International Civil Aviation Organization

**WORKING PAPER**

A41-WP/93
EX/45
03/08/22
**Revision No.1**
31/08/22

# ASSEMBLY — 41ST SESSION

## EXECUTIVE COMMITTEE

**Agenda Item 16: Environmental Protection – General provisions, Aircraft Noise and Local Air Quality**

## CIVIL AVIATION AND THE ENVIRONMENT

(Presented by the Council of ICAO)

**EXECUTIVE SUMMARY**

This paper reports on progress made by ICAO since the 40th Session of the Assembly in the field of civil aviation and the environment, including present and future aviation trends in the areas of aircraft noise and emissions, progress on the development of Standards and Recommended Practices (SARPs) and guidance on environment, and relevant developments in other United Nations bodies and international organizations.

**Action:** The Assembly is invited to:

a) acknowledge the substantial progress achieved by the Organization since the 40th Session of the Assembly in addressing the impact of noise, local air quality and global climate emissions;
b) request ICAO to closely follow-up innovative technologies and cleaner energy sources for aviation, and to prepare for the timely update and development of relevant ICAO environmental Standards and Recommended Practices (SARPs) and guidance, as appropriate;
c) support the continued work of ICAO on all areas relating to civil aviation and the environment; and
d) consider the information contained in this paper for the update of Assembly Resolution A40-17.

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| *Strategic Objectives:* | This working paper relates to Strategic Objective – *Environmental Protection.* |
| *Financial implications:* | The activities referred to in the attached Assembly working paper will be undertaken subject to the resources available in the 2023 – 2025 Regular Budget and/or from extra budgetary contributions as guided by the ICAO Business Plan 2023-2025. |
| *References:* | Doc 10140, *Assembly Resolutions in Force (*as of 4 October 2019)<br>A41-WP/95, *Consolidated statement of continuing ICAO policies and practices related to environmental protection - General provisions, noise and local air quality* |

## 1. INTRODUCTION

1.1 With a view to minimizing the adverse effects of international civil aviation on the environment, the Organization formulates policies, develops and updates Standards and Recommended Practices (SARPs) on aircraft noise and emissions, and conducts outreach activities. These activities are conducted by the Secretariat, with technical support provided by the ICAO Council's Committee on Aviation and Environmental Protection (CAEP). In pursuing its activities, ICAO also cooperates with other United Nations bodies and international organizations.

1.2 Significant advances were made in reducing the amount of noise and emissions produced by international civil aviation. For example, technological progress has resulted in aircraft produced today being more than 75 per cent quieter and over 80 per cent more fuel efficient per passenger kilometre than in the 1960s. This progress continues - new innovative technologies and energy sources for aviation are under development at a fast pace, and much work by ICAO will be required to keep pace with the timely environmental certification of such new technologies. Despite the COVID-19 pandemic, ICAO has made progress on its environmental activities on noise and emissions, including work on the feasibility of a long-term global aspirational goal for international aviation $CO_2$ emissions reductions, and the ICAO Stocktaking.

## 2. ICAO GLOBAL ENVIRONMENTAL TRENDS

2.1 The 40th Session of the Assembly endorsed the environmental trends as the basis for decision-making on environmental matters, and that the 41st Session of the Assembly should be updated thereon[1]. In response to this request and in support of a data-driven decision-making process, an extensive modelling and analysis exercise has been conducted during the triennium to deliver an updated set of trends, including noise, local air quality (LAQ), and emissions that affect the global climate. Details are provided in the Appendix.

2.2 Comparing with the previous trends assessment, the updated trends show lower long-term projections for fuel burn, noise, and LAQ than those presented at the last Assembly (A40-WP/54 refers) and most of this is attributed to differences between the central traffic demand forecasts, significantly impacted by the COVID-19 pandemic data. The previous 2015 forecast was produced during a period of steady global economic growth with the expectation that this expansion would continue with global gross domestic product (GDP) growing at an annual rate of 2.8% over the ten years from 2015 to 2025 and 2.6% over the thirty-year period from 2015 to 2045.

2.3 In contrast, the current forecast includes the effect of the COVID-19 pandemic both on the economic recovery path from 2020 and the long term outlook, and has a more tepid ten year annual global GDP growth rate of 2.4% for 2018-2028 and 2.5% over the thirty two year period from 2018-2050. These updated traffic forecast scenarios were designed to bound the possible trajectories of the aviation industry as it moves out of the current pandemic-driven downturn, and were used as the basis for the current environmental trends assessment, as well as for the feasibility study on a long-term global aspiration goal (LTAG) and the analyses on CORSIA (A41-WP/368, *Climate Change* refers).

### 2.4 Trends in Aircraft Fuel Burn and $CO_2$ Emissions

2.4.1 In 2018, international aviation consumed approximately 188 megatons (Mt) of fuel. By 2050, compared with an anticipated increase of 3.0 times growth in international air traffic (expressed in revenue tonne kilometres), fuel consumption is projected to increase by 1.9 to 2.6 times compared to 2018, depending on the technology and Air Traffic Management (ATM) scenarios. Comparing with the previous $CO_2$ trends, the current assessment shows in 2040 approximately 15% lower $CO_2$ emissions for the base scenario with technology freeze and no operational improvements.

[1] ICAO Doc 10136, Assembly 40th Session, Executive Committee Report and Minutes, paragraph 15.3 refers and Minutes of the Fifth Meeting, Agenda Item 15, paragraph 3.

2.4.2 It should be noted that, for the work on the feasibility of LTAG, when compared to the Trends in Aircraft Fuel Burn and $CO_2$ Emissions, additional considerations were given to aviation in-sector $CO_2$ emissions reduction potentials from innovations in technologies, operations and fuels, for the development of three LTAG integrated scenarios (refer to A41-WP/368, *Climate Change*). All forecast and fleet evolution input assumptions, out to 2050, in the LTAG work are the same as those used for the Environmental Trends.

2.5 **Trends in Aircraft Engine Emissions that Affect Local Air Quality**

2.5.1 In 2018, LAQ NOx emissions were approximately 0.20 Mt. In 2050, they are projected to range from 0.51 to 0.72 Mt depending on the technology and ATM scenario, which represents a growth of between 2.6 and 3.6 times over the period and can be compared with the forecasted 3.0 times growth in international air traffic.

2.5.2 On LAQ nvPM and total PM emissions, they are estimated as 0.63 and 1.36 kt (kilotonnes) in 2018 respectively. In 2050, they are projected to range from 1.1 to 1.2 kt, and 3.1 to 3.2 kt respectively, depending on the technology and ATM scenario, which represents a growth around 1.8 and 2.4 times for nvPM and total PM respectively over the period and can be compared with the forecasted 3.0 times growth in international air traffic.

2.6 **Trends in Aircraft Noise**

2.6.1 In 2018, the total area exposed to yearly average day-night noise levels (DNL) above 55 dB was 16,486 square-kilometres, and its growth by 2050 ranges from 0.9 to 1.9 times compared to 2018 depending on the technology scenario. The total population inside this 55 dB DNL area was approximately 36.6 million people in 2018. As with previous trends results, a decoupling of growth in yearly average DNL from air traffic growth can be observed. Of note is that under an advanced aircraft technology scenario, from about 2038, the total yearly average DNL may no longer increase with an increase in air traffic. A number of ambitious actions would need to be carried out on the part of Member States for that scenario to be realized.

## 3. AIRCRAFT NOISE

3.1 The CAEP recommendations to amend Annex 16, Volume I – *Aircraft Noise*, and the *Environmental Technical Manual* (ETM) (Doc 9501), Volume I – *Use of Procedures in the Noise Certification of Aircraft* have been under consideration by the Council, including general maintenance to keep the environmental SARPs up to date and relevant. ICAO is following up possible noise issues related to Emerging Technology Aircraft (including urban air mobility concepts, remotely piloted aircraft, among others) and the experiences of ICAO Member States on that area[2]. Work is ongoing to develop noise measurement guidelines for these aircraft.

## 4. AIRCRAFT ENGINE EMISSIONS AFFECTING LOCAL AIR QUALITY

4.1 The CAEP recommendations to amend Annex 16 — *Environmental Protection*, Volume II — *Aircraft Engine Emissions*, and the ETM (Doc 9501), Volume II – *Use of Procedures in the Emissions Certification of Engines* have been under consideration by the Council, including, amongst others, a complete restructuring to ensure alignment with the Air Navigation Commission's "Guide to the Drafting of SARPs and PANS", improvements to the equivalent procedure definition, amendments related to referenced documents, and changes to ensure applicability language consistency.

[2] https://www.icao.int/environmental-protection/Pages/noise_new_concepts.aspx

4.2 Updates to ICAO Doc 9889, *Airport Air Quality Manual*, were also made, including, amongst others, information on aircraft nvPM emissions, latest recommended calculation methodology, and dispersion modelling.

## 5. AEROPLANE $CO_2$ EMISSIONS

5.1 The CAEP recommendations to amend Annex 16, Volume III – *Aeroplane $CO_2$ emissions*, and the ETM (Doc 9501) – *Use of Procedures in the Procedures for Aeroplane $CO_2$ emissions Certification* have been under consideration by the Council, including, amongst others, improvements to definitions, clarification on the Reference Geometric Factor (RGF) parameter, and information on data reporting to the certificating authority.

## 6. ENVIRONMENTAL GUIDANCE FOR AIRPORTS AND OPERATIONS

6.1 While ICAO's efforts are mainly focused on mitigating the impact of international civil aviation on the global climate, the impact of climate change has been identified as a significant risk for the aviation sector. In this regard, ICAO's work on climate adaptation is the foundation of aviation's risk preparedness, including a new guidance on climate change risk assessment, identifying vulnerabilities, and adaptation measures. The guidance provides support to States and stakeholders on performing a climate change risk assessment and on developing and implementing a climate change adaptation plan. It includes an overview of key climate change vulnerabilities which a State or organisation may be at risk from, and a menu of potential adaptation options which can be considered to reduce those risk.

6.2 On aircraft noise, ICAO recently developed a new Manual on "Operational Opportunities to Reduce Aircraft Noise" (Doc 10177), encompassing the identification, and review, of both standard and innovative operational opportunities and techniques for minimising aircraft noise. The manual provides information on current practices that are available to States and industry stakeholders to reduce aircraft noise impacts. It also highlights recent developments, resulting from emerging innovations, and considers what concepts and enabling technologies are currently being developed by the industry.

6.3 The "Eco-Airport Toolkit e-collection"[3] was updated, which includes the topics on climate resilience, water management, air quality management, and sustainable surface access. In line with the ICAO *No Country Left Behind* Initiative, the e-collection provides practical, ready-to-use best practice information to the international aviation community in a timely manner through the ICAO public website.

6.4 ICAO also developed two reports on: environmental metrics of relevance to the global aviation system; and investigation on possible indicators for encroachment. These reports can be found on the ICAO website[4].

## 7. ENVIRONMENTAL TOOLS TO SUPPORT QUANTIFICATION

7.1 The ICAO Carbon Emissions Calculator (ICEC) is the official tool used to estimate the air travel-related portion of United Nations (UN) agencies' carbon inventories. The Secretariat is currently considering updates to the ICAO Carbon Emissions Calculator and continues to maintain and further develop an Application Programming Interface (API) to allow easy integration of the calculator into external websites and services. The Secretariat is investigating ways to improve the use of the ICEC, including showcasing the use of sustainable aviation fuels. Similar to ICEC, the ICAO Green Meetings

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[3] https://www.icao.int/environmental-protection/pages/ecoairports.aspx
[4] https://www.icao.int/environmental-protection/Pages/environment-publications.aspx

Calculator (IGMC) is a tool designed to support decision-making in reducing the carbon emissions from air travel to attend meetings. The enhanced IGMC was launched in April 2020 with its mobile interface[5].

7.2 The Secretariat has also continued to maintain tools associated with the ICAO State Action plan initiative (also refer to A41-WP/368, *Climate Change*), including the Aviation Environmental System (AES), Environmental Benefits Tool (EBT), the Marginal Abatement Cost Curve tool, and ICAO Fuel Savings Estimation Tool (IFSET)[6].

7.3 In addition, ICAO developed the Tracker Tools website[7], where all the latest information on aviation $CO_2$ emissions reduction initiatives is updated from three streams – technology, operations and fuels, as well as on aviation net zero initiatives. As of July 2022, the Tracker tools include information on 102 initiatives on technology, 97 initiatives on operations, and 67 net zero initiatives by aviation stakeholders. The Fuels trackers point provides details on announced SAF offtake agreements which sum up to 29.4 billion litres of SAF, 53 airports that are regularly distributing SAF, and 24 SAF-supporting policies adopted or under development. The Trackers also provide details on 196 facilities that could produce SAF.

## 8. ICAO GLOBAL COALITION FOR SUSTAINABLE AVIATION

8.1 The ICAO Global Coalition for Sustainable Aviation[8] continues to grow, with the objective of providing a forum of stakeholders to facilitate the development of new ideas and accelerate the implementation of environmental innovative solutions. During the UNFCCC COP26, the ICAO Secretariat also launched the first edition of "Innovation Driving Sustainable Aviation", which provides an overview of the innovations presented during the 2021 ICAO Stocktaking, and updates from the Coalition Partners (also refer to A41-WP/368, *Climate Change*). All stakeholders are invited to join the Coalition by visiting the ICAO website.

## 9. COOPERATION WITH OTHER UN BODIES

9.1 Of note during this triennium was ICAO's intense coordination within the UN system, including the United Nations Framework Convention on Climate Change (UNFCCC) process, the Intergovernmental Panel on Climate Change (IPCC), and the United Nations Environmental Management Group (EMG).

9.2 The Stockholm+50 international meeting, which took place in Stockholm, Sweden, from 2 to 3 June 2022, represented a milestone event celebrating 50 years of global environmental action. ICAO worked with Swedish stakeholders and other partners to showcase the latest innovations in sustainable aviation fuels and cleaner energy for international aviation. More information on climate-change-related cooperation is provided in A41-WP/368, *Climate Change*.

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[5] https://applications.icao.int/igmc
[6] https://applications.icao.int/ifset
[7] ICAO Tracker Tools website: Aviation CO2 emissions reduction initiatives - Tracker Tool (icao.int)
[8] ICAO Coalition: https://www.icao.int/environmental-protection/SAC/Pages/learn-more.aspx

# APPENDIX

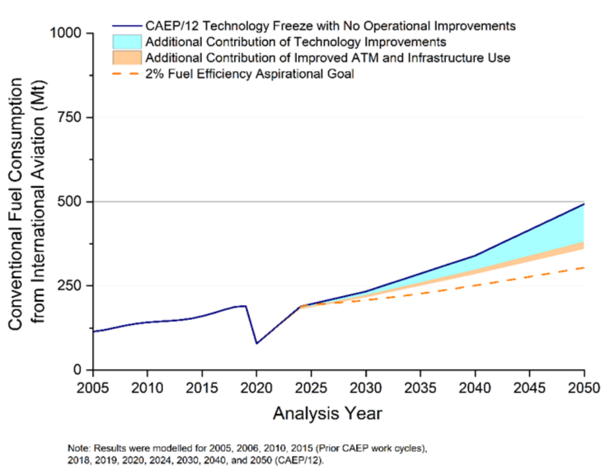
## ICAO GLOBAL ENVIRONMENTAL TRENDS – PRESENT AND FUTURE AIRCRAFT NOISE AND EMISSIONS

## 1. TRENDS IN EMISSIONS THAT AFFECT THE GLOBAL CLIMATE

### 1.1 Trends in Aircraft Fuel Burn and $CO_2$ Emissions

1.1.1 The green-house gas (GHG) portion of the trends assessment evaluated potential contributions of operational and technology improvements to reducing projected fuel demand and associated future emissions, focusing on combustion $CO_2$ emissions. The results are based on the 2018-2050 post-COVID traffic and fleet forecast, representing conventional fuel consumption, $CO_2$ emissions (i.e., $CO_2$ emitted during flight only), and NOx and nvPM emissions. The results contain the alternative fuel analyses, including the potential contribution of alternative jet fuel (AJF) on $CO_2$ net life-cycle emissions.

1.1.2 As shown in Figures 1 and 2, for the year 2050 and for the IEIR (Independent Expert Integrated Review) technology with high operational improvements scenario (Fuel Scenario 4), conventional fuel burn from international aviation, aircraft technology results in a reduction of 112 MT and operations provides an additional 22 MT for a total reduction of 134 MT. Fuel Scenario 1 value for international is 493 MT. ICAO's 2% aspirational goal for international aviation fuel burn is not achieved, and the average fuel efficiency (2010-2050) is 1.53% which is slightly improved from the 1.37% computed in previous trends assessment for the same time period. Overall, technology and operational improvements results in roughly a 27% reduction in fuel burn for international aviation in 2050 for the IEIR scenario. The most aggressive fuel burn technology improvement scenario is that defined by the CAEP/11 IEIR process.



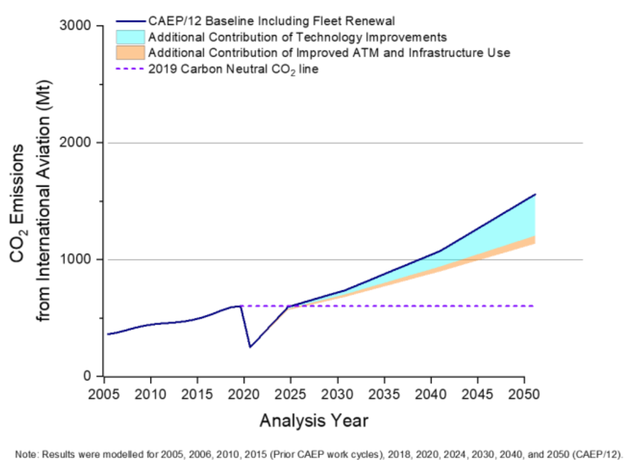




**Figure 1 (left). Conventional Fuel Consumption from International Aviation, 2005 to 2050.**
**Figure 2 (right). $CO_2$ Emissions from International Aviation, 2005 to 2050.**

1.1.3 As shown in Figure 3, in the year 2050 with alternative fuels replacement, in addition to the 27% reduction in $CO_2$ provided by technology and operations, alternative jet fuels replacement provides an additional 56% reduction in net life-cycle $CO_2$.

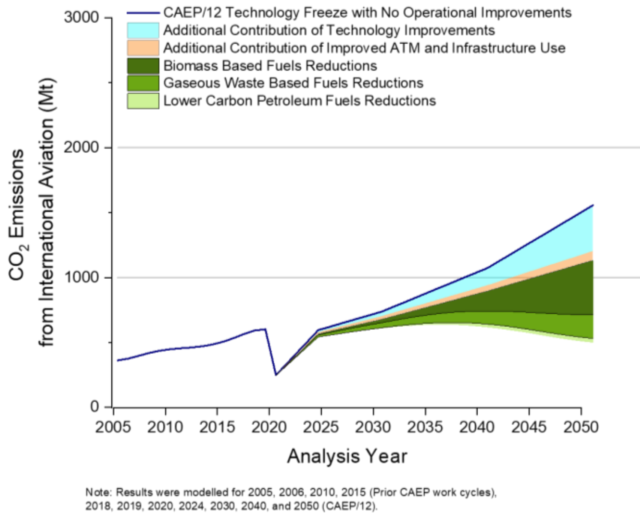
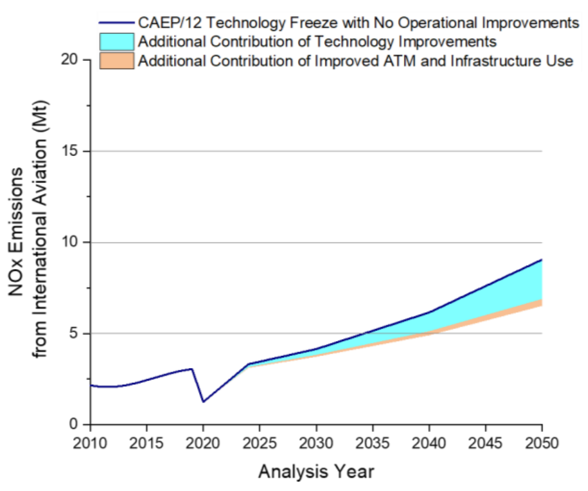



**Figure 3. $CO_2$ Emissions from International Aviation, 2005 to 2050, Including Alternative Fuels Net Life-Cycle Emissions Reductions.**

## 1.2 Trends in Aircraft Full-Flight NOx and nvPM Emissions

1.2.1 With technology and operational improvements (NOx Scenario 3), there is a combined reduction of 2.56 MT and 4.1 MT for international and global aviation, respectively. This amounts to roughly a 28% reduction in NOx from NOx Scenario 1 (technology freeze with no operational improvements), as presented on Figure 4.



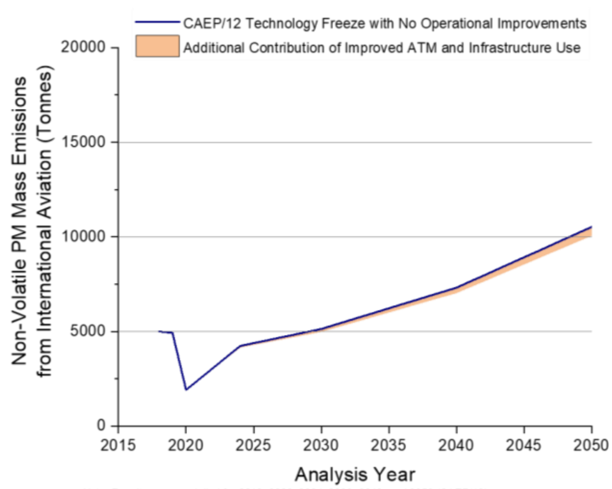



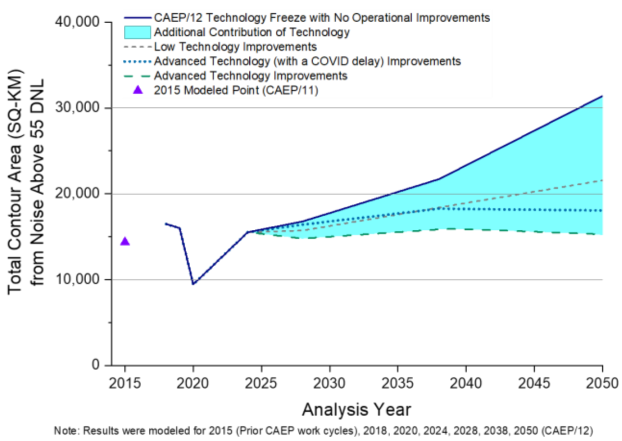

**Figure 4 (left). Full Flight NOx Emissions from International Aviation, 2010 to 2050.**
**Figure 5 (right). Full Flight NVPM Emissions from International Aviation, 2018 to 2050.**

1.2.2 nvPM Scenario 2 results in 465 tonnes and 895 tonnes reduction of nvPM mass emissions for international and global aviation, respectively. This amounts to roughly 5% reduction from nvPM Scenario 1 (technology freeze with no operational improvements), as presented on Figure 5.

## 2. AIRCRAFT NOISE TRENDS

2.1 The noise portion of the trends assessment evaluated potential contributions of operational and technology improvements to reducing population exposed to noise around airports. The results are based on the CAEP/12 2018 to 2050 post COVID traffic and fleet forecast, representing contour area and total population exposed to noise above a day-night average sound level in dB (DNL) of 55, 60, and 65. The noise trends assessment includes 319 global airports.

2.2 Figure 6 provides results for the total global 55 DNL contour area (i.e., for 319 airports) for 2018, 2028, 2038 and 2050 for the four scenarios. The 2018 technology freeze (scenario 1) contour area is 16 486 square km. This value decreases to 9 451 square km in 2020 due to the COVID-19 pandemic and increases to 15 530 square km by 2024. In 2050 the technology freeze (scenario 1) total global contour area is 31 407 square km and decreases to 15 196 square km with the advanced technology improvements and to 21 570 square km with low technology improvements.



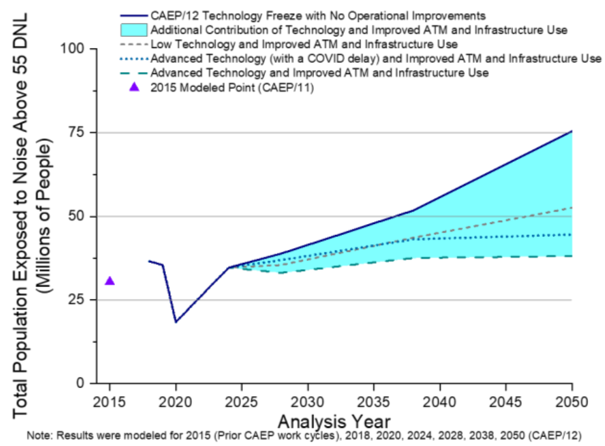




**Figure 6 (left). Global Contour Area from Noise above 55 DNL, 2015-2050.**
**Figure 7 (right). Global Population Exposed to Noise above 55 DNL, 2015-2050.**

2.3 Figure 7 provides results for the total global population exposed to aircraft noise above 55 DNL for 2018, 2028, 2038 and 2050 for the four scenarios. The 2018 baseline value is 36.55 million people. In 2020, the population decreases to 18.45 million due to the COVID-19 pandemic and increases to 34.70 by 2024. In 2050, the technology freeze (scenario 1) total population exposed is 75.5 million and decreases to 38.14 million people with the advanced technology and operational improvement scenario, and to 52.59 million people with low technology and operational improvement scenario.

## 3. TRENDS IN AIRCRAFT ENGINE EMISSIONS THAT AFFECT LOCAL AIR QUALITY

3.1 The LAQ portion of the trends assessment evaluated potential contributions of operational and technology improvements to reducing projected emissions of NOx and potential contributions of operational improvements to reducing projected emissions of the particulate matter (PM). The results are based on the CAEP/12 2018 to 2050 post COVID traffic and fleet forecast, representing NOx, non-volatile PM and Total PM emissions below 3 000 feet. NOx technology improvement scenarios leverage the latest Independent Experts (IE) work.

3.2 NOx emissions below 3 000 feet from international aviation are shown in Figure 8. In 2050, depending upon the scenario, technology improvements could provide up to 0.21 Mt of reductions in NOx emissions for international aviation. Operational improvements are smaller than those that could be realized by technology, namely additional reductions of up to 0.03 Mt in 2050 for international aviation.

3.3 Non-volatile PM emissions below 3 000 feet from international aviation are shown in Figure 9. In 2050, operational improvements could provide additional reductions of up to 50 tonnes in nvPM emissions for international aviation.

3.4 Total (volatile and non-volatile) PM emissions below 3 000 feet from international aviation are shown in Figure 10. In 2050, operational improvements could provide additional reductions of up to 150 tonnes in PM emissions for international aviation.

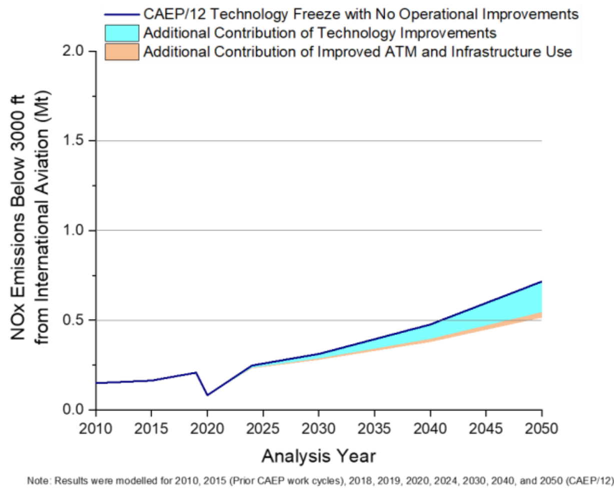



**Figure 8. NOx Emissions below 3 000 ft from International Aviation, 2010 to 2050.**

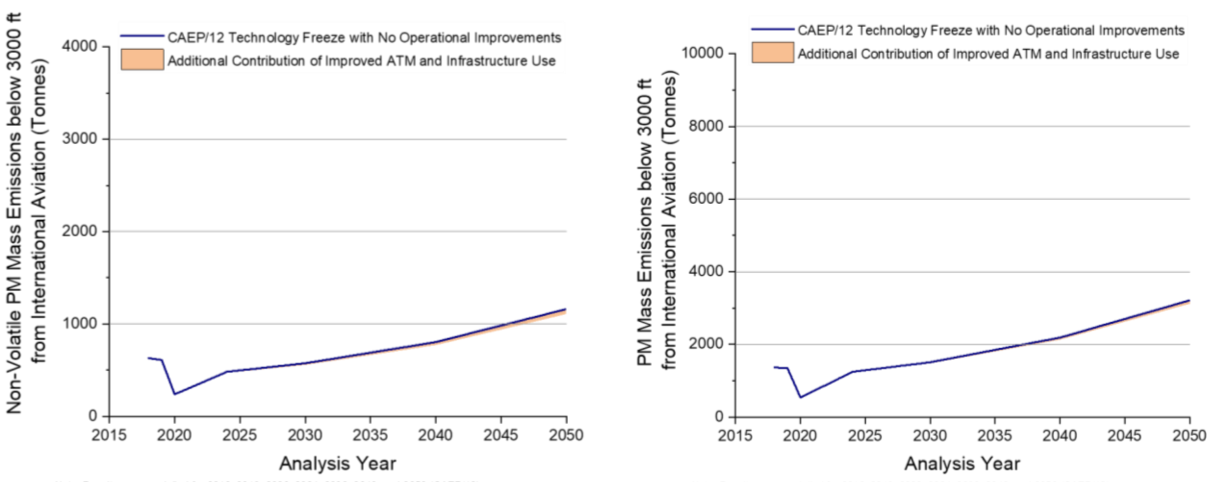



**Figure 9 (left). nvPM Emissions below 3 000 ft from International Aviation, 2018 to 2050.**
**Figure 10 (right). PM Emissions below 3 000 ft from International Aviation, 2018 to 2050.**

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