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Aviation, Air Pollution, and Climate Change

Some Members of Congress have expressed interest in addressing air pollution emissions, greenhouse gas (GHG) emissions, and the climate change effects from domestic and international aviation. Recent legislative proposals would provide for sustainable fuel mandates, incentives for airport efficiency improvements, and GHG emission targets, among other requirements.

Emissions from Aircraft

The U.S. Environmental Protection Agency (EPA) estimates that transportation—including passenger cars and light trucks, heavy-duty trucks, buses, trains, ships, and aircraft—accounted for 37% of carbon dioxide (CO_2, the principal GHG) emissions in 2021. While CO_2 emissions from passenger cars and light trucks exceed those from aircraft in the United States, CO_2 emissions from aviation are currently experiencing a faster rate of growth. All aircraft, including military, commercial, and privately chartered, accounted for 11% of the U.S. transportation sector's CO_2 emissions and 4% of all U.S. CO_2 emissions in 2021. Commercial aircraft, including those operated by passenger and all-cargo airlines, accounted for 7% of transportation sector and 3% of all emissions. These estimates include emissions from U.S. domestic flights and emissions from international flights departing the United States, referred to as "international bunkering."

In the United States, aggregate CO_2 emissions from aircraft have fluctuated due to changes in technology, the economy, travel frequency, and military activity, among other reasons. However, since the global financial crisis in 2009, aggregate CO_2 emissions from all aircraft types have grown steadily, increasing by almost 22% between 2009 and 2019. This increase makes aircraft one of the faster-growing sources of CO_2 emissions in the U.S. transportation sector over the past decade. This trend was affected, at least temporarily, by reduced air travel in 2020 and 2021 due to Coronavirus Disease 2019 (COVID-19).

The effects of aircraft emissions on the atmosphere are complex, reflecting differing altitudes, geography, time horizons, and environmental conditions. Research has shown that in addition to CO_2 emissions, other factors increase the climate change impacts of aviation. These factors include the contribution of aircraft emissions to ozone production; the formation of water condensation trails and cirrus clouds; the emission of various gases and particles, including water vapor, nitrous oxides, sulfates, and particulates from jet fuel combustion; and the high altitude location of the bulk of these emissions. In examining the warming and cooling influences of these factors, the United Nations' Intergovernmental Panel on Climate Change estimated aviation's total climate change impact could be from two to four times that of its past CO_2 emissions alone.

Aside from GHG emissions, aircraft engines emit a number of criteria—or common—pollutants, including nitrogen oxides, carbon monoxide, oxides of sulfur, unburned or partially combusted hydrocarbons (also known as volatile organic compounds [VOCs]), particulates, and other trace compounds. A subset of the VOCs and particulates are considered hazardous air pollutants.

Emission Reduction Strategies

In an effort to reduce emissions from the aviation sector, the U.S. government, other nations, and international organizations have worked together with the aviation industry toward improving technologies, increasing the efficient use of aircraft and airport infrastructure, adopting appropriate economic incentives, and setting standards.

Aircraft Emission Standards: Domestic Process

In the United States, in accordance with Clean Air Act (CAA) Section 231 (42 U.S.C. §7571), EPA sets emission levels for specified pollutants, as promulgated in 40 C.F.R. Part 87, "Control of Air Pollution from Aircraft and Aircraft Engines." EPA sets standards for Federal Aviation Administration (FAA)-certified aircraft according to the amount of thrust generated by their engines. Aircraft emission standards currently exist for fuel venting, and engine hydrocarbons, carbon monoxide, and nitrogen oxides. In 2021, EPA promulgated standards for CO_2 emissions from aircraft engines. In 2022, EPA finalized standards for particulate emissions from certain classes of engines used by civil subsonic jet aircraft (87 *Federal Register* 72312, November 23, 2022), and proposed an endangerment finding for lead pollution from gasoline-powered, piston-engine aircraft (87 *Federal Register* 62753, October 17, 2022).

The standard-setting language under CAA Section 231 is similar to the statutory language for other mobile sources in the CAA (e.g., cars, trucks, buses). However, compared to other mobile sources, EPA must meet additional requirements in setting emission standards for aircraft and aircraft engines: (1) the EPA Administrator must consult with the Administrator of the FAA and the Secretary of the U.S. Department of Transportation (DOT) in developing emission standards; (2) the EPA Administrator cannot change standards if doing so would "significantly increase noise and adversely affect safety"; and (3) the President may disapprove any such standards if the DOT Secretary finds that they "would create a hazard to aircraft safety." CAA Section 232 requires the FAA to enforce the standards at the time an engine is certified for emissions under 14 C.F.R. Part 34, "Fuel Venting and Exhaust Emission

Requirements for Turbine Engine Powered Airplanes." Since compliance with the federal standards is determined at engine certification, there are no operational emissions regulations for aircraft.

Aircraft Emission Standards: International Process

Due to the global nature of the aircraft manufacturing industry and its customer base, EPA has generally regulated emissions from aircraft only after the United States has negotiated an international agreement through the International Civil Aviation Organization (ICAO). ICAO is a United Nations specialized agency established in 1944 to manage the administration and governance of the Convention on International Civil Aviation (the Chicago Convention). ICAO has 193 member states, including the United States. ICAO addresses civil aviation (i.e., all nonmilitary, private, and commercial aviation).

ICAO's activities regarding environmental protection focus on issues that could benefit most from an industry-wide coordinated approach—for example, aircraft noise and engine emissions. ICAO has no direct regulatory or enforcement authority. After member states agree to a negotiated set of international standards, they implement these standards through their own domestic laws and regulatory processes. Typically, ICAO's international standards for pollutants from aircraft, unlike EPA's regulations for the same pollutants from on-road vehicles, have consistently avoided technology-forcing requirements. For example, the most recent ICAO standards for nitrogen oxides essentially ratified what the principal aircraft manufacturers had already achieved.

Greenhouse Gas Emission Reduction Strategies

CO_2 Emission Standards

Since 2010, ICAO has negotiated with the aviation industry and selected stakeholders to develop international CO_2 emission standards for aircraft engines. A delegation of EPA and FAA representatives have participated in ICAO's process. In March 2017, ICAO adopted international CO_2 standards for commercial aircraft engines to begin in 2020. The ICAO standards represent the world's first global design certification measure governing CO_2 emissions for any industry sector. The standards apply to newly developed civil aircraft designs phased-in between January 1, 2020, and January 1, 2023, and to in-production aircraft after January 1, 2028. They do not apply to already-manufactured aircraft that are currently in use. CO_2 emissions targets vary by aircraft type and are set as a function of the aircraft's maximum takeoff weight.

In accordance with the ICAO negotiations and the CAA, EPA issued a finding that GHG emissions (including CO_2 emissions) from civil aircraft contribute to the pollution that causes climate change and endangers U.S. public health and welfare (81 *Federal Register* 54422, August 15, 2016). EPA's endangerment finding, under Section 231 of the CAA, laid the necessary foundation for adoption and implementation of CO_2 standards for U.S. aircraft, in consultation with FAA. On January 11, 2021, EPA promulgated GHG emission standards for aircraft engines equivalent to the CO_2 standards adopted by the ICAO (86 *Federal Register* 2136, January 11, 2021). The standards cover U.S. subsonic jet and propeller-driven aircraft above certain takeoff weights.

Upon EPA's promulgation of the rule, CAA Section 232 requires the FAA to issue regulations to enforce the standards and apply such standards when certifying the engines of U.S. aircraft manufacturers (87 *Federal Register* 36076, June 15, 2022). EPA stated that the standards would make domestically manufactured aircraft engines competitive in the global marketplace; however, the agency also acknowledged that the rule likely would not spur any emissions reductions from U.S. aircraft manufacturers beyond their current trends.

Market-Based Mechanisms

In October 2016, ICAO also agreed on a framework for offsetting future carbon emissions from aviation—referred to as the Market-Based Mechanism, or MBM. ICAO member states agreed to implement a "Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to address any annual increase in total CO_2 emissions from international civil aviation (i.e. civil aviation flights that depart in one country and arrive in a different country) above the 2020 levels, taking into account special circumstances and respective capabilities." CORSIA relies on the use of emissions units from carbon markets to offset the amount of CO_2 emissions that cannot be reduced through the use of sustainable aviation fuels or technological and operational improvements. CORSIA began in 2021. Compliance was to be measured against a baseline of CO_2 emissions defined as the average from all international civil aviation in 2019 and 2020. However, due to the effects of the Coronavirus Disease 2019 (COVID-19) pandemic on international air travel in 2020, ICAO adopted a baseline based solely on 2019 emissions for a three-year pilot phase, and a baseline of 85% of 2019 emissions for the period 2024-2035.

Participation in CORSIA is voluntary through 2026. The U.S. aviation industry agreed to participate during ICAO negotiations. To fulfill the U.S. commitments under the Chicago Convention with respect to the MBM, FAA implemented the CORSIA Monitoring, Reporting, and Verification Program in 2019 (84 *Federal Register* 9412, March 14, 2019). Whether and what additional authorities are required by EPA and FAA to comply with CORSIA's mandatory trading scheme beginning in 2027 is under consideration.

Other Reduction Strategies

Beyond federal and international CO_2 emission standards for aircraft engines, other policy options are available to reduce GHGs from the aviation sector. These include (1) taxes or fees on fuel or its carbon content; (2) incentives or mandates to use sustainable aviation fuels or fuel alternatives; (3) incentives to modernize air traffic control systems (see CRS In Focus IF11420, *Aircraft Noise and Air Traffic Control Modernization*); and (4) ground-based measures aimed at reducing GHG emissions from nonaircraft operations at airports. EPA and FAA administer several initiatives in operations and research, and collaborate at the national and international levels, in support of many of these policies.

Richard K. Lattanzio, Specialist in Environmental Policy

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