

An hourglass-shaped graphic with a globe inside. The top bulb is dark blue, and the bottom bulb is light blue. The globe is centered in the narrow neck of the hourglass. The text is overlaid on the graphic.

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Report R40090

Aviation and Climate Change

James E. McCarthy, Specialist in Environmental Policy

December 16, 2008

Abstract. This report provides background on aviation emissions and the factors affecting them; it discusses the tools available to control emissions, including existing authority under the Clean Air Act and proposed economy-wide cap-and-trade legislation; and it examines international regulatory developments that may affect U.S. commercial airlines. These include the European Union's Emissions Trading Scheme for greenhouse gases (EU-ETS), which is to include the aviation sector beginning in 2012, and discussions under the auspices of the International Civil Aviation Organization (ICAO).

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Summary

Aircraft are a significant source of greenhouse gases—compounds that trap the sun’s heat, with effects on the Earth’s climate. In the United States, aircraft of all kinds are estimated to emit between 2.4% and 3.4% of the nation’s total greenhouse gas (GHG) emissions, depending on whether one counts international air travel. The impact of U.S. aviation on climate change is perhaps twice that size when other factors are considered. These include the contribution of aircraft emissions to ozone formation, the water vapor and soot that aircraft emit, and the high altitude location of the bulk of aircraft emissions. Worldwide, aviation is projected to be among the faster growing GHG sources.

If Congress and the new Administration decide to regulate aircraft GHG emissions, they face several choices. The Administration could use existing authority under Section 231 of the Clean Air Act, administered by the Environmental Protection Agency. EPA has already been petitioned to do so by several states, local governments, and environmental organizations. Congress could address aviation or aviation fuels legislatively, through cap-and-trade or carbon tax proposals.

Among the legislative options, the cap-and-trade approach (setting an economy-wide limit on GHG emissions and distributing tradable allowances to emitters) has received the most attention. In the 110th Congress, most cap-and-trade bills would have included aviation indirectly, through emission caps imposed upstream on their source of fuel—the petroleum refining sector. By capping emissions upstream of air carriers and eventually lowering the cap as much as 80%, bills such as these would have several effects: they would provide an incentive for refiners to produce lower carbon fuels; they would increase the price of fuels, and thus increase the demand for more fuel-efficient aircraft; and they might increase the cost of aviation services relative to other means of transport, giving airline passengers and shippers of freight incentives to substitute lower-cost, lower carbon alternatives.

Besides regulating emissions directly or through a cap-and-trade program or carbon tax, there are other tools available to policymakers that can lower aviation’s GHG emissions. These include implementation of the Next Generation Air Traffic Control System (not expected to be complete until 2025, although some elements that could reduce aircraft emissions may be implemented sooner); research and development of more fuel-efficient aircraft and engines; and perhaps the development of lower carbon jet fuel.

This report provides background on aviation emissions and the factors affecting them; it discusses the tools available to control emissions, including existing authority under the Clean Air Act and proposed economy-wide cap-and-trade legislation; and it examines international regulatory developments that may affect U.S. commercial airlines. These include the European Union’s Emissions Trading Scheme for greenhouse gases (EU-ETS), which is to include the aviation sector beginning in 2012, and discussions under the auspices of the International Civil Aviation Organization (ICAO).

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Contents

Introduction 1

Aircraft Emissions 1

Reducing Emissions: Non-Regulatory Factors..... 3

 Fuel Cost 3

 Air Traffic Control 4

Regulating Aircraft Under the Clean Air Act 4

Proposed Cap-and-Trade Legislation 5

International Developments..... 6

 European Union 6

 ICAO 8

Conclusion..... 8

Tables

Table 1. CO₂ Emissions from U.S. Aviation, 1990-2006 3

Contacts

Author Contact Information 10

<http://wikileaks.org/wiki/CRS-R40090>

Introduction

Research on climate change has identified a wide array of sources that emit “greenhouse gases” (GHGs)—compounds that trap the sun’s heat, with effects on Earth’s climate.¹ The largest sources of these emissions, particularly in developed economies, are electric utilities and the transportation sector.² In the United States, electricity generation accounts for about 40% of the emissions of carbon dioxide, the principal greenhouse gas, or about one-third of the emissions of the six major GHGs combined.³ The transportation sector, including cars, trucks, buses, trains, ships, and aircraft, accounts for roughly one-third of U.S. CO₂ emissions, or 27% of the six GHGs combined.

Aircraft Emissions

Aircraft account for about 10% of the U.S. transportation sector’s GHG emissions, or 2.4% to 3.4% of total U.S. GHG emissions, but they have been among the faster growing sources of GHG emissions worldwide. According to the Commission of the European Union, emissions from international aviation increased by almost 70% between 1990 and 2002.⁴ The United Nations Intergovernmental Panel on Climate Change (IPCC), in a 1999 study that is still widely cited, projected that the impact of aircraft emissions on climate would be 2.6 to 11 times as large in 2050 as it was in 1992.⁵ If, as many argue, GHG emissions must be reduced 50% to 80% in that time period, emissions from aviation would need to be drastically reduced to provide a proportional share of the targeted reduction.

U.S. emissions from aircraft have run counter to the worldwide trends and projections, however. Since 1990, aircraft GHG emissions have declined both as a percentage of total U.S. emissions and in absolute terms (see **Table 1**). The biggest factor in the decline was a 56 percent decrease in emissions from domestic military operations, which more than offset a small increase in domestic commercial and general aviation⁶ emissions.

¹ Six greenhouse gases are the primary focus of concern: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), hydrofluorocarbons, and perfluorocarbons. These six are the subject of international agreements (the U.N. Framework Convention on Climate Change and its Kyoto Protocol) and are the emissions that would be subject to control in most climate change cap-and-trade bills that have been introduced in Congress. As will be noted later in this report, other emissions from aircraft, especially water vapor and the persistent condensation trails (contrails) that form in jet engine exhaust, may have an impact on climate as well, but in general they have not been the subject of negotiations, international agreements, or legislation.

² For data on these and other sectors, see “Trends in Greenhouse Gas Emissions,” Chapter 2 of U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, at <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>, especially Table 2-1.

³ Because each gas has a different heat-trapping potential (e.g., methane has 25 times the heat-trapping potential of CO₂, and SF₆—although emitted in small quantities—has 22,800 times CO₂’s heat trapping potential), GHG emissions are generally converted to tons of CO₂ equivalent in order to assess the climate change contribution that an economic sector makes.

⁴ See Europa, website of the European Commission’s Directorate General for Environment, “Aviation and Climate Change” http://ec.europa.eu/environment/climat/aviation_en.htm. Visited November 12, 2008.

⁵ IPCC, *Aviation and the Global Atmosphere*, Summary for Policy Makers, 1999, at <http://www.ipcc.ch/ipccreports/sres/aviation/008.htm>. The term for its impact is “radiative forcing.”

⁶ The term “general aviation” refers to flights other than those by the military, scheduled commercial airlines, and large (continued...)

Emissions from domestic operation of commercial aircraft grew 4% between 1990 and 2006. That figure was well below the growth in air travel: according to the Air Transport Association (the association that represents the domestic airlines) passenger-miles traveled domestically on U.S. commercial airlines increased 74% between 1990 and 2006.⁷

Two types of efficiency increases contributed to the slow growth in U.S. commercial aircraft emissions. First, load factors (the percentage of seats occupied) increased to 79.9% in 2007, compared with 60.4% in 1990. Second, fuel efficiency itself increased, as older, less efficient aircraft were retired in favor of newer, more efficient models. These savings can be substantial. For example, American Airlines estimates that the 18-year old MD-80s currently flying use 35% more fuel than the Boeing 737-800 aircraft that are to replace them over the next two years.⁸

EPA's *Inventories of U.S. Greenhouse Gas Emissions and Sinks* shows that domestic flights of all kinds (military, commercial aircraft, and general aviation) accounted for about 10% of the GHG emissions from the U.S. transportation sector in 2006—2.4% of overall U.S. GHG emissions. Aviation's impact on climate may be greater than these figures suggest, however, for two reasons. First, emissions resulting from international transportation are not currently included in the U.S. emission totals.⁹ These emissions grew from 45.7 million metric tons in 1990 to 71.1 million in 2006, a 56% increase. If they were included in the U.S. aviation statistics, U.S. emissions from aircraft of all types would have risen 7% since 1990 (rather than falling 5%), and aviation would account for 3.4% of the U.S. GHG total. Second, the bulk of the aviation sector's emissions occur high in the atmosphere, where their impact on climate is greater than that of emissions at ground level. According to a number of sources, the total impact of aviation could be around twice the impact of carbon dioxide alone when this factor is taken into account.¹⁰ Emissions from jet aircraft also lead to the formation of cirrus clouds, as the condensation trails (contrails) of water vapor and sulfur particles emitted from engines at high altitudes form ice crystals that persist as clouds under some atmospheric conditions. Scientists are uncertain how to measure the occurrence and impact of such clouds, but they are reasonably certain that the clouds add to the greenhouse effect of aircraft emissions, perhaps substantially.¹¹

(...continued)

air cargo operators.

⁷ Data on load factors and revenue passenger miles (as well as other industry data) are available from the Air Transport Association's *2008 Economic Report*, at <http://www.airlines.org/NR/rdonlyres/770B5715-5C6F-44AA-AA8C-DC9AEB4E7E12/0/2008AnnualReport.pdf> for the period 1997-2007. Information for 1990 were provided in personal communications from ATA staff.

⁸ "American Speeds Plans to Phase Out Old Planes," *Greenwire*, August 14, 2008.

⁹ The UN Framework Convention on Climate Change refers to such emissions as combustion of "international bunker fuel," and categorizes the emissions separately from national emission totals, pending further agreement on how to address related emissions.

¹⁰ See, for example, Testimony of Dr. David W. Fahey, Office of Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration, at the Subcommittee on Aviation, House Committee on Transportation and Infrastructure hearing on Aviation and the Environment: Emissions, May 6, 2008. Dr. Fahey was a lead author of portions of the 1999 and 2007 IPCC reports that considered the impact of global aviation on climate.

¹¹ *Ibid.*

Table I. CO₂ Emissions from U.S. Aviation, 1990-2006
(million metric tons of CO₂ equivalent)

Fuel / Aircraft Type	1990	2000	2006
Jet Fuel			
Commercial Aircraft	136.7	164.2	142.1
Military Aircraft	33.9	20.5	14.8
General Aviation	6.3	9.2	11.4
Aviation Gasoline			
General Aviation	3.1	2.5	2.3
Total	180.0	196.4	170.6
% of Total U.S. GHG Emissions	2.9%	2.8%	2.4%

Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*

Thus, while the precise share of aviation in total greenhouse gas emissions depends on what is included, and the impact of some emissions is unclear, there is little doubt that aviation is a significant contributor to U.S. and world GHG emissions.¹²

Reducing Emissions: Non-Regulatory Factors

Fuel Cost

The cost of jet fuel represents a significant portion of total cost for most air carriers. There is a great deal of variation depending on the distance traveled, the age and efficiency of the aircraft, and the price of fuel at any given time, but the total fuel expenses of U.S. airlines consumed an average of 24% of airline operating revenues in 2007, according to the Air Transport Association. This percentage is expected to be even higher in 2008: although costs are now declining rapidly, in the first nine months of the year, domestic airlines spent \$46 billion on fuel for their domestic and international flights, 60% more than the cost in 2007.¹³

Given the importance of fuel costs, airlines and air freight companies have a major incentive to purchase more fuel-efficient aircraft, and thus, aircraft manufacturers are constantly seeking to improve the efficiency of airplanes and engines. These incentives have resulted in sizeable efficiency gains: U.S. airlines carried 20.4% more passenger and cargo traffic in 2007 than they did in 2000, but they used nearly 3% less fuel in doing so. This resulted in a reduction of 5.1

¹² Another source, a report prepared for the International Civil Aviation Organization (ICAO) in 1999, said, "Aircraft are estimated to contribute about 3.5 per cent of the total radiative forcing (a measure of change in climate) by all human activities and ... this percentage, which excludes the effects of possible changes in cirrus clouds, was projected to grow." ICAO, "Environmental (ENV) Unit, Aircraft Engine Emissions, Definition of the Problem," at http://www.icao.int/cgi/goto_m_atb.pl?icao/en/env/ae.htm, visited November 6, 2008. Similar conclusions were reached by the Federal Aviation Administration, which estimates that emissions of CO₂ and NO_x from domestic aircraft will increase 60% by 2025. See FAA, *Aviation and Emissions: A Primer*, January 2005, p. 10, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/aepimer.pdf.

¹³ ATA, "Monthly Jet Fuel Cost and Consumption Report," at <http://www.airlines.org/economics/energy/MonthlyJetFuel.htm>.

million metric tons of CO₂ emissions in 2007, as compared to 2000, according to ATA.¹⁴ The industry has committed to a further 30% increase in fuel efficiency by 2025.¹⁵

Air Traffic Control

In addition to improving the efficiency of individual aircraft, there is a general consensus that fuel use could be reduced by modernizing the Federal Aviation Administration (FAA)'s air traffic control system. The FAA is in the process of transforming air traffic control from a ground-based system of radars to a satellite-based system, dubbed the Next Generation (NextGen) Air Transportation System. The primary objective is to enable the air traffic control system to handle a projected doubling of current passenger loads by 2025. But, when fully implemented, NextGen is also expected to cut the GHG emissions of individual aircraft 10% to 15%, by allowing more direct routing, delay reduction, and through such features as Continuous Descent Approach.¹⁶ According to the FAA, United Parcel Service aircraft equipped with some of the NextGen technologies have reduced emissions as much as 34%.¹⁷

Regulating Aircraft Under the Clean Air Act

As policy-makers consider whether the federal government should regulate aircraft GHG emissions (versus continuing to rely solely on market forces to determine the level of emissions), some have turned their attention to the potential for regulation under the Clean Air Act. In December 2007, EPA received two petitions requesting that it exercise that authority to regulate GHG emissions from aircraft engines.¹⁸

To date, EPA has not promulgated regulations to control CO₂ from *any* source. In 2003, responding to an earlier petition to regulate GHGs from cars and trucks, the agency maintained that it did not have authority under the Clean Air Act to do so. That determination was challenged by Massachusetts and other petitioners, and in a 2007 decision, the U.S. Supreme Court found that GHGs *are* air pollutants within the Clean Air Act's definition, and thus, EPA would have authority to regulate them if it so chose.¹⁹

Under Section 231 of the Act, the EPA Administrator may propose emission standards applicable to any air pollutant from any class of aircraft engines which in the Administrator's judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public

¹⁴ ATA, *2008 Economic Report*, previously cited, p. 25.

¹⁵ *Ibid.*, p. 17.

¹⁶ Continuous Descent Approach, in which an aircraft lands by descending at a constant 3-degree angle rather than descending and holding at a series of altitude "steps," lowers fuel use and emissions by shortening flight time and eliminating the need for engine thrust required in a stepped approach to landing.

¹⁷ See FAA, "Fact Sheet: Next Generation Air Transportation System 2006 Progress Report," October 10, 2007, at http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8336.

¹⁸ The first petition, submitted December 4, 2007, was filed by California, Connecticut, New Jersey, New Mexico, the Pennsylvania Department of Environmental Protection, New York City, the District of Columbia, and California's South Coast Air Quality Management District (the air pollution control agency for the Los Angeles area). The second petition was filed December 31, 2007, by Earthjustice on behalf of four environmental organizations.

¹⁹ *Massachusetts v. EPA*, 127 S. Ct. 1438 (2007).

health or welfare. The Administrator is required to consult with the FAA Administrator and hold public hearings before finalizing such standards. The President may disapprove of such standards if the Secretary of Transportation finds that they would create a hazard to aircraft safety.

The December 2007 petitions request that EPA make a finding that aircraft GHG emissions do endanger public health or welfare, and that the agency adopt regulations that allow a range of compliance approaches: these might include emission limits, operational practices, fees, a cap-and-trade system, minimizing engine idling time, employing single engine taxiing, or use of ground-side electricity measures to replace the use of fuel-burning auxiliary power units at airport gates.²⁰

The decisions about whether and how to regulate aircraft might seem relatively straightforward, but the new Administration actually faces broader decisions than whether it should regulate GHGs from aircraft. For one thing, the aircraft petitions are among several others that EPA has received to regulate GHG emissions from power plants, cars and trucks, ships, and other sources. As a result, whatever decision is made (for any one of these sectors) is likely to affect the decisions regarding all the others—ultimately, a large portion of the economy. Given the relative size of aircraft emissions as compared to, say, power plants or cars and trucks, aviation would seem an unlikely choice to be the first sector whose GHG emissions EPA would regulate.

In addition, although the President-elect has said that he favors controls on GHG emissions, among the questions he faces will be whether to proceed with such regulation under the existing Clean Air Act authority or to support legislation targeted more specifically at GHGs. New legislation might be more efficient—clearly allowing sources in different industries to trade emission allowances to each other, for example—and it might avoid challenge in the courts if Congress were specific regarding the authority it was giving EPA to control GHG emissions. The current language of the act, while arguably providing regulatory authority, is sufficiently vague that legal challenges are considered almost a certainty if EPA proceeds. This might delay implementation of controls.

The two options—proceeding under the Clean Air Act or supporting new legislation—are not mutually exclusive. Existing EPA authority under the Clean Air Act could be used as a backstop, while Congress considers granting new authority. If EPA moves ahead with regulations, it could motivate Congress and interested parties to agree on a legislative approach. By holding open the possibility that regulation of some sort is a certainty, the development of regulations at EPA might speed the enactment of new, perhaps more flexible and more cost-effective, legislative authority.

Proposed Cap-and-Trade Legislation

Whether or not the new Administration moves forward with GHG regulations, GHG legislation is considered a high priority of the new Congress, with attention centered on legislation that would cap emissions of GHGs economy-wide and establish an allowance trading system for major emitters. (For a general discussion of how such cap-and-trade systems work, see CRS Report

²⁰ For a brief discussion of the petitions, see 73 *Federal Register* 44460, July 30, 2008. Some of these measures, such as minimizing engine idling time, employing single engine taxiing, and use of ground-side electricity measures to replace the use of fuel-burning auxiliary power units, are already widely used by the airlines as fuel-saving measures.

RL34502, *Emission Allowance Allocation in a Cap-and-Trade Program: Options and Considerations*, by Jonathan L. Ramseur, especially Appendix A.)

As noted, aviation is considered a significant source of GHG emissions. Despite this, the aviation sector (like other transportation sources) has not been targeted directly by the climate change bills introduced in Congress to date. In the 110th Congress, for example, the Lieberman-Warner bill (S. 2191/S. 3036), which was reported by the Senate Environment and Public Works Committee and debated briefly on the Senate floor before failing to achieve cloture, would have dealt with aviation emissions by including the refining sector in its overall emissions cap, thus regulating the aviation sector's emissions "upstream."²¹ The same would have been the case under the draft legislation prepared by Representatives Boucher and Dingell, posted on the House Energy and Commerce Committee website in October, 2008, but not actually introduced.

By capping emissions from fuels upstream of the air carriers and eventually lowering the cap as much as 80%, bills such as these would have several effects: first, they would provide an incentive for refiners to produce lower carbon fuels²²; second, they would increase the price of fuels, as refiners either purchased additional allowances for their emissions or were forced to reduce production, in essence rationing fuels through a higher price in order to stay beneath the emissions cap; third, as the cost of fuel increased, the demand for fuel-efficient aircraft would increase; and fourth, consumers of aviation services (airline passengers and shippers of freight) would have incentives to replace higher-cost air transportation with lower-cost alternatives (e.g., video-conferencing by business and government entities, increased reliance on lower-emission forms of transport, greater reliance on local sources of goods, etc.).

The cost of air travel and of air freight has been reduced substantially since its inception, as aircraft have become more efficient and airlines have reduced other costs in competitive markets. According to ATA, the cost of domestic air travel in real (inflation-adjusted) terms has declined by 51.9% since 1978.²³ By contrast, controlling GHG emissions, if it were done, would likely increase the price of air travel and air freight, reducing demand in comparison to a business as usual (i.e., without GHG controls) scenario.

International Developments

European Union

Unlike the upstream approach of U.S. cap-and-trade bills, the European Union (EU) has chosen to regulate aviation directly, by including the sector in its Emission Trading Scheme (ETS),

²¹ The Lieberman-Warner bill also provided for a National Academy of Sciences study of the aviation sector's emissions, including the identification of existing best practices to reduce emissions, recommendations for research for technologies and operations with the highest potential to reduce emissions, and recommendations of actions that the Federal Government could take to encourage or require additional emission reductions.

²² Besides incentives, S. 2191/S. 3036 actually would have required the production of low carbon fuels, although it is not clear whether the requirement would have applied to aviation fuels. For further discussion, see CRS Report RL34489, *Climate Change: Costs and Benefits of S. 2191/S. 3036*, by Larry Parker and Brent D. Yacobucci, pp. 54-55. The Boucher-Dingell draft would have given EPA authority to limit lifecycle GHG emissions from transportation fuels, although, as with the Lieberman-Warner bill, it is not clear that that authority would have applied to aviation fuels.

²³ ATA, *2008 Economic Report*, previously cited, p. 11.

beginning in 2012. The ETS began operation in 2005, capping emissions of CO₂ from more than 10,000 energy-intensive stationary sources of emissions. The currently covered sectors (power plants; petroleum refining; iron and steel production; coke ovens; pulp and paper; and cement, glass, lime, brick, and ceramics production) account for about half of EU CO₂ emissions.²⁴

On January 1, 2012, the aviation sector's CO₂ emissions are to be added to the ETS. The scheme is to cover all aircraft operators landing in or departing from the EU, with the exception of military aircraft, some small carriers, emergency services, research, and humanitarian flights. Thus, flights to and from the EU by U.S. air carriers would be subject to the emission limits. For the first year, the total quantity of allowances would be equivalent to 97% of the sector's average 2004-2006 emissions. The cap would be reduced to 95% in 2013, with further reductions to be agreed on as part of the ongoing review of the ETS. In allocating the emissions allowed under the cap, 85% of the sector's 2012 allowances are to be given to aircraft operators at no cost, and 15% of the allowances auctioned. The EU Commission has proposed that 80% of allowances be distributed free of charge in 2013, with 20% being auctioned; the percentage of free allowances is expected to continue declining with a goal of auctioning all allowances in 2020.

Operators emitting more than their allowed cap would need to buy additional allowances on the carbon market. A special reserve fund, taken from the sector's overall cap, is to allocate up to one million tons worth of allowances a year to ensure access to the market to new operators and to provide allowances to rapidly growing airlines.²⁵

The directive provides sanctions for failure to comply with the scheme, including the possibility that a non-complying airline might be banned from operating in the EU.²⁶ According to press reports, "This warning shot is aimed at foreign airlines—including US carriers—that have said they will not recognise the scheme."²⁷ For its part, the United States has responded by threatening trade sanctions if the EU makes an attempt to force foreign airlines to comply with the emissions trading system.²⁸

This dispute highlights a general problem in directly regulating emissions from sectors such as aviation or shipping, a substantial portion of whose total emissions occur outside of national borders. Without international agreement, it may be difficult to enforce emission limits, and the imposition of controls by any one country or bloc of countries is likely to be challenged through existing international institutions.

²⁴ For a description of the EU ETS, see CRS Report RL34150, *Climate Change and the EU Emissions Trading Scheme (ETS): Kyoto and Beyond*, by Larry Parker.

²⁵ "Airline Emissions Covered in EUETS from 2012," *ENDS Report*, July 2008, p. 51. The text of the ETS amendment adding the aviation sector to the scheme can be found at <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2008-0333+0+DOC+XML+V0//EN&language=EN>. The agreement on an EU-wide directive does not complete the legislative process. The 27 Member States now have until July 2009 to "transpose" the directive into national laws.

²⁶ The threat of a ban is found in Whereas clause (26): "In the event that an aircraft operator fails to comply with the requirements of this Directive and other enforcement measures by the administering Member State have failed to ensure compliance, Member States should act in solidarity. The administering Member State should therefore be able to request the Commission to decide on the imposition of an operating ban at Community level on the aircraft operator concerned, as a last resort."

²⁷ "Airline Emissions Covered in EUETS from 2012," *ENDS Report*, July 2008, p. 51.

²⁸ "Aviation and Emissions Trading," July 10, 2008, EurActive.com at <http://www.euractiv.com/en/climate-change/aviation-emissions-trading/article-139728>.

Regulating upstream of the aviation industry, as the climate change bills of the 110th Congress would have done, may avoid some of these issues, maintaining a level playing field for U.S. and foreign airlines and air freight companies, without imposing emission limits that could be directly challenged or circumvented. Whether enactment of such legislation would be sufficient to address European concerns over U.S. airlines' emissions, resolving the dispute, remains to be seen.

ICAO

The EU is not the only international body addressing aircraft emissions. The International Civil Aviation Organization (ICAO), the international organization that administers standards and recommended practices for the aviation authorities of more than 190 countries, agreed in September 2007 to support the development of an "aggressive" action plan on aviation and climate change, but without a fixed timetable or specific emission reduction targets.²⁹ The United States has supported the ICAO as the proper venue for international regulation of emissions, and maintains that the EU's approach is contrary to ICAO's charter, the Chicago Convention on International Civil Aviation.³⁰ A majority of ICAO's members agree with the United States that participation in an emissions trading scheme (such as EU-ETS) should only be on the basis of mutual consent.³¹

Conclusion

Greenhouse gas emission controls of some sort may affect U.S. aviation in the next few years, be they specific controls on engine emissions, emission caps applied to the sector as a whole, upstream caps (on fuel refiners), or carbon taxes.³² Depending on their stringency, the effects of most of these approaches could ripple through the economy, providing additional incentives for aircraft manufacturers to improve the fuel efficiency of aircraft, raising the cost of air travel and air freight, and providing further pressure to improve the air traffic control system.

U.S. airlines and air freight companies, like many other sectors, would prefer that they be allowed to address the GHG issue through voluntary measures. Unlike some other sectors, they have achieved substantial increases in fuel economy over the last three decades or more, and have stabilized their GHG emissions at roughly their 1990 levels. But the sector is still an important source of emissions, and its projected growth indicates that it may outstrip the economy as a whole's rate of emission growth, particularly if one includes emissions from international flights; thus, it is likely to be included in some fashion in any mandatory economy-wide approach to reducing GHG emissions.

On a practical level, reducing emissions from aviation may be more complicated than it is for most other sectors:

²⁹ "ICAO Backs Mutual Agreement Approach to Emissions Reductions but Europe Objects," *Daily Environment Report*, October 1, 2007.

³⁰ "Emissions Trading: EU Lawmakers Back Plan to Add Aviation To Emissions Trading Scheme in 2012," *Daily Environment Report*, July 9, 2008.

³¹ ICAO, *Annual Report of the Council, 2007*, pp. 41-42.

³² Carbon taxes are not discussed in this report, but their effects might be similar to the imposition of an upstream cap on emissions. They would raise the cost of fuel, thus encouraging the development of more fuel-efficient and lower carbon alternatives.

- The sector is composed of tens of thousands of mobile emission sources; thus, direct controls on engines or aircraft face obstacles that do not apply in industries composed of fewer and stationary emission sources. Even monitoring the relevant emissions for this sector is difficult.
- The sector's emissions affect climate in several ways. Controlling only CO₂ emissions might leave other impacts of aircraft on climate unaffected. More research is needed to identify the precise effects of some of these, such as the impact of contrails on cirrus cloud formation, and the effect of such clouds on climate change.
- The sector's impressive progress in making itself more energy-efficient in recent years poses obstacles as well: improving load factors was relatively easy when they were at 60%; at the current level, 80%, one begins to approach the limits of further improvement.
- Some means of emission reduction are beyond the industry's control, including the pace of modernization of the air traffic control system, and the degree to which aeronautical research and engine modifications can reduce fuel consumption. In both cases, emission reduction may depend, at least in part, on the actions of government agencies—the FAA and NASA, in particular. According to ATA, funding for NASA and FAA aviation environmental R&D programs has been cut by approximately 50 percent in the past 10 years.³³
- Finally, the sector faces controls from foreign countries, particularly the European Union. International negotiations for a post-Kyoto-Protocol emissions control scheme may give rise to emission limits in other countries, as well.

As discussed, Congress and the new Administration have a number of options, including several forms of legislation; regulation by EPA under the existing Clean Air Act is another possibility. If the Administration so chooses, the existing Clean Air Act might prove a particularly important tool to bring interested parties to the table, while providing a backdrop to consideration of legislation by Congress.

³³ ATA, *2008 Economic Report*, previously cited, p. 17. The FAA's efforts on NextGen have already been discussed. For an overview of aeronautics research goals, in which NASA plays a leading role, see National Science and Technology Council, *National Plan for Aeronautics Research and Development and Related Infrastructure*, December 2007, especially pp. 50-52, at http://www.aeronautics.nasa.gov/releases/aero_rd_plan_final_21_dec_2007.pdf.

Author Contact Information

James E. McCarthy
Specialist in Environmental Policy
jmccarthy@crs.loc.gov, 7-7225

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