The aviation industry has a long term goal to reduce greenhouse gas emissions, but will near term measures be enough to deliver the technologies needed?
Aircraft are a large and growing source of greenhouse gas (GHG) emissions. In 2015, commercial aviation emitted about 780 million metric tonnes of carbon dioxide (CO₂) globally, roughly equivalent to the emissions from Germany’s energy use.1,2 Business-as-usual projections suggest that those emissions will triple by mid-century unless further action is taken. Left unchecked, international aviation alone may account for 21 percent of global CO₂ emissions in 2050, assuming that other sectors decarbonize in line with the goals of the Paris Agreement.3 And, while scientific uncertainty persists, our best guess is that CO₂ may be only about half of the overall climate impact of aircraft emissions after accounting for other short-lived climate pollutants, including black carbon, nitrogen oxides (NOₓ) contributing to ozone formation, and aviation-induced cloudiness.4

Policies to control GHGs from international flights have been a long time coming. Under the 1997 Kyoto Protocol, two specialized United Nations agencies—the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO)—were assigned responsibility to develop policies to limit the climate impact of international aviation and shipping, respectively. Neither organization snapped to attention. It wasn’t until 2011 that IMO adopted legally binding energy efficiency targets for new ships,5 with ICAO following suit in 2016 for aircraft.6 Reduction targets for both sectors were subsequently left out of the Paris Agreement, which focuses on national targets rather than international energy use.

In 2016, almost two decades after Kyoto, ICAO took its first concrete steps to address CO₂ emissions from international flights. These included high-level goals (carbon-neutral growth from 2020 and a 2-percent annual fuel efficiency improvement target on a revenue–tonne–kilometer basis), supported by two mandatory measures: the world’s first fuel efficiency (CO₂) standard for new aircraft, and a carbon offsetting framework. In each case, regional pressure from developed countries—the United States on fuel efficiency targets and the European Union on emissions trading—forced ICAO’s hand. Industry’s own commitment, notably the goal to reduce net CO₂ emissions from aircraft by 50 percent in 2050 compared to a 2005 baseline,7 also helped set the stage for action.

The industry’s goal is relatively clear, but how does it relate to the range of technologies and measures to reduce emissions? Related, how relevant is ICAO’s policy framework toward reaching that end? Is the path to 2050 clear, or blurrier than we might hope?

To answer these questions, I first consider the options to reduce aircraft emissions, summarize the policies adopted to date, and see how those relate to each other and also industry’s long-term goal. What we’ll find is a big disconnect between what’s technologically possible, what’s needed to meet the Paris goals, and the policies on the books today.

Options to Reduce Emissions

Let’s begin by considering the options to reduce emissions. The natural place to start is aircraft fuel efficiency, which is inversely proportional to CO₂ emissions. Since the dawn of the jet age, year-on-year reductions in the average fuel burn of new aircraft have been on the order of 1.3 percent annually.8 But there’s ample evidence that manufacturers could do more. Fuel costs, as the single largest operating expense for airlines, are a necessary but not sufficient condition for technological improvement. Research from a number of groups, including ICAO,9 the National Aeronautics and Space Administration, academic researchers,10 and my organization, the International Council on Clean Transportation,11 has concluded that the fuel efficiency of new aircraft could be roughly doubled compared to a typical 2010 new aircraft over the next two decades using emerging technologies like advanced engine architectures, laminar flow technologies, and lightweight materials such as advanced composites. That’s not even taking into consideration radical improvements like alternative airframe configurations (e.g., the “double bubble” blended wing body configuration; see photo on opening page of this article) or hybrid or all electric aircraft.

Improving operational efficiency is a separate opportunity. A given aircraft can be operated more or less efficiently by an airline by varying operational parameters such as passenger load factors, routing, fuel loading practices, and freight carriage. In our work ranking the fuel efficiency of carriers, we’ve estimated gaps ranging from 50 percent to as high as 85 percent in the carbon intensity of carriers on international and U.S. domestic routes, respectively.12,13 The data clearly show that the most fuel-efficient carriers—Alaska Airlines, Norwegian Air Shuttle, and Hainan and ANA on U.S. domestic, transatlantic, and transpacific routes, respectively—burn significantly less fuel than the laggards (e.g., Virgin America, British Airways, and Qantas). Educating consumers, for example by integrating emission estimates for competing flights into travel search engines, could help close this gap. Another potentially important lever is the use of alternative jet fuel (AJF) derived from sustainable feedstocks. Developing “drop-in” biofuels, which can be used in today’s aircraft without modification, is somewhat of a holy grail for airlines. Clear progress has been made over the past decade certifying biofuels through initiatives like the U.S. Commercial Aviation Alternative Fuels Initiative (CAAFI), but concerns remain about cost, feedstock availability, and the sustainability of producing AJF at scale. Our best estimate is that in North
America, which is blessed with relatively abundant feedstocks, AJF may be able to offset about 5 percent of CO₂ emissions from international flights in 2030.¹⁴

Two additional policy levers deserve discussion. Economic measures like fuel taxes, emission charges and trading, differentiated landing fees, integrating fuel efficiency requirements into financing agreements, and so forth, could internalize the social cost of carbon and, if set aggressively, to generate additional market pull for energy efficiency. Because international aviation fuel is exempt from taxation, and sales and value added taxes are not applied to tickets, removing those exemptions would correct for the current market distortion favoring flying over other transport modes.¹⁵

Finally, we shouldn’t forget about short-lived climate pollutants. Engine standards for cruise NOₓ and black carbon could promote lean NOₓ and staged combustor designs that reduce those emissions. For its part, combining advanced atmospheric modeling with satellite-based air traffic control could allow aircraft to be rerouted to avoid supersaturated regions of the atmosphere susceptible to aviation induced cloudiness.

Goals and Policies in Place
So we’ve got our laundry list of strategies to address aviation’s climate challenge. Industry, for its part, is eager to point anxious fliers to longer term solutions like algal-based biofuels, radically improved aircraft (electrified in some cases), and carbon offsetting to demonstrate its commitment to make flying more sustainable. Indeed, the International Air Transport Association’s goal of halving net aircraft CO₂ emissions by 2050 would go a long way toward reconciling industry growth with the Paris Agreement. But how clear is the path from today’s policies to that bright future?

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The sad truth is that the policies developed to date, along with the industry’s own near-term commitments, don’t clearly link to a decarbonized future. Neither ICAO’s fuel efficiency standard, which was explicitly set as a technology following standard that wouldn’t require additional action from manufacturers, nor ICAO’s carbon offsetting framework,¹⁶ will directly reduce aircraft emissions. In recent years, manufacturers have chosen to forego roughly half of the technological potential to reduce new aircraft fuel burn by pursuing re-engining (i.e., refreshing old airframe designs with advanced engines) rather than new “clean sheet” designs deploying the trifecta of new engine, aerodynamic,
and structural technologies. Given the capital-intensive nature of aircraft development and the natural risk aversion of aerospace manufacturers, this strategy may make short-term economic sense, but it isn’t consistent with the long-term need to decarbonize aviation. It’s notable that the airlines’ two clear priorities, drop-in AJF and offsetting, shift the responsibility to reduce emissions away from aviation to other sectors.

Conclusion

Taken as a whole, the industry’s 2050 goal and vision for decarbonization is admirably farsighted: radically improved and sustainably fueled aircraft, algal-based biofuels that don’t compete with food production, even seat designs that capture body heat to power cabin features. Unfortunately, there’s no clear path from today’s policies and industry actions to these longer-term aspirations, given the current industry embrace of offsetting rather than reducing emissions, re-engining instead of clean-sheet designs, and hostility to real carbon pricing for aviation. A concerted effort on the part of policymakers, starting with the domestic implementation of ICAO’s climate framework starting this year, will be needed to bridge this gap.

For now, how the aviation industry will get from today to 2050 is decidedly blurry. Here’s hoping that its vision gets sharper, and fast. em

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References