CANADA'S ACTION PLAN

to Reduce Greenhouse Gas Emissions from Aviation

2012 ANNUAL REPORT

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CONTENTS

EXECUTIVE SUMMARY

This is the first Annual Report under *Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation* (the Action Plan).

In 2012, members of the Working Group on Aviation Emissions made good progress towards implementing the Action Plan, including a number of noteworthy achievements related to alternative jet fuels, improved air traffic management, and airport greenhouse gas (GHG) emissions.

Canadian air carriers have collected the necessary data to track fuel efficiency improvements achieved in 2012, which for the first time, reports domestic and international data separately. The results show that Canadian air carriers continue to improve their annual fuel efficiency. The combined fuel consumption rate in 2012 was 37.16 litres per 100 Revenue Tonne-Kilometres (RTK). For international activity, the fuel consumption rate was 33.91 litres per 100 RTK, and 44.96 litres per 100 RTK for domestic activity. Compared with 2011, Canadian air carriers improved fuel efficiency by 1.7 percent, which represents a 1.2 percent average annual improvement, from a 2005 baseline.

Section 5.0 of the Action Plan identifies three key measures that are expected to have the greatest impact in reducing GHG emissions: fleet renewals and upgrades; more efficient air operations; and improved capabilities in air traffic management. This Annual Report highlights the advances made on all three fronts in 2012, including Canadian air carriers replacing older aircraft with highly efficient aircraft and Canada making greater use of performance-based navigation and advanced surveillance technologies.

Section 6.0 of the Action Plan highlights progress on a second set of measures, which the Canadian aviation industry expects to produce beneficial environmental results. These measures include: aviation environmental research and development; alternative fuels; airport ground operations and infrastructure use; regulatory measures; and international coordination. Noteworthy advancements include Canada's first biofuel-powered revenue flight; Air Canada's Perfect Flight; the world's first 100 percent biofuel flight; and the release of the Airport Carbon and Emissions Report Tool. Efforts to modernize the Windsor-Toronto-Montreal airspace corridor progressed, as well.

Finally, this Annual Report concludes with a preview of some important 2013 milestones, including Canada's engagement in a new United States Centre of Excellence (COE) for Alternate Jet Fuels and the Environment, the continued advancement of performance-based navigation in Canada, and the National Research Council's *Aero21* research program.

BACKGROUND

On June 4, 2012, the Government of Canada and the Canadian aviation industry released *Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation* (the Action Plan) and submitted it to the International Civil Aviation Organization (ICAO). Developed by a joint industry-government Working Group on Aviation Emissions, the Action Plan builds on the success of previous collaborations between the Government of Canada and Canada's aviation stakeholders. This includes the world's first voluntary agreement to reduce greenhouse gas (GHG) emissions, which was signed in 2005 between Transport Canada and the Air Transport Association of Canada (ATAC) on behalf of air carriers in Canada.

The Action Plan commits to annual reporting to summarize and track the progress made towards meeting the GHG emissions reduction goals and other Action Plan activities. This report is the first Annual Report published under the Action Plan.

The Action Plan describes ongoing and planned activities to reduce GHG emissions from Canada's domestic and international aviation activities. These measures could contribute to both Canada's domestic climate change objectives and ICAO's global aspirational goals.

The Action Plan set a target to improve fuel efficiency of Canada's air carriers by 2 percent per year until 2020 from a 2005 baseline of 40.43 litres of fuel per 100 Revenue Tonne-Kilometres (RTK).

To support this goal, Section 5.0 of the Action Plan identifies three key measures that are expected to have the greatest impact in reducing GHG emissions:

- Fleet Renewals and Upgrades;
- More Efficient Air Operations; and
- Improved Capabilities in Air Traffic Management.

Section 6.0 of the Action Plan highlights a second set of measures. While the Canadian aviation industry expects these measures to have beneficial environmental results, these results are not expressed in quantitative terms due to the nature or current stage of development of the activity. These include:

- Aviation Environmental Research and Development;
- Alternative Fuels;
- Airport Ground Operations and Infrastructure Use;
- Regulatory Measures; and
- International Coordination.

Highlights for 2012

Canada has made good progress in implementing the Action Plan. Working Group members took advantage of opportunities to collaboratively advance a number of Action Plan measures. Several milestones were reached in 2012, including the following noteworthy achievements:

Canada's First Biofuel-Powered Revenue Flight: In April 2012, Porter Airlines successfully conducted Canada's first biofuel-powered revenue flight with one of its Bombardier Q400 turboprops using a 50-50 blend of Jet A1 fuel and biofuel derived from oilseed crops. The flight between Toronto and Ottawa marked the successful conclusion of a two-year test program, whose key members included Porter Airlines, Targeted Growth, Bombardier Aerospace, Pratt & Whitney Canada, and the Green Aviation Research & Development Network (GARDN).

The Perfect Flight: In June 2012, Air Canada and Airbus performed the first "Perfect Flight" over international borders. This flight was one in a series that carried ICAO delegates en route to Rio de Janeiro, Brazil for the United Nations Conference on Sustainable Development (Rio+20). In addition to being Air Canada's first biofuel-powered flight, it combined the best operational and environmental practices available to date, including:

- Operation of the most eco-efficient aircraft family in its market segment;
- Use of a sustainable biofuel blend (a 50 percent blend) made from used cooking oil supplied by SkyNRG;
- Optimized routings and flight altitude; and
- Combination of several eco-efficient operational procedures, such as single engine-taxiing, external aircraft cleaning for improved aerodynamics, light-weight cabin equipment, and a neatly tailored flight plan.

Compared with a flight using current practices and conventional jet fuel, the Perfect Flight demonstrated a net emissions reduction of over 40 percent.

The World's First 100 Percent Biofuel Test Flight: In October 2012, the National Research Council (NRC) of Canada flew the first civil jet powered by 100 percent biofuel. Funded by Transport Canada and GARDN, the NRC used its Falcon 20 test aircraft with both engines using ReadiJet aviation fuel produced from the sustainable oilseed crop Brassica carinata. An ex-military Lockheed T-33 aircraft trailed the Falcon, to capture and measure engine emissions produced from the fuel. Results showed 50 percent less aerosol emissions than conventional kerosene fuel. In addition to achieving comparable engine performance, the tests also showed an improvement of 1.5 percent in specific fuel consumption during steady state operation.

Windsor-Toronto-Montreal Airspace and Services Review: Much of the airspace and route structure in the Toronto-Ottawa-Montreal corridor was designed in the 1980s. The review recommended changes to better handle air traffic volumes that have almost doubled since that time, and to reflect advancements in air traffic control and aircraft navigational technologies. Beginning in February 2012, NAV CANADA adopted changes to the preferred routings in the Toronto-Montreal corridor and to the Standard Terminal Arrival Routes (STARs) at key airports that allow aircraft to fly in a more precise, efficient and predictable manner.

Airport Carbon and Emissions Reporting Tool (ACERT): In 2011/2012, Transport Canada updated and refined its GHG emissions inventory tool with help from the Airports Council International (ACI), Zurich Airport, and the Toronto Pearson International Airport. This tool enables an airport operator to calculate its GHG emissions inventory at no charge and can be used by non-experts by inputting readily available data. The resulting inventory gives enough detail for an airport to identify energy saving initiatives and establish a GHG reduction program. The tool is available to more than 1,600 airports worldwide, free of charge on ACI's website.

Aviation Emissions Data

In order to satisfy the reporting requirements of ICAO, the Action Plan includes a commitment to report domestic and international aviation activity and emissions separately, beginning with the 2014 Annual Report. The Working Group on Aviation Emissions formed a data subgroup to further evaluate this commitment.

The data subgroup organized an Aviation Emission Data Workshop on March 20, 2013. While this event took place outside of the reporting year, it is noted here due to its relevance and impact on data reported for 2012. Representatives from air carriers and their associations, and government officials met to help build consensus for: developing reliable data on domestic and international aviation fuel use and GHG emissions; and identifying sustainable, cost effective means to collect such data.

The Workshop was a success resulting in aviation industry stakeholders reporting activity and emissions data separately based upon fuel uplift data starting with this Annual Report. Canada can report air carriers' domestic and international activity and emissions data separately, two years ahead of schedule.

Results for 2012

The Air Transport Association of Canada (ATAC) and the National Airlines Council of Canada (NACC) have collected the necessary information to report on the fuel efficiency improvements achieved in 2012[1]. Although progress towards the Action Plan's target is measured in terms of litres of fuel used per RTK, the air operator associations have provided additional data (see Appendix A: Glossary of Key Terms and Acronyms for definitions) to calculate the industry's main activity measures. Other key aviation activity measurements include:

- Available Seat-Kilometres (ASK);
- Revenue Passenger-Kilometres (RPK);
- Passenger Revenue Tonne-Kilometres (Passenger RTK);
- Cargo Available Tonne-Kilometres (Cargo ATK);
- Cargo Revenue Tonne-Kilometres (Cargo RTK);
- Total Available Tonne-Kilometres (Total ATK);
- Total Revenue Tonne-Kilometres (Total RTK).

Table 1 illustrates the combined results for ATAC and NACC air carriers for calendar years 2005 to 2012. It shows trends in fuel consumption and its conversion to GHG emissions, expressed in carbon dioxide equivalent (CO_2e); as well as ratios of litres of fuel and grams of CO_2e per ASK, RPK, total ATK and total RTK.

Table 1 also shows the following results from the reporting carriers in 2012 (in slightly rounded figures):

- The combined fuel consumption rate was 37.16 litres per 100 RTK, which is an average annual improvement between 2005 and 2012 of 1.2 percent.
- Reported capacity was 178.57 billion ASK and 8.04 billion cargo ATK.
- Revenue service was 148.74 billion RPK and 1.96 billion cargo RTK.
- Total combined passenger and cargo capacity was therefore 25.9 billion ATK (i.e., approximately 17.86 billion ATK for passengers[2] plus the 8.04 billion ATK for cargo).
- Combined revenue service was 16.83 billion RTK (i.e., 14.87 billion RTK for passengers plus 1.96 billion for cargo).

1 It should be noted that the number of air carriers that provide data under the Action Plan could change from year to year. As a result, the statistics presented in this report may not be entirely comparable with those in subsequent annual reports.

2 ATK for passengers are calculated by converting ASK into weight using the industry's convention of 100 kg (220 lbs) per passenger.

TABLE 1 Annual Results of Operations, 2005-2012

	2005	2006	2007	2008	2009	2010	2011	2012
Fuel use (million litres)	4,887	5,186	5,543	5,575	5,077	5,659	6,089	6,256
GHG emissions (millions of tonnes of CO_2-equivalent)	12.495	13.258	14.171	14.254	12.980	14.467	15.566	15.994
Traffic (billions)								
Available seat-kilometres (ASK)	131.98	139.48	151.55	154.05	152.66	157.43	171.39	178.57
Revenue passenger-kilometres (RPK)	105.22	112.98	124.15	125.55	117.62	128.77	141.27	148.74
Passenger revenue-tonne-kilometres (pass. RTK)*	10.52	11.30	12.42	12.55	11.76	12.88	14.13	14.87
Cargo available tonne-kilometres (cargo ATK)	5.18	5.38	6.14	6.40	6.14	7.33	7.62	8.04
Cargo revenue-tonne-kilometres (cargo RTK)	1.57	1.53	1.82	1.57	1.38	2.01	1.98	1.96
Total available tonne-kilometres (ATK)	18.37	19.33	21.29	21.81	21.40	23.07	24.76	25.89
Total revenue-tonne-kilometres (RTK)	12.09	12.83	14.23	14.13	13.14	14.88	16.11	16.83
Fuel consumption rates								
Litres/ASK	0.0370	0.0372	0.0366	0.0362	0.0329	0.0351	0.0347	0.0346
Litres/RPK	0.0464	0.0459	0.0446	0.0444	0.0426	0.0425	0.0421	0.0415
Litres/Total ATK	0.2660	0.2683	0.2603	0.2557	0.2372	0.2453	0.2459	0.2416
Litres/Total RTK	0.4043	0.4043	0.3895	0.3947	0.3863	0.3802	0.3780	0.3716
Emission rates								
CO_2e grams/ASK	94.68	95.05	93.51	92.53	83.99	89.64	88.64	88.34
CO_2e grams/RPK	118.75	117.35	114.14	113.53	109.01	108.65	107.54	106.05
CO_2e grams/Total ATK	680	686	666	654	606	627	629	618
CO_2e grams/Total RTK	1,034	1,034	996	1,009	988	972	966	950

*Note that Passenger RTK are calculated by multiplying RPK by 100 kg, which is the industry's conventional assumption of the average weight per passenger, including baggage.

See Appendix D: Additional Figures Illustrating Key Trends for Figures 4, 6, 7, 8, 9, 10, 13, and 14 that illustrate trends presented in Table 1.

Table 2 provides data on international versus the domestic aviation activity for 2012.

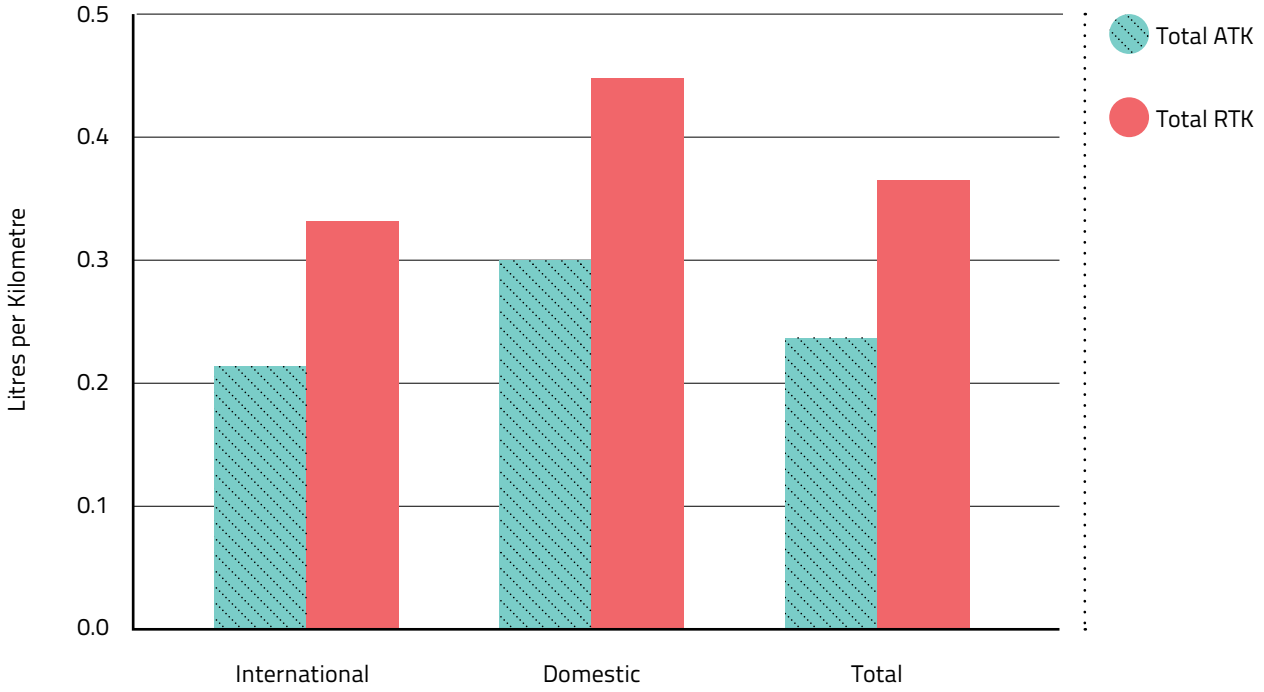
- Separately, the fuel consumption rate for international activity was 33.91 litres per 100 RTK, and 45.0 litres per 100 RTK for domestic activity.
- Total fuel consumed amounted to 6.26 billion litres (64.5 percent for international activity and 35.5 percent for domestic activity). (Also illustrated in Figure 1.)
- Total greenhouse gas emissions amounted to an estimated 15.99 megatonnes (Mt) (10.32 Mt for international activity and 5.68 Mt for domestic).

TABLE 2 International vs. Domestic Aviation Activity, 2012

	International	Domestic	Total
Fuel use (million litres)	4,035	2,221	6,256
GHG emissions (millions of tonnes of CO_2-equivalent)	10.32	5.68	15.99
Traffic (billions)			
Available seat-kilometres (ASK)	121.17	57.40	178.57
Revenue passenger-kilometres (RPK)	103.04	45.70	148.74
Passenger revenue-tonne-kilometres (pass. RTK))	10.30	4.57	14.87
Cargo available tonne-kilometres (cargo ATK)	6.45	1.61	8.04
Cargo revenue-tonne-kilometres (cargo RTK)	1.59	0.37	1.96
Total available tonne-kilometres (ATK)	18.57	7.35	25.89
Total revenue-tonne-kilometres (RTK)	11.90	4.94	16.83
Fuel consumption rates			
Litres/Total ATK	0.2174	0.3021	0.2416
Litres/Total RTK	0.3391	0.4496	0.3716
Emission rates			
CO_2e grams/Total ATK	556	773	618
CO_2e grams/Total RTK	867	1,149	950

See Appendix D: Additional Figures Illustrating Key Trends for Figures 3, 5, 11, and 12 that illustrate trends presented in Table 2.

FIGURE 1 Fuel Consumption Rates – International and Domestic, 2012



The main Action Plan target indicator is the ratio of fuel consumption to total traffic (litres/total RTK), aiming to achieve annual improvements of at least 2 percent per year until 2020 from a 2005 baseline. Table 3 shows progress towards reaching the Action Plan target, illustrating the change in the measures and rates between 2011 and 2012, and between 2005 and 2012.

Table 3 shows that fuel efficiency in 2012 improved by 1.7 percent over 2011, and that the cumulative annual improvement between 2005 and 2012 was 8.1 percent, or an annual average of 1.2 percent.

TABLE 3 Absolute and Proportional Changes Over Time, 2005-2012

	Change 2011-2012		Change 2005-2012		
	Absolute	**Proportional**	**Absolute**	**Proportional**	**Annual rate**
Fuel use (million litres)	167	2.7%	1,369	28.0%	3.6%
GHG emissions (millions of tonnes of CO_2-equivalent)	0.427	2.7%	3.50	28.0%	3.6%
Traffic (billions)					
Available seat-kilometres (ASK)	7.18	4.2%	46.59	35.3%	4.4%
Revenue passenger-kilometres (RPK)	7.47	5.3%	43.52	41.4%	5.1%
Passenger revenue-tonne-kilometres (pass. RTK)	0.75	5.3%	4.35	41.4%	5.1%
Cargo available tonne-kilometres (cargo ATK)	0.41	5.4%	2.86	55.3%	6.5%
Cargo revenue-tonne-kilometres (cargo RTK)	-0.02	-1.2%	0.39	25.0%	3.2%
Total available tonne-kilometres (ATK)	1.13	4.6%	7.52	40.9%	5.0%
Total revenue-tonne-kilometres (RTK)	0.72	4.5%	4.74	39.2%	4.8%
Fuel consumption rates					
Litres/ASK	-0.000	-0.3%	-0.002	-6.7%	-1.0%
Litres/RPK	-0.001	-1.4%	-0.005	-10.7%	-1.6%
Litres/Total ATK	-0.004	-1.7%	-0.024	-9.2%	-1.4%
Litres/Total RTK	-0.006	-1.7%	-0.033	-8.1%	-1.2%
Emission rates					
CO_2e grams/ASK	-0	-0.3%	-6	-6.7%	-1.0%
CO_2e grams/RPK	-1	-1.4%	-13	-10.7%	-1.6%
CO_2e grams/Total ATK	-11	-1.7%	-62	-9.2%	-1.4%
CO_2e grams/Total RTK	-16	-1.7%	-83	-8.1%	-1.2%

The figures presented in the three tables above allow for the following summary of trends:

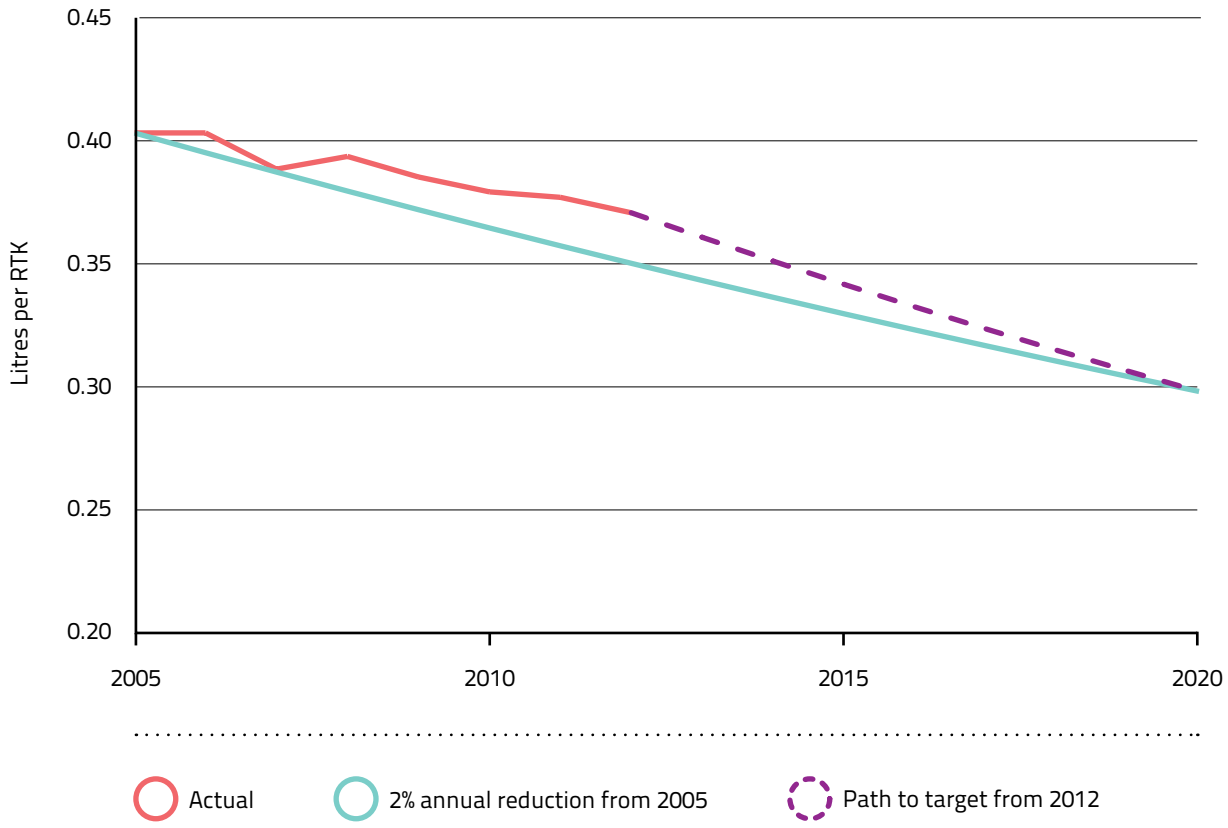
- In 2012 the rebound in industry activity continued after the worldwide downturn in economic activity: reported RPK rose by another 5.3 percent, following the increase of 9.7 percent in 2011. Between 2005 and 2012, RPK grew overall by 41.4 percent.
- The average passenger load factor, which is the ratio between RPK and ASK, continued to increase in 2012, to a new peak of 83.3 percent, from the 2011 peak of 82.4 percent.
- While changes in NACC and ATAC carriers reporting (reported in previous annual summaries under the 2005 voluntary agreement) make it difficult to compare reported trends in cargo, estimated total RTK is dominated by passengers. The revised reported figures suggest there was a substantial increase in total RTK of 4.5 percent from 2011 to 2012, and an increase of 39.2 percent between 2005 and 2012.
- The continued rebound in activity meant increased fuel use. After the extraordinary reduction in fuel use between 2008 and 2009, the total in 2012 was 6.26 billion litres, 2.7 percent greater than in 2011.
- GHG emissions from 2011 to 2012 also increased by 2.7 percent, to 15.99 Mt of CO_2e.
- GHG emissions per RTK improved by the same proportions as those for litres per RTK in 2012 compared to 2011 and 2005 (1.7 percent and 8.1 percent, respectively).

Airport Collaborative Decision Making

Airport Collaborative Decision Making (A-CDM) is a new philosophy for managing air traffic with the added benefit of reducing aircraft emissions. Its initial implementation is aimed at Ground Delay Program Enhancements (Toronto and Montreal). The A-CDM's underlying concepts have the potential for much broader applicability. New areas include: ground delay program enhancements; collaborative routing; performance monitoring and analysis; collaborative resource allocation mechanisms; game theory models for analyzing CDM procedures and information exchange; and collaborative information collection and distribution.

Figure 2 shows the target trajectory from 2005 to 2020 of 2 percent annual reductions and the progress made between 2005 and 2012. It also adds an indicative trajectory that would be required to meet the 2020 goal from the actual 2012 situation.

FIGURE 2 **Target Trajectory, 2005-2020**



Performance-Based Navigation

Performance-Based Navigation (PBN) is a broad range of technologies that enable aircraft to fly any desired flight path using onboard equipment and procedures. It reduces the need to fly exclusively to and from individual sensor-based navigational aids on the ground. This increases the flexibility of point-to-point flights and will enable more efficient operations in the air and on the ground, reducing fuel burned and associated GHG emissions.

Since the release of the Action Plan, the international approach to PBN has evolved. In the Spring of 2012, ICAO developed the Aviation System Block Upgrades (ASBU) framework, which consists of Block Modules, each related to an Air Traffic Management (ATM) system performance or capability improvement, and supported by a strong business case. Block Modules are to be implemented within different targeted periods. PBN is one key tool for implementing the ASBU, particularly for the immediate Block 0 and for Block 1 (to be implemented between 2013 and 2018).

Canada was a strong supporter and advocate of developing and adopting the ASBU framework at the Air Navigation Conference in November 2012 and at the 38th ICAO Assembly in Fall 2013. In line with the ICAO Global Air Navigation Plan (GANP), which includes the ASBU framework adopted at the 38th ICAO Assembly, Transport Canada and NAV CANADA continue to work to implement PBN and other ATM system tools, in collaboration with industry stakeholders.

Reporting on 5.0 Measures

Section 5.0 of *Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation* identifies measures that represent the greatest opportunities to reduce GHG emissions and help improve average annual fuel efficiency by 2 percent between 2005 and 2020. The following table summarizes the results achieved and the status of each measure.

Summary Table of Section 5.0 Measures

Measure	Results	Status
5.1 Fleet Renewals and Upgrades		
Canadian air carriers expect to achieve an annual fuel efficiency improvement of 0.7 percent for both domestic and international flights between 2005 and 2020 through further fleet changes.	NACC air carriers continue to operate and expand their fleets with highly efficient aircraft. The NACC fleet renewal plan for 2012 was on schedule: three B737-800 and five Q400 aircraft were added; nine CRJ-100/200 and one A310 aircraft were removed. ATAC air carriers that operate highly efficient aircraft such as B737-800 and Bombardier Q400 continue to use and/or grow their fleets with these types of aircraft. Operators of B737-200 aircraft have begun to replace these classic versions with B737-300/400/500 series aircraft with more efficient CFM56 engines. Cargo air carriers continue to upgrade from narrow body B727 to larger aircraft with high bypass ratio engines such as DC-10, B757 and B767 aircraft.	
The Canadian Business Aviation Association (CBAA) will also encourage its members to take advantage of opportunities to reduce GHG emissions through fleet renewal.	In 2012, the CBAA continued to encourage its members to reduce GHG emissions through fleet renewal. Going forward, the CBAA intends to use an online forum for its members to increase awareness and provide feedback on activities of interest to Canadian business aviation operators, including the Action Plan.	
5.2 More Efficient Air Operations		
Canadian air carriers expect to achieve an average annual fuel efficiency improvement of 0.2% for combined domestic and international flights between 2005 and 2020 through improved operations.	All ATAC and NACC carrier members continued to re-emphasize the use of fuel saving operating procedures. Carriers continue to look for more opportunities to reduce fuel burn.	

Measure	Results	Status
The CBAA will encourage its members to continue to adopt operational improvements to reduce emissions.	In 2012, the CBAA continued to encourage its members to adopt operational improvements to reduce GHG emissions. Going forward, the CBAA intends to use an online forum for its members to increase awareness and provide feedback on activities of interest to Canadian business aviation operators, including the Action Plan.	
Transport Canada will continue to work through ICAO to help provide guidance, and encourage technological and operational improvements, including updating ICAO Circular 303.	Transport Canada participated in updating ICAO Circular 303, which was completed in 2012 and will become available online in 2014.	
NACC, ATAC, and CBAA will encourage their members to continue to take advantage of the opportunities presented in the new ICAO manual.	The input for the updated manual was built upon the policies and procedures used by NACC and ATAC carriers. The final draft of the manual was circulated to NACC, ATAC and CBAA and will be promoted to their members once it becomes available online.	
5.3 Improved Capabilities in Air Traffic Management		
Performance-based Navigation (PBN) – Building on existing PBN activities, the Action Plan identified that average annual fuel efficiency could improve by 1 to 2 percent between 2005 and 2020 through further implementation of PBN. The benefits resulting from PBN will depend on collaboration between Transport Canada and the Canadian aviation industry, particularly NAV CANADA.		
Approval by Transport Canada for use of the United States Federal Aviation Authority (FAA) Order 8260.54A and 8260.52 instrument procedure.	Transport Canada approved FAA Orders 8260.54A in December 2011.	
Approval of guidance by Transport Canada for Operations Specifications in support of the use of FAA Order 8260.52 criteria.	In 2012, Transport Canada worked on an Advisory Circular for using procedures based on FAA Order 8260.52, targeted for final approval by the end of 2013.	
The Canadian Aviation Regulation Advisory Council (CARAC) to identify short-, medium-, and long-term opportunities for adopting PBN.	The CARAC PBN Working Group held three meetings in 2012 to develop recommendations for a regulatory framework to support PBN operational implementation in Canada.	

COMPLETE IN PROGRESS BEHIND SCHEDULE

Measure	Results	Status
Transport Canada, NAV CANADA, and Canada's aviation industry to jointly develop and put in place an ICAO State PBN Implementation Plan.	To facilitate the ICAO State PBN Implementation Plan, Transport Canada committed to develop a PBN policy framework by spring 2012. This framework has been delayed until early 2014, to be developed in consultation with Transport Canada and NAV CANADA experts.	
Surveillance – Increased surveillance capability and coverage will present opportunities for more efficient air operations. The Action Plan includes a NAV CANADA commitment to continue to use technologies to increase surveillance capability and coverage, both airborne and on the ground, which will result in more efficient air operations.	NAV CANADA has identified both short- and medium-term opportunities to improve surveillance. The best short-term opportunity is to broaden the current air traffic participation rates in existing Automatic Dependent Surveillance-Broadcast (ADS-B) coverage volumes. Transport Canada is working with NAV CANADA on modifying the conditions of the existing ADS-B exemption to increase the participation rates by 40-50 percent by December 2013. Medium- and longer-term opportunities could result from: ▪ applying space-based ADS-B; ▪ expanding existing ground-based ADS-B service volume; and ▪ expanding ADS-B surveillance application from high-level en route to low-level en route and terminal use.	
Improved Air Traffic Management in Targeted Corridors (new measure) – In 2007, NAV CANADA launched the Windsor-Toronto-Montreal (WTM) and Services Review, which aimed to enhance the efficiency of aircraft operations by optimizing airspace design, particularly for instrument flight rules (IFR) and visual flight rules (VFR) aircraft within the WTM corridor, while maintaining safety.	NAV CANADA worked closely with Toronto, Ottawa, and Montreal airports to incorporate existing PBN specifications. Such specifications were incorporated into the Toronto Flight Information Region in February 2012, which affected the Toronto Terminal Control Unit, the high level, and the low level airspace in the Toronto, Ottawa, and Montreal corridor to the East of Toronto. The enroute airspace STARs, and Standard Instrument Departure (SID) procedures were all designed to meet ICAO PBN criteria. 'Q' and 'T' RNAV routes were also introduced to replace existing VHF Victor and Jet airways.	

COMPLETE IN PROGRESS BEHIND SCHEDULE

Reporting on 6.0 Measures

The *Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation* contains other measures, whose expected results are not expressed in quantitative terms due to the nature of the activity or their current stage of implementation. Such measures will be essential to achieving the long-term aspirational goals.

Summary Table of Section 6.0 Measures

Measure	Results	Status
6.1 Aviation Environmental Research and Development		
Significant research efforts are underway to minimize or reduce aviation's environmental impacts and to inform the development of future regulations. This research provides valuable information on how best to address these environmental impacts. This research is being directed primarily through four areas.		
GARDN will continue to undertake research and development of technologies that will help reduce GHG emissions.	Since its beginning, GARDN has mobilized a large network of members and developed a strategic plan that pivots on key research themes essential to the future of the Canadian industry. As of 2012, GARDN selected and financially supported 17 projects, totalling almost $35 million. These projects have developed 35 technologies, including ten that were close to commercialization. Among the most notable projects in 2012 were Canada's first commercial flights using biofuels and the world's first 100 percent biofuel flight, funded jointly by Transport Canada and GARDN.	

 COMPLETE  IN PROGRESS  BEHIND SCHEDULE

Measure	Results	Status
Canada will continue its support of the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) to advance research in such areas as emissions; operations; alternative fuels; tools, system-level, and policy assessment; and noise.	Transport Canada has been a strong supporter of PARTNER. Each year the department makes a financial contribution to this Center of Excellence, which has provided access to $56 million worth of aviation research projects. In 2012/2013, Transport Canada provided direct support to five projects under PARTNER: 1. Health Impacts of Aviation-Related Air Pollutants (Project 11); 2. Emissions Atmospheric Impacts (Project 12); 3. Investigation of Aviation Emissions Air Quality Impacts (Project 16); 4. Metrics for an Aviation CO_2 Standard (Project 30); and 5. Non-volatile Particulate Matter – SAE E31 Aerospace Recommended Practice research issues (Project 37).	
Canada's NRC will continue to work on a number of projects that provided scientific support to inform regulatory decisions in Canada and will continue its program on developing and evaluating alternative fuels.	The NRC has conducted a number of critical safety and emissions tests on aviation biofuels. With financial support from the Government of Canada's Clean Transportation Initiative and the GARDN, the NRC conducted the world's first test flight of a 100 percent, unblended, renewable jet fuel that met petroleum jet fuel specifications. In conducting this test, the NRC was also able to obtain valuable in-flight emissions data. The NRC has developed a new technique to measure non-volatile particulate matter (nvPM, or black carbon), which has been commercialized as the Laser-Induced Incandescence (LII) 200 and 300 instruments. The NRC used this licensed technology in 2012, in collaboration with Transport Canada, to analyze the 100 percent biofuel test flight. The results revealed fewer black carbon emissions than conventional jet fuel. In collaboration with an international team, the SAE E-31 Aircraft Exhaust Emissions Measurement Committee, the NRC, with support from Transport Canada, is developing a recommended practice, which will lead to a new certification requirement for nvPM emissions from gas turbine engines.	

 COMPLETE  IN PROGRESS  BEHIND SCHEDULE

Measure	Results	Status
Transport Canada and CAC will continue to support and participate in the *United States Transportation Research Board's Airport Cooperative Research Program* (ACRP) in a number of key environmental research areas.	Transport Canada and CAC continue to support and participate in ACRP and to disseminate relevant information to Canadian airports. In 2012, ACRP released a number of items of interest to Canadian airports including: ▪ Report 78: *Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial*; and ▪ Report 80: *Guidebook for Incorporating Sustainability into Traditional Airport Projects*.	

6.2 Alternative Fuels

The Government of Canada and the Canadian aviation industry will work together to advance research and demonstration efforts relating alternative fuels for aviation.		
The Government of Canada will continue to support research, development, and demonstration of alternative fuels for aviation through going federal research and development efforts.	In April 2012, Porter Airlines successfully conducted Canada's first biofuel-powered revenue flight with one of its Bombardier Q400 turboprops using a 50-50 blend of Jet A1 fuel and biofuel derived from oilseed crops. On June 18, 2012, Air Canada operated its first biofuel flight ("Perfect Flight") from Toronto to Mexico City on an Airbus A319. The aircraft used a 50-50 blend of regular jet fuel and biofuel derived from recycled cooking oil certified to normal jet fuel standards. In October 2012, the National Research Council of Canada (NRC) flew the first civil jet powered by 100 percent biofuel. Funded by Transport Canada and GARDN, the NRC used its Falcon 20 test aircraft with both engines using ReadiJet aviation fuel produced from the sustainable oilseed crop Brassica carinata. A T-33 aircraft trailed the Falcon, to capture and measure engine emissions produced from the fuel. Results showed 50 percent less aerosol emissions than conventional kerosene fuel. In addition to achieving comparable engine performance, the tests also showed an improvement of 1.5 percent in specific fuel consumption during steady state operation.	

COMPLETE IN PROGRESS BEHIND SCHEDULE

Measure	Results	Status
	Since 2010, Sustainable Development Technology Canada (SDTC) has provided over $9 million to two ongoing alternative aviation fuel projects: $2.5 million to Agrisoma Biosciences Inc. for a Brassica carinata-based biofuel project and $6.7 million to MARA Renewables Corporation for an algae-based biofuel project. Both of these projects are in the demonstration phase. In 2012, there were no new alternative jet fuel projects funded under the SDTC, the Program of Energy Research and Development, or the ecoEnergy Innovation Initiative.	
Canada will pursue opportunities to collaborate with its key trading partners, particularly the United States, on alternative aviation fuel research and development and certification, and explore issues such as commercial production. For example, the ongoing Canada-United States Clean Energy Dialogue includes next generation biofuels as a priority research and development area.	Each month, Transport Canada meets with the United States Federal Aviation Administration, which are opportunities to exchange information on biofuels development in both countries. Transport Canada and the Canadian aviation industry are also engaging with the United States "Commercial Aviation Alternative Fuels Initiative," which provides information on how to assess the "sustainability" of aviation biofuels.	
The Government of Canada and the Canadian aviation industry will discuss the potential for, benefits of, and barriers to alternative aviation fuel production and use in Canada.	Government of Canada and Canadian aviation industry officials continue discussions on potential next steps, including a possible workshop on aviation biofuels.	
6.3 Airport Ground Operations and Infrastructure Use		
The Action Plan commits to reducing GHG emissions from airport ground operations and infrastructure use, primarily through the three initiatives.		
Air carriers and airports continue to work together to reduce emissions from Auxiliary Power Units (APU) and Ground Support Equipment (GSE).	GHG Emission Inventories were developed for 26 National Airports System (NAS) airports and all Transport Canada airports. A list of existing equipment, such as APUs, GSE, and existing preconditioned air equipment at gates was developed for the 2010 calendar year.	

 COMPLETE  IN PROGRESS  BEHIND SCHEDULE

Measure	Results	Status
	A number of emission reduction initiatives are being advanced at Canadian airports. Examples include pre-conditioned air (PCA) hose deployment at Vancouver airport and the tracking of GSE use with GPS technology at Toronto, Montreal and Halifax airports.	
The Canadian aviation industry (airports, air operators, and NAV CANADA) will continue to work together to reduce airport aircraft ground emissions through improved taxiing and queuing procedures. The Canadian aviation industry will also work to reduce taxi times associated with de-icing procedures.	WestJet is working with Vancouver Airport on a simulation "taxi bot" trial. Taxi bots tow the aircraft into position, thereby reducing GHG emissions. Multilateration (MLAT) systems make it possible to see all airport ground movement. Initially adopted for safety reasons, these systems can promote efficiencies and reduce emissions. By 2012, such systems were in place in Montreal, with implementation at Toronto and Calgary scheduled for 2013 and Vancouver for 2014. NAV CANADA has divided the Montreal airport into two different segments, "Ground 1" and "Ground 2," which operate separately. This should promote better service, reduce wait times for aircraft and decrease "crossing of runways," particularly with respect to de-icing processes. The ability to monitor taxi time helps in the management and reduction of aircraft operating times and emissions. A cost-sharing agreement between NAV CANADA and the Toronto Airport utilizes a program called EXCDS to produce taxi times. With this tool, average baselines for taxi times are being developed at the Toronto and Montreal airports and may be developed for the Calgary airport. Initial implementation of Airport Collaborative Decision Making (A-CDM) has been aimed at Ground Delay Program Enhancements at the Toronto and Montreal airports. Further implementation could have an added benefit of reducing emissions.	

 COMPLETE  IN PROGRESS  BEHIND SCHEDULE

Measure	Results	Status
CAC and Transport Canada will continue to refine and improve the data quality of the Airport GHG Emission Inventories and explore opportunities to adopt emissions reductions strategies.	Transport Canada updated and refined its GHG emissions inventory tool in 2011/2012, with assistance from ACI, Zurich Airport and Toronto Pearson International Airport. The tool was re-branded in 2012 and is now called the ACERT. The tool is available to more than 1,600 airports worldwide, free of charge on ACI's website. Transport Canada continues to work with Canadian airports to develop air quality reports using the Transport Canada Mobile Air Quality Laboratory. Joint studies have taken place most recently at Calgary International Airport, Regina International Airport and currently at Edmonton International Airport.	
6.4 Regulatory Measures		
Transport Canada is actively participating at ICAO on the development of the CO_2 standard.	While the schedule for completion of the new international standard was revised due to its complexity, the development is on-track for the 2016 timeline.	
Transport Canada is actively participating at ICAO on the development of the nvPM standard.	The completion of the new international standard is on-track for 2016.	
6.5 International Coordination		
Transport Canada continues to participate in ICAO's work to address climate change.	Canada actively participated in the High-level Group on Climate Change that developed a draft resolution for consideration by the 38th ICAO Assembly in 2013. Canada also worked with experts from other ICAO states to assess the technical feasibility of a market-based measure (MBM) for international aviation and to assess various elements of a MBM framework. Canada continues to actively participate in ICAO's Committee on Aviation and Environmental Protection (CAEP), to develop the new CO_2 standard for aeroplanes and the new particulate matter standard for aircraft engines.	

Measure	Results	Status
	Transport Canada and NAV CANADA are supporting ICAO efforts to estimate environmental benefits associated with the ICAO Aviation System Block Upgrade (ASBU) initiative. NAV CANADA is leading the work for the module dealing with ADS-B, as Canada has significant experience in both using ADS-B and estimating the associated environmental benefits. Transport Canada and CAC are also supporting ICAO's CAEP as a task lead in Working Group 2 – Operations (WG2). Transport Canada will lead the update to the Airport Planning Manual Part 2. The update will include adding eco-friendly airport planning information as well as best practices in land-use planning and management. Once completed, the manual will provide ICAO Member States with guidance and recommendations on airport planning.	
As the Canadian member of the International Coordinating Council of Aerospace Industries Associations (ICCAIA), the Aerospace Industries Association of Canada (AIAC) will strive to lead Canadian aerospace manufacturers in working directly with its international counterparts and through the ICAO CAEP process in developing and producing aircraft and engines that meet or exceed ICAO required improvements.	AIAC member companies continue to provide subject matter experts to advise ICAO's CAEP; and AIAC provides the link to the international community through its membership in ICCAIA. The AIAC also plays a key leadership role by chairing and facilitating the work of GARDN, which includes international coordination. Since it was formed, GARDN has signed agreements with the Air Transport Action Group (ATAG), the Advisory Council for Aeronautics Research in Europe (ACARE), and Canadian Composites Manufacturing R&D Inc. (CCMRD). AIAC is also the Canadian representative for the Civil Aviation sector in the context of the Canada-China Science & Technology Agreement.	

 COMPLETE  IN PROGRESS  BEHIND SCHEDULE

CONCLUSIONS

Summary of Results

Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation sets a target of an average annual improvement in aviation fuel efficiency (measured in litres of fuel per RTK) of at least 2 percent per year until 2020 from a 2005 baseline of 40.43 litres of fuel per 100 RTK.

Aviation activity and associated fuel use data for 2012 provided by members of ATAC and NACC, demonstrate continued progress towards meeting this ambitious target. For the first time, air carriers reported domestic and international data separately, two years ahead of schedule.

Since 2010, the demand for aviation services has continued to grow. Combined revenue passenger and cargo operations increased by 4.5 percent in 2012, compared with 2011. Canadian air carriers consumed 6.26 billion litres of fuel, a 2.7 percent increase compared with 2011. Consequently, total GHG emissions increased by 2.7 percent to 15.99 Mt in 2012, compared with 2011.

Despite the increased demand for aviation services in 2012, the overall fuel consumption rate (i.e., litres per RTK) declined by 1.7 percent, compared with 2011. The combined domestic and international fuel consumption rate reported for 2012 was 37.16 litres per 100 RTK (combining both passenger and cargo traffic). This translates to an average reduction in fuel consumption per RTK of 1.2 per year percent between 2005 and 2012, and a cumulative improvement of 8.1 percent.

2013 Look Ahead

While Canada made significant progress in 2012, a number of important milestones were also advanced in 2013. These milestones will be addressed in more detail in the 2013 Annual Report scheduled to be released by December 2014, including:

- The United States FAA's October 2013 announcement about the new Air Transportation Centre of Excellence (COE) for Alternate Jet Fuels and the Environment. This COE program will be a cost-shared research partnership between academia, industry and the United States government. The FAA anticipates providing this COE with $4 million a year for 10 years. Transport Canada will continue to work with the United States on aviation environmental research through this new COE.
- The continued implementation of PBN in Canada, including:
  - Final publication of the Advisory Circular for use of procedures based on FAA Order 8260.52 on March 31, 2013;
  - Transport Canada approval of FAA Order 8260.58 (which consolidates 8260.54A and 8260.52), which was incorporated and published in the Canadian Criteria for the Development of Instrument Procedures (TP 308) in October, 2013;
  - The publication of additional Advisory Circulars for new PBN navigation specification (Required Navigation Performance Authorization Required Approach (RNP AR APCH) in March, 2013; Radius-to-fix (RF) legs in September, 2013; and Required Navigation Performance (RNP) 1 in October, 2013);
  - The decision to transition the CARAC PBN working group to a standing working group that will continue to work on the long-term solutions for implementing PBN in Canada. The new standing working group will address the benefits achievable through revised air traffic control (ATC) separation attributable to PBN operations.
- In October 2013, the NRC announced its *Aeronautics for the 21st Century* (*Aero21*) research program, which will help develop and advance critical technologies for existing and new aircraft configurations. To meet the demand for an increasingly efficient, economical aircraft fleet, *Aero21* will focus on four areas: manufacturing efficiency, fuel efficiency, emissions control, and emerging technologies with significant benefits to aviation.

Appendix A: Glossary of Key Terms and Acronyms

Key Aviation Activity Measurements

Available Seat-Kilometres (ASK): are available when a seat is flown one kilometre. ASK are equal to the sum of the products obtained by multiplying the number of passenger seats available for sale on each flight by the distance flown.

Revenue Passenger-Kilometres (RPK): is a measure of traffic showing revenue-paying passengers carried, multiplied by distance flown (and note that the ratio between RPK and ASK is the passenger load factor).

Passenger Revenue Tonne-Kilometres (Passenger RTK): is the total tonnes of revenue-paying passengers carried, estimated by converting RPK into weight using the industry's convention of 100 kg (220 lbs) per passenger, multiplied by distance flown.

Cargo Available Tonne-Kilometres (Cargo ATK): is the total tonnes available for the carriage of cargo (freight and mail) multiplied by distance flown (reflects available cargo carrying capacity).

Cargo Revenue Tonne-Kilometres (Cargo RTK): is the total tonnes of revenue-generating cargo (freight and mail) multiplied by distance flown (reflects actual cargo carried).

Total Available Tonne-Kilometres (Total ATK): is the total tonnes available for the carriage of passengers, freight, and mail (revenue load) multiplied by distance flown.

Total Revenue Tonne-Kilometres (Total RTK): is the total tonnes of passengers, freight, and mail carried (revenue load) multiplied by distance flown.

Acronyms

A-CDM: Airport Collaborative Decision Making

ACARE: Advisory Council for Aeronautics Research in Europe

ACERT: Airport Carbon and Emissions Reporting Tool

ACI: Airports Council International

ACRP: Airport Cooperative Research Program

ADS-B: Automatic dependent surveillance-broadcast

AIAC: Aerospace Industries Association of Canada

ATAC: Air Transport Association of Canada

ATAG: Air Transport Action Group

ATC: Air Traffic Control

ASBU: Aviation System Block Upgrades

APU: Auxiliary power unit

CAC: Canadian Airports Council

CAEP: Committee on Aviation and Environmental Protection

CARAC: Canadian Aviation Regulation Advisory Council

CBAA: Canadian Business Aviation Association

CCMRD: Canadian Composites Manufacturing R&D Inc.

CO_2e: Carbon dioxide equivalent

COE: Center of Excellence

FAA: Federal Aviation Authority

GANP: Global Air Navigation Plan

GARDN: Green Aviation Research and Development Network

GHG: Greenhouse Gas

GSE: Ground support equipment

ICAO: International Civil Aviation Organization

ICCAIA: International Coordinating Council of Aerospace Industries Associations

IFR: Instrument flight rules

Mt: Megatonnes

MLAT: Multilateration

NACC: National Airlines Council of Canada

NAS: National Airports System

NRC: National Research Council

nvPM: Non-volatile particulate matter

PARTNER: Partnership for AiR Transportation Noise and Emissions Reduction

PBN: Performance-based navigation

PCA: Pre-conditioned air

RNP: Required Navigation Performance

RNP AR APCH: RNP Authorization Required Approach

RF: Radius-to-Fix

RTK: Revenue tonne-kilometres

SDTC: Sustainable Development Technology Canada

SID: Standard Instrument Departure

STARs: Standard Terminal Arrival Routes

VFR: Visual flight rules

WTM: Windsor-Toronto-Montreal

WG2: Working Group 2 – Operations

Appendix B: Calculations and Caveats

The following factors and formulas were applied in preparation of the aggregated report from the NACC and ATAC. Note that industry statistics are still maintained in imperial units, including miles and tons, which are converted to International System (SI) units (kilometres and tonnes) for the present report. The emissions factors for all calendar years are the latest factors used by Environment Canada in Canada's National Greenhouse Gas Inventory since 2009.

Aviation Jet Fuel emission factors:
2534 grams CO_2 per litre
2557 grams CO_2e per litre

Conversion miles to kilometres:
1 m = 1.609344 km

Conversion tons to tonnes:
1 ton = 0.907185 tonnes

Formulae for CO_2 equivalents:
CO_2e (grams)/RPK = (Fuel Used x 2557) / (RPM x 1.609344)

CO_2e (grams)/Cargo RTK = (Fuel Used x 2557) / (Cargo RTM x 1.609344 x 0.907185)

CO_2e (grams)/Total RTK = (Fuel Used x 2557) / {(RPM x 1.609344 x 0.907185)+(Cargo RTM x 1.609344 x 0.907185)}

Reports by ATAC and NACC members have been revised from time to time, notably of activity statistics. The consolidated statistics presented in this report include all the latest figures reported by ATAC and NACC carriers, including all such revisions. Keep in mind that the statistics are not entirely comparable between years.

The reported annual emission statistics do not account for 100 percent of Canadian aviation operations, and therefore will not be directly comparable to Environment Canada's annual National Greenhouse Gas Emissions Inventory. *Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation*, and therefore this report, did not cover private aviation, military and other government operations, or foreign carriers' operations in Canada.

Further, while NACC members have reported consistently in each year, the extent of reporting of activities by ATAC members has varied year to year. ATAC estimated in earlier annual reports that coverage by reporting members was over 97 percent of domestic passenger and cargo traffic in 2001, over 92 percent in 2002, and over 95 percent in each of the years from 2003 to 2007. Nevertheless, it seems safe to conclude that including the remaining carriers would not substantially affect the ratios and longer-term trends computed for fuel use and emissions per unit of traffic.

Appendix C: List of Signatories and Air Operator Member Companies Reporting

The members of the Working Group on Aviation Emissions, which developed the Action Plan, are:

- Aerospace Industries Association of Canada (AIAC);
- Air Transport Association of Canada (ATAC);
- Canadian Airports Council (CAC);
- Canadian Business Aviation Association (CBAA);
- National Airlines Council of Canada (NACC);
- NAV CANADA; and
- Transport Canada.

All four members of NACC contributed 2012 data for this annual report, including:

- Air Canada;
- Air Transat;
- Jazz Air LP; and
- WestJet.

The ATAC member carriers who contributed 2012 data for this annual report were:

- Air North;
- Bearskin;
- Calm Air;
- Canadian North;
- First Air;
- Flair;
- Kelowna Flightcraft;
- Nolinor;
- Porter Airlines; and
- Sunwing.

Appendix D: Additional Figures Illustrating Key Trends

FIGURE 3 Fuel Use – International and Domestic, 2012

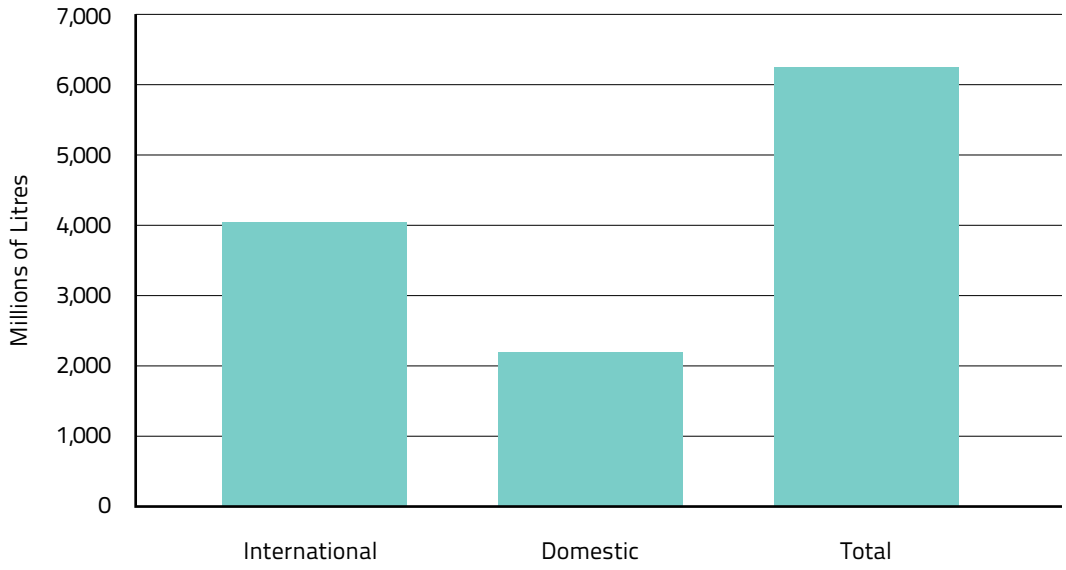


FIGURE 4 Fuel Use, 2005-2012

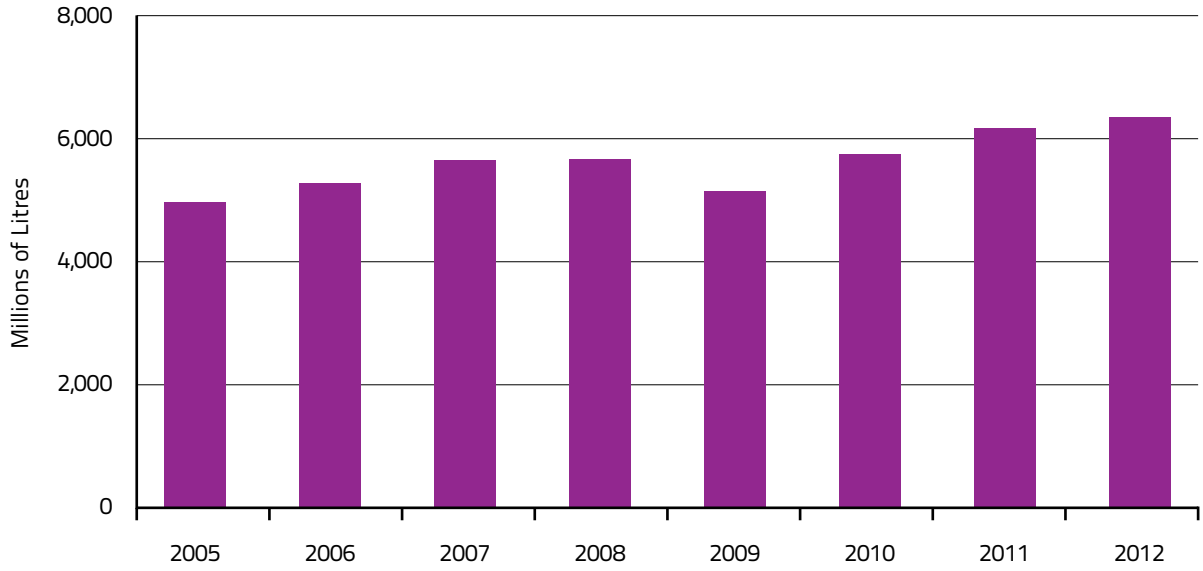


FIGURE 5 Passenger Capacity and Service, 2005-2012

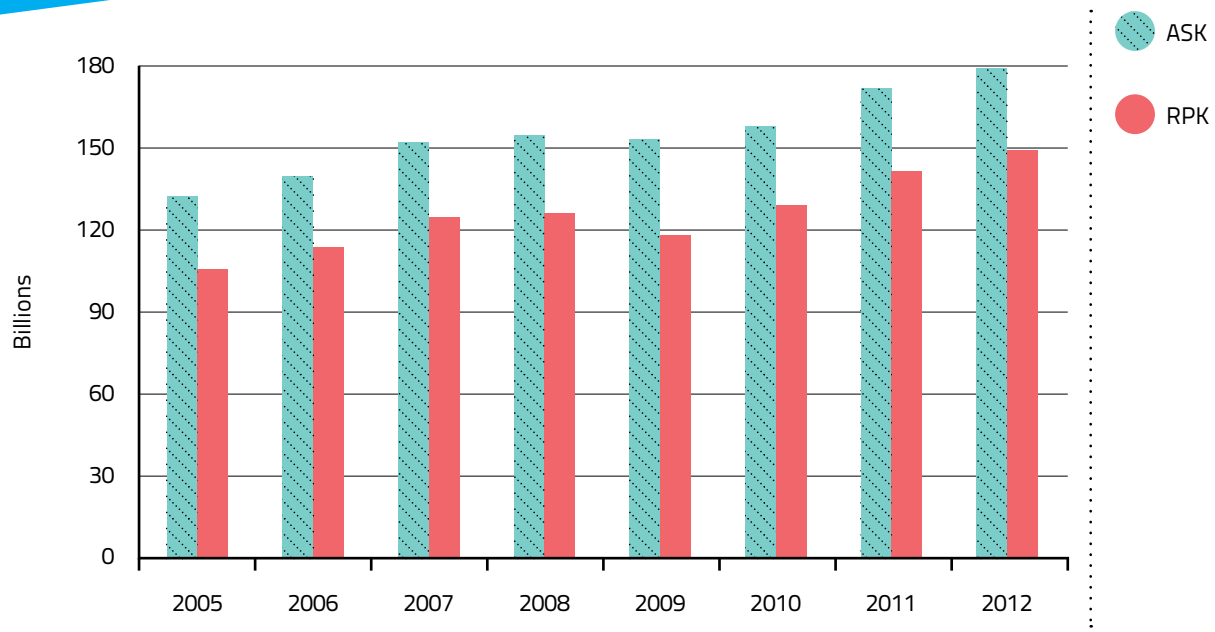


FIGURE 6 Cargo Capacity and Service, 2005-2012

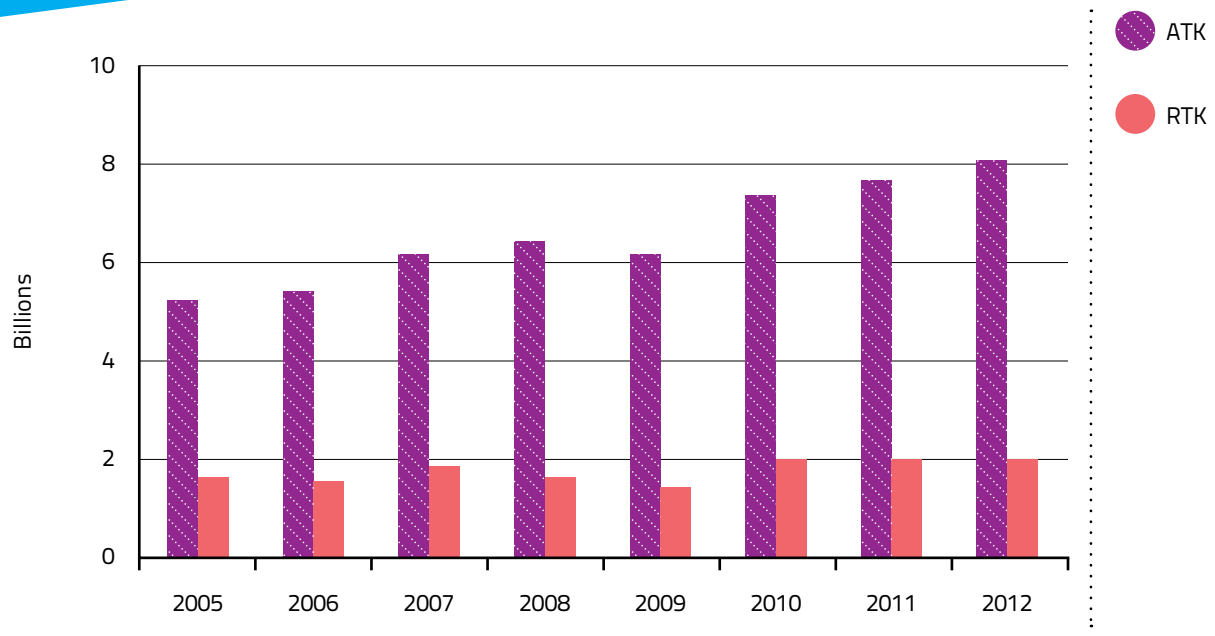


FIGURE 7 Total Passenger and Cargo Capacity and Service, 2005-2012

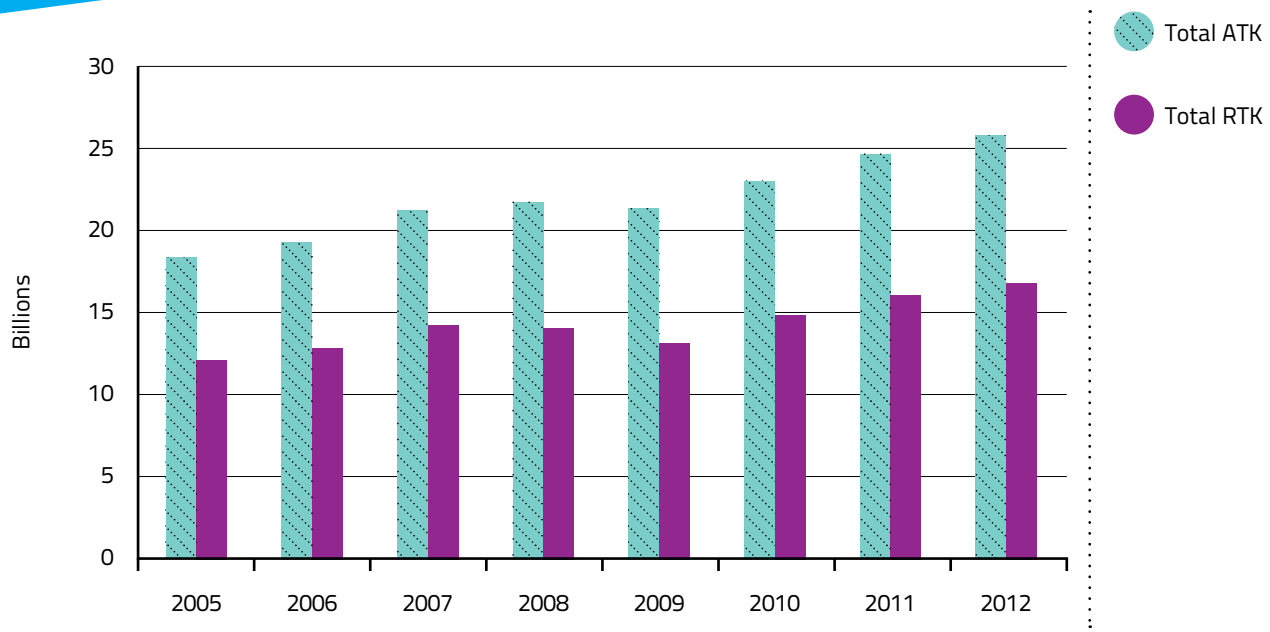


FIGURE 8 Passenger and Cargo Capacity and Service – International and Domestic, 2012

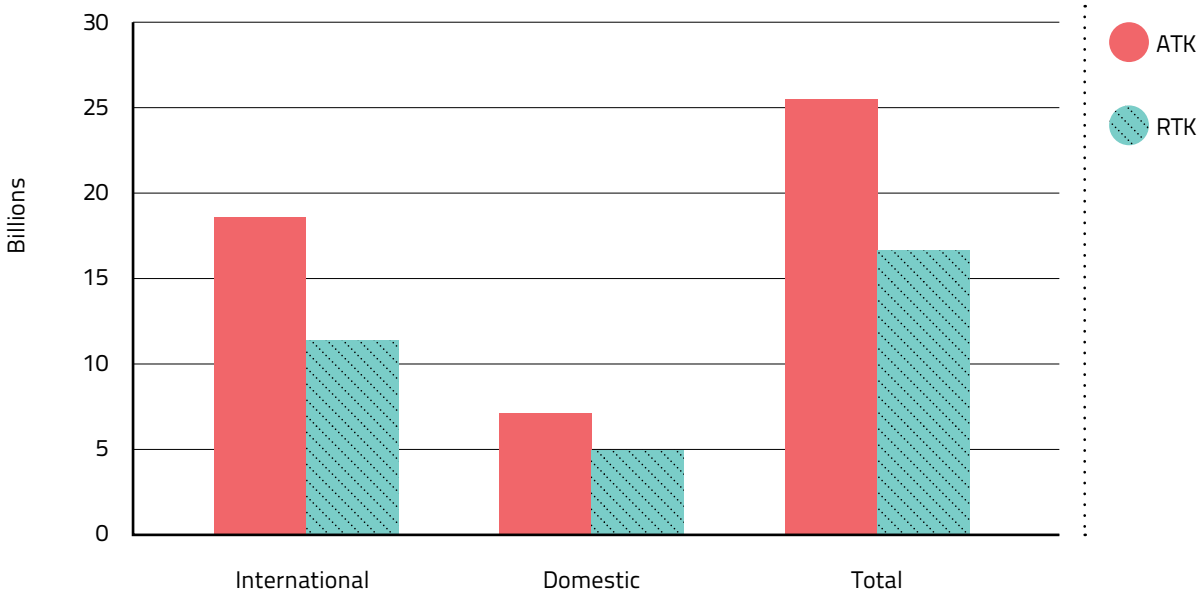


FIGURE 9 Fuel Consumption Rates – Passengers, 2005-2012

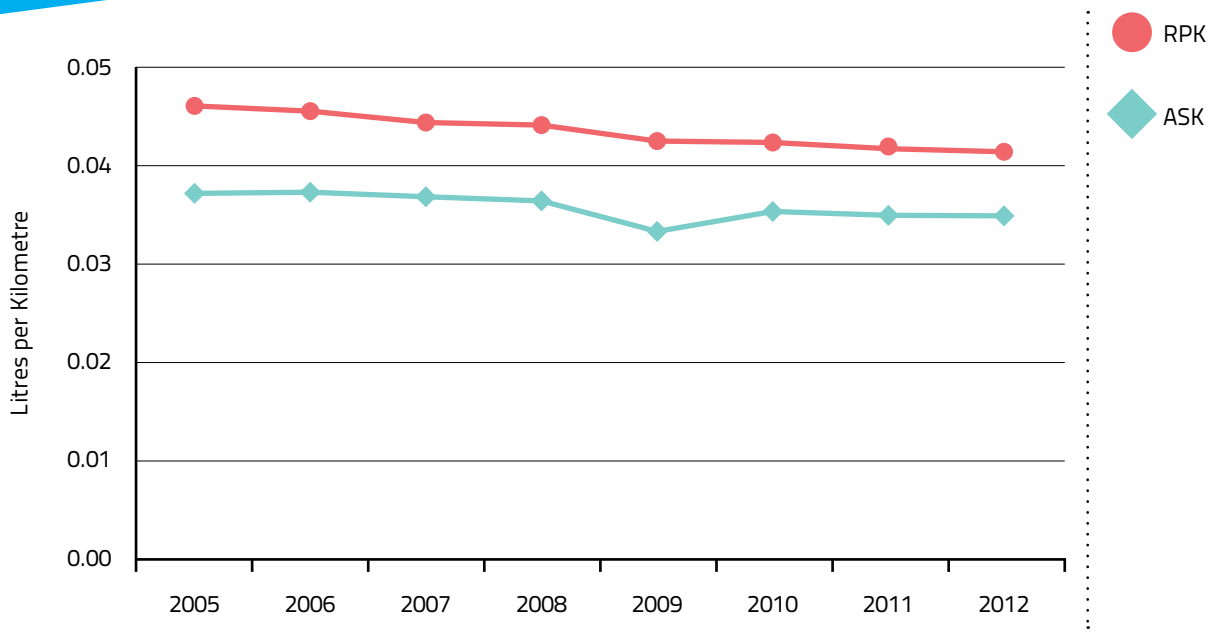


FIGURE 10 Fuel Consumption Rates – Combined Passengers and Cargo , 2005-2012

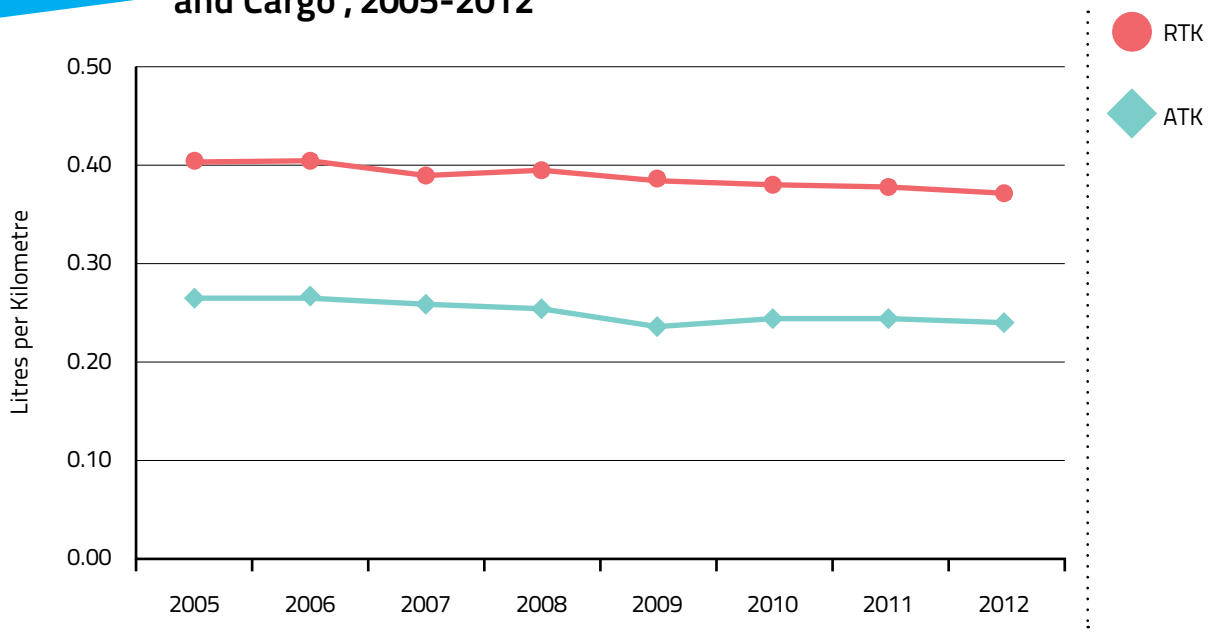


FIGURE 11 GHG Emissions – International and Domestic, 2012

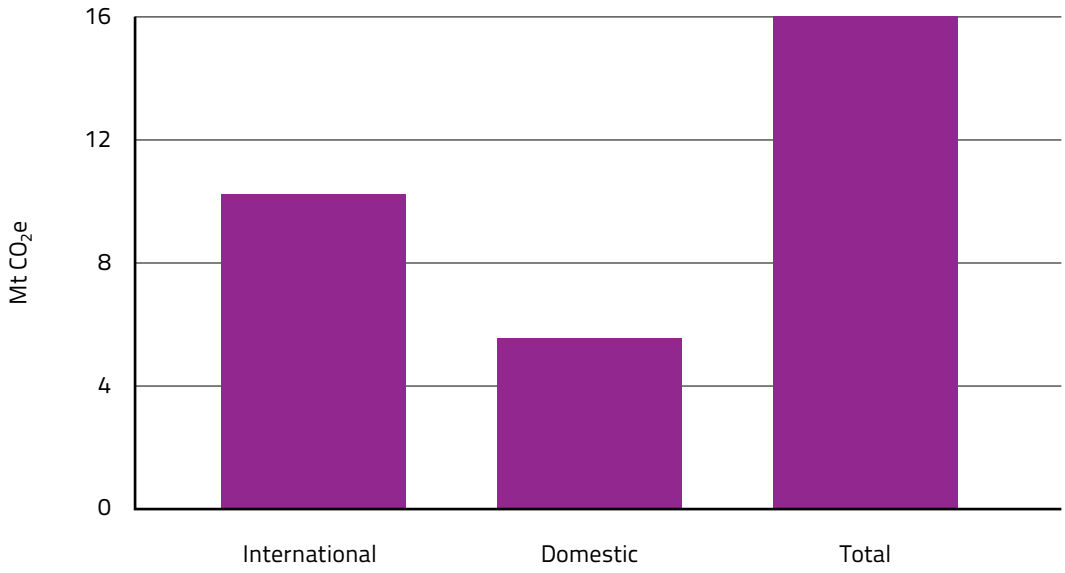


FIGURE 12 GHG Emission Rates – International and Domestic, 2012

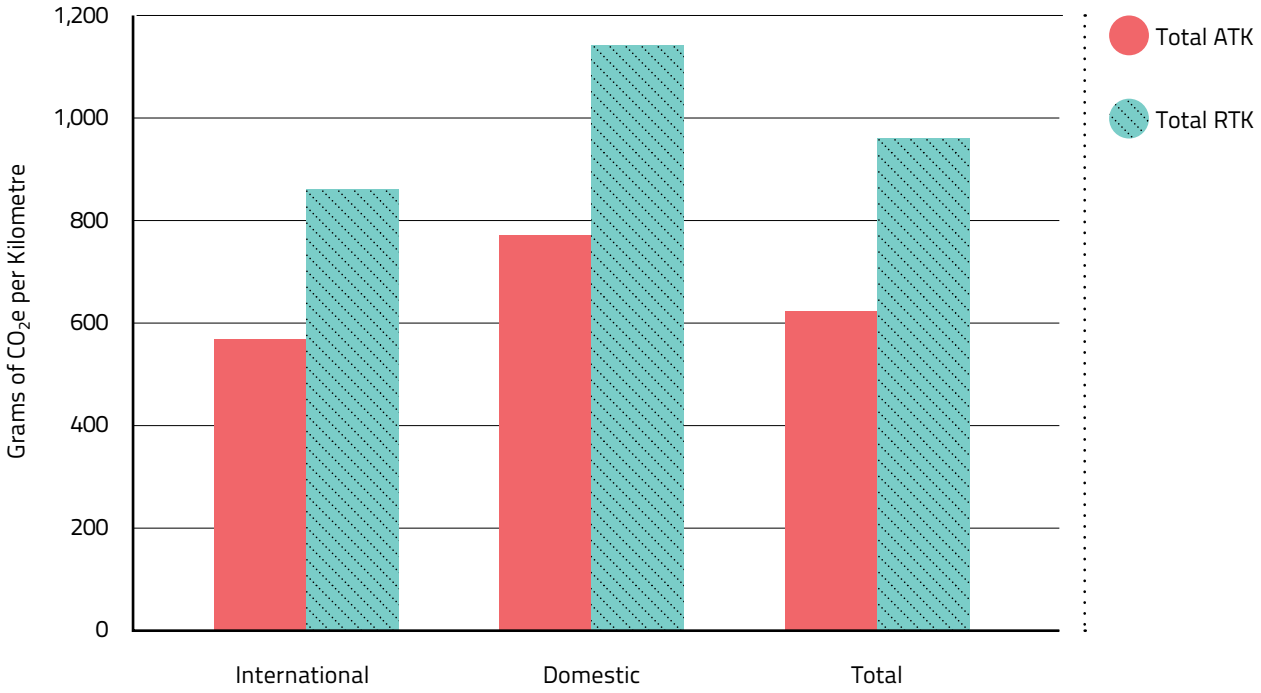


FIGURE 13 GHG Emission Rates – Passengers, 2005-2012

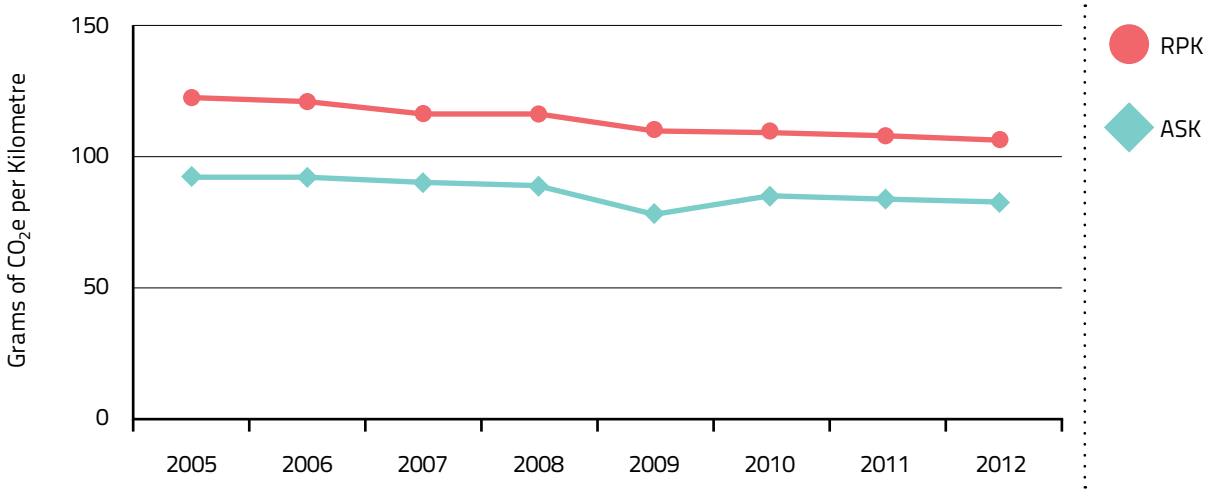


FIGURE 14 GHG Emission Rates – Combined Passengers and Cargo, 2005-2012