Making ¢ents of Reducing Aviation Greenhouse Gas Emissions

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Introduction

As party to the 2016 United Nations Framework Convention on Climate Change's (UNFCCC) Paris Agreement, Canada has committed to reducing its greenhouse gas (GHG) emissions to 30% below 2005 levels by 2030. According to Physical Flow Accounts, Canada's total GHG emissions output, including all industries and households, was 755.1 Megatonnes (Mt) of carbon dioxide equivalent ($CO_{2\ eq}$) in 2015.[1] Aviation – both domestic and international flights – contributed 2.5% of this total, emitting 18.7 Mt $CO_{2\ eq}$ in 2015.[2] Domestic aviation emissions from both domestic and foreign airlines operating in Canada fall under the Paris Agreement, whereas emissions from international aviation fall under the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA's goal is to achieve carbon-neutral growth from 2020 onward.

Transport Canada has identified several measures that are expected to help reduce GHG emissions from aviation.[3] These measures include fleet renewal, more efficient air operations, improved air traffic management and alternative fuels, among others. Not only would a reduction in GHG emissions by air carriers help Canada towards its commitments under the Paris Agreement, but it may also be in the carriers' financial interest to become as fuel-efficient as possible to reduce operating expenses.[4] This paper examines Canadian air services beginning with a review of the current trends in airline passenger traffic along with total emissions output. It then investigates how two types of GHG reduction measures – fleet renewal and more efficient air operations – offer an opportunity for Canadian air carriers to see both environmental and financial benefits.

Analysis

Traffic & Emission

With the deregulation of the Canadian airline industry in 1987, there has been continuous growth in airline passenger traffic and, consequently, fuel consumption and GHG emissions. Since the early 1990s, with the exception of the years after September 11, 2001 and the economic downturn of 2008-2009, the number of passenger-kilometres has steadily increased (Figure 1). In 2015, the number of passenger-kilometres reached an all-time high of 176.1 billion, nearly triple the 66.6 billion in 1990[5], an average annual increase of 4.2% since 1990. As a result, both fuel consumption and overall GHG output also continued to increase, reaching record highs of 7.02 billion litres (L) and 18,746 kilotonnes (kt) $CO_{2\ eq}$, respectively, in 2015. As Figure 1 indicates however, the increase in output (i.e. passenger-kilometres) was significantly greater than both the fuel consumed and the GHG equivalents emitted since the mid-1990s.

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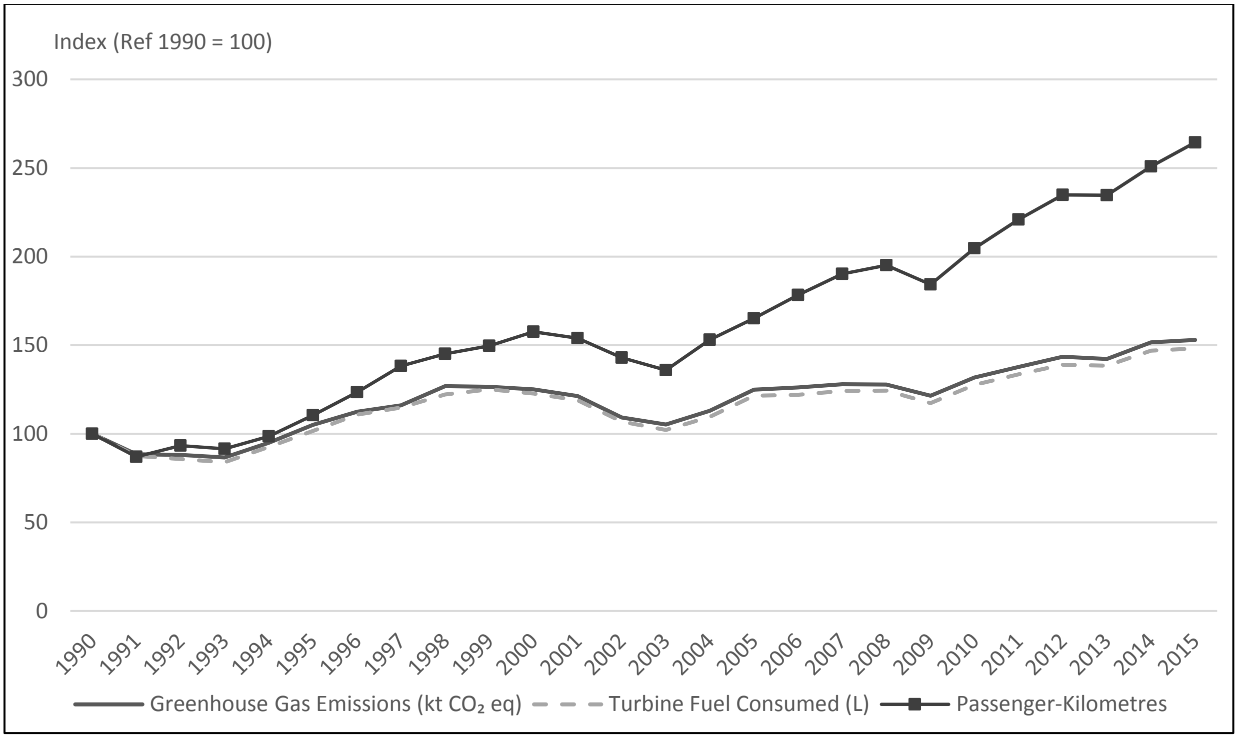
Figure 1 – GHG emissions, turbine fuel consumed and passenger-kilometres,
Canadian level I-III carriers, 1990-2015



Source: Statistics Canada. CANSIM Tables 153-0114 & 153-0034, and Civil Aviation Surveys

It is evident that Canadian air carriers have made improvements and we will examine two in particular: Fleet renewal and more efficient air operations.

Fleet Renewal

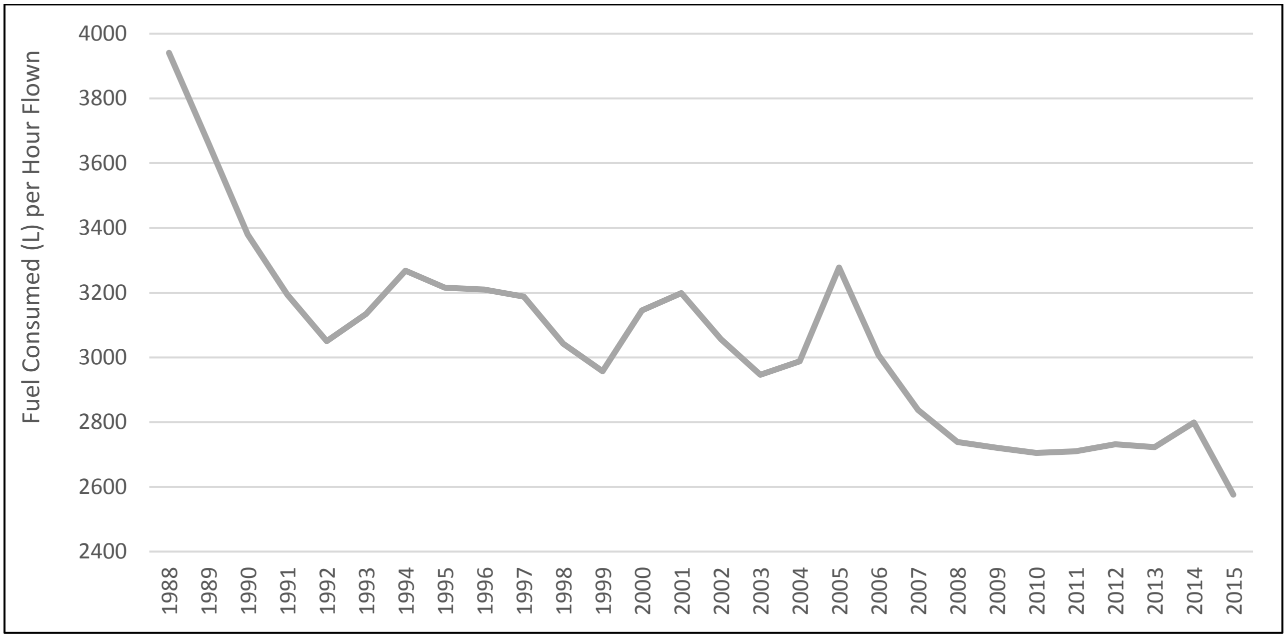
Improving fuel efficiency through fleet renewal helps reduce GHG emissions and decrease the volume of fuel consumed. The two largest Canadian air carriers – Air Canada and WestJet – continually invest in fleet renewal. For example, Air Canada invested roughly $3 billion towards fleet renewal in 2016, while WestJet also continues to upgrade their fleet via the acquisition of new fuel-efficient aircraft, such as the fuel-efficient Boeing 737 Max.[6]

The volume of fuel that aircraft consume on an hourly basis, during a flight, is one metric that can provide some insight into the current state of the fuel efficiencies of the aircraft themselves. In looking at fuel consumption per hour flown (L/HF) by Canadian aircraft, we are able to garner some information regarding the environmental benefits of having more efficient aircraft via fleet renewal.

Indeed, as air carriers improve their fleet – via the addition of aircraft with improved engine technology, wing design, etc. – the volume of fuel consumed per hour flown follows a downward trend (Figure 2). In 1988, about 3941 L of turbine fuel was consumed for every hour of flight time by the Canadian level I-II air carriers. Over the next four years, there was a steady decline. During this time between 1987 and 1990, Canadian Airlines – which has since merged with Air Canada in 2000 – invested in significant fleet renewal via their acquisition of new Boeing 737s and Airbus A310-300s, among other deliveries.[7]

In 2005, Air Canada implemented their Fuel Efficiency Program that tracks various initiatives, such as the reduction of aircraft weight and the increase in compliance of various aircraft standards, which includes the optimization of aircraft speed, in addition to the regular washing of engines. These efforts from Canada's largest air carrier contributed towards a reduction of 70 million litres of fuel use between 2006 and 2008 – coinciding with the beginning of a steady decline in fuel consumption per hour flown since 2005.[8] In 2015, fuel consumption reached an all-time low of 2576 L/HF.

Figure 2 – Fuel consumed per hour flown, Canadian level I-II carriers, 1988-2015



Source: Statistics Canada, Civil Aviation Surveys

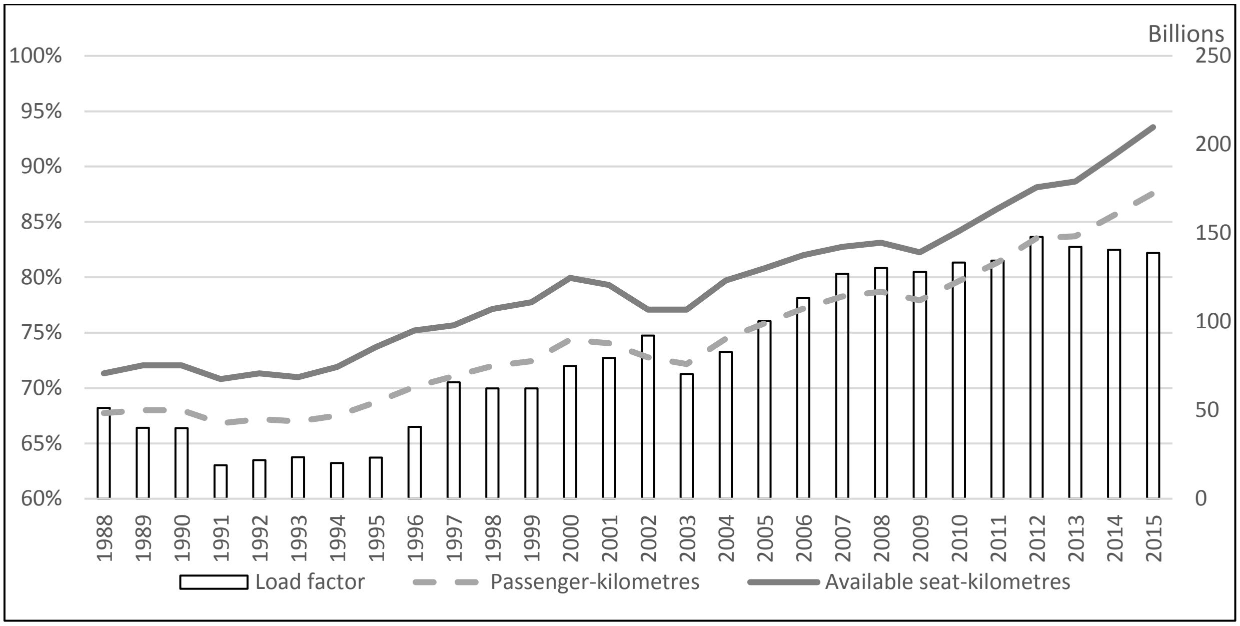
Along with these fuel efficiency program efforts, there has been continuous fleet renewal over the last few decades. For example, not only has the delivery of the Boeing 787 Dreamliner allowed Air Canada to pursue international growth possibilities in Asia directly from its Toronto hub, but this addition has allowed the airline to achieve higher fuel efficiency in terms of consuming less fuel per hour flown.[9] In essence, fleet renewal serves to reduce GHG emissions per flight.

Air Operations

In addition to fleet renewal, having more efficient air operations is another important measure expected to reduce GHG emissions. Passenger load factor – the ratio of passenger-kilometres to available seat-kilometres – is a measure of capacity utilization to assess the profitability of air operations.[10] From both financial and environmental perspectives, it is important for air carriers to strive to optimize this metric, and operate as close as possible to 100% passenger capacity in a competitive marketplace.[11]

Since the late 1980s, passenger load factor has greatly improved for all Canadian level I-II air carriers (Figure 3). After hovering at or below 70% between 1988 and 1999, passenger load factor eclipsed and remained above 70% from 2000 to 2006. Since 2007, passenger load factor has remained above 80% - reaching an all-time high of 83.6% in 2012. Optimizing passenger load factor not only increases an air carrier's profit per trip, as more revenue passengers are onboard, but it also improves fuel consumption and as a result, lowers GHG emissions per passenger-kilometre.

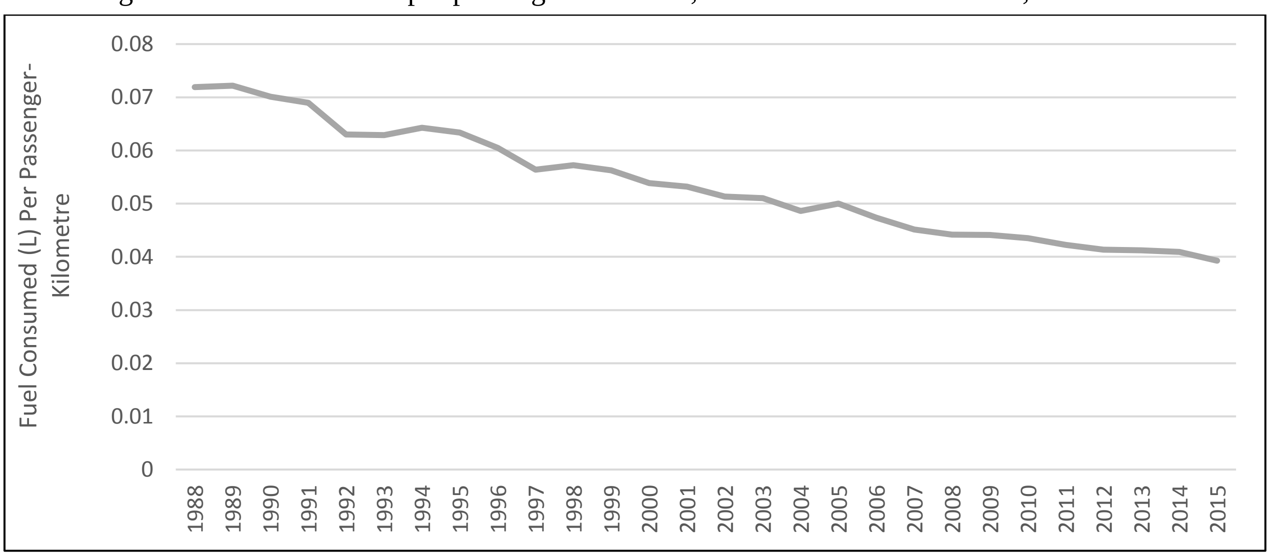
Figure 3 – Passenger-/available seat-kilometres and load factor, Canadian level I-II carriers, 1988-2015



Note: For scheduled services only.
Source: Statistics Canada, Civil Aviation Surveys

Increased passenger load factors has a positive impact on operational fuel efficiency. Although GHG emissions and fuel consumption have increased along with passenger traffic, Canadian air carriers are consuming less turbine fuel in Litres per passenger-kilometre (L/pk) since 1988, as they become more efficient and operate closer to full passenger capacity (Figure 4). Since the late 1980s, there has been a steady improvement. In 2015, Canadian air carriers consumed 0.039 L/pk, compared to 0.072 L/pk in 1988 – a 46% reduction over this period, or an average annual decrease of 2.2%.

Figure 4 – Fuel consumed per passenger-kilometre, Canadian level I-II carriers, 1988-2015



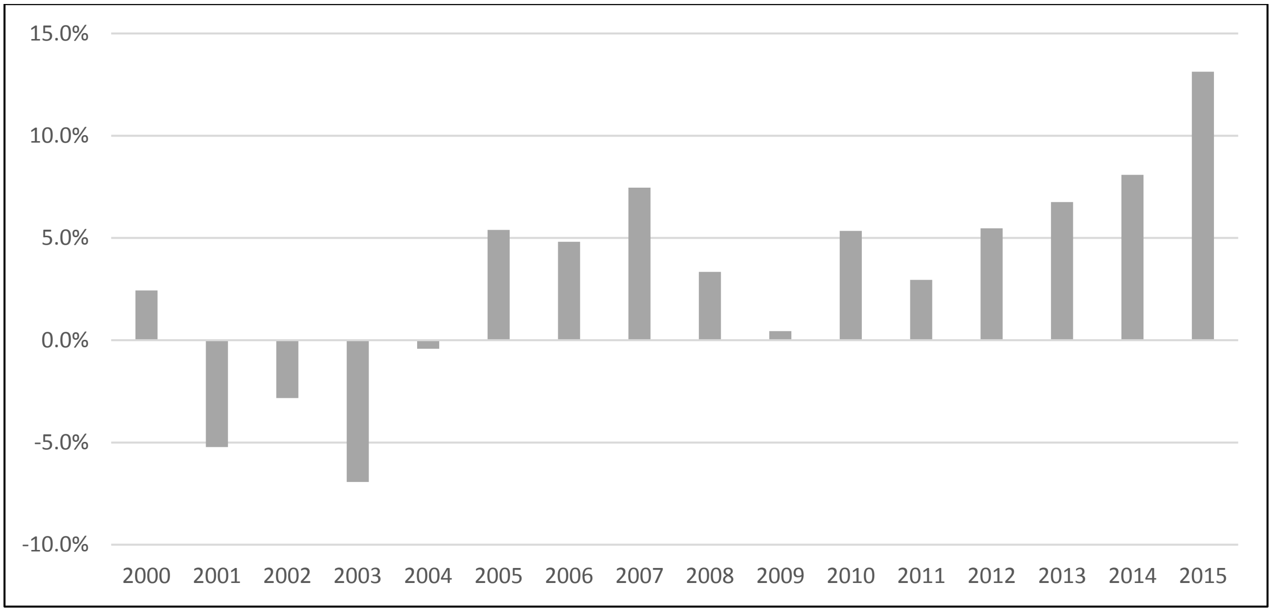
Source: Statistics Canada, Civil Aviation Surveys

Canadian air carriers are improving their air operation efficiencies, which has led to a reduction in fuel consumption (GHG emissions) per passenger-kilometre, along with increased profits per flight. Together, both fleet renewal and more efficient air operations can have positive impacts on air carriers' operating margins.

Operating Margins

As Canadian air carriers have improved capacity utilization per flight, operating margins have increased.[12] From 2000-2015, the average operating margin of Canadian Level I-II air carriers was 3.1%, indicating that every dollar spent on operations resulted in just 3.1 cents of operating profit (Figure 5). Carriers experienced four consecutive operating losses between 2001 and 2004 in the aftermath of the events of September 11, 2001, serving to exacerbate an already difficult situation, stemming from a worsening economy and declining domestic travel.[13] Since, air carriers have achieved positive margins in each year thereafter, a result of steady improvements in passenger load factors. Indeed in 2015, operating margins reached 13.1% – the highest value this century.

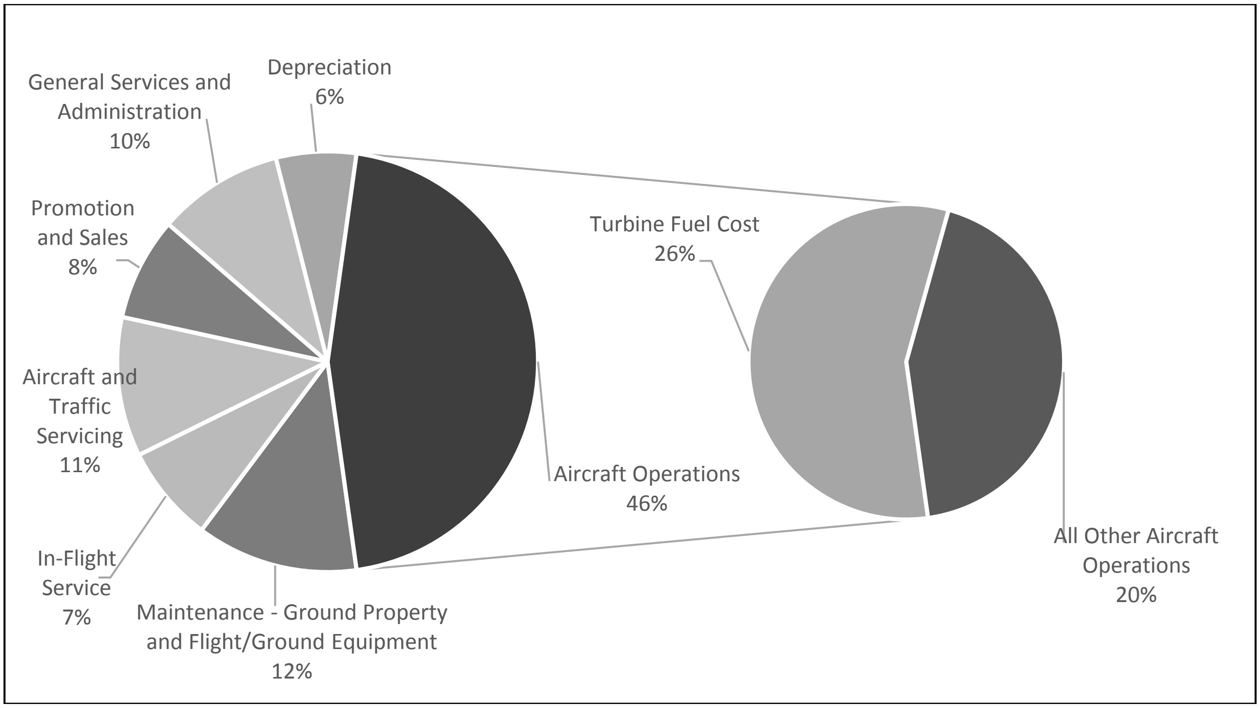
Figure 5 – Operating margins, Canadian level I-II carriers, 2000-2015



Source: Statistics Canada, Civil Aviation Surveys

As fuel expenses are a large portion of aircraft operations expenses, they represent an opportunity to reduce costs. In 2015 for example, about a quarter (26%) of the total operating expenses of Canadian air carriers was from turbine fuel purchases, more than half (57%) of aircraft operations expenses (Figure 6). Although the world price of oil tends to determine the exact proportion of expenses dedicated to fuel, any opportunity to reduce the volume of fuel required only serves to benefit a carrier's operating margins. As examined, investing in more fuel-efficient aircraft and improving operational efficiency are two examples of how carriers can reduce expenditures and increase operating margins. And in addition, reduced GHG emissions from aviation is essential to help Canada move towards its long-term goals under both the Paris Agreement and CORSIA.

Figure 6 – Total operating expenses, Canadian level I-II carriers, 2015



Source: Statistics Canada, Civil Aviation Surveys

Summary and Next Steps

This paper uses data from the Aviation Statistics Centre to examine turbine fuel consumption trends in aviation, focussing on fleet renewal and more efficient air operations. All transportation modes, including aviation, must lower their GHG emission levels in order for Canada to meet its commitments under the Paris Agreement. With aviation, emission reductions can be a by-product as air carriers improve their operating margins via improvements in fuel and operational efficiencies.

Although total aviation fuel consumption and, as a result, greenhouse gas emissions, continue to rise and reach all-time highs, there have been significant improvements in both fleet renewal (i.e., fuel consumption per hour flown) and air operations efficiency (i.e. fuel consumption per passenger-kilometre). Through investment in more efficient aircraft and through more efficient air operations, the aviation industry has certainly improved efficiencies. And given the significant increase in passenger traffic, total GHG emissions from aviation would be much higher otherwise.

However, the physical structure of an aircraft and optimizing air traffic operations can only help reduce emissions up to a certain level. It remains a question as to whether aircraft design and maximizing load factors using current jet fuels can result in further improvements. While the potential use of alternative fuels to reduce GHG emissions from aviation appears to be many years away, a small Canadian biotechnology firm recently provided biofuel derived from an industrial oilseed to fuel a transoceanic flight from Los Angeles to Melbourne, Australia.[14] Up to this point, Canadian air carriers have steadily become more fuel-efficient and, in so doing, improved operating margins as well as potentially helped Canada towards its GHG emission targets under the Paris Agreement.

Acknowledgements
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Endnotes

[1] Statistics Canada, CANSIM tables 153-0114 & 153-0034. Carbon dioxide equivalent emissions are estimated using global warming potentials (multipliers) for methane and nitrous oxide of 25 and 298 respectively. For example, in terms of the ability to trap heat in the atmosphere relative to carbon dioxide over 100 years, the impact of one unit of methane is the equivalent of 25 units of carbon dioxide.
[2] Includes Level I-III Canadian air carriers. Level I Canadian air carriers include every Canadian air carrier that, in the calendar year before the year in which information is provided, transported at least 2 million revenue passengers or at least 400 thousand tonnes of cargo. Level II Canadian air carriers include every Canadian air carrier that transported *(a)* at least 100 thousand but fewer than 2 million revenue passengers; or *(b)* at least 50 thousand but less than 400 thousand tonnes of cargo. Level III Canadian air carriers include every Canadian air carrier that *(a)* is not a level I air carrier or level II air carrier; and *(b)* realized gross revenues of at least 2 million dollars for the provision of air services for which the air carrier held a licence.
[3] Transport Canada – Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation – 2015 Annual Report (date accessed: January 22, 2018):
http://www.tc.gc.ca/media/documents/policy/canadas-action-plan-reduce-greenhouse-gas-emmissions-aviation.pdf
[4] The business case for the airline, presumably, is comparing the reductions in fuel expenditures against capital costs associated with the purchase of new aircraft.
[5] Passenger-kilometres indicates the number of revenue passengers carried on each flight stage multiplied by the number of kilometres flown on that stage.
[6] Air Canada 2016 Annual Report (accessed January 22, 2018):
https://www.aircanada.com/content/dam/aircanada/portal/documents/PDF/en/annual-report/2016_ar.pdf
WestJet 2016 Annual Report (accessed January 22, 2018):
https://www.westjet.com/assets/wj-web/documents/en/about-us/financialReports/WestJet2016AR.pdf
[7] Civil aviation database – Canadian Airlines (accessed January 22, 2018):
https://www.planespotters.net/airline/Canadian-Airlines-International
[8] Air Canada Timeline: 2008 Story (accessed March 1, 2018):
http://moments.aircanada.com/timeline/2008-fuel-efficiency-a-central-concern/
[9] Parcher, C., Bova, T., Larmour, R., and McKeown, L (*forthcoming*). From across the border to across the pond: Canadian Air Passenger Travel, 2007 to 2016. Canadian Transportation Research Forum, Proceedings. Ottawa, June 2018.
[10] Available seat-kilometres indicates the aircraft kilometres flown on each flight stage multiplied by the number of seats available for use on that stage.
[11] Peter, J. and McKeown, L. (2012). Trends in the Canadian airline industry: A statistical review. Paper presented to the North American Regional Science Association International. Ottawa (November).
[12] Operating margin is derived by expressing the percentage difference of the ratio of operating revenues to operating expenses.
[13] Masse, R. (2002). How much did the airline industry recover since September 11, 2001? Aviation Service Bulletin (Special Issue, November). Statistics Canada: 51-004.
[14] Agrisoma Biosciences Inc. provided a bio-fuel blend with 10% carinata for this maiden flight and the agreement reached by the IATA in 2016 to address GHG emissions was cited as a key catalyst in the development, see McCarthy, S. (2018) Quebec's startup's biofuel powers transoceanic flight, The Globe and Mail, Report of Business, January 28, p. B1.