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Aviation and Climate Change

Updated January 27, 2010

Congressional Research Service
https://crsreports.congress.gov
R40090

CRS REPORT
Prepared for Members and
Committees of Congress

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 2.6% 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 or the Administration decides to regulate aircraft GHG emissions, they face several choices. The Administration could use existing authority under Sections 231 and 211 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, or could require EPA to set emission standards.

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. Most cap-and-trade bills, including the House-passed energy and climate bill, H.R. 2454, would include 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 more than 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 policy makers 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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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. CO_2 emissions, or 28% of the six GHGs combined.

Aircraft Emissions

Aircraft account for about 10% of the U.S. transportation sector's GHG emissions, or 2.6% to 3.4% of total U.S. GHG emissions. In the United States, aviation emissions have grown more slowly than those of other transportation sectors, and slightly less than the emissions of the economy as a whole over the last two decades, but worldwide aviation has been among the faster-growing sources of GHG emissions. 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. Since 1990, aircraft GHG emissions have declined as a percentage of total U.S. emissions (see **Table 1**). The biggest factor in the decline was a 54% decrease in emissions from domestic military

[1] Six greenhouse gases are the primary focus of concern: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), 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. A seventh greenhouse gas, nitrogen trifluoride (NF_3), is included in H.R. 2454, the Waxman-Markey bill. 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: 1990-2007*, 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 CO_2, and SF_6—although emitted in small quantities—has 22,800 times CO_2's heat trapping potential), GHG emissions are generally converted to tons of CO_2 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.

[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."

operations, which more than offset increases in domestic commercial and general aviation[6] emissions.

Emissions from domestic operation of commercial aircraft grew 13% between 1990 and 2007. 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 2007 and cargo revenue-ton miles increased 136%.[7]

Two types of efficiency increases contributed to the relatively slow growth in U.S. commercial aircraft emissions. First, load factors (the percentage of seats occupied) increased to 79.8% 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 *Inventory 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—2.6% 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 totaled 52.7 million metric tons in 2007. If they were included in the U.S. aviation statistics, emissions from aircraft of all types would have accounted 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]

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[6] The term "general aviation" refers to flights other than those by the military, scheduled commercial airlines, and large 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 1. CO_2 Emissions from U.S. Aviation, 1990-2007

(million metric tons of CO_2 equivalent)

Fuel / Aircraft Type	1990	2000	2007
Jet Fuel			
Commercial Aircraft	135.5	166.0	153.6
Military Aircraft	34.4	20.7	15.8
General Aviation	6.4	9.3	15.8
Aviation Gasoline			
General Aviation	3.1	2.5	2.2
Total	179.4	198.5	187.4
% of Total U.S. GHG Emissions	2.9%	2.8%	2.6%

Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*

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.[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/aee.htm. Similar conclusions were reached by the Federal Aviation Administration, which estimates that emissions of CO_2 and NOx 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/aeprimer.pdf.

[13] This percentage was even higher in 2008, although it has since declined. Because of the rapid increase in the price of oil in that year, domestic airlines spent 42% more on fuel for their domestic and international flights in 2008 than in 2007. See "Airline Fuel Cost and Consumption (US Carriers – Scheduled)," at http://www.transtats.bts.gov/fuel.asp?pn=1. Also see ATA, "Monthly Jet Fuel Cost and Consumption Report," at http://www.airlines.org/economics/energy/MonthlyJetFuel.htm.

million metric tons of CO_2 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, reducing delays, 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]

EPA has not responded to these petitions, nor has it promulgated regulations to control CO_2 from *any* source, to date. 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 has authority to regulate them if it finds that they "cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."[19]

Using the authority of 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

[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] The court case was Massachusetts v. EPA, 127 S. Ct. 1438 (2007). The quoted language is from Section 202(a) of the Clean Air Act, which requires emission standards for motor vehicles. Similar, but not identical, language regarding endangerment appears as the prerequisite to the setting of emission standards for other categories of sources elsewhere in the act.

anticipated to endanger public 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 aircraft petitions are among several others that EPA has received to regulate GHG emissions from cars and trucks, ships, and nonroad engines and vehicles. As a result, whatever decision is made (for any one of these sectors) is considered likely to affect the decisions regarding all the others—ultimately, a large portion of the economy.[21] Furthermore, as soon as greenhouse gases become "subject to regulation" under any section of the act, new stationary sources, such as electric generating units, will be required to install best available GHG control technology under the act's New Source Review/Prevention of Significant Deterioration provisions.[22]

Given the relative size of aircraft emissions as compared to power plants, cars, and trucks, aviation was never likely to be the first sector whose GHG emissions EPA would regulate. Thus, not surprisingly, EPA has taken no action on the aircraft petitions, to date. The agency is moving ahead with regulation of GHG emissions from cars and trucks, however: on May 19, at a press conference in the White House Rose Garden, the President announced that EPA would proceed to set greenhouse gas emission standards for new motor vehicles, in coordination with new fuel efficiency standards to be established by the National Highway Traffic Safety Administration.[23] A formal set of proposed standards appeared in a joint EPA-NHTSA notice in the September 28, 2009 *Federal Register*.

Both EPA and the President have made clear that, despite their action under existing authority, they support legislation targeted more specifically at GHGs, and would prefer that Congress enact a bill addressing GHG emissions specifically rather than EPA using its current authority. 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 as EPA proceeds. This might delay implementation of controls.

[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.

[21] The wording of these "endangerment" requirements varies, however, from one section of the act to the next, and, of course, the amount of pollution from each category of sources may affect the Administrator's judgment as to whether emissions from the category are sufficient to cause or contribute to endangerment.

[22] The phrase "subject to regulation" appears in Section 169(3) of the act, and would trigger regulation under Section 165. For a further discussion, see CRS Report R40585, *Climate Change: Potential Regulation of Stationary Greenhouse Gas Sources Under the Clean Air Act*, by Larry Parker and James E. McCarthy, pp. 22-24.

[23] The President's announcement was followed three days later by a more detailed "Notice of Upcoming Joint Rulemaking to Establish Vehicle GHG Emissions and CAFE Standards," in the *Federal Register*. See 74 *Federal Register* 24007, May 22, 2009.

The two options—proceeding under the Clean Air Act or supporting new legislation—are not mutually exclusive, however. Existing EPA authority under the Clean Air Act can be used as a backstop, while Congress considers granting new authority. In the meantime, EPA's development of regulations is among the factors motivating Congress and interested parties to agree on a legislative approach.

Proposed Legislation

GHG legislation has been a high priority of the current Congress. Attention has centered on legislation (H.R. 2454 in the House) 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 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. Nevertheless, the aviation sector has not generally been targeted directly by the climate change bills introduced in Congress to date. An exception was the reported version of H.R. 2454, the Waxman-Markey bill. As reported by the House Energy and Commerce Committee in May, the bill would have required EPA to promulgate best achievable control technology standards for emissions of GHGs from new aircraft and new engines used in aircraft by December 31, 2012. This requirement was removed from the version of the bill that passed the House June 26.

Instead, the House-passed version encourages the development of a global framework for the regulation of GHG emissions from civil aircraft within the International Civil Aviation Organization. And, instead of direct regulation, the bill would deal with aviation emissions indirectly: by including the refining sector in its overall emissions cap, it would address the aviation sector's emissions "upstream."[24]

Capping emissions from fuels upstream of the air carriers and eventually lowering the cap more than 80%, as the bill would do, could have several effects: first, it would provide an incentive for refiners to produce lower-carbon fuels[25]; second, it 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.

[24] S. 2191/S. 3036 (the Lieberman-Warner bill, reported in the 110th Congress) would have 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.

[25] The Lieberman-Warner bill, as reported in the 110th Congress, 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.

According to ATA, the cost of domestic air travel in real (inflation-adjusted) terms has declined by 51.9% since 1978.[26] 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), beginning in 2012. The ETS began operation in 2005, capping emissions of CO_2 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 CO_2 emissions.[27]

On January 1, 2012, the aviation sector's CO_2 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.[28]

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.[29] According to press reports, "This warning shot is aimed at foreign airlines—including US carriers—that have said they will not recognise the scheme."[30] For its part, the United States has responded by threatening

[26] ATA, *2008 Economic Report*, previously cited, p. 11.

[27] 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.

[28] "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 must "transpose" the directive into national laws.

[29] 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."

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

trade sanctions if the EU makes an attempt to force foreign airlines to comply with the emissions trading system.[31]

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.

Regulating upstream of the aviation industry, as most U.S. climate change bills would do, 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.[32] 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.[33] 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.[34]

As noted earlier, the House-passed version of H.R. 2454 encourages the development of a global regulatory framework through ICAO. Section 276 of the bill declares it to be the sense of Congress that the United States should actively promote an ICAO framework and work with foreign governments to reconcile emissions reduction programs to "minimize duplicative requirements" and avoid "unnecessary complication for the aviation industry, while still achieving the environmental goals."

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.[35] Depending on their stringency, the effects of most of these approaches could ripple through the economy, providing additional incentives for

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

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

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

[34] ICAO, *Annual Report of the Council, 2007*, pp. 41-42.

[35] 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.

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 in the current recession, their GHG emissions are at roughly their 1990 levels.

Compared to other means of transportation, in fact, U.S. commercial aviation's record on GHG emissions over the last two decades is much better. As shown in **Table 2**, GHG emissions from U.S. commercial aviation increased less than those of any other segment of the transportation market, despite the demand for aviation services (measured in passenger-miles traveled) increasing at a faster pace than the other sectors.

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 in future years. 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 complicated:

- 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.

Table 2. Greenhouse Gas Emissions from U.S. Transportation Sectors, 1990-2007

(million metric tons of CO_2 equivalent)

Transportation Sector	Level of Activity, 1990-2007	Greenhouse Gas Emissions, 1990	Greenhouse Gas Emissions, 2007	% Change
Commercial Aviation	+74%	135.5	153.6	+13.4%
Rail	+71%	38.5	57.9	+50.3%
Medium- and Heavy- Duty Trucks	+55%	228.8	410.7	+79.5%
Passenger Cars and Light Duty Trucks	+40%	993.0	1,227.1	+23.6%
Transportation Total		1,546.7	2,000.1	+29.3%
U.S. Total		6,098.7	7,150.1	+17.2%

Source: EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*; trade association data for level of activity.

Notes: Level of activity is measured as vehicle miles traveled for cars and trucks, passenger miles traveled for commercial aircraft, and revenue ton miles for rail. The data for commercial aviation actually understates the increase in activity, since it excludes cargo operations, which rose 136% during the period, as measured by cargo revenue-ton miles.

- The sector's emissions affect climate in several ways. Controlling only CO_2 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, roughly 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.[36]
- 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 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.

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[36] 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.