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Demand response to aviation carbon pricing in Canada

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INTRODUCTION

Canada was the world's 12th-largest emitter of carbon dioxide (CO_2) from air travel operations in 2019, with passenger flights originating in the country emitting 18.1 million tonnes of CO_2 (Graver et al., 2020). That total included 6.3 million tonnes from domestic flights, making Canada the ninth-largest emitter of carbon related to domestic air travel. Interprovincial flights accounted for 83% of the domestic aviation emissions, and the vast majority of those were short- and medium-haul flights (Table 1).

Table 1

Tonnes of CO_2 emissions from Canadian domestic passenger flights in 2019 by distance and seating class

Distance bands	Interprovincial		Intraprovincial		Total CO_2 emissions (tonnes)
	Economy class	Premium class	Economy class	Premium class	
Commuter (< 500 km)	186,000	1,217	696,899	22,961	907,078
Short haul (500–1,499 km)	1,551,279	145,997	362,929	4,065	2,064,270
Medium haul (1,500–4,000 km)	2,799,880	495,872	1,161	—	3,296,914
Long haul (> 4,000 km)	15,024	—	—	—	15,024
Total tonnes	**4,552,183**	**643,086**	**1,060,990**	**27,027**	**6,283,286**

Source: Graver et al. (2020)

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In line with global climate ambitions, Canada has set a goal of net-zero carbon emissions by 2050 for its aviation industry. Steps toward this vision are detailed in Transport Canada's 2022–2030 Aviation Climate Action Plan (Government of Canada, 2022).

While a carbon price on aviation has been discussed and studied generally, its potential impact on traffic and emissions has not been quantified for the Canadian market. This study models the effect of introducing a Canada-wide carbon price on interprovincial flights and assesses a scenario of using a frequent flyer levy to achieve the same change in demand as carbon pricing. We estimate the impact on demand and emissions in 2030, 2040, and 2050 by flight distance, seating class, and different fuel efficiency assumptions. The following analysis is a hypothetical approach for pricing aviation emissions in Canada and does not intend to reflect the policies and requirements of the Canadian federal carbon pricing system.

BACKGROUND

Airlines worldwide emitted about 920 million tonnes of CO_2 in 2019, or about as much as the German and Dutch economies combined. Emissions fell in recent years because of the COVID-19 pandemic but have now fully recovered and are expected to double from 2019 levels by 2050 without policy intervention (International Air Transport Association [IATA], 2023). In October 2022, the International Civil Aviation Organization adopted a global goal of net-zero carbon emissions by 2050 (International Civil Aviation Organization [ICAO], 2022), marking the start of a new climate-conscious era for the industry.

Demand management and carbon pricing are considered policy levers in some global aviation decarbonization pathways. In the short run, a carbon price on flights directly reduces aviation emissions in relation to air passengers' response to higher ticket prices. Over time, it should provide an economic incentive for airlines to invest in lower-emission planes and fuels. The International Energy Agency's net-zero roadmap assumes that demand management and economic measures will result in a 20% reduction in air traffic over the next 3 decades compared to business-as-usual growth (International Energy Agency [IEA], 2021). Meanwhile, ICCT's Vision 2050 roadmap estimates 4% less traffic in 2050 in its most ambitious Breakthrough scenario compared to the Baseline continuation-of-the-status-quo scenario, citing fuel price increases from SAF deployment and a limited modal shift to rail (Graver et al., 2022).

A recent study by Chatham House also highlights that demand-side policies can play a crucial role in buying more time for supply-side solutions to mature, providing a hedge against the technological and economic uncertainties of those solutions (Quiggin, 2023). The study identifies an air passenger duty (APD), a fuel duty, a value-added tax (VAT), carbon pricing (including both carbon levies and emissions trading systems such as the European Union's ETS), and carbon offsets as existing policy options for aviation demand management in the UK, along with two new policy concepts: a frequent flyer levy (FFL) and airport capacity management. Some countries have policies related to airport expansions, and France has banned certain domestic short-haul flights when a train alternative is available. However, demand management typically involves fiscal policies that increase ticket prices to reduce the number of trips made by travelers. This is despite the fact that air travel—especially on long-haul flights—has rather inelastic demand; price increases are therefore expected have a moderate impact on air traffic.

Air travel is considered a luxury good. Demand increases more than proportionally as income rises, giving air travel an income elasticity of greater than 1 (Gallet & Doucouliagos, 2014). This means that a carbon price on aviation emissions or a flat fee per ticket would be considered a progressive tax because wealthier households would end up paying a greater share of the total tax burden (Buchs & Mattioli, 2022; Zheng, 2023). However, some argue that raising the cost of flying across the board could unduly burden those with lower incomes and those who fly only occasionally. A uniform carbon charge could also make it difficult for people who have an infrequent but highly essential demand for air travel, such as island residents and immigrants. In the meantime, wealthy frequent flyers will be less sensitive to price changes and could continue to fly as before. An alternative type of tax, in the form of a frequent flyer levy that escalates with the number of flights taken in a year, has been proposed to mitigate these equity concerns (Chapman et al., 2020; Zheng & Rutherford, 2022).

Regardless of the instrument utilized, reducing demand by increasing ticket prices is unlikely to be the main driver of a net-zero transition in the aviation sector. The cost of SAF could be so high that airlines may find it more economically rational to continue using conventional jet fuel and pay the carbon price. It is possible, however, to boost the impact of a carbon charge and unlock additional emission reductions if part of the revenue is recycled to support SAF uptake; this potential effect is explored in this analysis. Therefore, carbon pricing needs to be paired with revenue recycling if the goal is to maximize potential emission reductions in the near term. However, Canada may choose to design its pricing policy for aviation emissions as a revenue-neutral carbon levy, aligning it with the current federal carbon pricing system.

METHODS

This study analyzes interprovincial passenger operations in 2019 to assess the potential impact of carbon pricing. We use 2019 as the baseline year given that it is the most recent year with available data reflecting travel patterns unaffected by the COVID-19 pandemic.

Based on ICCT's Global Aviation Carbon Assessment (GACA) model, interprovincial plane tickets sold in 2019 are categorized into a total of eight segments: four distance bands (commuter, short haul, medium haul, and long haul), each broken down into economy-class and premium-class tickets (Graver et al., 2020). The distance bands are determined so that flights within the same band have a similar level of carbon intensity. Economy-class tickets include basic economy, regular economy, and premium economy. Premium-class tickets include both business class and first class. A total of 36 million tickets were sold, of which 96% were economy class (Table 2).

GACA is used to model tank-to-wake carbon emissions for each route-airline-aircraft combination using PIANO 5 software and operations data from OAG, an air travel intelligence company. Modeled fuel burns are validated by aircraft type against data on quarterly operations and fuel burn reported by airlines to the U.S. Department of Transportation—using U.S. DOT Form 41—for flights to, from, and within the United States. Real-world fuel-burn correction factors, averaging 9% across all aircraft types, were applied to account for varying weather and airport congestion conditions not captured in the modeling. A majority of the aircraft types operating in the Canadian domestic market are covered in the U.S. DOT validation data.

Table 2
Number of interprovincial tickets sold in 2019 by distance and seating class

Distance bands	Interprovincial tickets		Total
	Economy class	Premium class	
Commuter (< 500 km)	3,019,787	12,024	3,031,811
Short haul (500–1,499 km)	17,639,058	557,972	18,197,031
Medium haul (1,500–4,000 km)	13,971,626	734,065	14,705,691
Long haul (> 4,000 km)	46,126	—	46,126
Total	**34,676,597**	**1,304,061**	**35,980,658**

Both air traffic growth and reductions in the carbon intensity of flights affect the amount of proceeds collected from carbon pricing. Boeing's Commercial Market Outlook report estimated that traffic within North America will grow at a rate of 1.6% per annum through 2050 (Boeing, 2021). Meanwhile, Canada's domestic aviation traffic grew by 3.4% per annum between 2012 and 2019, 1.8 times faster than the 1.8% per annum growth in the country's GDP in the same time period (Canada Energy Regulator, 2023; Statistics Canada, 2023). Based on this statistical relationship and the forecast of Canada's GDP (i.e., 1.2% per annum growth between 2019 and 2050), Canada's domestic air traffic is estimated to increase at a rate of 2.2% per annum. This study uses an average of the Boeing projection and the Canada GDP-based projection, which is an annual growth rate of 1.9%. Each segment's share of total ticket sales is assumed to be constant over time.

Two carbon-intensity-improvement scenarios are used, a Business-As-Usual (BAU) scenario and a Deep Decarbonization scenario. These are based on the Baseline and Breakthrough scenarios in ICCT's Vision 2050 decarbonization roadmap (Graver et al., 2022), as well as Environment and Climate Change Canada's inputs of Canada-specific assumptions. The BAU scenario assumes a 34% reduction in fuel intensity, measured in megajoules per revenue passenger-kilometer (MJ/RPK), in 2050 compared to 2019 and no deployment of alternative fuel. The Deep Decarbonization scenario assumes a 46% reduction in fuel intensity (MJ/RPK) in 2050 compared to 2019, as well as a 5% global market share for alternative fuel by 2030 and a 37% global market share by 2050.

The process to develop a national approach for applying a carbon price to interjurisdictional aviation in Canada is ongoing at the time of this analysis. Therefore, various hypothetical scenarios are used as a proxy. All pricing throughout this paper is in Canadian dollars. The modeled carbon price starts at $20 per tonne of CO_2 in 2019 and gradually escalates to $170 per tonne in 2030, which mirrors the federal price schedule (Environment and Climate Change Canada [ECCC], 2021). As the Canadian carbon price schedule post-2030 has yet to be announced, a $500 per tonne price is assumed for 2050 based on the pre-2030 price-escalation rate. These carbon prices are in nominal dollar amounts and were converted into constant 2019 dollars using a 3% discount rate in the analysis: $123 per tonne in 2030, $161 in 2040, and $200 in 2050. Demand responses to specific carbon prices are calculated based on the specific assumptions for each key analysis year. In reality, the carbon price increases gradually while demand decreases gradually.[1]

The price of fossil jet fuel is assumed to increase gradually from $0.77 per liter in 2019 to $0.96 per liter in 2050, while the SAF price increases from $2.19 per liter in 2030 (for fuel blended with 5% SAF) to $2.44 per liter in 2040 (for a 21% SAF blend), and then

1 For example, when a 4% demand reduction is estimated in this paper for a nominal CAD $170 carbon price in 2030, it aggregates the year-on-year incremental demand response to a linearly increasing carbon price between the base year 2019 and the key analysis year 2030.

drops to $2.25 in 2050 (for a 37% SAF blend), based on ICCT's feedstock availability and cost analysis as described in Graver et al. (2022). All decarbonization assumptions are summarized in Table 3. These fuel prices are in constant 2019 dollars.

Table 3

Summary of carbon price, fuel efficiency, and SAF assumptions for each key analysis year

Year	Base fuel cost ($/L)	Carbon price ($/tonne)	Business-As-Usual scenario			Deep Decarbonization scenario		
			Fuel efficiency[a] (2019 = 1)	SAF blend (%)	SAF price premium ($/L)	Fuel efficiency (2019 = 1)	SAF blend (%)	SAF price premium ($/L)
2030	0.77	123	0.83	0	—	0.83	5%	1.42
2040	0.82	161	0.73	0	—	0.66	21%	1.62
2050	0.96	200	0.66	0	—	0.54	37%	1.29

Note: Dollar amounts are in 2019 Canadian dollars
[a] Measured in megajoules of energy per revenue passenger-kilometer (MJ/RPK)

The carbon price is treated as an increase to fuel costs. The average price increase for each ticket in each segment is calculated as shown in Equation 1:

$$\text{Change in ticket price (\%)} = [\text{carbon price (\$/L)} \times \text{share of fuel that is fossil fuel (\%)} + \text{SAF price premium (\$/L)} \times \text{SAF blend (\%)}] \times \text{fuel burn (L)} / \text{base fare (\$)} \times \text{cost pass-through rate} \quad (1)$$

Fare data for 2019 were purchased from RDC Aviation (2021). The non-fuel costs of each flight are assumed to remain constant over time. While fuel prices increase over time, fuel's share of total operating costs is assumed to stay the same and even decrease slightly in the later years due to fuel efficiency improvements.

Fuel's share of airline operating costs averaged 23.7% in 2019 (IATA, 2019), and accounts for a larger share of costs for longer flights. We calibrated fuel's typical share of costs for each segment by dividing the average fuel cost per ticket by the average fare for that segment in 2019. The calibrated fuel shares range from 18% for commuter flights to 26% for long-haul flights. All fares used in this analysis are in constant 2019 Canadian dollars.

A fuel cost pass-through rate of 75% is used; this assumes that airlines absorb 25% of fuel cost increases to remain competitive and then pass the remaining 75% onto consumers (Albers et al., 2009; Koopmans & Lieshout, 2016; Wang et al., 2017).

While the carbon charge levied per ticket depends on flight emissions, calculating a frequent flyer levy depends on the number of tickets purchased by infrequent, occasional, and frequent flyers. For the purposes of this study, infrequent flyers are defined as those who took one or two flights in a year, occasional flyers took three to six flights a year, and frequent flyers took more than six flights in a year. Canada-specific data on flying frequency were taken from International Air Transportation Association's Global Passenger Survey (IATA, 2020a), and validated by an omnibus survey commissioned by Environment and Climate Change Canada (ECCC, 2023).

The International Air Transportation Association survey results included 413 responses from flyers who declared Canada as their country of residence. These flyers provided the number of flights taken for business and leisure purposes, household income bracket, and typical seating class for short-haul and long-haul flights. This information allows traveler attributes to be applied to the total number of interprovincial ticket sales in 2019 (Table 4). When a specific category had fewer than 50 responses, the average percentages for North America are used.

Both surveys indicate that only about half of the Canadian population flies in a given year, similar to the flying-behavior distributions seen in other high-income countries. Frequent flyers, who make up 10% of the nation's population, are estimated to have purchased 63% of the economy-class tickets and 79% of the premium-class tickets in 2019. An overwhelming majority of trips made by infrequent flyers are for leisure purposes. Occasional and frequent flyers have an even spread between leisure and business trips. People from high-income households take about 40%–50% of the trips attributed to infrequent and occasional flyers. This trend is even more pronounced among frequent flyers, with travelers from high-income households taking about 70%–90% of the trips made by frequent flyers.

Table 4

Share of total interprovincial tickets sold by air passenger attributes in 2019

Flying frequency	Share of population	Share of all tickets sold		Purpose	Share of tickets	Household income level[a]	Share of economy or premium tickets sold[b]	
		Economy	Premium				Economy	Premium
Non-flyers	49%	0%		—	0%	—	0%	
Infrequent (1–2 flights per year)	28%	14%	0.3%	Leisure	90%	High	42%	45%
						Middle	40%	26%
						Low	18%	29%
						Total	100%	100%
				Business	10%	High	13%	33%
						Middle	35%	33%
						Low	52%	34%
						Total	100%	100%
Occasional (3–6 flights per year)	13%	20%	0.5%	Leisure	50%	High	42%	49%
						Middle	42%	27%
						Low	15%	24%
						Total	100%	100%
				Business	50%	High	42%	49%
						Middle	42%	27%
						Low	15%	24%
						Total	100%	100%
Frequent (more than 6 flights per year)	10%	61%	2.9%	Leisure	50%	High	71%	89%
						Middle	19%	11%
						Low	10%	0%
						Total	100%	100%
				Business	50%	High	79%	90%
						Middle	15%	10%
						Low	6%	0%
						Total	100%	100%
Total[c]	**100%**	**96%**	**4%**	—	—	—	—	—

[a] Annual household income levels are determined as the following: low, less than $50,000; middle, $50,000–$100,000; high, more than $100,000.
[b] Percentages represent the share of all economy or premium tickets sold to passengers who fly for leisure and to passengers who fly for business within a flying-frequency group. For example, passengers from high-income households purchased 45% of all premium-class tickets sold to passengers who flew infrequently for leisure purposes. This is a very small percentage, .012%, of all premium tickets sold in 2019.
[c] Individual values may not add up to the total value because of rounding.

A frequent flyer levy charges passengers based on their travel frequency. In most of the existing levy proposals, FFL exempts the first one or two flights and then linearly increases with each flight taken subsequently. For this study, because there is no information about which segment (i.e., flight distance bands and seating class) a person's Nth flight falls in, the average levy paid per flight in a year by a traveler is used for analysis. Appendix A details the conversion from a Nth flight-based levy schedule to an annual average schedule.

The frequent flyer levy schedules shown in Table 5 for 2030 are generated so that the total demand response to the FFL matches the demand response to the price on carbon, within an accuracy of 1%. Using the commuter-distance segment as a baseline, the FFL is scaled at 1.5x, 3x, and 5x for the longer-distance tickets in economy class, and 2x, 3x, and 3x of the economy-class levy for premium-class tickets in each segment, based on the average emissions per ticket of each segment from ICCT's GACA model. This mimics the effect of a levy based on air miles without actually collecting the mileage data; it can also be viewed as a carbon charge with flying-frequency adjustment factors applied. An FFL is added to the segment-average fare based on the traveler's frequency bracket.

Table 5
Average annual frequent flyer levy per ticket that would reduce demand as much as a $123 per tonne carbon price in 2030

Flying frequency	Economy class				Premium class		
	Commuter	Short haul	Medium haul	Long haul	Commuter	Short haul	Medium haul
Infrequent	—	—	—	—	—	—	—
Occasional	$3	$4	$8	$14	$5	$12	$25
Frequent	$7	$10	$21	$34	$14	$31	$62

Note: Dollar amounts are in 2019 Canadian dollars.

The total ticket price increase for each segment is then translated into the change in demand for tickets using the demand elasticity for air travel gathered from literature, as shown in Equation 2:

$$\text{Change in demand (\%)} = \text{change in ticket price (\%)} \times \text{demand elasticity} \qquad (2)$$

A meta-analysis of aviation demand elasticities estimates that, for the intra-North America market, a national-level ticket price change would have an elasticity of -0.9 for short-haul flights and -0.8 for long-haul flights (InterVISTAS, 2007). This means an overall 10% price increase leads to a 9% and 8% decrease in overall demand for short-haul and long-haul flights, respectively.

Demand elasticities also vary by trip purpose and household income. Business travelers are significantly less price-sensitive because those trips are often essential and typically paid for by employers. High-income travelers are also generally less price-sensitive because they have a higher level of disposable income that can be used to cover extra airfare.[2] Table 6 shows the elasticities used in this study.

2 However, Brons et al. (2002) pointed out that as a luxury good it is possible for airfare to take up a higher share of expenses for high-income households than for low-income households, leading to potentially higher price sensitivity depending on the scale of ticket price increases.

Table 6
Air travel's demand elasticities to price by trip purpose, household income, and flight distance

Purpose	Household income level	Elasticity	
		Short haul	Long haul
Leisure	High	1.1	0.9
	Middle	1.3	1.0
	Low	1.4	1.1
Business	High	0.6	0.8
	Middle	0.6	0.8
	Low	0.6	0.8

Lastly, the reduction in demand is translated into the reduction in emissions using Equation 3:

$$\text{Emissions reduction } (tCO_2) = \text{total number of passengers in a year (in absence of a carbon price)} \times \text{change in demand (\%)} \times \text{per-passenger flight } CO_2 \text{ emissions } (tCO_2) \quad (3)$$

We assume that the decrease in emissions is proportional to the decrease in the number of passengers because airlines need to achieve a breakeven load factor on a given route to maintain profitability (IATA, 2020b). Therefore, when the number of passengers on a route decreases significantly, airlines would operate fewer flights to help improve the passenger load factor.

RESULTS

Under the BAU scenario in 2030, a $123 carbon price (with a nominal value of $170) would add about $0.3 to the cost of each liter of jet fuel consumed, leading to an estimated 40% increase in fuel cost. With a 17% improvement in fuel efficiency in the BAU scenario and no SAF deployment, interprovincial airfare would increase by 4% on average in 2030. The ticket price increase would be greater for longer flights because per-passenger carbon emissions are higher. Due to the price increase, a total of 1.8 million fewer tickets would be purchased, equivalent to a 4% demand reduction when compared to 2030 traffic totals without a carbon price (Table 7). The demand change will reduce carbon emissions by 240 kilotons, or 4% relative to baseline (i.e., with BAU fuel-efficiency improvements but no carbon pricing). A carbon price, at least in the early years, is not expected to trigger additional fuel-efficiency improvements or a switch to cleaner fuels, as those technologies' marginal abatement cost is higher than the carbon price.

Table 7

Demand response and emissions reduction to a $123/tonne carbon price in 2030 in the Business-As-Usual scenario

Distance band	Fuel price increase*	Ticket price increase*	Demand change		Emissions change	
			Number of tickets (thousands)	% relative to baseline	$ktCO_2$	% relative to baseline
Commuter	40%	3%	(94)	-3%	(5)	-3%
Short haul		4%	(809)	-4%	(62)	-4%
Medium haul		5%	(918)	-5%	(173)	-5%
Long haul		5%	(3)	-5%	(0.7)	-5%
Total		**4%**	**(1,825)**	**-4%**	**(240)**	**-4%**

* Relative to the 2030 real (adjusted for inflation) prices for fuel and tickets without carbon pricing

If no actions are taken to reduce emissions other than BAU fuel-efficiency improvements, a carbon price of $200/tonne in 2050 is estimated to cause a 52% increase in fuel cost, a 5% increase in ticket price, and a 6% reduction in traffic. Even though the unit price is much higher, the 2050 ticket price increase and demand change are not too much higher than in 2030 due to further fuel-efficiency improvement (34% less fuel burn in 2050 compared to 2019). Detailed results for 2040 and 2050 can be found in Appendix B.

In the Deep Decarbonization scenario, we assume 5% SAF blending is achieved in 2030 and—if the aviation carbon pricing is designed similarly to the current Canadian federal carbon pricing system—SAF would be exempted from the carbon price. In this hypothetical case, the modeled charge of $123 per tonne will only be applied to the remaining 95% of the jet fuel consumption that is coming from fossil fuel. The near-term efficiency improvement is assumed to be a 17% fuel-burn reduction in 2030 compared to 2019, which is the same as in the Baseline scenario. As a function of both carbon pricing and the SAF price premium, airfare increases by 5% on average and demand decreases by 5%, or about 2.2 million tickets not purchased (Table 8).

Table 8

Demand response to $123/tonne carbon price in 2030, without or with revenue recycling to support 5% SAF blending

Distance band	Demand change without revenue recycling		Carbon price revenue (millions)		Demand change with revenue recycling	
	Number of tickets (thousands)	% relative to baseline	Total	Recycled for SAF	Number of tickets (thousands)	% relative to baseline
Commuter	(112)	-3%	$22	$5	(90)	-2%
Short haul	(957)	-4%	$199	$49	(769)	-3%
Medium haul	(1,086)	-6%	$390	$96	(873)	-5%
Long haul	(3)	-5%	$2	$0.4	(2)	-4%
Total	**(2,158)**	**-5%**	**$612**	**$150**	**(1,733)**	**-4%**

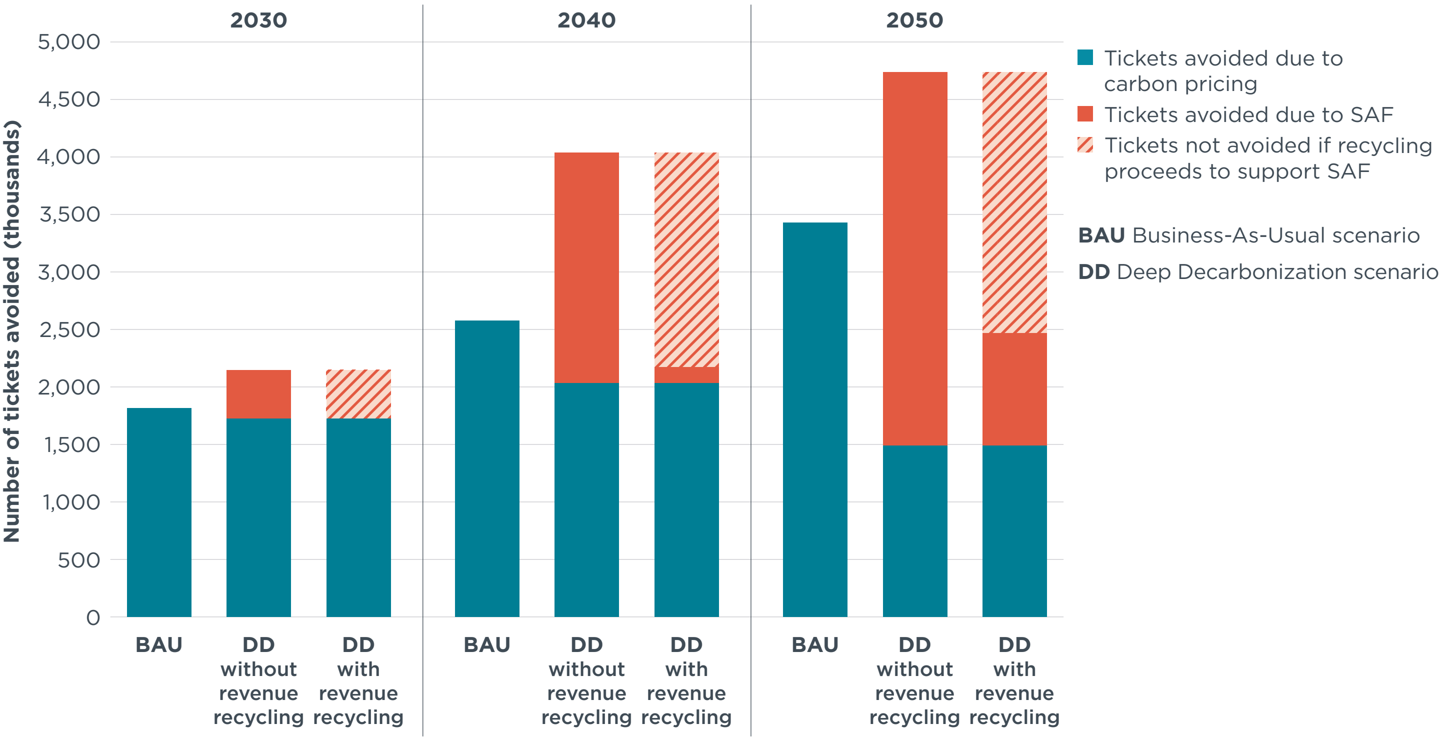
Note: Dollar amounts are in 2019 Canadian dollars.

However, carbon pricing can dampen the demand change triggered by SAF deployment if a portion of the revenue collected is recycled to provide SAF incentives. For instance, $612 million in carbon-pricing revenue would be collected in this scenario, of which $150 million could be diverted to cover the SAF cost differential with fossil jet fuel. This would eliminate the ticket price increase due to the 5% SAF blending, reducing the demand impact by 425,000 tickets, to a total of 1.7 million forgone tickets rather than 2.2 million.

In 2040 under the Deep Decarbonization scenario, fuel costs are estimated to increase 80% due to both the carbon price and SAF (i.e., $161 per tonne applied to 79% of fuel consumption and the SAF premium of $1.62/L for the remaining 21%), resulting in a demand reduction of 3.9 million tickets. The total revenue generated from carbon pricing would be $655 million, which is slightly short of the total SAF price premium of $704 million. With targeted revenue recycling, the demand reduction from SAF deployment can be mitigated, retaining 1.9 million tickets (dashed red area in Figure 1) that would have otherwise been priced out. The total demand impact, mitigated by revenue recycling, would be 2 million tickets rather than 3.9 million tickets.

Figure 1

Demand reduction by decarbonization scenario in each key analysis year



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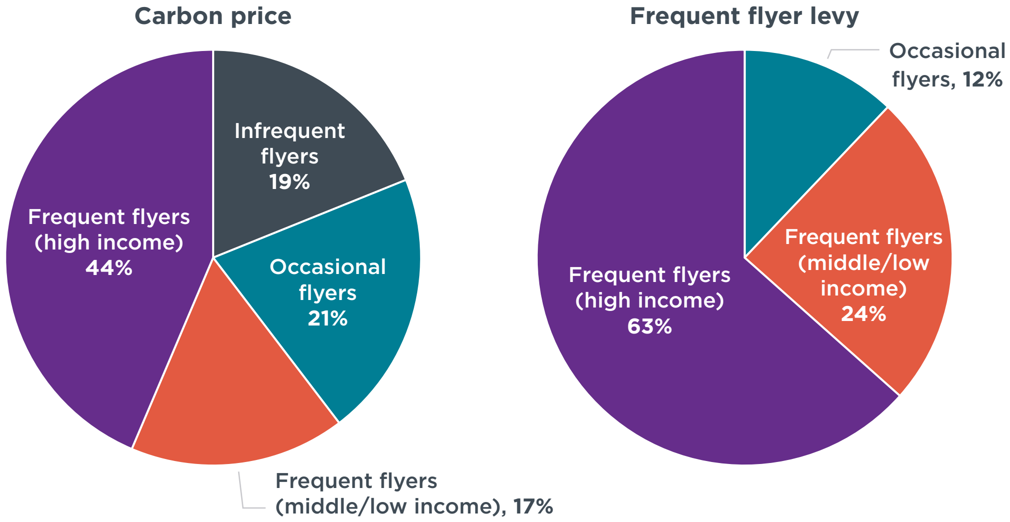
In 2050, further fuel price increases from carbon pricing and SAF in the Deep Decarbonization scenario are somewhat offset by fuel-efficiency improvements (i.e., 46% fuel-burn reduction compared to 2019). The impact on demand is slightly higher than in 2040, at 4.8 million tickets. In this case, recycling all $659 million in carbon pricing revenues for SAF would reduce the demand change to 2.9 million tickets and deliver additional emissions reduction benefits by enabling SAF uptake. Even with revenue recycling, airlines would still pay $344 million more in SAF price premiums under a 37% blending scenario. Detailed results for analysis years 2040 and 2050 under the Deep Decarbonization scenario are shown in Appendix B.

A frequent flyer levy would shift demand response away from infrequent and occasional flyers by exempting the first two flights in a year and charging higher rates for each additional flight (Figure 2). Under a carbon price of $123/tonne in 2030, infrequent flyers would avoid about 345,000 ticket purchases, accounting for 19% of the total demand reduction. These trips would be exempt from carbon pricing under an FFL. Since the FFL is designed to generate the same overall demand response as the carbon price, the 19% demand reduction would come from frequent flyers instead. High-income frequent flyers in particular would increase their share of avoided trips from 44% of the total to 63% of the total. In addition, occasional flyers would experience less of a demand reduction, from 21% of avoided trips under a carbon price to 12% under an FFL. Appendix C shows the difference in demand response to the two policies by flying frequency, trip purpose, and household income level.

Figure 2

Share of demand reduction by flying frequency under carbon pricing and an FFL in the 2030 Business-As-Usual scenario



Note: Individual values may not add up to 100% because of rounding.

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Frequent flyers take 64% of the baseline trips but would account for 88% of the reduced trips under an FFL, with a total of 1.6 million trips avoided. Meanwhile, leisure travel demand is reduced more under FLL because of its higher demand elasticity compared to business travel. Although 56% of the baseline trips are for leisure purposes, 66% of the demand reduction will be attributed to leisure trips. High-income households account for more than two thirds of baseline trips. However, the percentage difference between the number of baseline trips and the number of avoided trips does not vary much across household income levels.

Table 9

Percentage contribution of different traveler categories to overall demand reduction under an FFL in the Business-As-Usual scenario

Passenger categories	Baseline		With FFL		Change	
	Number of tickets sold (thousands)	Percentage of tickets sold	Number of tickets sold (thousands)	Percentage of tickets sold	Number of tickets avoided (thousands)	Percentage of tickets avoided
Infrequent flyers	6,712	15%	6,712	16%	—	0%
Occasional flyers	9,419	21%	9,199	22%	221	12%
Frequent flyers	28,374	64%	26,770	63%	1,604	88%
Total	**44,505**	**100%**	**42,680**	**100%**	**1,825**	**100%**
Leisure travelers	24,937	56%	23,728	56%	1,209	66%
Business travelers	19,568	44%	18,952	44%	616	34%
Total	**44,505**	**100%**	**42,680**	**100%**	**1,825**	**100%**
Low-income flyers	4,953	11%	4,768	11%	185	10%
Middle-income flyers	11,322	25%	10,927	26%	395	22%
High-income flyers	28,231	63%	26,986	63%	1,245	68%
Total	**44,505**	**100%**	**42,680**	**100%**	**1,825**	**100%**

DISCUSSION

A $123 per tonne carbon price (with a nominal value of $170) on aviation could potentially reduce 2030 domestic interprovincial passenger air travel demand by 1.8 million tickets in the Business-As-Usual scenario. This translates to a 4% reduction in traffic compared to baseline. As a result, emissions could potentially be reduced by 240 kilotons, or by 4% relative to 2030 baseline emissions without a carbon price.

In 2040 and 2050 under the Business-As-Usual scenario, fuel-efficiency improvements balance out most of the market growth and carbon price escalation, keeping the demand reduction rates to 5%. The absolute number of forgone tickets, however, increases to 2.6 million and 3.4 million respectively, because baseline traffic continues to grow each year.

Under the Deep Decarbonization scenario, SAF uptake decreases fossil fuel consumption upon which a carbon price would be imposed. The more aggressive fuel efficiency improvements assumed for 2040 and 2050 in this scenario also reduces the demand impact from carbon pricing. Therefore, more modest demand reductions would occur, totaling 1.7 million tickets in 2030, 2 million tickets in 2040, and 2.9 million tickets in 2050. These results assume minimal demand response to a SAF price premium based on a hypothetical policy design where carbon pricing proceeds are recycled to cover the premium and dampen the demand impacts. For instance, recycling 25% of carbon price revenues in 2030, a total of $150 million, can cover the price premium for 5% SAF blending. However, current federal policy is to return all proceeds directly to the jurisdiction of origin.

When SAF penetration reaches a high level, there would be much fewer fossil fuel emissions on which to apply a carbon price. A carbon price could be gradually phased out or converted to a ticket tax to support SAF deployment and to mitigate demand impacts from higher SAF costs. All revenue recycling mentioned in this study could be replaced by a direct government subsidy for SAF or other forms of fiscal incentives aimed at achieving net-zero aviation. However, revenue recycling can significantly increase the emissions reduction benefits from a carbon pricing policy because emissions are reduced by using more SAF and less fossil fuel as well as by lowering the demand for flying.

With a uniform carbon price, infrequent flyers will account for about 19% of the avoided trips and occasional flyers will account for about 21% of avoided trips. An FFL can help shift the impact of demand-reduction strategies away from these passengers, keeping the travel plans of infrequent flyers intact and lowering the share of avoided trips by occasional flyers to 12%. High-income frequent flyers will account for more than two thirds of the forgone tickets under an FFL, while frequent flyers from all income levels combined will account for 88% of the avoided trips. This study models an FFL schedule that generates the same overall demand response as a carbon price. The average levy amount per ticket needs to be higher when an FFL-like instrument is used because frequent flyers have lower demand elasticity, but that effect is balanced out by the fact that airlines absorb part of the carbon price burden (assumed to be 25% in this study) and pass the rest onto passengers. An FFL is added onto ticket costs directly without any layer of cost pass-through.

Regardless of the instrument used, leisure travelers would cut back on more trips compared to business travelers because of their higher demand elasticity, unless levies are differentiated by trip purpose. Theoretically, a frequent flyer levy could be higher for business travel to place more decarbonization costs onto corporations rather than individuals. This levy differentiation was not modeled in this study because of the implementation challenges associated with identifying the trip purpose at the point of purchase.

Future research topics to consider include quantifying the emissions benefits of recycling carbon pricing revenues for aviation-related climate mitigation (e.g., SAFs, green hydrogen, high-speed rail), comparing a frequent flyer levy to a carbon price with direct rebates, and the effect of applying the interprovincial carbon price to flights entirely within a province or territory.

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APPENDIX A

Tables A1 and A2 show how a conventional frequent flyer levy schedule, with the levy amount escalating starting with the third flight in a year, can be translated into an annual average levy schedule based on a person's flying frequency. The average levies are used for this study because data on the sequence of flights is not available and using average levies will not materially affect the findings.

Having different rates for Nth flights for economy-class and premium-class tickets would add complexity to the implementation of a frequent flyer levy, because whether premium class travel occurs earlier in the year or later would greatly affect the levy amount charged. This complexity can be mitigated if the regulator is able to collect levies retrospectively; once each traveler is already categorized as an infrequent, occasional, or frequent flyer based on the number of flights taken that year, an average levy can be charged for each economy-class flight and each premium-class flight respectively, as shown in Table 5.

Table A1
Illustrative frequent flyer levy schedule per Nth economy-class flight

Distance band	Frequent flyer levy charged for Nth annual flight											
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Commuter	—	—	$3	$4	$5	$6	$7	$8	$10	$12	$14	$16
Short haul	—	—	$5	$6	$8	$9	$11	$12	$15	$18	$21	$24
Medium haul	—	—	$9	$12	$15	$18	$21	$24	$30	$36	$42	$48
Long haul	—	—	$15	$20	$25	$30	$35	$40	$50	$60	$70	$80

Notes: Levies would be charged in addition to ticket prices. All dollar amounts are in 2019 Canadian dollars.

Table A2
Illustrative average frequent flyer levy for economy-class flights by flying frequency and distance band

Distance band	Annual average levy per flight		
	Infrequent flyer	Occasional flyer	Frequent flyer
Commuter	—	$3	$7
Short haul	—	$5	$11
Medium haul	—	$9	$21
Long haul	—	$15	$35

Note: All dollar amounts are in 2019 Canadian dollars.

APPENDIX B

The four tables below show the price increase, demand reduction, and emissions reduction by distance band for both the Business-As-Usual and Deep Decarbonization scenarios in 2040 and 2050. For the Deep Decarbonization scenario, results with and without revenue recycling to cover SAF price premiums are both shown.

Table B1

Demand response and emissions reduction to $161/tonne carbon price in 2040, Business-As-Usual scenario

Distance band	Fuel price increase*	Ticket price increase[a]	Demand change		Emissions change	
			Number of tickets (thousands)	% relative to baseline	tCO_2	% relative to baseline
Commuter	49%	3%	(130)	-3%	(5.6)	-3%
Short haul		4%	(1,140)	-4%	(77)	-4%
Medium haul		6%	(1,313)	-6%	(219)	-6%
Long haul		6%	(3.7)	-5%	(0.9)	-5%
Total		**5%**	**(2,587)**	**-5%**	**(302)**	**-5%**

[a] Relative to the 2040 real (adjusted for inflation) prices for fuel and tickets without carbon pricing

Table B2

Demand response and emissions reduction to 2050 carbon price of $200/tonne, Business-As-Usual scenario

Distance band	Fuel price increase[a]	Ticket price increase[a]	Demand change		Emissions change	
			Number of tickets (thousands)	% relative to baseline	tCO_2	% relative to baseline
Commuter	52%	3%	(174)	-3%	(7)	-3%
Short haul		5%	(1,520)	-5%	(92)	-5%
Medium haul		7%	(1,747)	-7%	(263)	-7%
Long haul		7%	(4.9)	-6%	(1.1)	-6%
Total		**6%**	**(3,446)**	**-5%**	**(363)**	**-6%**

[a] Relative to the 2050 real (adjusted for inflation) prices for fuel and tickets without carbon pricing

Table B3

Demand response and emissions reduction to 2040 carbon price of $161/tonne carbon, with and without revenue recycling for SAF (Deep Decarbonization scenario)

Distance band	Demand change (thousand tickets)		Emissions change (tCO_2)[a]	
	No revenue recycling	100% revenue recycled	No revenue recycling	100% revenue recycled
Commuter	(195)	(101)	(6)	(4)
Short haul	(1,719)	(890)	(86)	(56)
Medium haul	(1,997)	(1,034)	(248)	(156)
Long haul	(5.6)	(2.9)	(1.0)	(0.6)
Total	**(3,916)**	**(2,027)**	**(342)**	**(177)**

[a] Does not include emissions reduction due to SAF deployment

Table B4

Demand and emissions response to $200/tonne carbon price in 2050, with aggressive fuel efficiency improvements and no revenue recycling for SAF (Deep Decarbonization scenario)

Distance band	Demand change (thousand tickets)		Emissions change (tCO_2)[a]	
	No revenue recycling	100% revenue recycled	No revenue recycling	100% revenue recycled
Commuter	(214)	(129)	(4)	(2)
Short haul	(2,039)	(1,230)	(67)	(40)
Medium haul	(2,497)	(1,507)	(216)	(131)
Long haul	(6.9)	(4.1)	(0.8)	(0.5)
Total	**(4,756)**	**(2,870)**	**(288)**	**(174)**

[a] Does not include emissions reduction due to SAF deployment

APPENDIX C

While a carbon price and the FFL are designed to generate the same demand response in this study, the distribution of avoided ticket purchases differs greatly between the two policy instruments. Table C1 shows the number of tickets that would have been avoided because of a carbon price, but are not avoided under an FFL, as positive values, and vice versa as negative values. As discussed in the main text, the demand response shifts from infrequent flyers and occasional flyers toward frequent flyers. Notably, short- and medium-haul leisure trips by high-income frequent flyers are affected the most under an FFL, while short- and medium-haul leisure trips by middle-income infrequent travelers are affected the least by an FFL.

Table C1

Absolute difference in ticket purchases resulting from a frequent flyer levy instead of carbon pricing in the 2030 Business-As-Usual scenario

Flying frequency	Trip purpose	Household income level	Difference in ticket purchases			
			Commuter	Short haul	Medium haul	Long haul
Infrequent	Leisure	High	6,183	52,314	58,610	142
		Middle	6,831	57,505	64,126	157
		Low	3,397	28,929	32,612	78
	Business	High	115	989	1,126	5
		Middle	309	2,607	2,917	12
		Low	458	3,858	4,303	18
Occasional	Leisure	High	1,747	13,953	19,783	45
		Middle	2,054	16,239	22,737	53
		Low	812	6,539	9,362	21
	Business	High	948	7,576	10,742	43
		Middle	948	7,495	10,494	43
		Low	341	2,744	3,928	15
Frequent	Leisure	High	(14,040)	(134,762)	(101,745)	(254)
		Middle	(4,372)	(41,029)	(30,842)	(79)
		Low	(2,423)	(22,285)	(16,685)	(44)
	Business	High	(8,462)	(80,923)	(61,053)	(266)
		Middle	(1,602)	(15,080)	(11,342)	(50)
		Low	(593)	(5,458)	(4,087)	(19)

Note: Positive values denote trips that would have been avoided under a carbon pricing scheme but would not be impacted by an FFL. Negative values (in parentheses) indicate trips that would have been taken under a carbon pricing scheme but are avoided under an FFL scheme.

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