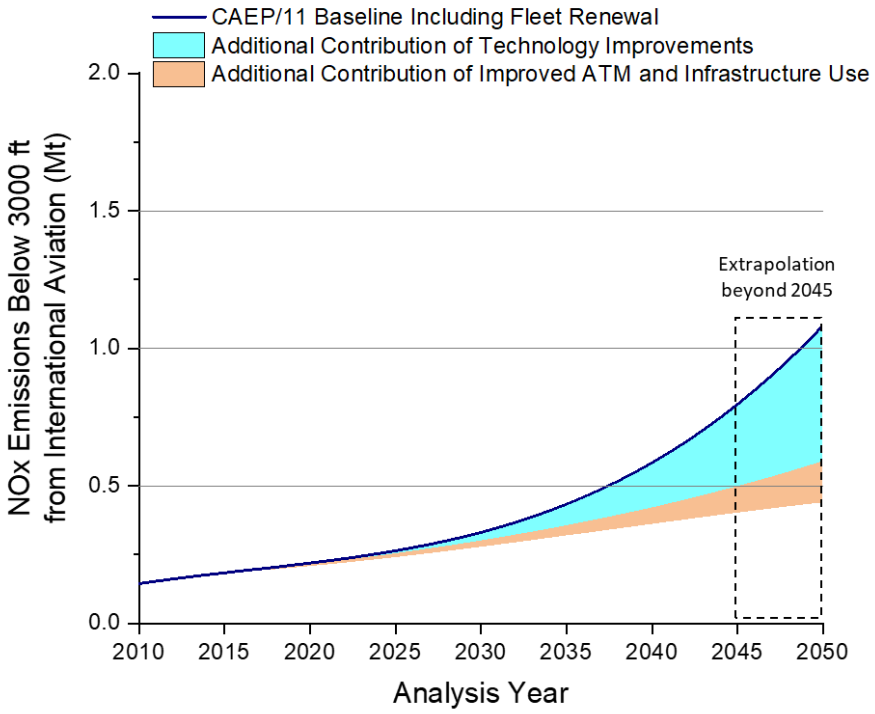

Figure 10-3 - Aircraft NOx Emissions Below 3,000 ft. from International Aviation (2010-2050)
Source: ICAO

Aerial pollution (e.g. NOx and particles) and greenhouse emissions (e.g., carbon dioxide) are the main types of gaseous externalities of an airport. Airports shall have a holistic vision of these emissions when preparing a sustainable plan. They should include the emissions of aircraft, ground handling services, passenger terminals and support facilities, landside facilities, but also ground transportation from and to the airport for passengers and airport workers, and emissions of their supply chain as well. On the airside, in addition to the tremendous improvements accumulated over the years by the introduction of new aircraft compliant with stringent certification requirements based on ICAO SARPs, the rapid dissemination of electric ground support equipment and the restriction of the use of APU have the potential to bring the direct emissions of the turnaround process at the gate down to zero. Lower-emission taxiing using tow-tractors (e.g., TaxiBOT) or built-in device (e.g., EGTS, Wheeltug) can reduce emissions from the gate to the runway threshold area. The attractiveness and commercial success of these technologies are highly dependent on the variation of fuel price and their compatibility with existing airport facilities. On the landside, providing and promoting mass transit and greener modes of transportation is an active part of a sustainable plan. Passenger terminal facilities are also major energy consumers and waste producers. Standards, building codes and certifications such as EDGE of the World Green Building Council (WGBC), Leadership in Energy and Environmental Design (LEED) in the United States, the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom or the Green Building Index (GBI) in Malaysia lead the way toward greener buildings.

Impact on natural spaces – streams and biodiversity – have been recognized since the years 1970 with one of the first ever airport environmental studies carried out by the Everglades Jetport project in the United States. The study led to the cancellation of the project due to the significant impact it would have had on the Floridian Everglades. Since then, conducting environmental impact assessments has become progressively a standard in eco-responsible countries that have made them a requirement by law. Other externalities include water discharges that can be a specific concern during winter operations – salts from pavement de-icing and glycols from aircraft de-icing. More recently, the awareness of nocturnal artificial light as a public health issue has arisen. Its impact on wildlife has also been documented. Switzerland was one of the first countries to take measures to fight this pollution with recommendations made in 2005 by the Federal Office for Environment that was followed by local and then federal regulations. Other countries and local governments[b] have followed with their own regulatory framework (Slovenia, 2010; France, 2018; Mexico, 2020).

The Value Added of Aviation to Society

Aviation is essential to our modern, globalized economy. Aviation supports most of the 17 Sustainable Development Goals (SDGs), developed by the United Nations in 2015. A comprehensive study was developed by the Air Transport Action Group (ATAG) in 2017.[12]

Airports make a massive contribution to the economic welfare of regions. They are centers of direct and indirect employment: personnel employed by airport operators directly and by other entities at the airport represent more than 6.1 million jobs globally. Airports trigger large investments for maintaining and developing their infrastructure that lead to further local jobs. The typical multiplier between direct (airport) and indirect (airport-induced) jobs at an airport is around 2. They require ground infrastructure that will benefit the outer community and the region, such as highways, trains, and utilities. They create revenues being taxed by governments, from additional income tax to VAT. Amsterdam Airport Schiphol accounts for about 3% of the Dutch GDP. The larger Schiphol Mainport region generates about 15% of the national GDP. High-quality air service increases the offer. It enables a broad range of opportunities and widens the horizon of possibilities, attracting businesses, residents and tourists.

[b] While the U.S. does not have federal regulations on light pollution, nearly 20 of States and territories impose restrictions.

Airports create high speed mobility options between cities, regions, and countries offering direct connections to the world for manufacturers and investors. Some businesses require aviation to move their workforce (e.g., banking, insurance, consultancy, IT, etc.) and goods (e.g., pharmaceutical industry, IT, flowers). Aviation does not benefit to large corporations only. It creates new opportunities for small local producers. The Nuestra Huerta initiative of Mariscal Sucre International Airport in Quito, Ecuador, integrates small farmers to sell their product at the airport. Kenya's booming horticulture industry could not export their products to the world up to the worldwide market of Amsterdam without air freight.

Tourism has been a powerful economic contributor and development driver for many regions and countries all over the world such as the Greater Paris in France, the U.S. State of Florida, Brazilian's Nordeste, Morocco, Mauritius or Thailand. More than half of the international tourists travel by air[c]. In 2001, 72% of tourists visiting Costa Rica arrived by plane. While the country has pledged to shutdown mineral extraction, stop deforestation, and focus on more sustainable resources such as responsible tourism, air transportation is a necessity to achieve these goals.

Airports provide mobility to remote or scarcely populated areas. Communities in the Great North, the Caribbean, and the Pacific Ocean or the Amazon forest are delivered with essential goods and services (freight and mail), have access to education and health services, and can move long-range by plane only. Juneau, the capital city of Alaska, is not served by any road. Traveling between major Andean cities can take days by roads that do not always meet the international practices on roadway safety. Aviation is vital to the Navajo Nation that operates its own system of airports for providing medevac and other services. Humanitarian aid and search and rescue missions need aviation facilities to support their operations as well. In remote areas and across vast territories, connectivity provided by air transport can be more sustainable than if ground infrastructure were built – assuming it is even realistically achievable and desirable. For many insular countries and overseas territories, air transportation is the only means to connect to the world and to move passengers and goods from island to island in a timely manner.

Aviation Has Worked for a Greener Future

The impact of airports – and aviation as a whole – on climate change have been taken into consideration for decades.[13] Aviation accounts for about 2% of the worldwide CO_2 emissions, a constant share since the early 1990s, even if the absolute emissions regularly increase due to the growing demand for air travel. Although CO_2 is the only greenhouse gas (GHG) significantly emitted by aviation, other pollutants (NOx, fine particulates, etc.) are also emitted. Part of these emissions occur at high altitudes, which might increase its net impact according to models. However, there is still an uncertainty on the exact direct contribution of aviation to climate change due to the complexity of its chemistry. For instance, aviation NOx contribute to ozone generation (increasing the greenhouse effect) under certain conditions, and to methane depletion at other altitudes (reducing this same effect). Also, the impact of contrails and their ability to generate cirrus clouds have to be taken into consideration.

This impact should be approached in a holistic way. For instance, comparisons between modes should take into consideration the carbon emitted by the construction and maintenance of the infrastructure, the production and procurement of the materials, and the real emissions of the trip itself – including emissions due to the electricity production for electric trains for instance. It should also include the other environmental impacts of the whole transportation system – e.g., modification of natural spaces and urban/rural discontinuity created by linear ground transportation systems. Modes should also be compared with what they provide. The value of time and the final mobility service should be considered.[d]

[c] 57% in 2017 according to the 2018 Aviation Benefits Beyond Borders of Air Transport Action Group (ATAG).

[d] For instance, long-range, transoceanic flights cannot be compared to light rail.

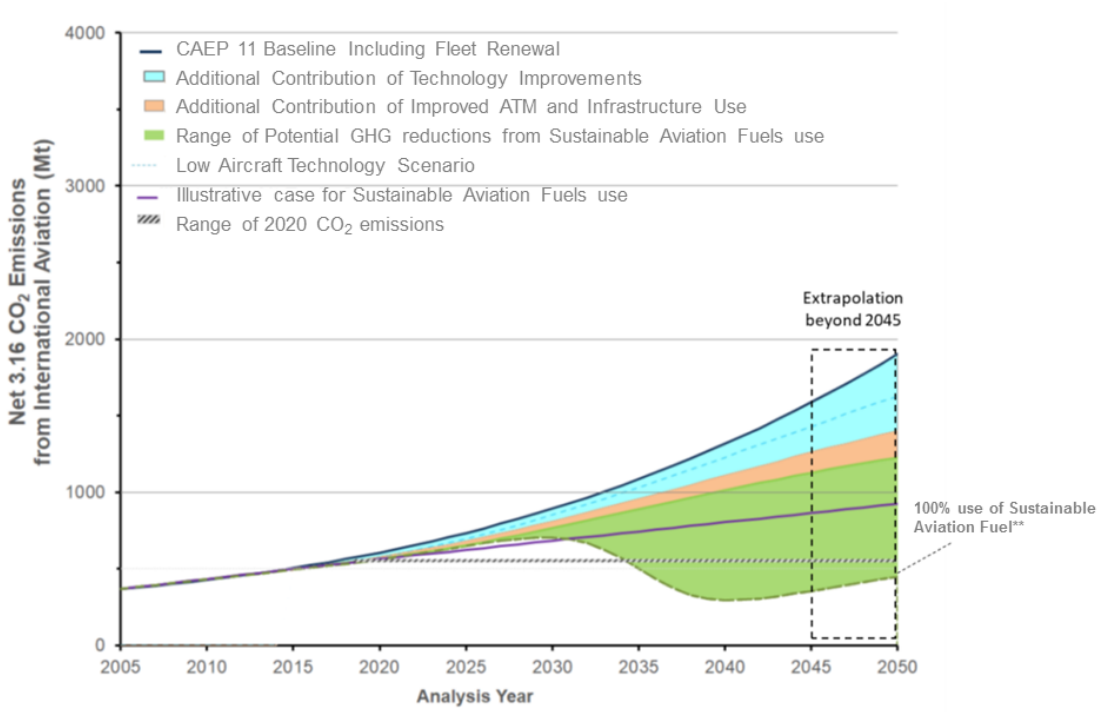

Figure 10-4 - Net CO2 Emissions from International Aviation Including Sustainable Aviation Fuels Life Cycle CO_2 Emissions (2005-2050)
Source: ICAO

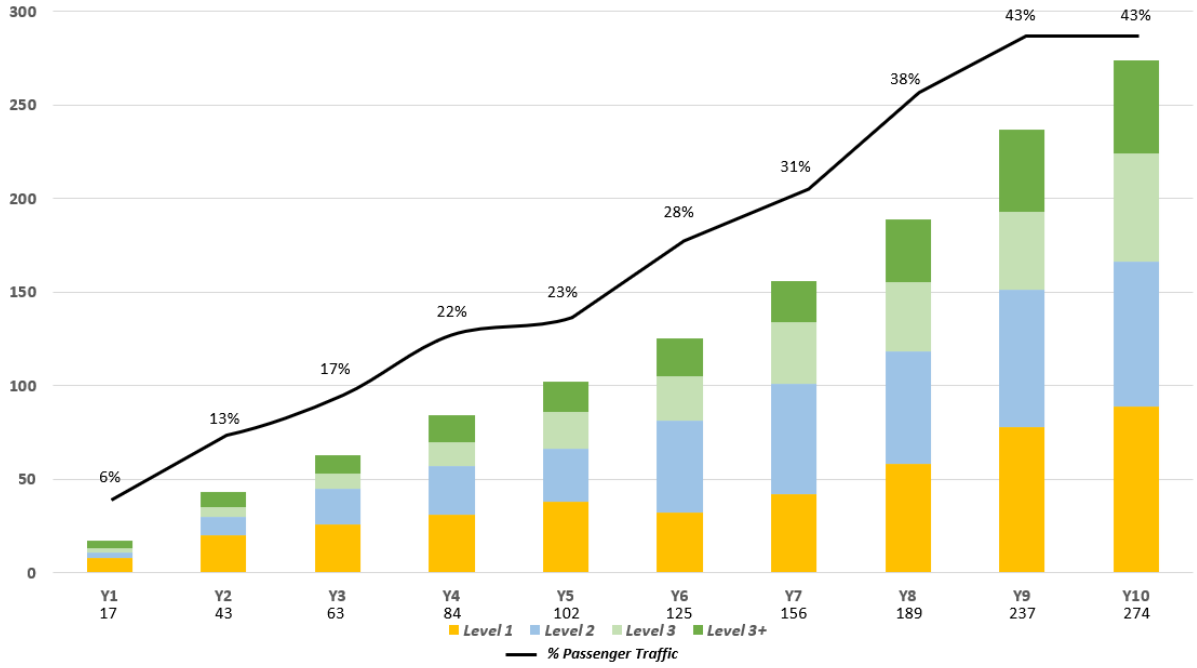

Figure 10-5 - Airports Certified Under ACI's Airport Carbon Accreditation Program (2009-2018)
Source: Airports Council International

The Airport Carbon Accreditation program of Airports Council International (ACI) is a global carbon management initiative that specifically targets airport emissions[e]. The program has been endorsed by the ICAO since 2011. The initiative provides a framework for airports to reduce their carbon footprint through local green initiatives as well as carbon offsetting in an objective to carbon neutrality. Several airports have already achieved the highest certification Level 4 – which implies carbon neutrality. To apply for certification at one of the 4 levels of the program, airports must have their carbon footprints independently verified in accordance with ISO14064 (Greenhouse Gas Accounting). Evidence of this must be provided to the administrator together with all claims regarding carbon management processes, which must also be independently verified. The definitions of emissions footprints used by Airport Carbon Accreditation follow the principles of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) "Greenhouse Gas Protocol" Corporate Accounting and Reporting Standard, the reference in GHG accounting and reporting. When considering the emissions from aircraft within the airport perimeter and on final approach and initial departure, Airport Carbon Accreditation uses the International Civil Aviation Organisation's (ICAO) definition of the Landing-Take Off cycle and requires airports to comply with these definitions. As of 2020, 304 airports are accredited. They account for more than half of the global traffic. Among them, 62 airports around the world are certified Level 4 (5% of the global traffic). Moreover, ACI Europe members pledged in 2017 to become carbon neutral by 2030. Over 20 airport management companies have signed this commitment.

The Airport Carbon Accreditation and carbon offset as a way to reduce the footprint of individual airports should not be underestimated – as should not be ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)[14,15]. At the same time, it is just a first step toward greener airports. Comprehensive decarbonization of airports will require the reduction and, as far as practicable, the elimination of emissions at the source. This includes local ordinances banning excessively emitting solutions when lower-emission alternatives are available (such as the use of the APU at the gate when 400Hz blocks are provided) or incentives to encourage the transition to lower-emission technologies such as VALE in the United States. Avinor at OSL and Port of Seattle at SEA have contributed to the implementation of Sustainable Aviation Fuels (SAF). Per CORSIA, Sustainable Aviation Fuels (SAF) must be produced from sustainable biomass sources harvested from land whose uses changed after January 1, 2008. The first fuel standards were approved in 2009. SAF can be blended with fossil fuels and delivered via existing fueling systems. Electric aviation has a potential of further decarbonization, especially for the general aviation and for short-haul, commuter traffic starting over the coming decade. In Norway, Avinor is leading a national roadmap on the development of e-aviation. London Heathrow is committed to exempt e-aircraft from landing fees. A massive move to e-aviation should be part of a broader vision for a virtuous electric economy. The electricity used for charging aircraft batteries should be itself low-emission – including the supply chain – and the batteries should have a virtuous lifecycle – which might have yet to be developed.

Finally, airports are also stricken by the effects of climate change. The direct effects are specifically explored in Topic No. 8 on operational performance and resilience. In addition, it has several indirect effects in relation to sustainability and corporate responsibility. For instance, in some areas, climate gentrification where the move of higher-income households to areas protected from climate-related events drive a rapid increase of home values and rents might push lower-income households to consider airports' vicinity. Also, climate change will adversely impact the attractiveness of entire regions, and sometimes wipe out natural treasures and leisure activities inducing a loss of revenues – including for airports. It is in the interest of the airport industry to reduce its carbon footprint and work collaboratively with their communities on climate resilience. In 2009, the overall aviation industry (including

[e] Aircraft emissions are not included in the program.

manufacturers, airlines, airports and air navigation service providers) committed to reducing their impact on climate change through three main levers:

- Improve fleet fuel efficiency by 1.5% per annum between 2009 and 2020. It is noticeable that a drop of 2.1% per year was actually achieved over that period;
- Starting in 2020, net carbon emissions from international aviation will be capped through carbon-neutral growth. This will be achieved with the implementation of CORSIA, as part of the Basket of Measures defined by ICAO[16];
- By 2050, the net aviation carbon emissions will be half of what they were in 2005. The massive introduction of Sustainable Aviation Fuels (SAF) will highly contribute to this objective.

Aviation Shall Pay for Itself and its Future

In the recent years, several countries have passed or considered passing laws establishing green taxes also known as eco-taxes on aviation (France, Germany). Some have declared they will utilize the funds collected through these taxes to finance or subsidize non-aviation projects – which could include support to highway and railway projects. This would be a disturbing move diverting profits from a mode to give to another that is not necessarily greener, and would create competition distortion. It would raise further questions since rail and road transportation have been progressively privatized. Finally, this is sending a very negative message to aviation that should not been used as a band-aid to the general budget of governments. Furthermore, taxing airlines will reduce their financial ability to renew their fleet with more efficient and greener aircraft.

Such unilateral decisions miss the opportunity to make a bold political statement and create an impetus. Aviation eco-taxes should be used as incentives to aviation pursue further in that direction and reward the efforts made for a lower-emission aviation. In the United States, a popular expression is that “aviation shall pay for itself”. This has been the successful driver of the development of the U.S. aviation system since after World War II. This motto should be applied worldwide and to greener aviation as well.

Abbreviations

ACRP	Airport Cooperative Research Program
AI	Artificial Intelligence
AMS	Amsterdam Airport Schiphol
ATAG	Air Transport Action Group
ATC	Air Traffic Control
ATL	Hartsfield-Jackson Atlanta International Airport
AV/CV	Automated Vehicles/Connected Vehicles
BREEAM	Building Research Establishment Environmental Assessment Method
CAGR	Compound Annual Growth Rate
CDG	Paris-Charles de Gaulle Airport
CDM	Collaborative Decision Making
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DFW	Dallas-Fort Worth International Airport
DOK	Donetsk Airport
EASA	European Aviation Safety Agency
ENSO	El Niño–Southern Oscillation
FAA	U.S. Federal Aviation Administration
FAB	Força Aérea Brasileira
FAB	Functional Airspace Block
FIT	Florida Institute of Technology
GANP	Global Air Navigation Plan
GASeP	Global Aviation Security Plan
GASP	Global Aviation Safety Plan
GBI	Green Building Index
GRU	GRU Airport / São Paulo/Guarulhos–Gov. André Franco Montoro Intl. Airport
GTAA	Greater Toronto Airport Authority
GTC	Ground Transportation Center
HCC	Hub Control Center
HKG	Hong Kong International Airport
HOV	High Occupancy Vehicle
HST	High Speed Rail
IAD	Washington Dulles International Airport
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
Infraero	Empresa Brasileira de Infraestrutura Aeroportuária
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IST	Istanbul Airport
JFK	John F. Kennedy International Airport
KIX	Kansai International Airport
KUL	Kuala Lumpur International Airport
LAC	Latin American and Caribbean
LAMP	Landside Access Modernization Program
LAWA	Los Angeles Airport World
LAX	Los Angeles International Airport
LCY	London City Airport

LEED	Leadership in Energy and Environmental Design
LGA	New York LaGuardia Airport
LGP	LaGuardia Gateway Partners
LGW	London Gatwick Airport
LHR	London-Heathrow
LRT	Light Rail Transit
MaaS	Mobility as a Service
MIA	Miami International Airport
ML	Machine Learning
MRS	Marseille-Provence International Airport
MUC	Munich International Airport
MWAA	Metropolitan Washington Airports Authority
NEXTT	New Experience Travel Technologies
NFC	Near-Field Communication
NM	Network Manager
NOAA	U.S. National Oceanic and Atmospheric Administration
ORD	Chicago-O'Hare International Airport
ORY	Paris-Orly International Airport
PHL	Philadelphia International Airport
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PKX	Beijing Daxing International Airport
PRT	Personal Rapid Transit
RAM	Rural (or Regional) Air Mobility
RPA	Regional Plan Association
RPK	Revenue Passenger Kilometer
SAF	Sustainable Aviation Fuels
SAT	San Antonio International Airport
SARP	Standards and Recommended Practices
SDI	Space Data Integrator
SDL	Sundsvall–Timrå Airport
SES	Single European Sky
SFB	Orlando Sanford International Airport
SFO	San Francisco International Airport
SIIED	Surgically Implanted Improvised Explosive Device
SIN	Singapore-Changi International Airport
SJU	San Juan Luis Muñoz Marín International Airport
SMS	Safety Management System
SWIM	System Wide Information Management
TAM	Total Airport Management
TNC	Transportation Network Companies
TRB	Transportation Research Board
UAM	Urban Air Mobility
UATM	Urban Air Traffic Management
UTM	Unmanned Traffic Management
VALE	Voluntary Airport Low Emissions Program
VAT	Value-Added Tax
VCE	Venice Marco Polo Airport

WGBC World Green Building Council

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