BRIEFING

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Reducing aircraft CO_2 emissions: The role of U.S. federal, state, and local policies

Prepared by Xinyi Sola Zheng and Dan Rutherford

In January 2021, the U.S. Environmental Protection Agency (EPA) finalized a domestic aircraft carbon dioxide (CO_2) standard (U.S. Environmental Protection Agency, 2021). This is the first-ever federal policy that regulates greenhouse gas (GHG) emissions from commercial aircraft. The EPA's rule closely follows the international aircraft CO_2 standard adopted by the International Civil Aviation Organization (ICAO) in 2016 and will go into effect for all new aircraft delivered in 2028 and thereafter.

The EPA was legally obligated to set a standard under Section 231(a) of the Clean Air Act, and public comments submitted by various stakeholder groups after the standard was proposed in July 2020 highlighted that the standard would not reduce GHG emissions from aircraft and aircraft engines. ICCT's analysis has also showed that the standard lags state-of-the-art aircraft technology by more than 10 years (Zheng & Rutherford, 2020).

Twelve states and the District of Columbia—which our analysis shows represent half of U.S. passenger airline emissions—have initiated a legal challenge to EPA's standard (State of California Department of Justice, 2021). All but Pennsylvania[1] submitted a joint comment letter to EPA in October 2020 that emphasized the serious impacts of climate change on their states and aircraft's significant contribution to GHG emissions. The states argued that EPA's failure to consider options for a stricter standard that actually reduces GHG emissions is "unlawful and arbitrary." In particular, the states pointed out that they are preempted by the Clean Air Act from setting their own

1 The commenting states are California, Connecticut, Illinois, Maryland, Massachusetts, Minnesota, New Jersey, New York, Oregon, Vermont, and Washington. Accessible at https://beta.regulations.gov/comment/EPA-HQ-OAR-2018-0276-0176.

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION aircraft emission standards to protect public health and welfare, and that therefore the federal government must adopt meaningful standards on their behalf.

This briefing evaluates the states' claim that EPA should set stronger federal regulations on aircraft emissions. We also discuss specific state- and local-level policy instruments that could help mitigate aircraft emissions. Other papers discuss the limitations of EPA's proposed standard (Zheng & Rutherford, 2020; Rutherford & Kharina, 2016), the technological potential to accelerate fuel burn reductions in new aircraft (Kharina, Rutherford, & Zeinali, 2016; Tecolote Research Inc., 2016), and ways that ICAO's technology-following standard could be strengthened to reduce emissions (Graver & Rutherford, 2018; Kharina & Rutherford, 2019). Central to those efforts is the idea of applying the standard to in-service, rather than just new, aircraft (Rutherford, 2020). While the COVID-19 pandemic has brought the aviation industry unprecedented challenges, airlines are accelerating their fleet renewal as a coping mechanism, and this will make them better positioned for more progressive emission standards in the future when COVID impacts subside.

AIRCRAFT ARE A SIGNIFICANT SOURCE OF STATE GHG EMISSIONS

To quantify aviation emissions at the state level, we allocated emissions to individual states based on the location of the airport of departure and the estimated CO_2 emissions of each flight, based on ICCT's Global Aviation Carbon Assessment (GACA) model for 2019.[2] The analyses in this briefing concern passenger flights only and dedicated freighter operations are not included. Emissions attributed to belly freight carried on passenger flights are included.

Table 1 lists the top 10 states by aviation's share of total energy-related CO_2 emissions. Challenging states are highlighted in blue.

Table 1. Top 10 states by aviation's share of total energy-related CO_2 emissions

Rank	State	CO_2 emissions (million tonnes)			Percentage aviation
		Aviation emissions (2018)[a]	Other energy-related emissions (2017)[b]	State total	
1	**Hawaii**	5.5	17.6	23.1	24%
2	**Nevada**	4.2	36.2	40.3	10%
3	**New York**	17.4	156.7	174.1	10%
4	**California**	34.2	358.6	392.9	9%
5	**Washington**	5.7	78.2	83.9	7%
6	**Florida**	16.3	226.5	242.8	7%
7	**Massachusetts**	4.5	63.3	67.8	7%
8	**New Jersey**	7.1	101.0	108.1	7%
9	**Georgia**	9.2	131.9	141.0	7%
10	**Virginia**	6.3	97.9	104.2	5%

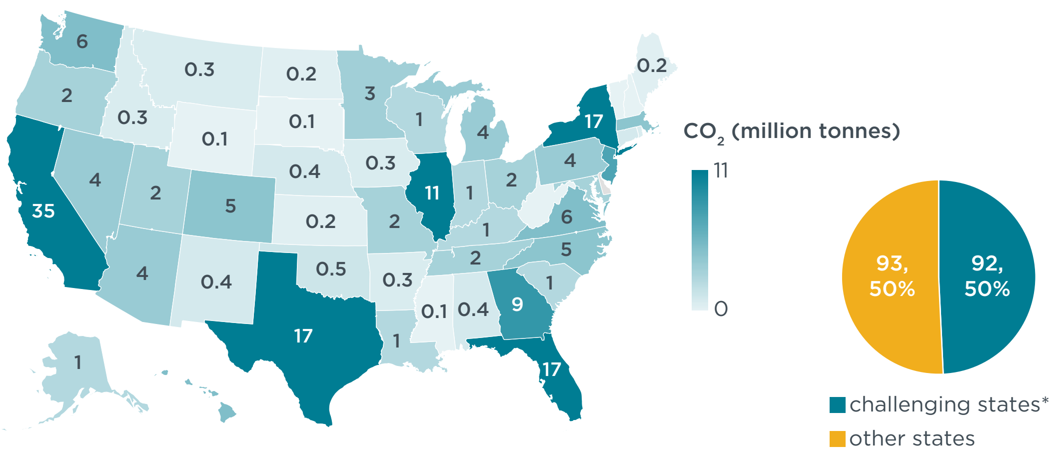
a. Graver, Rutherford, and Zheng, 2020. State-level aviation emissions data are from 2017, as that is the inventory data available closest to 2018.

b. U.S. Energy Information Administration, 2020.

2 Departing airports representing less than 0.1% of total U.S. aviation emissions were not matched to states due to limited data availability. This is considered to have minimal impact on the overall results.

The 12 challenging states, in total, represented 50% of U.S.-departing passenger flight emissions in 2019 and 41% of U.S. domestic air travel emissions. Five of these states are among the top 10 emitting states shown in the table. The District of Columbia, because its residents transit airports in Virginia, is categorized as part of Virginia and thus also made the list.

Aviation's effect is particularly pronounced for Hawaii, where a quarter of the state's emissions can be attributed to passenger flights. Nevada follows with 10% and this is unsurprising, as both states have a large tourism industry. Passenger flights also account for about 10% of CO_2 emitted in New York and California, mainly because they are the two highest emitting states in terms of total passenger flight emissions, as illustrated in Figure 1.



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*California, Connecticut, District of Columbia, Illinois, Maryland, Massachusetts, Minnesota, New Jersey, New York, Oregon, Pennsylvania, Vermont, Washington

Figure 1. Total passenger flight CO_2 emissions (million tonnes) by state in 2019.

It is not surprising that aviation emissions strongly correlate with densely populated metropolitan areas. While an allocation by departure airport does not account for the residency state of each traveler, and flights leaving geographically concentrated northeastern states and airports that serve as major airline hubs are expected to have a higher percentage of passengers from out of state, the impacts of takeoff pollution are mostly borne by the departure state. The difference in aviation emissions among states implies different levels of local air pollution and economic dependency on aviation, as well as a difference in residents' access to aviation services. The distribution supports the challenging states' argument for stronger federal policies to reduce aviation emissions, given the legal challenges to state action highlighted below.

Even though aviation's share of all states' CO_2 emissions is currently around 3%, the share is expected to grow in the coming decades. This is because most other sectors are fairly well positioned to decarbonize, while zero-emission aviation technologies are still in the early stages. As a reference, aviation could consume a quarter of world's 1.5C carbon budget by 2050 (Carbon Brief, 2016). Thus the urgency for states to address aviation emissions is likely to increase over time.

AUTHORITY TO REGULATE AVIATION EMISSIONS IN THE UNITED STATES

As much as individual states might like to address aircraft emissions with their own measures, they face both legal and practical challenges in doing so.

First, based on Executive Order 13132, if an EPA proposed rule has federalism implications, the agency is obligated to consult with state or local officials early in the process of promulgation. In the case of the CO_2 standard, the rule has direct effects on states and on the relationship between the national government and the states, as the states' emissions profiles above clearly show. However, in the published rule, the EPA denied any federalism implications and failed to consider the impact of the rule on the states (U.S. Environmental Protection Agency, 2021).

Because sections 231 and 233 of the Clean Air Act preempt states from adopting their own aircraft emission standards, they rely on the federal government to put forward meaningful regulations that protect public health. The challenging states argue that an ineffective standard would directly harm the states' public health and economy, and would disrupt the collaborative federalism where states entrust the federal government to protect public welfare when they are precluded from doing so.

On the practical side, the interregional and international nature of aviation makes it challenging for states to regulate aviation emissions. For example, while domestic flights are almost two-thirds of total U.S. departing flight emissions, an overwhelming majority of those flights are interstate rather than intrastate. Intrastate flights are only 3% of U.S. aviation CO_2 and 2% of traffic in terms of revenue tonne kilometers (Table 2). Individual states' actions, therefore, are limited without harmonized aviation emission regulations on the federal level. Even if states with many intrastate flights, such as California, Texas, Hawaii, and Alaska, were to regulate emissions from these flights, that would only cover a small fraction of total U.S. emissions. Thus a key lever would still be effective federal-level aircraft emission standards.

Table 2. U.S. passenger flight CO_2 emissions by jurisdictions of flight category in 2019.

Flight category	Departures		Revenue tonne-kilometer (RTK)		Total CO_2 emissions	
	thousand	%	trillion	%	million tonnes	%
International	**793**	**9%**	**78**	**39%**	**68**	**37%**
Domestic	**8,482**	**91%**	**123**	**61%**	**117**	**63%**
interstate	7,277	77%	120	60%	112	60%
intrastate	1,205	13%	3	2%	6	3%
Total	**9,275**	**100%**	**200**	**100%**	**185**	**100%**

Note: A small subset of flights was not matched to individual states due to limited data availability. These accounted for 2.3% of departures, 0.02% of RTK, and 0.09% of CO_2 emissions. The unassigned flights are not included in the statistics in this table.

Note that there are differences between the types of planes that are used on intrastate flights compared to other flights. Almost 40% of intrastate flights are flown by regional jets, and these aircraft are 38% more carbon-intensive than the average. Moreover, as shown in Figure 2, the carbon intensity of domestic flights by state is strongly correlated with the share of regional jet operations. The EPA's standard includes especially lenient targets for regional jets compared to other aircraft. Adopting more fuel-efficient regional aircraft, and eventually transitioning to zero-emission aircraft and fuels, will be crucial to "greening" these shorter intrastate flights.

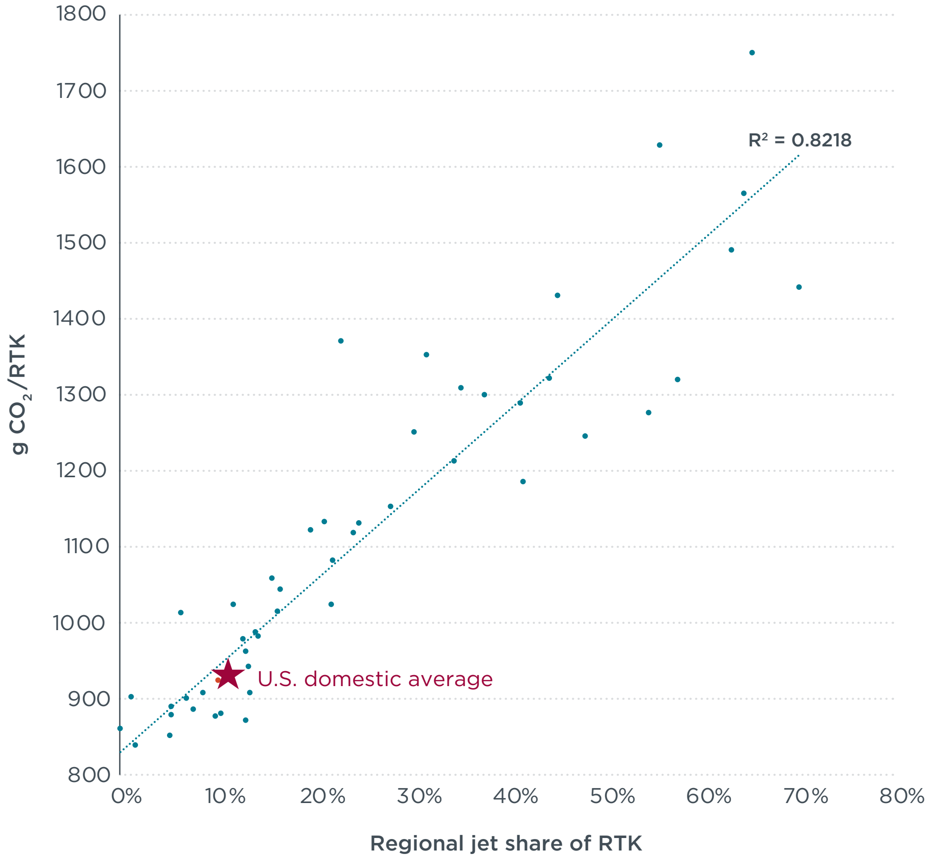

Figure 2. State regional jet share versus aviation CO_2 intensity.

AVIATION'S SHARE OF GHG EMISSIONS IN LARGE METROPOLITAN AREAS

Airports are an integral part of the metropolitan area in which they are located, and the importance of air transport connectivity to the development of global metropolises has risen rapidly as globalization has sped up. Just as with railways and seaports, airports transform a city's economy in fundamental ways, with international commerce and tourism being two prominent examples.

Nevertheless, these economic and social benefits come with environmental impacts. When comparing select metropolitan areas' passenger flight emissions to its most recent GHG inventory, aviation share of total emissions for select cities averages 8%, with a range from 4% to 14% (Table 3).[3] Even though local residents only generated a subset of these aviation emissions, the air and noise pollution near an airport is very much a local issue and can directly affect the health of area residents. Research has also shown that airport emissions disproportionately impact minority and low-income

3 Subject to data availability and drawn from the membership of the C40 Cities Climate Leadership Group. Unless the metropolitan area's GHG inventory specified that it includes aviation, the area's aviation CO_2 emissions were added to the emission total. When scope 1 (landing and take-off) emissions were included in the inventory, these scope 1 emissions are subtracted from the area's total aviation emissions. Of all 14 U.S. C40 cities, recent (2015 and after) GHG inventory data for Houston, New Orleans, and Portland were not available.

households living near large airports, and those households tend to fly less than the average American (Gössling & Humpe, 2020; Woodburn, 2016).

Table 3. Domestic and international passenger flight emissions of select U.S. metropolitan areas

Metropolitan areas[a]	CO_2 emissions from passenger flights (million tonnes)[b]			Metro area total GHG (million tonnes CO_2 equivalent)[c]	Aviation CO_2 / (Metro GHG+Aviation CO_2)
	Domestic	International	Total		
Austin metro	1.1	0.2	1.3	13.5	9%
Boston metro	3.1	1.9	5.0	86.7	5%
Chicago metro	6.0	4.2	10.2	119.0	9%
District of Columbia metro	4.4	2.9	7.4	157.2	4%
District of Columbia	1.6	0.0	1.6	7.7	21%
Los Angeles metro	7.2	9.3	16.5	176.0	9%
Miami metro	3.5	4.5	8.0	48.8	14%
New York metro	8.1	13.7	21.8	189.5	7%
New York City	5.1	10.0	15.2	55.1	28%
Philadelphia metro	2.1	0.9	3.0	74.0	4%
Phoenix metro	3.2	0.3	3.5	51.3	6%
San Francisco Bay Area	6.0	6.2	12.2	115.2	11%
Seattle metro	3.9	1.5	5.4	34.4	14%

a. Where exact GHG inventory data for the metropolitan area was not available, emissions were estimated from the following data sources: Austin metro – Travis County; Boston metro – Massachusetts, DC metro – DC, Maryland, and Virginia; Miami metro – Miami-Dade County; New York metro – New York City, Connecticut, and New Jersey; Phoenix metro – Maricopa County.

b. Each metropolitan area's corresponding airports are based on the list in Zeinali et al. 2013. District of Columbia corresponds to Ronald Reagan Washington National Airport. New York City corresponds to John F. Kennedy International Airport and LaGuardia Airport.

c. City of Austin, 2018; City of Boston, 2015; ICF, 2018 (Chicago); DCDOE, 2018; Gurney et al., 2019 (Los Angeles); Southeast Florida Regional Climate Change Compact, 2015 (Miami); New York City Mayor's Office of Sustainability, 2019; DVRPC, 2015 (Philadelphia); Maricopa County, 2018 (Phoenix); Bay Area Air Quality Management District, 2015; Cascadia Consulting Group, 2018 (Seattle).

Notably, the greenhouse gas inventories for the Los Angeles metro area and the San Francisco Bay Area currently include full-flight emissions originating from their airports. Other cities either only track landing and take-off emissions or do not include aviation in their inventories at all. As air travel makes up a significant portion of the carbon footprint of many individual U.S. residents nowadays, it makes sense for consumption-based GHG inventories to include full-flight emissions taken by a city's or a region's residents when data are available.

Managing aviation emissions is a critical task that involves many stakeholders—original equipment manufacturers (OEMs), airlines, airports, fuel providers, passengers, civil society organizations, freight companies, and importantly, governments on all levels. While policymaking has largely been carried out by the ICAO and national governments, there are ways that subnational governments can help reduce air transport's environmental impacts.

STATE AND LOCAL POLICIES TO MITIGATE AVIATION EMISSIONS

As several industry groups have argued in their comment letters, an aircraft CO_2 emission standard is part of "a basket of measures" needed for reducing emissions from air transportation. While many of the other policy options also require effective federal rulemaking on behalf of states, a few of them could be implemented on the state or local level (Table 4, below).

First, the development of zero-emission aircraft will start with and likely focus on regional and short-haul flights. This is due to the technical challenges associated with energy storage, which are particularly pronounced on long flights, and it opens up opportunities for those states with high volumes of intrastate flights to provide policy and financial support for zero-emission aviation. California is especially well-positioned to do so, as a few electric aircraft start-ups are located in the state. If the state government gives direct research and development (R&D) funding to these companies, and they in turn pilot zero-emission flights within the state, that would be a win-win strategy in terms of emission reductions and economic development.

Fuels policy could serve as another key lever for state-level actions, as exemplified by low carbon fuel standards (LCFS) in California and Oregon. Currently, alternative jet fuels are included in California's program as an opt-in fuel that can generate credits without any concurrent obligations on fossil jet fuel (i.e., petroleum jet fuels do not generate deficits). Alternative jet fuels are unlikely to significantly expand through such an LCFS alone, because it is only an opt-in pathway, and diesel-substitutes generally yield more credit within the program. However, LCFS credits may still be an important revenue source for new alternative jet fuel production driven by other policies.

Another notable state-level opportunity concerns modal shift policies and incentives, which can effectively replace a portion of intrastate flights flown by fuel-inefficient regional jets and thus lower emissions. States could collaborate with the federal government to make investments in key infrastructure to develop fast alternatives to short-haul flights such as high-speed rail; this could also support local public transportation and land-use planning to reduce emissions from related car use.

Table 4. Potential policy instruments by government

Government	Target	Instrument	Role
State	**New aircraft**	R&D funding for zero-emission aviation	Direct government funding toward researching and developing alternative energy powered aircraft designs that could be suitable for intrastate flights.
	Fuels	Low-carbon fuel standard	Credits generated can serve as part of the economic incentives for producing more alternative jet fuel.
	Modal shift	High-speed rail	Shift travel to less carbon-intensive transportation modes
Local	**Fuels**	Alternative jet fuel procurement at airports	Airports can partner with fuel producers to include a certain amount of lower-emission fuels in their fuel supply.
	In-service aircraft	Differentiated landing fees	Airports can charge differential landing fees based on the fuel efficiency of aircraft to incentivize deploying newer, cleaner aircraft.
		Airport facility priority	Priorities are given to more fuel-efficient aircraft for take-off queues, landing slots, and the like.
		Air quality monitoring and emissions inventory	Include CO_2 emissions and air pollution from aircraft in local inventories
	Infrastructure planning	Environmental impact assessment	Mandate environmental justice investigation and consideration in the environmental impact assessments for new airport projects and airport expansions.

When it comes to local governments, metropolitan areas in the United States should consider including aviation in their GHG inventories and climate action plans. Some cities and airports already track landing and take-off emissions, which have the most direct impact on local environments. There are policy options for cities to work with airports in order to address these local emissions and pollutions. For example, municipal governments can work with airports to create incentives for more fuel-efficient aircraft and to manage local air pollution. The incentives can take the form of graduated landing fees, where more fuel-efficient aircraft are charged less, or facility priorities, where fuel-efficient aircraft have preferred access to landing slots (Kharina & Rutherford, 2019). Additionally, city governments are well equipped to mitigate environmental injustice for airport-adjacent communities by requiring equity investigation in airports' environmental impact assessments and by integrating equity considerations into infrastructure planning processes.

Moreover, as mentioned before, local governments should start to include full-flight emissions in their local GHG inventories. The information can help residents reflect on the environmental impacts of their travel and can aid municipal governments when planning local transportation infrastructure. In addition, just as it does for states, understanding the magnitude of aviation emissions builds the case for cities to increase their political engagement on aviation policymaking at higher administrative levels.

CONCLUSIONS

Policies and incentives that reduce U.S. aviation emissions are urgently needed. While international standards are undoubtedly crucial, the U.S. federal government can and should enact more meaningful policies on aircraft emissions, based on the existing technological capabilities of U.S. manufacturers and airlines. Despite the significant role aviation plays in states' and cities' overall GHG emissions, these subnational governments are legally and practically limited in some important ways when it comes to regulating emissions from aircraft, and this highlights the need for stronger federal policymaking.

Still, state and local governments have some options to craft policies and incentives that address the environmental impacts of aviation, and these include research funding, a low-carbon fuel standard, modal shift incentives, and airport policies. While these bottom-up approaches need to be adopted by a number of states in order to achieve substantial GHG reductions, once there are forerunners setting successful examples, other states could establish similar policies with potentially moderate efforts. This is exemplified by the diffusion of low-carbon fuel standards from California to other states. The interconnected nature of aviation makes it challenging to regulate, but at the same time, progressive policies in one region hold the potential to mobilize other regions. This was seen when the inclusion of aviation in the European Union's Emissions Trading System led to the creation of ICAO's carbon-offsetting system.

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