BRIEFING

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Standards to promote airline fuel efficiency

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U.S. airlines emitted 210 million tonnes of carbon dioxide (CO_2) in 2018 across all their operations, an amount equal to 4% of CO_2 emissions from U.S. national energy use and about one-quarter of all CO_2 emissions from commercial aviation worldwide that year. The federal government has acknowledged that CO_2 from aircraft presents a problem that should be specifically and quickly addressed. In 2015, in its national plan for reducing greenhouse gas (GHG) emissions from aviation submitted to the International Civil Aviation Organization (ICAO), the United States established an aspirational goal of capping CO_2 emissions from its carriers at 2005 levels starting in 2020. In 2016 the United States Environmental Protection Agency issued a formal "endangerment finding" that GHG emissions from aircraft pose a risk to human health and welfare. And yet, no federal greenhouse gas or fuel efficiency requirements have been established for either aircraft manufacturers or airlines that would help bring about progress toward the goal of reducing the climate impacts of aviation.

There are avenues by which the United States could pursue that goal, and impose such requirements, in the near future. The 2016 EPA endangerment finding, for example, triggered a statutory requirement that the agency propose an emission standard. And the issue is timely. More recently, the U.S. Congress considered integrating GHG emission requirements for U.S. airlines as part of an industry bailout under an economic stimulus bill.[1]

This briefing summarizes the policy levers that exist under current U.S. statutes and regulations to accelerate airline fuel efficiency, and collects in one place a convenient reference guide to supporting research and analyses.

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1 U.S. Congress, House, *Take Responsibility for Workers and Families Act*, H.R. 6379, 116th Cong., 2nd sess., Sec. 704–707. https://www.congress.gov/bill/116th-congress/house-bill/6379/text?q=%7B%22search%22%3A%5B%22hr+6379%22%5D%7D&r=1&s=1

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BACKGROUND AND LEVERS

Research has demonstrated significant differences in fuel efficiency and carbon intensity across carriers and flights. The carbon intensity of airlines flying to and from U.S. airports varies by up to 26% over their networks, and by 50% and more on nonstop international flights. Differences of 80% or more have been observed at the route level.

The aviation industry has three main levers by which to improve fuel efficiency: (1) replacing older aircraft with newer, more fuel-efficient designs; (2) improving operations to carry more payload (passengers and freight) per flight and to fly more directly to destinations; and (3) finding optimal flight paths and avoiding congestion near airports via advanced air traffic management.

New aircraft. Each new generation of aircraft burns roughly 15% less fuel per passenger kilometer than the aircraft it replaces. Key technologies include more fuel-efficient engines, improved aerodynamics, lightweight materials such as advanced composites, plus advanced systems (e.g., all-electric aircraft) and integrated design. Historically, new aircraft fuel burn has fallen by 1.3% per year since the late 1960s. Recently, the rate of improvement has been declining due to the prevalence of cheaper "re-engined" aircraft, such as the Boeing 737 MAX. and a lack of "clean sheet" designs like the Boeing 787 Dreamliner.[2]

Improved operations. In addition to buying new aircraft, airlines can improve fuel efficiency by increasing flight payloads and flying more directly to destinations. Payload can be increased by better filling a given capacity (e.g., flying with fewer empty seats) or by expanding capacity (e.g., packing more seats into the same space). Increasing load factor, which rose from 55% in 1976 (prior to deregulation) to 85% last year, has been an important contributor to U.S. airline fuel-efficiency gains. Reducing "circuity" by avoiding unnecessary layovers and routing flights more directly can also reduce fuel burn. Operational improvements typically provide fuel efficiency gains around 0.5% per year.

Improving air traffic management. The final, smallest component is to improve air traffic management to reduce air delay and near-airport congestion through technologies like GPS-based navigation. In 2008, ICAO estimated that systemwide fuel efficiency could be improved by 12% through improved air traffic management. Subsequent analysis has found that half (6%) of that potential has been achieved, and that another 3% is possible over the next 10 years.

2 Re-engined aircraft, which pair a new, advanced engine with a legacy airframe, deploy only about half of the total technological potential to improve new aircraft efficiency.

Table 1 summarizes research on airline fuel efficiency and the relative contribution of each lever.

Table 1: Components of airline fuel efficiency and historical trends

Lever	Measure	Annual improvement	Sources
New aircraft	Efficient engines Improved aerodynamics Lightweight materials Electric systems	1.3% (-0.4% to 2.6%)	Kharina & Rutherford (2015) Tecolote Research (2016)
Improved operations	Higher load factors Increased seating density More direct flights	0.5%[a] (0% to 1.3%)	Young (2019) ATAG (2019)
Advanced air traffic management	Reduced congestion through GPS-based navigation	0.2% (0% to 0.6%)	Brain & Voorbach (2019) IATA (2019)
Total		2% (0% to 2.7%)	ATAG (2019) Graver (2018) Young (2019)

[a] Estimated as the difference between systemwide and new aircraft fuel efficiency.

FUEL EFFICIENCY STANDARDS FOR IN-SERVICE AIRCRAFT AND AIRLINES

Airlines have questioned the need for GHG regulations, arguing that they already maximize fuel efficiency and that U.S. regulations should conform to the minimum international requirements proposed by ICAO. Fuel costs typically account for about one-quarter of total airline operational expenses, providing a market driver for efficiency. Since being deregulated in 1978, the fuel efficiency of U.S. carriers improved by more than 125%, or an annual compound improvement of 2.6%. Internationally, airlines improved fuel efficiency by 2.3% per annum since 2009 in terms of fuel per revenue tonne-kilometer. But those improvements are falling over time and have historically been dwarfed by increases in traffic. From 2013 to 2018, air traffic increased by three (United States) to six (globally) times faster than fuel efficiency improved, driving rapid growth in CO_2 emissions.

Currently, there are no federal, state, or local fuel efficiency requirements for aircraft or airlines in the United States. In 2016, ICAO, which recommends global standards for civil aviation, proposed a CO_2 (fuel efficiency) standard for new aircraft starting in 2020. ICAO member states need to adopt a standard at least as stringent as ICAO's in order for their manufacturers to continue selling aircraft internationally. The EPA is legally obligated to set a standard under Section 231 of the Clean Air Act.

ICAO's standard would apply directly to airframers (e.g., Boeing, Gulfstream) and indirectly to engine manufacturers (e.g., General Electric, Pratt & Whitney) and was explicitly designed to be technology-following—that is, to reflect technology developments after the fact, rather than to spur technical innovation and investment by setting ambitious targets ("technology forcing"). The EPA has authority to regulate GHGs from all aircraft, not just new ones.[3] Under the Obama administration the agency declared its intention to set a standard "at least as stringent as ICAO's." An airline

3 Under the Clean Air Act EPA must set emission standards applicable to harmful pollutants from "any class or classes of aircraft engines." Since all GHGs from aircraft are emitted from their engines and depend on aircraft design, EPA can set emission standards for both new and in-service aircraft and promote airframe technologies to boost fuel efficiency, not just engine improvements.

standard, for example a "phaseout" that accelerates fleet turnover by pushing older, noncompliant aircraft out of service, could support the United States' goal of carbon-neutral growth for its carriers.

There are at least three options for applying a fuel efficiency standard to airlines: (1) a pass/fail phaseout for individual in-service aircraft; (2) tiered standards under which each airline would need to have an increasing share of their aircraft meet more stringent standards over time; and (3) a declining fleet average standard.

A "tier 1" pass/fail standard for in-service aircraft set at ICAO's recommended stringency for new aircraft would promote the early retirement of aircraft delivered prior to 2016 and could improve fleetwide fuel efficiency up to 1.1% per year. Additional tiers could be built on top of such a pass/fail standard by defining higher requirements based upon the fuel efficiency of new designs.[4] A tiered standard could support fuel-efficiency improvements up to 2% per year by promoting new investments by manufacturers.

A declining fleet-average standard incorporating operational and air traffic control improvements could provide additional flexibility for least-cost reductions and support more ambitious targets on the order of 2.5% improvement per year, with some added complexity linked to defining fuel efficiency at the airline (as opposed to aircraft) level. Alternative jet fuels could be incorporated into a fleetwide standard through lifecycle assessment of the resulting GHG emissions. That would enable more ambitious targets, although care would need to be taken to accurately assess upstream emissions from fuel production.

Table 2 summarizes the options outlined above. Other measures, including economic incentives for the purchase of new aircraft and mandatory emissions disclosure to consumers at the point of ticket purchase, could support additional GHG reductions from airlines.

Table 2: Options for regulating airline fuel efficiency

Approach	Target	Means of compliance	Potential improvement (%/ year.)	Advantages	Disadvantages
Pass/fail phaseout	In-service aircraft	Aircraft retirement	<1.1%	Easy to implement Best matched to current type certification	Inflexible Higher cost Static Cannot credit early action
Tiered standard for fleets	Airlines via in-service aircraft	Aircraft purchase	<2.0%	Easy to implement Dynamic Medium flexibility and compliance cost Can credit early action Can be matched with fines	Medium complexity Requires multiple stringency levels
Declining fleet average GHG standard	Airlines	Aircraft purchase Operational improvements Alt fuels	<2.5% + alt jet fuels	Highly flexible Lowest cost Dynamic; easily tightened over time Can credit early action Can be matched with fines	Added complexity Requires initial benchmarking of airlines

4 For example, a tier 2 standard could be set that recognizes aircraft that burn 10% less fuel per passenger kilometer than ICAO's recommended standard, as measured under standardized CO_2 certification procedures. See Rutherford and Kharina (2016), for further details.

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