Railway Association of Canada™

LOCOMOTIVE EMISSIONS MONITORING PROGRAM 2013

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Review Notice

This report has been reviewed and approved by the Technical Review and Management Committees of the Memorandum of Understanding between Transport Canada and the Railway Association of Canada for reducing locomotive emissions.

This report has been prepared with funding support from the Railway Association of Canada and Transport Canada.

Executive Summary

The Locomotive Emissions Monitoring Program (LEM) data filing for 2013 has been completed in accordance with the terms of the 2011–2015 Memorandum of Understanding (2011–2015 MOU) signed on April 30, 2013, between the Railway Association of Canada (RAC) and Transport Canada (TC) concerning the emissions of greenhouse gases (GHGs) and criteria air contaminants (CACs) from locomotives operating in Canada. This is the third report prepared under the 2011–2015 MOU.

This report highlights that Canadian railways are well placed to meet their GHG reduction targets by 2015 by incorporating more fuel-efficient locomotives and fuel management technologies and policies, particularly within the Class I freight railways. GHG emissions from all railway operations in Canada totalled 6,367.68 kilotonnes (kt), down 1.6 percent from 6,472.83 kt in 2012. In absolute terms, GHG emissions remain moderate despite increasing traffic.

The following table presents the GHG emission intensity targets for 2015 and emissions from 2010 to 2013, expressed as kilograms (kg) of carbon dioxide equivalent ($CO_{2eq.}$) per productivity unit[1]:

Railway Operation	Percent Reduction Target (by 2015)	2010	2011	2012	2013	2015 Target	Productivity Unit
Class I Freight	6% reduction from 2010	16.51	16.24[a]	15.88	15.03	15.52	kg $CO_{2eq.}$ per 1,000 revenue tonne kilometres
Intercity Passenger	6% reduction from 2010	0.12	0.12	0.11	0.10	0.12	kg $CO_{2eq.}$ per passenger kilometre
Regional & Short Lines	3% reduction from 2010	15.28	14.95	13.51	13.65	14.82	kg $CO_{2eq.}$ per 1,000 revenue tonne kilometres

Note All values above, including the 2015 targets, have been revised to reflect the new emission factors and global warming potentials introduced by the IPCC in 2006. Historical values have been updated from previous reports.

a The 2011 freight emissions and emission factors were revised after a review of fuel consumption data by RAC members.

CACs emissions from all railway operations decreased, with NO_x emissions decreasing to 95.43 kt in 2013 compared to 99.22 kt in 2012. The total freight NO_x emissions intensity was 0.23 kg/1,000 revenue tonne kilometres (RTK) in 2013, compared to 0.25 kg/1,000 RTK in 2012 and down from 0.52 kg/1,000 RTK in 1990.

1 The CO_2 emission factor and the global warming potentials for CH_4 and N_2O were updated in the 2013 United Nations Framework Convention on Climate Change (UNFCCC) Reporting Guidelines that reflect the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines. These changes are documented in *Environment Canada's National Inventory Report 1990-2013: Greenhouse Gas Sources and Sinks in Canada*. All GHG emissions included in this report have been calculated based on these updated factors and potentials. Refer to Section 5 and Appendix F for the updated GHG potentials. GHG data in previous LEM reports were calculated on the previous global warming potentials and therefore should not be used.

Similar to previous years, Canadian railways invested heavily in fleet upgrades in 2013 with 10 Tier 3 high-horsepower locomotives added to the Class I Freight Line-haul fleet and 225 locomotives upgraded to Tier 0+, Tier 1+, or Tier 2+. Older and lower-horsepower locomotives continue to be retired, and in 2013, 94 medium-horsepower locomotives manufactured between 1973 and 1999 were taken out of active duty.

Overall, the Canadian fleet totalled 3,063 units in 2013, of which 2,293 locomotives were subject to United States Environmental Protection Agency (USEPA) emissions regulations. 1,631 (71.1 percent) of the locomotives subject to the USEPA emissions regulations achieved tier level standards. The number of locomotives equipped with Auxiliary Power Units (APUs) or Automatic Engine Stop-Start (AESS) systems to minimize unnecessary idling totalled 2,179 or 71.1 percent of the in-service fleet.

LEM 2013 Additional Key Findings

Railway Traffic

Freight Traffic

Gross Tonne-Kilometres (GTK): In 2013, the railways handled over 743.17 billion GTK of traffic compared to 722.35 billion GTK in 2012, an increase of 2.9 percent. GTK traffic is 63.4 percent higher than for 1990, the reference year, having increased by an average annual rate of 3.0 percent. Class I GTK traffic accounted for 93.6 percent of the total GTK hauled in 2013.

Revenue Tonne-Kilometres (RTK): In 2013, the railways handled 395.81 billion RTK of traffic compared to 380.87 billion RTK in 2012, an increase of 3.9 percent. RTK traffic is 58.2 percent higher than for 1990 having risen by an average annual rate of 2.9 percent. Of the freight RTK traffic handled in 2013, Class I freight railways were responsible for 93.9 percent of the total traffic.

Intermodal Traffic

Intermodal tonnage increased 5.1 percent to 35.26 million tonnes in 2013 from 33.53 million tonnes in 2012. Overall, intermodal tonnage comprising both container-on-flat-car and trailer-on-flat-car traffic has risen 175.7 percent since 1990, equating to an average annual growth of 7.6 percent. Class I railway intermodal traffic increased from 91.19 billion RTK in 2012 to 95.82 billion RTK in 2013, an increase of 5.1 percent. Of the total freight car loadings in 2013, intermodal dominated at 24.4 percent.

Passenger Traffic

Intercity passenger traffic in 2013 by all carriers totalled 4.19 million passengers compared to 4.25 million in 2012, a decrease of 1.4 percent. VIA Rail Canada transported 3.89 million passengers, which equates to 92.8 percent of the intercity traffic.

Commuter rail traffic increased from 70.03 million passengers in 2012 to 70.27 million in 2013, an increase of 0.3 percent. This is up from 41 million passengers in 1997, when the RAC first started collecting commuter statistics, an increase of 71.4 percent.

In 2013, ten RAC member railways reported Tourist and Excursion traffic totalling 213 thousand passengers, a decrease of 0.8 percent below the 214 thousand passengers transported in 2012.

Fuel Consumption Data

Fuel Consumption: Overall, the fuel consumed in railway operations in Canada decreased by 1.6 percent from 2,142.22 million litres in 2012 to 2,107.42 million litres in 2013.

Of the total fuel consumed by all railway operations, Class I freight train operations consumed 87.8 percent and Regional and Short Lines consumed 5.2 percent. Yard switching and work train operations consumed 2.5 percent, and passenger operations accounted for 4.6 percent.

For freight operations, the overall fuel consumption in 2013 was 2,010.39 million litres, 1.4 percent below the corresponding figure for 2012.

For total freight operations, fuel consumption per productivity unit (litres per 1,000 RTK) in 2013 was 5.08 litres per 1,000 RTK as compared to 5.35 litres per 1000 RTK in 2012, an improvement in efficiency of 5.1 percent. This is down from 8.40 litres per 1,000 RTK in 1990, an improvement of 39.5 percent.

For total passenger operations, the overall fuel consumption in 2013 was 97.03 million litres, 6.2 percent below the corresponding figure for 2012.

Diesel Fuel Properties: In 2013, the sulphur content of railway diesel fuel was 15 parts per million (ppm).

Locomotive Inventory

Locomotive Fleet: The number of diesel-powered locomotives and diesel mobile units (DMUs) in active service totalled 3,063 in 2013 versus 3,092 in 2012.

For freight operations, 2,569 locomotives are in service, of which 1,994 are on Class I Mainline, 296 are on Class I Road Switching service, 107 are owned by regional railways and 172 are owned by Short Lines. A further 263 are in Switching and Work Train operations, of which 178 are in Class I service and 85 in Regional and Short lines. A total of 231 locomotives and DMUs are in passenger operations, of which 79 are in VIA Rail Canada intercity services, 2 are in intercity-other services, 131 in Commuter, 15 in Tourist and Excursion services, and 4 in Passenger Switching operations.

Locomotives Compliant with USEPA Emission Limits: In 2013, 71.1 percent of the total fleet subject to USEPA regulations met the USEPA Tier 0, Tier 0+, Tier 1, Tier 1+, Tier 2, Tier 2+, and Tier 3 emissions standards. A total of 10 Tier 3 high-horsepower locomotives were added to the Class I line-haul fleet in 2013. A total of 94 medium-horsepower locomotives manufactured between 1973 and 1999 were retired.

Locomotives Equipped with Anti-Idling Devices: The number of locomotives in 2013 equipped with a device to minimize unnecessary idling, such as an AESS system or APU, increased to 2,179, which represents 71.1 percent of the fleet, compared with 2,111 in 2012.

Tropospheric Ozone Management Areas (TOMA): Of the total Canadian rail sector fuel consumed and corresponding GHGs emitted in 2013, 2.9 percent occurred in the Lower Fraser Valley of British Columbia, 14.1 percent in the Windsor-Québec City Corridor, and 0.2 percent in the Saint John area of New Brunswick. Similarly, NO_x emissions for the three TOMA were, respectively, 2.9 percent, 14.1 percent, and 0.2 percent.

Emissions Reduction Initiatives by Railways: Railways continue to implement a number of initiatives outlined in the *Locomotive Emissions Monitoring Program 2011–2015 Action Plan for Reducing GHG Emissions*. This action plan presents a variety of initiatives for railways, governments, and the RAC to implement in an effort to achieve the expected outcomes of the 2011–2015 MOU.

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1 Introduction/Background

This report contains the LEM data filing for 2013 in accordance with the terms of the MOU signed on April 30, 2013, between the RAC and TC concerning voluntary arrangements to limit GHGs and CACs emitted from locomotives operating in Canada. This MOU establishes a framework through which the RAC, its member companies (as listed in Appendix A), and TC will address emissions of GHGs and CACs from railway locomotives operating in Canada. The 2011–2015 MOU includes measures, targets, and actions that will further reduce GHG and CAC emission intensities from rail operations to help protect the health and environment for Canadians and address climate change. The 2011–2015 MOU is posted on the RAC website. This is the third report prepared under the MOU.

GHG Commitments:

As stated in the 2011–2015 MOU, the RAC will encourage all of its members to make every effort to reduce the GHG emission intensity from railway operations. The GHG emission targets for 2015 and the actual emissions from 2010 to 2013, expressed as kilograms (kg) of carbon dioxide equivalent ($CO_{2eq.}$) per productivity unit, for the rail industry are outlined in the following table[2]:

Railway Operation	Percent Reduction Target (by 2015)	2010	2011	2012	2013	2015 Target	Productivity Unit
Class I Freight	6% reduction from 2010	16.51	16.24[a]	15.88	15.03	15.52	kg $CO_{2eq.}$ per 1,000 revenue tonne kilometres
Intercity Passenger	6% reduction from 2010	0.12	0.12	0.11	0.10	0.12	kg $CO_{2eq.}$ per passenger kilometre
Regional & Short Lines	3% reduction from 2010	15.28	14.95	13.51	13.65	14.82	kg $CO_{2eq.}$ per 1,000 revenue tonne kilometres

Note All values above, including the 2015 targets, have been revised to reflect the new emission factors and global warming potentials introduced by the IPCC in 2006. Historical values have been updated from previous reports.

a The 2011 freight emissions and emission factors were revised after a review of fuel consumption data by RAC members.

2 The CO_2 emission factor and the global warming potentials for CH_4 and N_2O were updated in the 2013 United Nations Framework Convention on Climate Change (UNFCCC) Reporting Guidelines that reflect the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines. These changes are documented in *Environment Canada's National Inventory Report 1990–2013: Greenhouse Gas Sources and Sinks in Canada*. All GHG emissions included in this report have been calculated based on these updated factors and potentials. Refer to Section 5 and Appendix F for the updated GHG potentials. GHG data in previous LEM reports were calculated on the previous global warming potentials and therefore should not be used.

CAC Commitments:

As stated in the 2011-2015 MOU, until such time that new Canadian regulations to control CAC emissions are introduced, the RAC will encourage all of its members to conform to USEPA emission standards (Title 40 of the Code of Federal Regulations of the United States, Part 1033).

For the duration of the MOU, the RAC will encourage all members to:

- adopt operating practices aimed at reducing CAC emissions; and
- conform to appropriate CAC emission standards and/or Canadian Regulations for the duration of the 2011–2015 MOU.

Conversely, TC will undertake compliance promotion activities with affected stakeholders, including education and outreach related to the regulatory requirements.

In accordance with the RAC LEM protocol, annual data for this report was collected via a survey sent to each member railway of the RAC. An overview of the survey methodology is posted to the RAC website. Based on this data, the GHG and CAC emissions produced by in-service locomotives in Canada were calculated. The GHG emissions in this report are expressed as $CO_{2eq.}$, the constituents of which are CO_2, CH_4, and N_2O. CAC emissions include NO_x, PM, CO, HC, and SO_x. The SO_x emitted is a function of the sulphur content of the diesel fuel and is expressed as SO_2. The calculation methodology is available from the RAC website.

The report provides an overview of 2013 rail performance including traffic, fuel consumption, fleet inventory, and GHG and CAC emissions. Also included is a section on initiatives being taken or examined by the sector to reduce fuel consumption and, consequently, all emissions, particularly GHGs.

In addition, the report contains data on the fuel consumed and emissions produced by railways operating in three designated TOMA: the Lower Fraser Valley in British Columbia, the Windsor–Québec City Corridor, and the Saint John area in New Brunswick. Data for winter and summer operations have also been segregated.

For the most part, data and statistics by year for traffic, fuel consumption, and emissions are listed for the period starting with 2006. For historical comparison purposes, 1990 has been set as the reference year. LEM statistics from 1995 to present can be obtained from the RAC.

Unless otherwise specified, metric units are used and quantities are expressed to two significant figures, while percentages are expressed to one significant figure. To facilitate comparison with American railway operations, traffic, fuel consumption, and emissions data in US units have been posted on the RAC website.

2 Traffic Data

2.1 Freight Traffic Handled

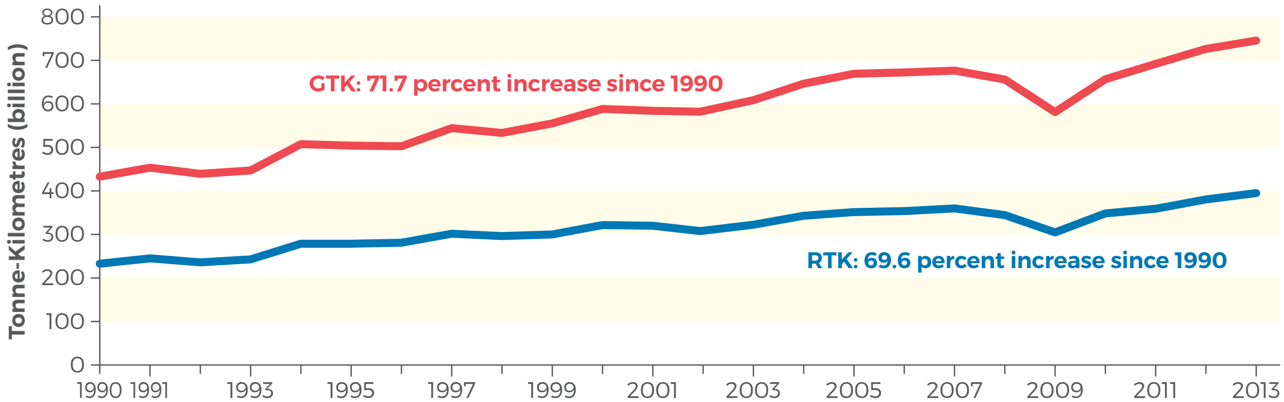
As shown in Table 1 and Figure 1, traffic in 2013 handled by Canadian railways totalled 743.17 billion gross tonne-kilometres (GTK) compared with 722.35 billion GTK in 2012, an increase of 2.9 percent, and 432.74 billion GTK for 1990 for an increase of 71.7 percent. Similarly, revenue traffic in 2013 increased to 395.81 billion revenue tonne-kilometres (RTK) from 380.87 billion RTK in 2012, and is up from 233.45 billion RTK in 1990—increases of 3.9 and 69.6 percent, respectively. Since 1990, the average annual growth was 3.0 percent for GTK and 2.9 percent for RTK.

Table 1. Total Freight Traffic in Tonne-kilometres (billion)

	1990	2006	2007	2008	2009	2010	2011	2012	2013
GTK									
Class I		629.93	638.66	621.90	549.17	620.16	644.75	674.62	695.58
Regional + Short Line		41.07	37.77	34.92[a]	30.82	32.47	44.94	47.74	47.59
Total	**432.74[a]**	**671.00**	**676.43**	**656.82**	**579.99**	**652.63**	**689.69**	**722.35**	**743.17**
RTK									
Class I		330.96	338.32	324.99	288.82	327.81	337.90	356.91	371.77
Regional + Short Line		24.87	23.30	21.46[a]	19.06	21.33	21.79	23.96	24.04
Total	**233.45[a]**	**355.83**	**361.62**	**346.46**	**307.88**	**349.14**	**359.69**	**380.87**	**395.81**
Ratio of RTK/GTK	**0.54**	**0.53**	**0.54**	**0.53**	**0.53**	**0.53[a]**	**0.52**	**0.53**	**0.53**

Note: No data is available separating Class I and Short Line traffic for the reference year, 1990.
a Corrected figure

Figure 1. Total Freight Traffic



In 2013, Class I GTK traffic increased by 3.1 percent to 695.58 billion from 674.62 billion in 2012 (Table 1), accounting for 93.6 percent of the total GTK hauled. Similarly, Class I RTK traffic increased 4.2 percent in 2013 to 371.77 billion from 356.91 billion in 2012, accounting for 93.9 percent of the total RTK. Of the total freight traffic, Regional and Short Lines were responsible for 47.59 billion GTK (or 6.4 percent) and 24.04 billion RTK (or 6.1 percent). In 2013, Regional and Short Lines traffic experienced a 0.4 percent increase in RTK compared to 2012.

2.1.1 Freight Carloads by Commodity Grouping

The total 2013 freight carloads for 11 commodity groups are shown in Figure 2 and Table 2 below.

Figure 2. Canadian Rail Originated Freight by Commodity Grouping

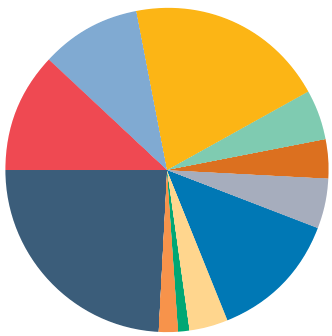


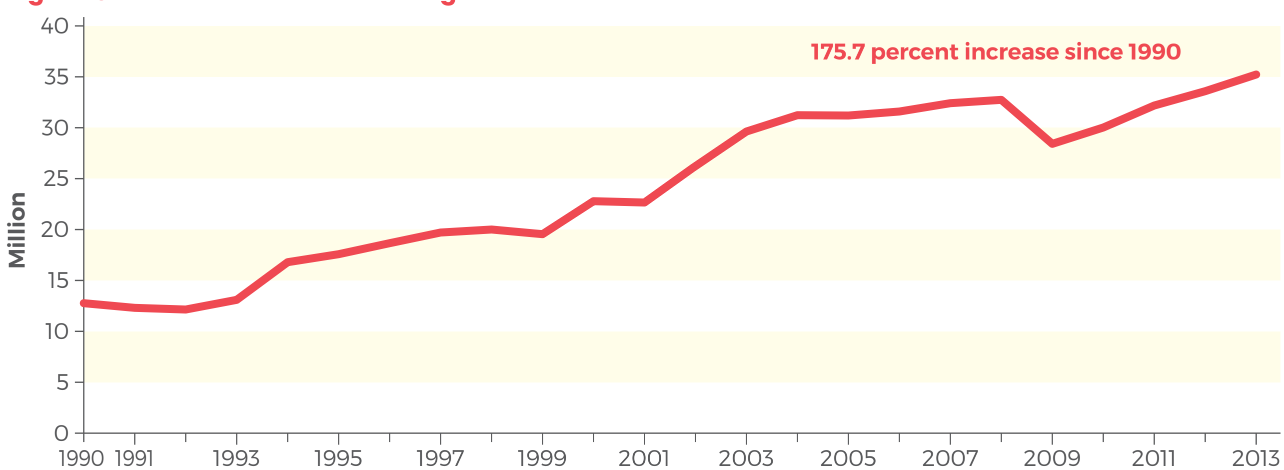
Table 2. Canadian Rail Originated Freight Carloads by Commodity Grouping

Agriculture	465,722
Coal	383,013
Minerals	806,193
Forest Products	212,839
Metals	150,401
Machinery & Automotive	199,068
Fuel & Chemicals	539,634
Paper Products	150,025
Food Products	56,405
Manufactured & Miscellaneous	97,081
Intermodal	987,186
Total	**4,047,566**

2.1.2 Class I Intermodal Traffic

Of the total freight carloads in 2013, intermodal led at 24.4 percent, as illustrated by Figure 2 and Table 2 above. The number of intermodal carloads handled by the Class I railways in Canada rose to 984,890 from 944,359 in 2012, an increase of 4.3 percent. Intermodal tonnage rose 5.1 percent to 35.26 million tonnes from 33.53 million tonnes in 2012. Overall since 1990, intermodal tonnage, comprising both container-on-flat-car and trailer-on-flat-car traffic, has risen 175.7 percent, equating to an average annual growth of 7.6 percent, as illustrated in Figure 3.

Figure 3. Class 1 Intermodal Tonnage



Class I intermodal RTK totalled 95.82 billion in 2013 versus 91.19 billion for 2012, an increase of 5.1 percent. Of the 371.77 billion RTK transported by the Class I railways in 2013, intermodal accounted for 25.8 percent.

Intermodal service growth is an indication that the Canadian railways have been effective in partnering with shippers and other elements of the transportation supply chain, such as trucking, to move more goods by rail.

2.2 Passenger Traffic Handled

2.2.1 Intercity Passenger Services

Intercity passenger traffic in 2013 totalled 4.19 million, as compared to 4.25 million in 2012, a drop of 1.4 percent. The carriers were VIA Rail Canada, CN / Algoma Central, Ontario Northland Railway, Amtrak, and Tshiuetin Rail Transportation. Of the total, 92.9 percent (3.89 million) was transported by VIA Rail Canada (Figure 4). This was a 0.8 percent decrease from the 3.92 million transported in 2012, and an increase of 12.4 percent from 3.46 million in 1990.

The total revenue passenger-kilometres (RPK) for intercity passenger traffic totalled 1,386 million. This is a decrease of 1.1 percent as compared to 1,401 million in 2012. RPK for VIA Rail Canada for 2013 were 1,339 million, versus 1,341 million for 2012, a decrease of 0.2 percent. This is up from 1,263 million in 1990, a rise of 6.1 percent (Figure 5).

Figure 4. VIA Rail Canada Passenger Traffic

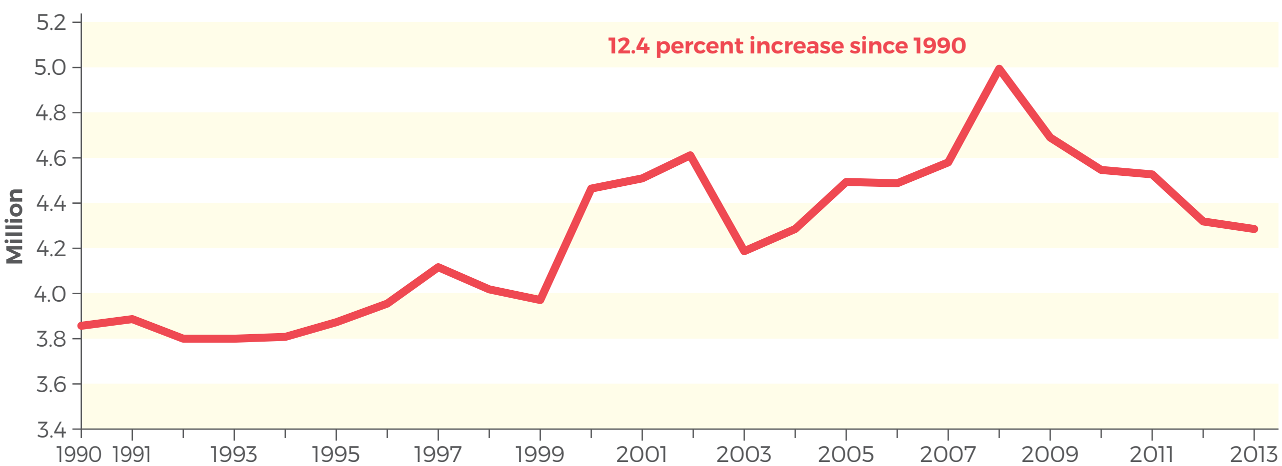
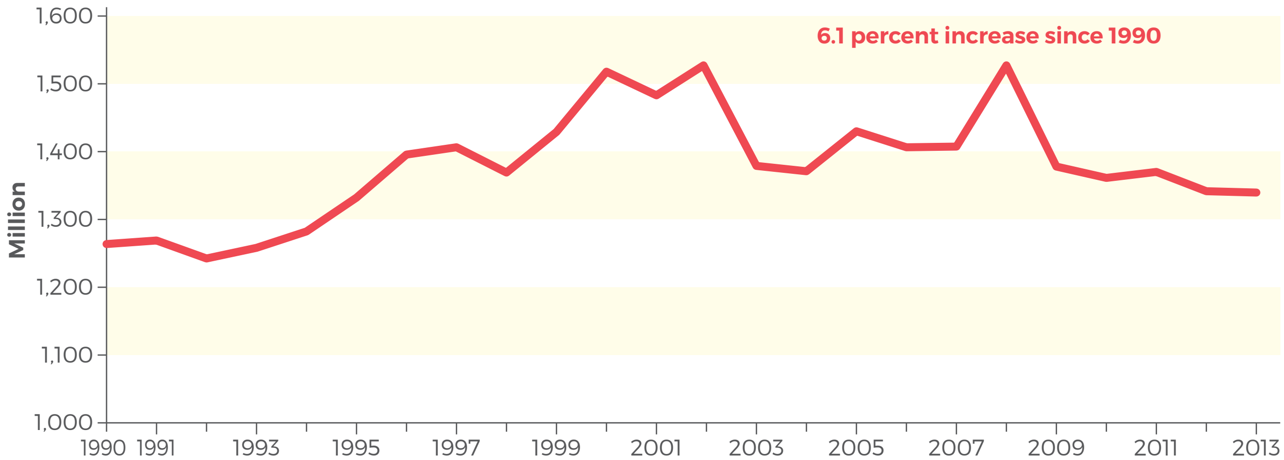
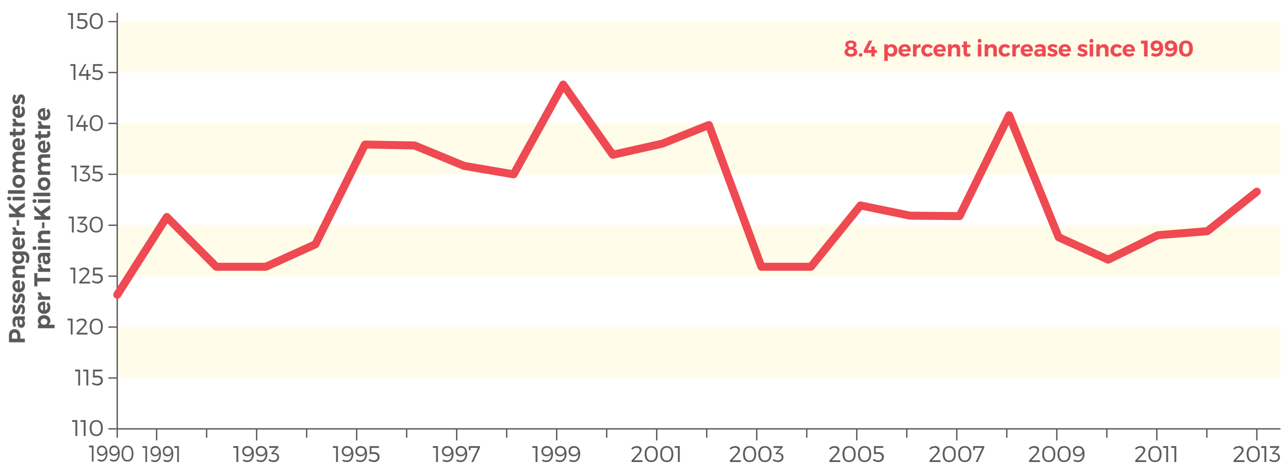


Figure 5. VIA Rail Canada Revenue Passenger-Kilometres



Intercity train efficiency is expressed in terms of average passenger-kilometres (km) per train-km. As shown in Figure 6, VIA's train efficiency was 133 passenger-km per train-km in 2013, 129 in 2012, and 123 in 1990. As a percentage, train efficiency in 2013 was 8.4 percent above that in 1990.

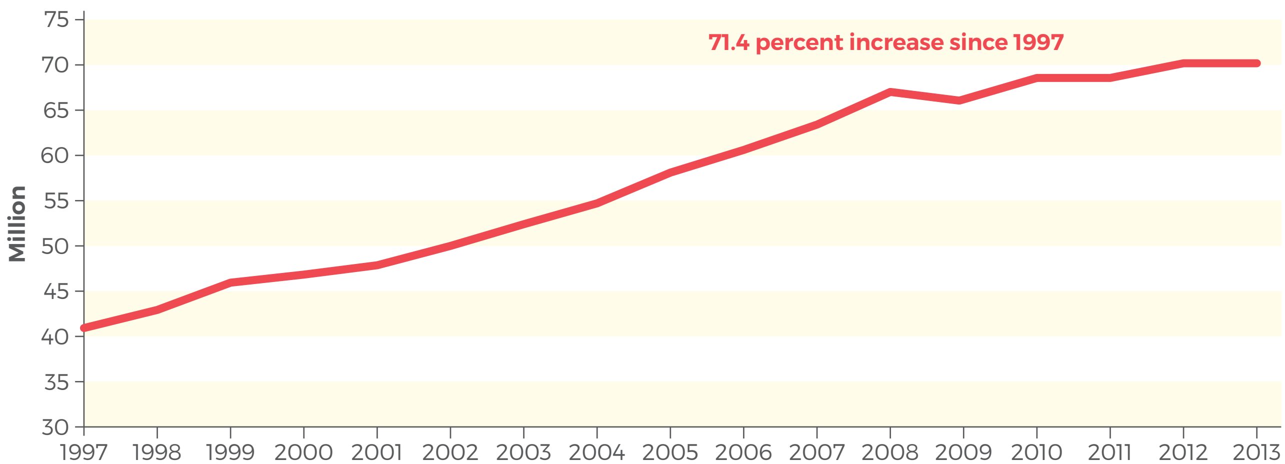
Figure 6. VIA rail Canada Train Efficiency



2.2.2 Commuter Rail

In 2013, commuter rail passengers totalled 70.27 million (Figure 7). This is up from 70.03 million in 2012, an increase of 0.3 percent. As shown in Figure 7, by 2013, commuter traffic has increased 71.4 percent since 1997 for an average annual growth rate of 4.5 percent. The four commuter operations in Canada using diesel locomotives are Agence métropolitaine de transport (serving the Montréal-centred region), Capital Railway (serving Ottawa), Metrolinx (serving the Greater Toronto Area), and West Coast Express (serving the Vancouver-Lower Fraser Valley region).

Figure 7. Commuter Rail Passenger



2.2.3 Tourist and Excursion Services

In 2013, the ten RAC member railways offering tourist and excursion services transported 213 thousand passengers compared to 214 thousand in 2012, a decrease of 0.8 percent. The railways reporting these services were Alberta Prairie Railway Excursions, Barrie-Collingwood Railway, CN/Algoma Central (which also operates a scheduled passenger service), CP/Royal Canadian Pacific, Great Canadian Railtour Company, Ontario Northland Railway (which also operates a scheduled passenger service), Prairie Dog Central Railway, South Simcoe Railway, Tshiuetin Rail Transportation (which also operates a scheduled passenger service), and Train Touristique Charlevoix.

3 Fuel Consumption Data

"In 2013, Canadian railways moved a tonne of freight over 198 kilometres on just one litre of fuel."[3]

As shown in Table 3, total rail sector fuel consumption decreased to 2,107.42 million litres in 2013 from 2,142.22 million litres in 2012 and increased from 2,063.55[4] million litres in 1990. As a percentage, fuel consumption in 2013 was 1.6 percent lower than in 2012 and 2.1 percent higher than the 1990 level. The lower fuel consumption in 2013 relative to 2012 reflects improvements made to the locomotive fleet, such as more fuel-efficient, high-horsepower locomotives and optimizing in-train locomotive power with traffic weight. Of the total fuel consumed by all railway operations, freight train operations consumed 92.9 percent, yard switching and work train operations consumed 2.5 percent, and passenger operations accounted for 4.6 percent. For total freight train operations, Class I railways accounted for 92.0 percent, Regional and Short Lines 5.4 percent, and yard switching and work trains 2.6 percent.

3 Rail Trends Database.

4 Total freight operations fuel consumption for 1990 was revised after a review of historical fuel consumption data for the 2012 LEM report.

Table 3. Canadian Rail Operations Fuel Consumption in Litres (million)

	1990	2006	2007	2008	2009	2010	2011	2012	2013
Class I	1,825.05	1,914.92	1,948.75	1,902.88[i]	1,626.47	1,791.11	1,816.44[e]	1,875.85	1,849.57
Regional and Short Line	n/a*	122.13	117.89	113.12[h]	90.01	107.88	107.78	107.08	108.58
Total Freight Train	**1825.05[b]**	**2,037.05**	**2,066.64**	**2,016.00[h]**	**1,716.48**	**1,898.99**	**1,924.22[e]**	**1,982.93**	**1,958.15**
Yard Switching	120.13	64.67	62.20	55.52[h]	40.73	35.70	45.15[e]	47.05	41.94
Work Train	15.67	7.49	6.09	7.60[h]	5.97	7.06	7.72[e]	8.77	10.30
Total Yard Switching and Work Train	**135.80[b]**	**72.16**	**68.29**	**63.13[h]**	**46.70**	**42.76**	**52.87[e]**	**55.81**	**52.24**
TOTAL FREIGHT OPERATIONS	**1,960.85[b]**	**2,109.21**	**2,134.92[a]**	**2,079.13[h]**	**1,763.18**	**1,941.76**	**1,977.09[e]**	**2,038.74**	**2,010.39**
VIA Rail Canada	n/a*	58.75[c]	58.97	59.70	57.43	52.16			
Intercity – Non-VIA Rail Canada	n/a*	5.50[f]	5.06[f]	4.57[f]	6.07[f]	5.93[f]			
Intercity – Total	n/a*	64.25	64.03	64.27	63.50	58.09	58.32	50.99	46.17
Commuter	n/a*	34.23	35.94	37.85[h]	42.68	46.92	49.81	50.22	48.61
Tourist Train & Excursion	n/a*	2.81[g]	2.33[g]	3.87[g]	1.82[g]	2.05[g]	2.19[g]	2.19[i]	2.25
Total Passenger Operations[d]	**102.70**	**101.29[c]**	**102.30**	**105.99[f]**	**108.00[i]**	**107.06**	**110.32**	**103.48**	**97.03**
TOTAL RAIL OPERATIONS	**2,063.55**	**2,210.50**	**2,237.24**	**2,185.12[h]**	**1,871.18[i]**	**2,048.82**	**2,087.41[e]**	**2,142.22**	**2,107.42**

a Total freight operations fuel consumption for 2007 was revised from 2,134.94 to 2,134.92 for 2012 LEM report.

b Total freight operations fuel consumption for 1990 was revised from 1,957.96 to 1,960.85 due to review of historical fuel consumption data for the 2012 LEM report.

c Corrected from 58.63 to 58.75 following an internal VIA audit in 2007 of its 2006 operations.

d Pre-2004 passenger fuel breakdown is not available.

e The 2011 Fuel consumption was revised as a result of a Class I change in methodology.

f The intercity passenger fuel consumption figures were revised. Prior to 2011, only VIA's fuel consumption was used to calculate the intercity passenger GHG emission intensity figure. The intercity target in the 2011-2015 MOU encompasses all intercity rail operators.

g The tourist train & excursion fuel consumption figures were revised. Prior to 2011, intercity rail operators that weren't VIA Rail or Amtrak were included in this category. These operators are now included in the Intercity – Total category.

h A revision of fuel consumption data led to changes in 2008 fuel consumption data for some short lines and commuter services.

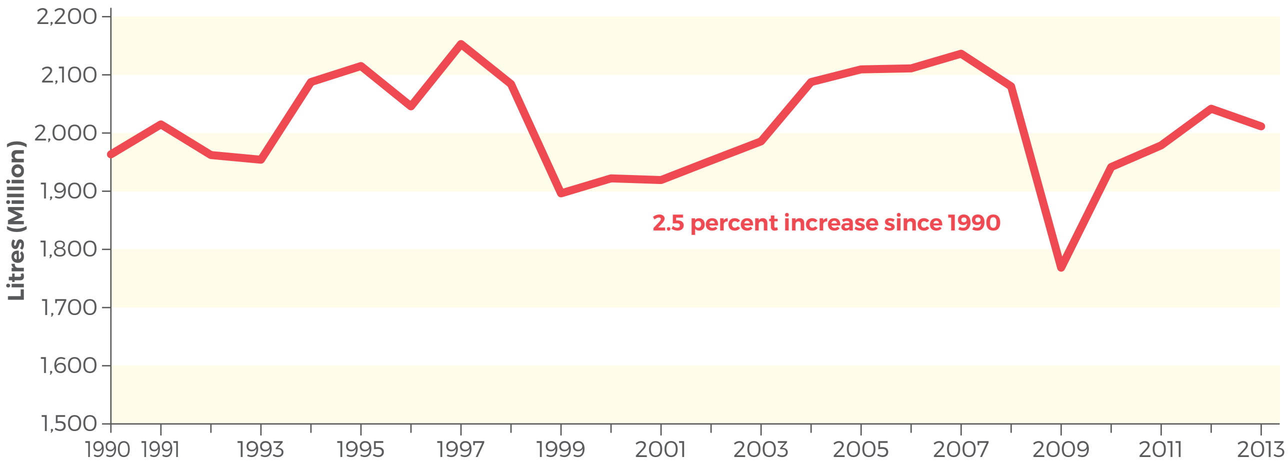
i Revised figure in the 2013 LEM Report

*n/a = not available

3.1 Freight Operations

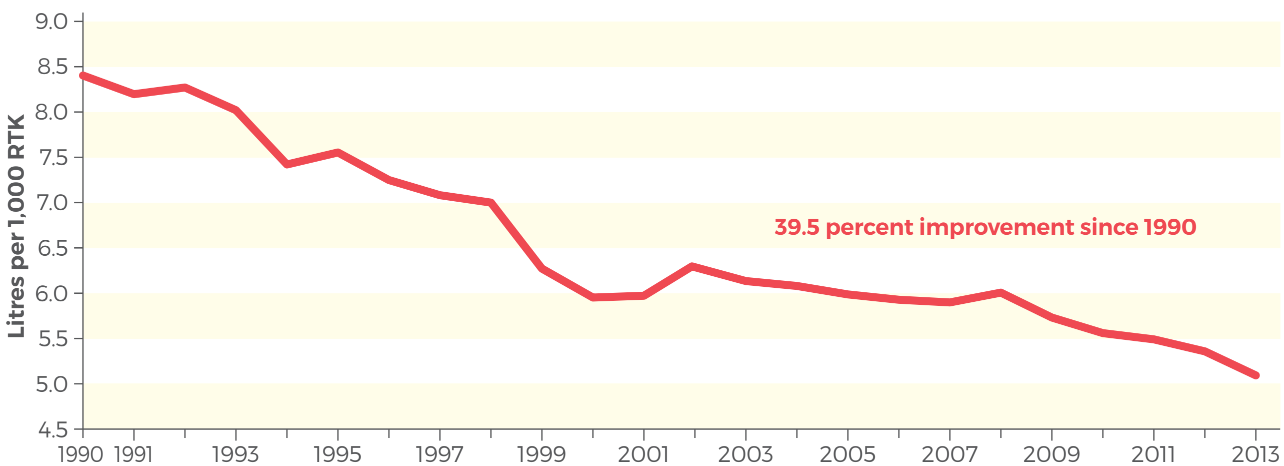
The volume of fuel consumption since 1990 in overall freight operations is shown in Figure 8. Fuel consumption in 2013 for all freight train, yard switching, and work train operations was 2,010.39 million litres, a decrease of 1.4 percent from the 2,038.74 million litres consumed in 2012 and an increase of 2.5 percent from the 1990 level of 1,960.85[5] million litres.

Figure 8. Freight Operations Fuel Consumption



A measure of freight traffic fuel efficiency is the amount of fuel consumed per 1,000 RTK. As shown in Figure 9, the value in 2013 for overall rail freight traffic was 5.08 litres per 1,000 RTK. Compared to 5.35 litres per 1,000 RTK in 2012, it is a 5.0 percent improvement, and is 39.5 percent below the 1990 level of 8.04[6] litres per 1,000 RTK. The improvement since 1990 shows the ability of the Canadian freight railways to accommodate traffic growth while reducing fuel consumption per unit of work by carefully matching locomotive power with train weight.

Figure 9. Freight Fuel Consumption per 1,000 RTK



Member railways have implemented many practices to improve fuel efficiency. Improved fuel efficiency has been achieved primarily by replacing older locomotives with modern, fuel-efficient, USEPA-compliant locomotives. Additionally, operating practices that reduce fuel consumption are being implemented, and new strategies are emerging to accommodate specific commodities and their respective weight and destination. Section 7 provides details on a number of initiatives

5 Total freight operations fuel consumption for 1990 was revised after a review of historical fuel consumption data for the 2012 LEM report.

implemented in 2013 to reduce their fuel consumption. A comprehensive list of emerging technologies and management options available to the railways can be viewed in the LEM 2011-2015 Action Plan for Reducing GHG Emissions available on the RAC's website.

3.2 Passenger Services

Overall rail passenger fuel consumption—that is the sum of intercity, commuter, and tourist and excursion train operations—was 97.03 million litres in 2013, down from 103.48 million litres in 2012, a decrease of 6.2 percent. The breakdown and comparison with previous years are shown on Table 3.

Intercity passenger's fuel consumption in 2013 decreased by 9.5 percent from that of 2012. Fuel consumption for commuter rail in 2013 decreased 3.2 percent over 2012. Finally, tourist rail excursion fuel consumption decreased by 1.2 percent from that of 2012.

3.3 Diesel Fuel Properties

Effective June 1, 2007, amendments to Environment Canada's *Sulphur in Diesel Fuel Regulations* came into force limiting the sulphur content of railway diesel fuel to 500 ppm (or 0.05 percent). A further reduction came into force June 1, 2013, limiting sulphur content in diesel fuel produced or imported for use in locomotives to 15 ppm (or 0.0015 percent)—referred to as ultra-low sulphur diesel (ULSD) fuel.

The RAC survey confirmed that in 2013 VIA Rail Canada and the commuter railways have standardized use of ULSD fuel, with an average sulphur content of 15 ppm, in their operations. The survey also showed that the majority of Canadian freight railways have standardized the use of ULSD fuel, and the weighted average sulphur content also 15 ppm. This is down from the average of 1,275 ppm in 2006, 500 ppm in 2007, and 40.1 ppm in 2012. The reduced sulphur content in 2013 resulted in a significant reduction in SO_2 emissions (see Section 5.2.2).

4 Locomotive Inventory

Table 4 presents an overview of the active fleet of diesel and non-diesel locomotives in Canada for freight and passenger railways. The detailed locomotive fleet inventory is presented in Appendix B.

Table 4. 2013 Canadian Locomotive Fleet Summary

Freight Operations	
Locomotives for Line Haul Freight	
Mainline	1,994
Regional	107
Short line	172
Locomotives for Freight Switching Operations	
Yard	263
Road Switching	296
Total – Freight Operations	**2,832**
Passenger Operations	
Passenger Train	224
DMUs	3
Yard Switching	4
Total – Passenger Operations	**231**
TOTAL – PASSENGER & FREIGHT OPERATIONS	**3,063**

4.1 Locomotives Compliant with United States Environmental Protection Agency Emissions Limits

The MOU indicates that RAC member railways are encouraged to conform to all applicable emission standards, which includes the current USEPA Tier standards that are listed in Appendix D.

The CAC and GHG emissions intensity for the Canadian fleet is projected to decrease as the railways continue to introduce new locomotives, retrofit high-horsepower and medium-horsepower in-service locomotives when remanufactured, and retire non-compliant locomotives.

Table 5 shows the total number of in-service locomotives meeting applicable standards compared to the total number of freight and passenger line-haul train locomotives. Excluded were steam locomotives, non-powered slug units, and Electrical Multiple Units (EMUs) as they do not contribute diesel combustion emissions.

Table 5. Locomotives in Canadian Fleet Meeting USEPA Emissions Limits

	2000	2006	2007	2008	2009	2010	2011	2012	2013
Total number of line-haul locomotives subject to regulation[a]	1,498	2,319	2,216	2,051	1,898	2,196	2,112	2,290	2,293
Total number of locomotives not subject to regulation[b]	1,578	680	811	772	829	752	866	802	770
Number of locomotives meeting USEPA emissions limits	80	914	1,023[c]	1,042	1,094	1,209	1,317	1,512	1,631

a Includes locomotives which are subject to Title 40 of the United States Code of Federal Regulations, part 1033, "Control of Emissions from Locomotives."

b Includes locomotives which are not subject to Title 40 of the United States Code of Federal Regulations, part 1033, "Control of Emissions from Locomotives."

c Corrected following RAC internal audit from 1,065 to 1,023

In 2013, 71.1 percent of the total line-haul fleet (1,631 locomotives) subject to USEPA regulations met the applicable emissions standards. The USEPA emission standards are phased in over time and are applicable only to "new" locomotives (i.e., originally manufactured and remanufactured locomotives). Locomotives manufactured prior to 1973 and that have not been upgraded and locomotives below 1,006 horsepower (hp) are not required to meet the USEPA emission standards. The remaining locomotive fleet is not required to meet the standards until the time of its next remanufacture. Table 6 provides an overview of the 2013 locomotive fleet and includes details about the number of locomotives meeting each tier level.

Table 6. 2013 Locomotive Fleet Breakdown By USEPA Tier Level

Not subject to regulation[a]	770
Subject to regulation — Non Tier-Level Locomotives	662
Tier 0	368
Tier 0+	408
Tier 1	56
Tier 1+	264
Tier 2	376
Tier 2+	65
Tier 3	94
TOTAL	**3,063**

a Includes locomotives which are not subject to the regulations because of exclusions. Regulations refer to Title 40 of the United States Code of Federal Regulations, part 1033, "Control of Emissions from Locomotives."

Table 7 provides a summary of the fleet changes by emissions tier level for the overall fleet with the Class I Freight Line-Haul fleet noted in parenthesis. As noted in Table 7, the reductions in overall fleet numbers are due to older locomotives being replaced with newer, more efficient locomotives.

In 2013, 10 Tier 3 high-horsepower locomotives were added to the Class I Freight Line-haul fleet; a total of 225 Class I Freight Line-haul locomotives were upgraded to Tier 0+, Tier 1+,Tier 2+; 80 medium-horsepower locomotives manufactured between 1973 and 1999 were retired from Class I; and 14 were retired from other operations.

The number of locomotives in 2013 equipped with a device to minimize unnecessary idling such as an Automatic Engine Stop-Start (AESS) system or Auxiliary Power Unit (APU) was 2,179, compared with 2,111 in 2012. This represents 71.1 percent of the total in-service fleet in 2013 versus 68.3 percent in 2012.

Table 7. Changes in Locomotive Fleet by Tier Level

	Added	Retired	Remanufactured	Locomotives with anti-idling devices
Not upgraded		88 (78)		628 (509)
Tier 0		4		258 (240)
Tier 0+			92 (92)	436 (436)
Tier 1				44 (35)
Tier 1+			57 (57)	264 (264)
Tier 2		2 (2)		390 (276)
Tier 2+			76 (76)	95 (95)
Tier 3	10 (10)			64 (64)
TOTAL	**10 (10)**	**94 (80)**	**225 (225)**	**2,179 (2,019)**

5 Locomotive Emissions

5.1 Emission Factors

Emission Factors for Greenhouse Gases

The emission factors (EFs) used to calculate the three GHGs emitted from diesel locomotive engines (i.e. CO_2, CH_4, and N_2O) are those used in Environment Canada's *National Inventory Report 1990–2013: Greenhouse Gas Sources and Sinks in Canada* submitted annually to the UNFCCC[6]. In 2015, the EFs used in the National Inventory Report were updated to incorporate new UNFCCC Reporting Guidelines that reflect the 2006 Guidelines for National Greenhouse Gas Inventories.

The EFs for GHGs can be found in Appendix F, "Conversion Factors Related to Railway Emissions." The $CO_{2eq.}$ EF used to calculate GHG emissions was 3.02155 kilograms per litre (kg/L). The CO_2 emission factor and global warming potentials for CH_4 and N_2O were updated in 2015 by Environment Canada (EC). These changes are documented in EC's National Inventory Report 1990–2013. As such, the $CO_{2eq.}$ EF was changed from 3.00715 kg/L to 3.02155 kg/L. For this report, all reported GHG emissions (1990–2013) have been updated to reflect the new emission factors and global warming potentials.

Emission Factors for Criteria Air Contaminant Emissions:

The methodology for calculating CAC emissions for the annual LEM Report has evolved since reporting began in 1995. For the 2008 LEM Report, new CAC EFs were established based on the amount of diesel fuel consumed, the USEPA EFs, and Canadian duty cycles. The duty cycle is an element of the daily locomotive utilization profile. It is determined by evaluating the time spent at each power notch level for a statistically significant sample of locomotives. The duty cycles for the different services as well as the year of update can be found on the RAC website. An explanation of the Locomotive Utilization Profile is provided in Appendix E.

New CAC EFs for 2013 have been calculated in grams per litre (g/L) of fuel consumed for NO_x, PM, CO, HC, and SO_x for each category of operation (i.e., freight, switch, and passenger operations). The methodology for these emission factors is posted on the RAC website.

6 *National Inventory Report 1990–2013: Greenhouse Gas Sources and Sinks in Canada*, Environment Canada, 2011. http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=A07097EF-8EE1-4FF0-9AFB-6C392078D1A9

The EFs to calculate emissions of SO_x (calculated as SO_2) are based on the sulphur content of the diesel fuel. As noted in Section 3.3 of this report, the new regulations in 2007 and 2013 have contributed to significant reductions in the sulphur content of railway diesel fuel in Canada.

The CAC EFs are listed in Table 8 for 1990 and 2006–2013. EFs for years prior to 2005 are posted on the RAC website.

Table 8. CAC Emissions Factors for Diesel Locomotives (g/L)

	Year	NO_x	PM	CO	HC	SO_2
Total Freight	2013	44.41	1.01	7.05	2.00	0.02
	2012	46.09	1.09	7.05	2.13	0.07
	2011	47.50[a]	1.15[a]	7.03[a]	2.21[a]	0.17[a]
	2010	49.23	1.23	7.06	2.38	0.21
	2009	50.41	1.31	7.07	2.47	0.18
	2008	51.19	1.38	7.32	2.74	0.24
	2007	52.74	1.44	7.35	2.79	0.82
	2006	55.39	1.50	6.98	2.53	2.10
	1990	71.44	1.59	7.03	2.64	2.47
Total Yard Switching	2013	68.79	1.50	7.35	4.01	0.02
	2012	69.19	1.52	7.35	4.03	0.07
	2011	69.64[a]	1.53[a]	7.35[a]	4.06[a]	0.17[a]
	2010	69.65	1.54	7.35	4.06	0.21
	2009	69.42	1.53	7.35	4.04	0.18
	2008	69.88	1.54	7.35	4.06	0.24
	2007	69.88	1.57	7.35	4.06	0.82
	2006	69.88	1.63	7.35	4.06	2.10
	1990	69.88	1.65	7.35	4.06	2.47
Total Passenger	2013	51.64	1.06	7.03	2.03	0.02
	2012	54.04	1.13	7.03	2.17	0.07
	2011	54.94	1.16	7.02	2.19	0.18
	2010	56.23	1.18	7.03	2.23	0.21
	2009	62.60	1.29	7.03	2.40	0.18
	2008	62.37	1.29	7.03	2.39	0.24
	2007	70.69	1.47	7.03	2.62	0.82
	2006	71.44	1.57	7.03	2.64	2.10
	1990	71.44	1.59	7.03	2.64	2.47

a The 2011 fuel consumption was revised as a result of a Class I change in methodology.

5.2 Emissions Generated

5.2.1 Greenhouse Gases

In 2013, GHG emissions produced by the railway sector (expressed as $CO_{2eq.}$) were 6,367.68 kt, a decrease of 1.6 percent compared to 6,472.83 kt in 2012. This is an increase of 2.1 percent as compared to 6,235.13 kt in 1990, with a corresponding rise in RTK traffic of 58.2 percent. The GHG emissions intensities for freight traffic decreased in 2013 to 15.35 kg per 1,000 RTK from 16.17 kg in 2012, and decreased from 25.38 kg in 1990. As a percentage, the 2013 GHG emissions intensity for total freight was 5.1 percent below the level for 2012 and 39.5 percent below that for 1990. Table 9 displays the GHG emissions produced in the reference year (1990) and annually since 2006 for railway operations. The GHG emissions for years prior to 2006 are posted on the RAC website.

Table 9[a]. 2013 GHG Emissions and Emission Intensities by Railway Service in Canada (in kilotonnes unless otherwise specified)

	1990	2006	2007	2008	2009	2010	2011[b]	2012	2013
Total Railway									
$CO_{2eq.}$	6,235.13[b]	6,679.14[b]	6,759.92	6,602.45[d]	5,653.87	6,190.60[b]	6,307.21[c]	6,472.83	6,367.68
CO_2	5,550.96[b]	5,946.25[b]	6,018.17	5,877.97[d]	5,033.48	5,511.32[b]	5,615.13[c]	5,762.58	5,668.97
CH_4	7.74[b]	8.29[b]	8.39	8.19[d]	7.02	7.68[b]	7.83[c]	8.03	7.90
N_2O	676.43[b]	724.60[b]	733.37	716.28[d]	613.37	671.60[b]	684.25[c]	702.22	690.81
Passenger - Intercity, Commuter, Tourist/Excursion									
$CO_{2eq.}$	310.31	306.05[b]	309.11	320.26	326.33	323.49[b]	333.34	312.67	293.18
CO_2	276.26	272.47[b]	275.19	285.12	290.52	287.99[b]	296.76	278.36	261.01
CH_4	0.39	0.38[b]	0.38	0.40	0.40	0.40[b]	0.41	0.39	0.36
N_2O	33.67	33.20[b]	33.53	34.74	35.40	35.09[b]	36.16	33.92	31.81
Freight-Line Haul									
$CO_{2eq.}$	5,514.47[b]	6,155.05	6,244.47	6,091.45[d]	5,186.42	5,737.90	5,814.13[c]	5,991.52	5,916.64
CO_2	4,909.37[b]	5,479.66	5,559.27	5,423.04[d]	4,617.33	5,108.29	5,176.16[c]	5,334.08	5,267.42
CH_4	6.84[b]	7.64	7.75	7.56[d]	6.44	7.12	7.22[c]	7.44	7.34
N_2O	598.25[b]	667.74	677.45	660.85[d]	562.66	622.49	630.76[c]	650.00	641.88
Yard Switching and Work Train									
$CO_{2eq.}$	410.35[b]	218.04	206.35	190.74[d]	141.12	129.21	159.74[c]	168.64[d]	157.86
CO_2	365.32[b]	194.12	183.71	169.81[d]	125.63	115.04	142.21[c]	150.14[d]	140.53
CH_4	0.51[b]	0.27	0.26	0.24[d]	0.18	0.16	0.20[c]	0.21[d]	0.20
N_2O	44.52[b]	23.65	22.39	20.69[d]	15.31	14.02	17.33[c]	18.30[d]	17.13
Total Freight Operations									
$CO_{2eq.}$	5,924.81[b]	6,373.09	6,450.82	6,282.19[d]	5,327.54	5,867.12	5,973.87[c]	6,160.16	6,074.50
CO_2	5,274.69[b]	5,673.78	5,742.98	5,592.86[d]	4,742.96	5,223.33	5,318.37[c]	5,484.21	5,407.95
CH_4	7.35[b]	7.91	8.01	7.80[d]	6.61	7.28	7.41[c]	7.65	7.54
N_2O	642.77[b]	691.40	699.83	681.54[d]	577.97	636.51	648.09[c]	668.30	659.01

Table 9[a]. 2013 GHG Emissions and Emission Intensities by Railway Service in Canada (in kilotonnes unless otherwise specified) *(continued)*

	1990	2006	2007	2008	2009	2010	2011[b]	2012	2013
Emissions Intensity – Total Freight (kg/1,000 RTK)									
$CO_{2eq.}$	25.38[b]	17.91	17.84	18.14[d]	17.30	16.80	16.61[c]	16.17	15.35
CO_2	22.59[b]	15.95	15.88	16.14[d]	15.41	14.96	14.79[c]	14.40	13.66
CH_4	0.03[b]	0.02	0.02	0.02[d]	0.02	0.02	0.02[c]	0.02	0.02
N_2O	2.75[b]	1.94	1.94	1.97[d]	1.88	1.82	1.80[c]	1.75	1.66
Emissions Intensity – Class I Freight Line-Haul (kg/1,000 RTK)									
$CO_{2eq.}$	n/a*	17.48	17.40	17.69	17.02	16.51	16.24[c]	15.88	15.03
Emissions Intensity – Regional and Short Line Freight (kg/1,000 RTK)									
$CO_{2eq.}$	n/a*	14.84	15.29	15.92[d]	14.27	15.28	14.95	13.51	13.65
Emissions Intensity – Intercity Passenger (kg/Passenger-km)									
$CO_{2eq.}$	n/a*	0.13	0.13	0.12	0.13	0.12	0.12	0.11	0.10
Emissions Intensity – Commuter Rail (kg/Passenger)									
$CO_{2eq.}$	n/a*	1.71	1.71	1.71[d]	1.96	2.07	2.20	2.17	2.09

*n/a = indicates not available

a The 2013 values in the table have been calculated, and historical values revised, based on the new emission factors and global warming potentials.

b Indicates values revised in 2013 LEM report based on review of historical consumption data

c The 2011 freight emissions and emission factors were revised after a review of fuel consumption data by RAC members

d A revision of operational data led to changes for some short lines and commuter members.

The 2011–2015 MOU sets out targets to be achieved by 2015. In relation to the 2015 targets, Table 10 shows the GHG emissions intensity levels for Class I freight, Intercity passenger, and Regional and Short Lines for 2013.

Table 10[a]. GHG Emissions Intensities by Category of Operation

Railway Operation	Units	2010	2011	2012	2013	MOU 2015 Target
Class I Freight	kg $CO_{2eq.}$/1,000 RTK	16.51	16.24[b]	15.88	15.03	15.52
Intercity Passenger	kg $CO_{2eq.}$/passenger-km	0.12	0.12	0.11	0.10	0.12
Regional and Short Lines	kg $CO_{2eq.}$/1,000 RTK	15.28	14.95	13.51	13.65	14.82

a All values above, including the 2015 targets, have been calculated based on the new emission factors and global warming potentials. Historical values have been updated from previous reports.

b The 2011 emission factor was revised after a review of fuel consumption data by RAC members.

In 2013, the Class I freight railways were able to re-match locomotive power with the increase in freight traffic, resulting in a decrease of 5.3 percent in GHG emission intensity from 2012.

Intercity Passenger operations successfully matched locomotive power with fluctuating traffic levels, reducing their GHG intensity by 8.4 percent compared to 2012. As previously stated, commuter railways do not have a target under the MOU.

Regional and Short Lines were not able to re-match locomotive power with freight traffic as successfully in 2013, resulting in a 1.0 percent increase in the GHG intensity relative to 2012.

5.2.2 Criteria Air Contaminants

Table 11 displays the CAC emissions produced annually by locomotives in operation in Canada for the reference year (1990) and annually from 2006 to 2013. The values present are for both absolute amounts and intensities per productivity unit. The emissions and intensities for years previous to 2006 are available on the RAC website.

The CAC of key concern for the railway sector is NO_x. As shown in Table 11, the Canadian railway-generated NO_x emissions in 2013 totalled 95.43 kt. Freight operations accounted for 94.9 percent of railway-generated NO_x emissions in Canada.

The Total Freight NO_x emissions intensity (i.e., the quantity of NO_x emitted per unit of productivity) was 0.23 kg per 1,000 RTK in 2013. This was 7.0 percent lower than the 2012 figure (0.25 kg per 1,000 RTK) and is down from 0.52 kg per 1,000 RTK in 1990, a 56.1 percent reduction.

Table 11. Locomotive CAC Emissions in kilotonnes, unless otherwise noted

Operation	Year	NO_x	PM	CO	HC	SO_2 (tonnes)
Total Freight	2013	86.96	1.98	13.81	3.91	48.26
	2012	89.88	2.13	13.59	4.18	126.97
	2011	91.40[a]	2.22[a]	13.52[a]	4.26[a]	336.10[a]
	2010	93.49	2.34	13.40	4.52	403.08
	2009	86.52	2.25	12.13	4.24	310.67
	2008	103.15	2.78	14.76	5.51	487.40
	2007	109.00	2.97	15.20	5.76	1,700.23
	2006	112.83	3.06	14.22	5.15	4,273.51
	1990	130.38	2.91	12.84	4.81	4,504.32
Total Yard Switching	2013	3.59	0.08	0.38	0.21	1.29
	2012	3.86	0.08	0.41	0.22	3.68
	2011	3.68[a]	0.08[a]	0.39[a]	0.21[a]	7.67[a]
	2010	2.98	0.07	0.31	0.17	9.08
	2009	3.24	0.07	0.34	0.19	8.45
	2008	4.39	0.10	0.46	0.26	15.21
	2007	4.77	0.11	0.50	0.28	56.18
	2006	5.04	0.12	0.53	0.29	151.38
	1990	9.49	0.22	1.00	0.55	335.18
Total Passenger[(1)]	2013	4.88	0.10	0.67	0.19	2.36
	2012	5.51	0.12	0.72	0.22	6.72
	2011	5.98	0.13	0.76	0.24	19.12
	2010	5.94	0.12	0.74	0.24	22.43
	2009	6.65	0.14	0.75	0.25	19.24
	2008	6.56	0.14	0.74	0.25	25.45
	2007	7.19	0.15	0.72	0.27	83.64
	2006	7.18	0.16	0.71	0.27	210.90
	1990	7.35	0.16	0.72	0.27	253.80

Table 11. Locomotive CAC Emissions in kilotonnes, unless otherwise noted *(continued)*

Operation	Year	NO_x	PM	CO	HC	SO_2 (tonnes)
Total Freight Operations[(2)]	2013	90.55	2.06	14.19	4.12	49.55
	2012	93.71	2.22	14.00	4.40	130.57
	2011	95.08[a]	2.30[a]	13.91[a]	4.47[a]	343.78[a]
	2010	96.47	2.40	13.27	4.69	412.15
	2009	89.76	2.32	12.47	4.43	315.85
	2008	107.54	2.88	15.22	5.77	502.60
	2007	113.78	3.08	15.70	6.03	1,756.41
	2006	117.88	3.18	14.75	5.44	4,424.89
	1990	139.87	3.13	13.84	5.36	4,839.50
Total Railway Operations[(3)]	2013	95.43	2.16	14.86	4.31	51.91
	2012	99.22	2.33	14.71	4.62	137.28
	2011	101.06[a]	2.43[a]	14.67[a]	4.71[a]	363.16[a]
	2010	102.41	2.53	14.46	4.92	434.58
	2009	96.41	2.46	13.22	4.68	338.36
	2008	114.10	3.01	15.96	6.02	528.05
	2007	120.96	3.23	16.41	6.30	1,840.05
	2006	125.06	3.34	15.46	5.71	4,635.79
	1990	147.21	3.30	14.56	5.64	5,093.30
Total Freight Emissions Intensity (kg/1000 RTK)	2013	0.23	0.01	0.04	0.01	0.00
	2012	0.25	0.01	0.04	0.01	0.00
	2011	0.26[a]	0.01[a]	0.04[a]	0.01[a]	0.00[a]
	2010	0.28	0.01	0.04	0.01	0.00
	2009	0.29	0.01	0.04	0.01	0.00
	2008	0.31	0.01	0.04	0.02	0.00
	2007	0.31	0.01	0.04	0.02	0.00
	2006	0.33	0.01	0.04	0.02	0.01
	1990	0.52	0.01	0.05	0.02	0.02

(1) Passenger data does not take into account Amtrak due to the definition of active locomotive fleet used to calculate CAC emissions.
(2) Freight Operations = Freight + Yard Switching
(3) Total Railway Operations = Freight + Yard Switching + Passenger
a 2011 freight CAC emissions and emission intensity were revised after a review of fuel consumption data by RAC members.

6 Tropospheric Ozone Management Areas

6.1 Data Derivation

The TOMA relate to air quality for the Lower Fraser Valley in British Columbia, the Windsor-Québec City Corridor, and the Saint John area in New Brunswick:

TOMA No. 1: The Lower Fraser Valley in British Columbia represents a 16,800-km^2 area in the southwestern corner of the province averaging 80 km in width and extending 200 km up the Fraser River Valley from the mouth of the river in the Strait of Georgia to Boothroyd, British Columbia. Its southern boundary is the Canada/United States (US) international boundary, and it includes the Greater Vancouver Regional District.

TOMA No. 2: The Windsor-Québec City Corridor in Ontario and Québec represents a 157,000-km^2 area consisting of a strip of land 1,100 km long and averaging 140 km in width stretching from the City of Windsor (adjacent to Detroit in the US) in Ontario to Québec City. The Windsor-Québec City Corridor TOMA is located along the north shore of the Great Lakes and the St. Lawrence River in Ontario and straddles the St. Lawrence River from the Ontario/Québec border to Québec City. It includes the urban centres of Windsor, London, Hamilton, Toronto, Ottawa, Montréal, Trois-Rivières, and Québec City.

TOMA No. 3: The Saint John TOMA is represented by the two counties in southern New Brunswick—Saint John County and Kings County. The area covers 4,944.67 km^2.

Fuel Consumption and Emissions

The fuel consumption in each TOMA region is derived from the total traffic in the area as provided by the railways. Table 12 shows the fuel consumption and the GHG emissions in the TOMA regions as a percentage of the total fuel consumption for all rail operations in Canada. Table 13 shows NO_x emissions in the TOMA regions as a percentage of the total NO_x emissions for all rail operations.

Table 12. TOMA Percentages of Total Fuel Consumption and GHG Emissions

	1999	2006	2007	2008	2009	2010	2011	2012	2013
Lower Fraser Valley, B.C.	4.2	2.8	3.0	2.8	3.0	3.1	3.0	2.8	2.9
Windsor-Québec City Corridor	17.1	16.8	17.4	17.1	15.7	15.3	14.8	14.2	14.1
Saint John, N.B.	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 13. TOMA Percentages of Total NO_x Emissions*

	1999	2006	2007	2008	2009	2010	2011	2012	2013
Lower Fraser Valley, B.C.	4.4	2.8	2.9	2.8	2.9	3.1	3.0	3.1	2.9
Windsor-Québec City Corridor	17.8	17.4	16.6	16.8	15.1	15.3	14.8	15.7	14.1
Saint John, N.B.	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2

* 2009–2013 values are the only values that were updated using the revised CAC EFs implemented in the 2009 LEM Report due to the CAC emission factor review as referenced in Section 5.1.

The CAC and GHG emission factors and emissions for the TOMA regions were calculated based on the total fuel usage for each region. The CAC emission factors reflect a weighted average of the Freight, Switch, and Passenger EFs presented in Section 5.1, and Passenger and Freight fuel usage. Since the Freight fuel usage includes both the Freight Train fuel usage and the Switching fuel usage, the percentage of fuel allocated for these TOMA regions to Switching was based on the percentage of fuel used Canada-wide. The emissions for each CAC were then calculated by multiplying the EFs by the fuel usage for each TOMA region.

6.2 Seasonal Data

The emissions in each TOMA have been split according to two seasonal periods:

- Winter (seven months) January to April and October to December, inclusively; and
- Summer (five months) May to September, inclusively

The division of traffic in the TOMA region in the seasonal periods was taken as equivalent to that on the whole system for each railway. The fuel consumption in each of the TOMA was divided by the proportion derived for the traffic on each railway. The 2013 traffic, fuel consumption, and emissions data in the seasonal periods for each railway are summarized in Tables 14 to 16.

Table 14. TOMA No. 1 Lower Fraser Valley, B.C.
Traffic, Fuel and Emissions Data

		Seasonal Split	
	Total 100%	Winter 58%	Summer 42%
TRAFFIC		**Million GTK**	
CN	8,829	5,121	3,708
CP	11,987	6,953	5,035
Southern Rail of BC	308	178	129
TOTAL FREIGHT TRAFFIC	**21,124**	**12,252**	**8,872**
FUEL CONSUMPTION		**Million Litres**	
Freight operations			
Freight Fuel Rate (L/1,000 GTK) = 2.71[1]			
Total Freight Fuel Consumption	**57.14**	**33.14**	**24.00**
Passenger Fuel Consumption			
VIA Rail Canada	0.40	0.23	0.17
Great Canadian Railtours	2.05	1.19	0.86
West Coast Express	1.30	0.75	0.54
Total Passenger Fuel Consumption	**3.74**	**2.17**	**1.57**
TOTAL RAIL FUEL CONSUMPTION	**60.89**	**35.31**	**25.57**
EMISSIONS		**Kilotonnes/Year**	
Emission Factors (g/L)[2]			
NO_x: 45.31	2.76	1.60	1.16
PM: 1.03	0.06	0.04	0.03
CO: 7.06	0.43	0.25	0.18
HC: 2.05	0.12	0.07	0.05
SO_2: 0.02	0.00	0.00	0.00
CO_2: 2,690.00[3]	163.79	95.00	68.79
CH_4: 3.75[3]	0.23	0.13	0.10
N_2O: 327.8[3]	19.96	11.58	8.38
$CO_{2eq.}$: 3,021.55[3]	183.97	106.70	77.27

(1) Freight fuel rate has been calculated by dividing the total Canadian freight fuel usage (see Table 3) by the total Canadian freight GTK (see Table 1).

(2) The emission factor used in the emissions calculations is a weighted average of the overall Freight, Switching, and Passenger emissions factor based on the quantity of Freight and Passenger fuel used.

(3) The emission factors for each GHG include their respective global warming potential factor.

Table 15. TOMA No. 2 Windsor-Québec City Corridor Traffic, Fuel and Emissions Data

		Seasonal Split	
	Total 100%	Winter 58%	Summer 42%
TRAFFIC		**Million GTK**	
CN	51,242	29,720	21,522
CP	28,056	16,272	11,783
Essex Terminals	37	21	15
Goderich & Exeter	400	232	168
Norfolk Southern	2	1	1
Ottawa Valley Railway[1]	0	0	0
Québec Gatineau	863	500	362
Southern Ontario	229	133	96
St-Lawrence & Atlantic (Canada)	322	187	135
TOTAL FREIGHT TRAFFIC	**81,151**	**47,067**	**34,083**
FUEL CONSUMPTION		**Million Litres**	
Freight operations			
Freight Fuel Rate (L/1,000 GTK) = 2.71[2]			
Total Freight Fuel Consumption	**219.53**	**127.32**	**92.20**
Passenger Fuel Consumption			
VIA Rail Canada	30.59	17.74	12.85
Commuter Rail	47.32	27.44	19.87
Total Passenger Fuel Consumption	**77.91**	**45.19**	**32.72**
TOTAL RAIL FUEL CONSUMPTION	**297.43**	**172.51**	**124.92**
EMISSIONS		**Kilotonnes/Year**	
Emission Factors (g/L)[3]			
NO_x: 45.31	13.48	7.82	5.66
PM: 1.03	0.31	0.18	0.13
CO: 7.06	2.10	1.22	0.88
HC: 2.05	0.61	0.35	0.26
SO_2: 0.02	0.01	0.00	0.00
CO_2: 2,690.00[4]	800.10	464.06	336.04
CH_4: 3.75[4]	1.12	0.65	0.47
N_2O: 327.80[4]	97.50	56.55	40.95
$CO_{2eq.}$: 3,021.55[4]	898.71	521.25	377.46

(1) Ottawa Valley Railway data are included in CP data.

(2) Freight fuel rate has been calculated by dividing the total Canadian freight fuel usage (see Table 3) by the total Canadian freight GTK (see Table 1).

(3) The emission factor used in the emissions calculations is a weighted average of the overall Freight, Switching, and Passenger emissions factor based on the quantity of Freight and Passenger fuel used.

(4) The emission factors for each GHG include their respective global warming potential factor.

Table 16. TOMA No. 3 Saint John Area, New Brunswick Traffic, Fuel and Emissions Data

	Total 100%	Seasonal Split Winter 58%	Summer 42%
TRAFFIC		Million GTK	
CN	963	559	404
New Brunswick Southern Railway	745	432	313
Total Freight Traffic	**1,708**	**991**	**717**
FUEL CONSUMPTION		Million Litres	
Freight Operations			
Freight Fuel Rate (L/1,000 GTK) = 2.71[(1)]			
Total Freight Fuel Consumption	**4.62**	**2.68**	**1.94**
Passenger Fuel Consumption			
Total Passenger Fuel Consumption	**0.00**	**0.00**	**0.00**
Total Rail Fuel Consumption	**4.62**	**2.68**	**1.94**
EMISSIONS		Kilotonnes/Year	
Emission Factors (g/L)[(2)]			
NO_x: 45.31	0.21	0.12	0.09
PM: 1.03	0.00	0.00	0.00
CO: 7.06	0.03	0.02	0.01
HC: 2.05	0.01	0.01	0.00
SO_2: 0.02	0.00	0.00	0.00
CO_2: 2,690.00[(3)]	12.43	7.21	5.22
CH_4: 3.75[(3)]	0.02	0.01	0.01
N_2O: 327.80[(3)]	1.51	0.88	0.64
$CO_{2eq.}$: 3,021.55[(3)]	13.96	8.10	5.86

(1) Freight fuel rate has been calculated by dividing the total Canadian freight fuel usage (see Table 3) by the total Canadian freight GTK (see Table 1).

(2) The emission factor used in the emissions calculations is a weighted average of the overall Freight, Switching, and Passenger emissions factor based on the quantity of Freight and Passenger fuel used.

(3) The emission factors for each GHG include their respective global warming potential factor.

7 Emissions Reduction Initiatives

There are multiple approaches for achieving the emission reduction targets outlined in the MOU, with railways and governments playing a critical role in reducing emissions and achieving expected results.

Investments in new technologies, management strategies focused on fuel economy and fluidity training, and research and development programs are effective methods for reducing emissions. The *Locomotive Emissions Monitoring Program 2011–2015 Action Plan for Reducing GHG Emissions* presents a roadmap for railways to reduce their emissions. It includes a comprehensive list of emerging technologies and novel management strategies to be implemented by the railway sector, as appropriate.

Below is a short summary of a few initiatives undertaken by railways and government in 2013 to reduce emissions.

GO Transit — Energy efficiencies

In 2013 the railway undertook a number of initiatives to improve its fuel economy and as a result lower its emissions. This included the successful procurement of 10 Tier 3 MP40 locomotives and 10 Tier 4 MP40 locomotives for future use, as well as the conversion of all Tier 2 MP40 locomotives to Tier 4 locomotives. Moreover the railway initiated a study to explore the possibilities of electrification across its commuter rail system, and continued its efforts to develop a system to monitor and report on excessive locomotive idling.

CN — Fuel efficiency technologies and HPTA (Horse Power Tonnage Analyzer)

CN maintains a longstanding commitment to reducing its emissions by investing in innovative fuel efficiency technologies such as Trip Optimizer and Wi-tronix®. Trip Optimizer works like an advanced "auto-pilot" for locomotives. It calculates the locomotive's ideal speed to minimize braking and increase fuel efficiency.

Wi-Tronix® is a real-time wireless data acquisition system that collects operational and performance data on locomotives as they operate, and distributes this information to a central location where real-time decisions and data analysis can be completed to assess a train's operations and fuel efficiency. This technology's data feeds CN's HPTA (Horse Power Tonnage Analyzer) system which works to optimize a locomotive's horsepower to tonnage ratio. For example, if a train is overpowered, the crew would receive instructions to shut down one of the units or reduce the notch at which it is operating so that it can conserve fuel and as a result produce fewer emissions.

By the end of 2013, CN had 240 locomotives equipped with Trip Optimizer and 1180 locomotives equipped with Wi-Tronix®.

CP — Energy efficiencies

As part of its $1.2 billion capital expenditure program for 2013, CP focused on identifying and implementing operational enhancements to improve network velocity and fuel efficiency. The company invested in longer sidings across its network, of which many were completed in the later part of the year, with additional sidings scheduled for completion in 2014. The investments enabled the railway to improve train length, weight, velocity and productivity over a long-term period, improving fuel economy by 8% over the previous year.

Canada-US Regulatory Cooperation Council

In 2013, work continued under the Canada-U.S. Regulatory Cooperation Council (RCC) Locomotive Emissions Initiative — an initiative for Canada and the U.S. to work together to reduce emissions produced by locomotives. A number of stakeholders meetings were held in 2013 to discuss the path forward for this initiative. It was agreed that a Canada-U.S. voluntary Action Plan would be developed with a goal of creating a framework for actions and measures to reduce GHG emissions from the rail sector. A Steering Committee was formed, consisting of representatives from Transport Canada, the U.S. Environmental Protection Agency, the Railway Association of Canada, and the Association of American Railroads, to develop recommendations on the approach to, and content for, the voluntary Action Plan.

Transport Canada — Clean Rail Academic Grant Program

Transport Canada launched the 2013–2014 Clean Rail Academic Grant Program as part of the Government of Canada's efforts to reduce rail sector emissions and support research of new and emerging technologies. The program provides grants of $25,000 to existing academic research programs that are developing emission reduction technologies and practices for the transportation sector that could be applied to the rail industry. As part of the Clean Rail Academic Grant Program ten rail-related research and development (R&D) projects were awarded in 2013-2014 with topics including lightweighting, alternative fuels, aerodynamics, electrical energy storage, friction reduction, operational change, and computer simulation. Other rail R&D projects funded by Transport Canada during this period included such subjects as the development of a renewable diesel fuel, lightweight biomaterials and testing of a flywheel energy storage system.

8 Summary and Conclusions

The 2013 Locomotive Emissions Monitoring Report highlights that Canadian railways are well placed to meet their GHG reduction targets by 2015.

GHG emissions from all railway operations in Canada totalled 6,367.68 kt, down 1.6 percent from 6,472.83 kt in 2012. This decrease reflects improvements in fuel consumption due to better matching of available locomotive power to freight traffic and implementation of modern technologies and novel management strategies as described in the *Locomotive Emissions Monitoring Program 2011—2015 Action Plan for Reducing GHG Emissions*. It also notes that in absolute terms, railway-generated GHG emissions remain moderate despite increasing traffic.

For total freight operations, the GHG emissions intensity (in kg of $CO_{2eq.}$ per 1,000 RTK) decreased by 5.1 percent from 16.17 in 2012 to 15.35 in 2013. Compared to 25.38 in 1990, 2013 performance is a 39.5 percent improvement. For Class I freight, the GHG emission intensity (in kg $CO_{2eq.}$ per 1000 RTK) decreased by 5.3 percent from 15.88 in 2012 to 15.03 in 2013. For intercity passenger operations, the GHG emissions intensity (in kg of $CO_{2eq.}$ per passenger kilometre) decreased by 8.4 percent from 0.11 in 2012 to 0.10 in 2013. Regional and Short Lines lowered their GHG emission intensity (in kg of $CO_{2eq.}$ per 1,000 RTK) increased by 1.0 percent from 13.51 in 2012 to 13.65 in 2013. The CAC emissions from all railway operations decreased, with total locomotive NO_x emissions decreasing to 95.43 kt in 2013 as compared to 99.22 kt in 2012. The total freight NO_x emissions intensity was 0.23 kg/1,000 RTK in 2013, compared to 0.25 kg/1,000 RTK in 2012 and down from 0.52 kg/1,000 RTK in 1990.

In 2013, Canadian railways invested heavily in fleet upgrades with 10 Tier 3 high-horsepower locomotives added to the Class I Freight Line-haul fleet and 225 locomotives upgraded to Tier 0+, Tier 1+, or Tier 2+. Older and lower-horsepower locomotives continue to be retired, and in 2013, 94 medium-horsepower locomotives manufactured between 1973 and 1999 were taken out of active duty. Overall, the Canadian fleet totalled 3,063 units in 2013, of which 2,293 locomotives were subject to the USEPA emissions regulations (of which 77.1 percent achieved tier level emission standards). The number of locomotives equipped with APUs or AESS systems to minimize unnecessary idling totalled 2,179 or 71.1 percent of the in-service fleet.

Through implementation of the *Locomotive Emissions Monitoring Program 2011–2015 Action Plan for Reducing GHG Emissions*, Canadian railways and the Government of Canada will continue their efforts to reduce GHG emissions in the railway sector and achieve the expected outcome of the MOU.

This report meets the filing requirements for 2013.

Appendix A
RAC Member Railways Participating in the 2011–2015 MOU by Province

Railway	Provinces of Operation
6970184 Canada Ltd	Saskatchewan
Agence métropolitaine de transport	Québec
Alberta Prairie Railway Excursions	Alberta
Amtrak	British Columbia, Ontario, Québec
ArcelorMittal Mines Canada	Québec
Arnaud Railway Company	Québec
Barrie-Collingwood Railway	Ontario
Battle River Railway	Alberta
BCR Properties	British Columbia
Canadian Pacific	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec
Cape Breton & Central Nova Scotia Railway	Nova Scotia
Capital Railway	Ontario
Carlton Trail Railway	Saskatchewan
Central Manitoba Railway Inc.	Manitoba
Charlevoix Railway Company Inc.	Québec
CN	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia
CSX Transportation Inc.	Ontario, Québec
Eastern Maine Railway Company	(Maine)
Essex Terminal Railway Company	Ontario
Goderich-Exeter Railway Company Ltd.	Ontario
Great Canadian Railtour Company Ltd.	British Columbia
Great Sandhills Railway Ltd.	Saskatchewan
Great Western Railway Ltd.	Saskatchewan
Hudson Bay Railway	Manitoba
Huron Central Railway Inc.	Ontario
Keewatin Railway Company	Manitoba
Kettle Falls International Railway, LLC	British Columbia
Labrador Iron Mines	Newfoundland and Labrador
Metrolinx	Ontario

Railway	Provinces of Operation
New Brunswick Southern Railway Company Ltd.	New Brunswick
Nipissing Central Railway Company	Ontario, Québec
Norfolk Southern Railway	Ontario
Ontario Northland Transportation Commission	Ontario, Québec
Ontario Southland Railway Inc.	Ontario
Ottawa Valley Railway	Ontario, Québec
Prairie Dog Central Railway	Manitoba
Québec Gatineau Railway Inc.	Québec
Québec North Shore and Labrador Railway Company Inc.	Québec, Newfoundland and Labrador
Roberval and Saguenay Railway Company, The	Québec
Romaine River Railway Company	Québec
Société du chemin de fer de la Gaspésie	Québec
South Simcoe Railway	Ontario
Southern Ontario Railway	Ontario
Southern Railway of British Columbia Ltd.	British Columbia
Southern Railway of Vancouver Island	British Columbia
St. Lawrence & Atlantic Railroad (Québec) Inc.	Québec
Sydney Coal Railway	Nova Scotia
Toronto Terminals Railway Company Limited, The	Ontario
Trillium Railway Co. Ltd.	Ontario
Tshiuetin Rail Transportation Inc.	Québec
VIA Rail Canada Inc.	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia
Wabush Lake Railway Company, Limited	Newfoundland and Labrador
West Coast Express Ltd.	British Columbia

Appendix B-1
2013 Locomotive Fleet — Freight Train Line-Haul Operations

OEM	Model	USEPA Tier Level	Engine	Cylinders	hp	Year of Manufac-ture	Year of Remanufac-ture	CN	CP	Total Class 1	Regional	Short Lines	Total Regional and Short Lines	Total Freight Fleet
MAINLINE LOCOMOTIVES														
GM/EMD	RM (EMD-1)		567	12V	1200	1958				0		3	3	3
	GP9		567	16V	1750	1950-1960	1980-1981			0		3	3	3
	GP10		567	16V	1800	1967-1977				0		3	3	3
	GP30		567	16V	2250	1961-1963				0			0	0
	GP40-3		567	16V	3000	1966-1968	2002			0		3	3	3
	GP40-3		567	16V	3100	1966-1968				0		2	2	2
	GMD-1		645	12V	1200	1958-1960				0		1	1	1
	GP9		645C	16V	1800	1955-1981[a]				0		9	9	9
	SD38-2		645	16V	2000	1975				0		3	3	3
	SD38		645	16V	2000	1971-1974				0		1	1	1
	GP38		645	16V	2000	1970-1986				0		35	35	35
	GP35-2		645	16V	2000	1963-1966				0		1	1	1
	GP38-2		645E	16V	2000	1972-1986				0	8	12	20	20
	GP38-3		645	16V	2000	1981-1983				0		13	13	13
	GP39-2		645E3	16V	2300	1974-1984				0		4	4	4
	GP35-3		645	16V	2500					0		4	4	4
	GP40		645	16V	3000	1975-1987				0		5	5	5
	GP40-2		645	16V	3000	1972-1986		52	2	54	3	24	27	81
	SD40-2		645E3	16V	3000	1972-1990	1994-1995	54	193	247	15	17	32	279
	SD40-3		645E3B	16V	3000	1966-1972		13		13		4	4	17
	SD40-3		567	16V	3100					0			0	0
	F40-PHR		645E3B	16V	3200	1940				0			0	0
	SD40		645	16V	3200	1966-1972				0			0	0
	SD45-2		645	16V	3600	1972-1974				0		1	1	1
	SD60		710	16V	3800	1985-1989		55		55			0	55
	SD70		710	16V	4000	1995				0			0	0
	SD70 ACE		710	16V	4000	1995-2000				0	23		23	23
	SD75-I		710G3C	16V	4300	1996-1999				0	5		5	5
	SD90-MAC		710	16V	4300	1989-1999			54	54			0	54
	SD40-2	Tier 0	645E3	16V	3000	1978-1985		6	16	22	2		2	24
	SD60	Tier 0	710	16V	3800	1985-1989	2002-2005	18		18			0	18
	SD70	Tier 0	710	16V	4000	1995	2001-2005			0			0	0
	SD75-I	Tier 0	710	16V	4300	1996-1999	2002-2005	73		73			0	73
	SD90-MAC	Tier 0	710	16V	4300	1998			4	4	5		5	9
	SD90-MAC-H	Tier 0	265H	16V	6000	1999				0			0	0
	SD40-3	Tier 0+	645E3B	16V	3000	1966-1972	2012	13		13			0	13
	SD40-2	Tier 0+	645E3	16V	3000	1978-1985	2012	15		15			0	15
	GP40-2	Tier 0+	645	16V	3000	1972-1986	2012	4		4		1	1	5
	SD60	Tier 0+	710	16V	3800	1985-1989	2002-2012	54		54			0	54
	SD70	Tier 0+	710	16V	4000	1995	2001-2011			0			0	0
	SD75-I	Tier 0+	710	16V	4300	1996-1999	2002-2012	88		88			0	88
	SD70-M2	Tier 2	710G3C	16V	4300	2005-2010		144		144			0	144
	SD70-M2	Tier 2+	710G3C	16V	4300	2005-2010	2013	34		34			0	34
GM/EMD Sub-Total								**623**	**269**	**892**	**61**	**149**	**210**	**1102**

OEM	Model	USEPA Tier Level	Engine	Cylinders	hp	Year of Manufac-ture	Year of Remanufac-ture	CN	CP	Total Class 1	Regional	Short Lines	Total Regional and Short Lines	Total Freight Fleet
MAINLINE LOCOMOTIVES														
GE	B23-7		7FDL12	12V	2250	1979-1980				0		2	2	2
	Dash 8-40CM		7FDL16	16V	4000	1990-1992		13		13		2	2	15
	Dash 9-44CW		7FDL16	16V	4400	1996-1999		8		8			0	8
	Dash 9-44CW	Tier 0	7FDL16	16V	4400	1994-2001	2001-2003	57		57	11		11	68
	AC4400CW	Tier 0	7FDL16	16V	4400	1995-2001			179	179	12	9	21	200
	Dash 8-40CM	Tier 0+	7FDL16	16V	4400	1990-1992	2011-2012	168		168			0	168
	AC4400CW	Tier 0+	7FDL16	16V	4400	1995-2001				0			0	0
	Dash 9-44CW	Tier 1	7FDL16	16V	4400	2002-2004		22		22			0	22
	AC4400CW	Tier 1	7FDL16	16V	4400	2002-2004			34	34	9		9	43
	Dash 9-44CW	Tier 1+	7FDL16	16V	4400	1994-2004	2011-2012	123		123			0	123
	AC4400CW	Tier 1+	7FDL16	16V	4400	2002-2004			141	141			0	141
	AC4400CW	Tier 2	7FDL16	16V	4400	2005-2007				0	12		12	12
	ES44AC	Tier 2	GEVO12	16V	4360	2005-2011			143	143	2		2	145
	ES44DC	Tier 2	GEVO12	16V	4400	2006-2008		89		89			0	89
	ES44AC	Tier 2+	GEVO12	16V	4360	2005-2011	2012		31	31			0	31
	ES44AC	Tier 3	GEVO12	16V	4360	2012		34	30	64			0	64
	ES44DC	Tier 3	GEVO12	16V	4400	2013		30						
	EA4400AC	Tier 3	GEVO12	16V	4400	2012				0			0	0
GE Sub-Total								**544**	**558**	**1102**	**46**	**13**	**59**	**1161**
MLW	RS-18		251	12V	1800	1954-1958				0		4	4	4
	M420(W)		251-B	12V	2000	1971-1975				0		3	3	3
	M420R(W)		251-B	12V	2000	1971-1975				0		2	2	2
	HR412		251	12V	2000	1975				0		1	1	1
MLW Sub-Total								**0**	**0**	**0**	**0**	**10**	**10**	**10**
FREIGHT MAINLINE SUB-TOTAL								**1167**	**827**	**1994**	**107**	**172**	**279**	**2273**
ROAD SWITCHERS														
GM/EMD	GMD-1		645	12V	1200	1958-1960		15		15			0	15
	SW-1200		567	12V	1200	1955-1962		1		1			0	1
	GP9		567	16V	1750	1950-1960	1980-1981			0			0	0
	GP9		645C	16V	1800	1955-1981[a]		21	28	49			0	49
	GP38		645	16V	2000	1970-1986			12	12			0	12
	SD38-2		645E	16V	2000	1975		1		1			0	1
	GP38-2		645E	16V	2000	1972-1986		68	79	147			0	147
	SD38-2		645	16V	2000	1975				0			0	0
	GP38-2	Tier 0	645E	16V	2000	1972-1986	2010-2011		12	12			0	12
	GP38-2	Tier 0+	645	16V	2000	1970-1986	2011-2012	5	53	58			0	58
	SD38-2	Tier 0+	645E	16V	2000	1975	2012	1		1			0	1
	GS1B	Tier 2	Cum-mins		2100	2008				0			0	0
GM/EMD Road Switchers Sub-Total								**112**	**184**	**296**	**0**	**0**	**0**	**296**
ROAD SWITCHERS SUB-TOTAL								**112**	**184**	**296**	**0**	**0**	**0**	**296**
TOTAL MAINLINE FREIGHT								**1279**	**1011**	**2290**	**107**	**172**	**279**	**2569**

a A review of the locomotive fleet led to the change of the manufacturing period from 1954-1981 to 1955-1981.

Appendix B-2

2013 Locomotive Fleet — Freight Yard Switching & Work Train Operations

OEM	Model	USEPA Tier Level	Engine	Cylinders	HP	Year of Manufac-ture	Year of Remanu-facture	CN	CP	Total Class 1	Regional	Short Lines	Total Regional and Short Lines	Total Freight Fleet
GM/EMD	SW900		567	8V	900	1954-1965			1	1		13	13	14
	SW1200		567	12V	1200	1955-1962				0		4	4	4
	SW1500		567	12V	1500	1966-1974				0		6	6	6
	MP15		567	12V	1500	1974-1980				0		4	4	4
	GP7		567	16V	1500	1949-1954	1980-1988		2	2		2	2	4
	GP9		567	16V	1750	1950-1963	1980-1991			0	2	5	7	7
	GMD-1		645	12V	1200	1958-1960				0		5	5	5
	SW14		645E	12V	1400	1950				0		1	1	1
	GP15		645	16V	1500	1981-1984				0		3	3	3
	GP9		645	16V	1700	1960	1980-1981			0		1	1	1
	GP9		645	16V	1750	1954-1981	1980-1991		39	39	3	3	6	45
	GP9		645	16V	1800	1954-1981	1980-1981	89		89		1	1	90
	GP20		170B20	16V	2000	2000-2001				0		8	8	8
	GP38		645	16V	2000	1970-1986				0	3		3	3
	GP38-2		645E	16V	2000	1972-1986		16		16			0	16
	SD40-2		645	16V	3000	1972-1990			21	21			0	21
	SD40-2	Tier 0	645	16V	3000	1983-1985	2009		3	3			0	3
	GP38-2	Tier 0+	645	16V	2000	1970-1986	2012	7		7			0	7
GM/EMD Sub-Total								**112**	**66**	**178**	**8**	**56**	**64**	**242**
GE	44T		Cummins		300	1947				0		1	1	1
GE Sub-Total								**0**	**0**	**0**	**0**	**1**	**1**	**1**
MLW	S-13		251	6V	1000	1959-1960	1978			0		5	5	5
	RS-18		251	12V	1800	1954-1958				0		10	10	10
	RS-23		251	18V	1000	1959-1960				0		3	3	3
MLW Sub-Total								**0**	**0**	**0**	**0**	**18**	**18**	**18**
ALCO	S-6		251	6V	900	1953				0		1	1	1
	S-2		539	6V	1000	1954				0		1	1	1
ALCO Sub-Total								**0**	**0**	**0**	**0**	**2**	**2**	**2**
YARD SWITCHING & WORK TRAIN TOTAL								**112**	**66**	**178**	**8**	**77**	**85**	**263**

Appendix B-3
2013 Locomotive and DMU Fleet — Passenger Train Operations

OEM	Model	USEPA Tier Level	Engine	Cylinders	HP	Year of Manufacture	Year of Remanufacture	VIA Rail Canada	Non-VIA Rail Intercity Passengers	Commuter	Tourist & Excursion	Total
PASSENGER TRAIN LOCOMOTIVES												
GM/EMD	GP9		645	16V	1800	1967-1978				1		1
	FP40-PH2		645	16V	3000	1987-1989		52		14		66
	F40-PH2		645E3C	16V	3000	1976-1981						0
	GP40		645	16V	3000	1970-1979						0
	GP40-2		645E3C	16V	3000	1974-1976	1993			5		5
	F40-PHR		645E3B	16V	3200	1940			2			2
	F59-PH		710G3	12V	3000	1988-1994				12		12
	F59-PHI		710G3	12V	3000	1995	2000-2001			16		16
GM/EMD Sub-Total								**52**	**2**	**48**	**0**	**102**
GE	LL 162/162		251		990	1954-1966						0
	P42DC		7FDL16	16V	4250	2001		21			9	30
GE Sub-Total								**21**	**0**	**0**	**9**	**30**
Motive Power	MP36PH-3C	Tier 1	645	16V	3600	2006				1		1
	MP40PH-3C	Tier 2	710	16V	4000	2007				59		59
Motive Power Sub-Total								**0**	**0**	**60**	**0**	**60**
Bombardier	MR90		Electric 25kv		1500	1994-1995						0
	ALP 45DP	Tier 3	MITRAC TG	12V	3600	2009-2010				20		20
Bombardier Sub-Total								**0**	**0**	**20**	**0**	**20**
R&H	28-ton				165	1950					1	1
CLC	44-ton		H44A3		400	1960					1	1
GE	70-ton		FWL-6T		600	1948					1	1
BUDD	RDC-4		Cummins		600	1956-1958		6				6
Other Sub-Total								**6**	**0**	**0**	**3**	**9**
Baldwin	B280					1920					1	1
Baldwin Steam Engines Sub-Total								**0**	**0**	**0**	**1**	**1**
Other											2	2
Other Steam Engines Sub-Total								**0**	**0**	**0**	**2**	**2**
PASSENGER TRAIN LOCOMOTIVES SUB-TOTAL								**79**	**2**	**128**	**15**	**224**
YARD SWITCHING PASSENGER OPERATIONS												
GM/EMD	SW1000		645	8V	900	1967-1969		2				2
ALCO	DQS18		251		1800	1957					2	2
Yard Switching Passenger Operations Sub-Total								**2**	**0**	**0**	**2**	**4**
DMUS												
Bombardier	DMU		BR643		846	2001				3		3
BUDD	RDC-1		DD6-110		520	1955						0
	RDC-1		Cummins		600	1956-1958						0
	RDC-2		Cummins		600	1956-1958						0
DMUs Sub-Total								**0**	**0**	**3**	**0**	**3**
PASSENGER OPERATIONS TOTAL								**81**	**2**	**131**	**17**	**231**

Appendix C
Railways Operating in Tropospheric Ozone Management Areas

Railway Lines Included in Tropospheric Ozone Management Areas

TOMA Region No. 1: LOWER FRASER VALLEY, BRITISH COLUMBIA

CN

Division	**Subdivision**
Pacific	Squamish
	Yale

CP

Operations Service Area	**Subdivision**
Vancouver	Cascade
	Mission
	Page
	Westminster

BCR Properties	All
Southern Railway of BC Ltd	All
Great Canadian Railtour Company	Part
VIA Rail Canada	Part
West Coast Express	All

TOMA Region No. 3: SAINT JOHN AREA, NEW BRUNSWICK

CN

District	**Subdivision**
Champlain	Denison
	Sussex

TOMA Region No. 2: WINDSOR-QUÉBEC CITY CORRIDOR, ONTARIO AND QUÉBEC

CN

District — **Champlain**

Subdivisions

Becancour	Rouses Point	Bridge
Sorel	Deux-Montagnes	St. Hyacinthe
Drummondville	St. Laurent	Joliette
Valleyfield	Montréal	

District — **Great Lakes**

Subdivisions

Alexandria	Grimsby	Strathroy
Caso	Halton	Talbot
Chatham	Kingston	Uxbridge
Dundas	Oakville	Weston
Guelph	Paynes	York

CP

Operations Service Area — **Montréal**

Subdivisions — All

Operations Service Area — **Southern Ontario**

Subdivisions

Belleville	Hamilton	North Toronto
Canpa	MacTier	St. Thomas
Galt	Montrose	Waterloo
Windsor		

Agence métropolitaine de transport	All
Capital Railway	All
GO Transit	All
VIA Rail Canada	Part
CSX	All
Essex Terminal Railway	All
Goderich – Exeter Railway	All
Norfolk Southern	All
Ottawa Central	All
Ottawa Valley Railway	Part
Québec Gatineau	All
Southern Ontario Railway	All
St. Lawrence & Atlantic	All

Appendix D
Locomotive Emissions Standards in the United States

The US Environmental Protection Agency (USEPA) rulemaking promulgated in 1998 contains three levels of locomotive-specific emissions limits corresponding to the date of a locomotive's original manufacture — Tier 0, Tier 1, and Tier 2 (as listed below). The significance of the USEPA regulations for Canadian railways is that the new locomotives they traditionally acquire from the American locomotive original equipment manufacturers (OEM) are manufactured to meet the latest USEPA emissions limits. Hence, emissions in Canada are reduced as these new locomotives are acquired.

Compliance Schedule for USEPA Locomotive-Specific Emissions Limits (g/bhp-hr)

Duty Cycle	HC	CO	NO_x	PM
	Tier 0 (1973–2001)			
Line-haul	1.0	5.0	9.5	0.60
Switching	2.1	8.0	14.0	0.72
	Tier 1 (2002–2004)			
Line-haul	0.55	2.2	7.4	0.45
Switching	1.2	2.5	11.0	0.54
	Tier 2 (2005 and later)			
Line-haul	0.3	1.5	5.5	0.20
Switching	0.6	2.4	8.1	0.24
	Estimated Pre-Regulation (1997) Locomotive Emissions Rates			
Line-haul	0.5	1.5	13.5	0.34
Switching	1.1	2.4	19.8	0.41

Referencing the above-listed limits for locomotives operating in the US, the USEPA in 2008 put into force revisions that tighten the existing Tier 0 to Tier 2 standards. The revisions are now referred to as Tier 0+, Tier 1+, and Tier 2+ standards. As indicated in the tables below, the revised standards also take into account the year of original manufacture of the locomotive. Also, two, new, more stringent standards levels were introduced, designated as Tier 3 and Tier 4. The revised and new standards are to be phased in between 2011 and 2015 for locomotives as they become new (new in this case includes both when locomotives are originally manufactured and when remanufactured). Tier 3 standards have since been implemented for the 2013 reporting year. Elaboration on the USEPA locomotive emissions regulations can be viewed on the website: http://www.epa.gov/otaq/locomotives.htm.

Line-Haul Locomotive Emission Standards (g/bhp-hr)

Tier	*MY	Date	HC	CO	NO_x	PM
Tier 0+[a]	1973–1992	2011[c]	1.00	5.0	8.0	0.22
Tier 1+[a]	1993–2004[b]	2011[c]	0.55	2.2	7.4	0.22
Tier 2+[a]	2005–2011	2013[c]	0.30	1.5	5.5	0.10[d]
Tier 3[e]	2013–2014	2013	0.30	1.5	5.5	0.10
Tier 4	2015 or later	2015	0.14[f]	1.5	1.3[f]	0.03

a Tier 0+ to Tier 2+ line-haul locomotives must also meet switch standards of the same Tier.

b 1993–2001 locomotives that were not equipped with an intake air coolant system are subject to Tier 0+ rather than Tier 1+ standards.

c As early as 2008 if approved engine upgrade kits become available.

d 0.20 g/bhp-hr until January 1, 2013 (with some exceptions).

e Tier 3 line-haul locomotives must also meet Tier 2+ switching standards.

f Manufacturers may elect to meet a combined NO_x + HC standard of 1.4 g/bhp-hr.

* MY—Year of original manufacture

Switching Locomotive Emission Standards (g/bhp-hr)

Tier	*MY	Date	HC	CO	NO_x	PM
Tier 0+	1973–2001	2011[b]	2.10	8.0	11.8	0.26
Tier 1+[a]	2002–2004	2011[b]	1.20	2.5	11.0	0.26
Tier 2+[a]	2005–2010	2013[b]	0.60	2.4	8.1	0.13[c]
Tier 3	2011–2014	2011	0.60	2.4	5.0	0.10
Tier 4	2015 or later	2015	0.14[d]	2.4	1.3[d]	0.03

a Tier 1+ and Tier 2+ switching locomotives must also meet line-haul standards of the same Tier.

b As early as 2008 if approved engine upgrade kits become available.

c 0.24 g/bhp-hr until January 1, 2013 (with some exceptions).

d Manufacturers may elect to meet a combined NO_x + HC standard of 1.3 g/bhp-hr.

* MY—Year of original manufacture

Appendix E
Glossary of Terms

Terminology Pertaining to Railway Operations

Class I Railway: This is a class of railway within the legislative authority of the Parliament of Canada that realized gross revenues that exceed a threshold indexed to a base of $250 million annually in 1991 dollars for the provision of Canadian railway services. The three Canadian Class I railways are CN, CP and VIA Rail Canada.

Intermodal Service: The movement of trailers on flat cars (TOFC) or containers on flat cars (COFC) by rail and at least one other mode of transportation. Import and export containers generally are shipped via marine and rail. Domestic intermodal services usually involve the truck and rail modes.

Locomotive Active Fleet: This refers to the total number of all locomotives owned and on long-term lease, including units that are stored but available for use. Not counted in the active fleet are locomotives on short-term lease and those declared surplus or have been retired or scrapped.

Locomotive Power Ranges: Locomotives are categorized as high horsepower (having engines greater than 3,000 hp), medium horsepower (2,000 to 3,000 hp) or low horsepower (less than 2,000 hp).

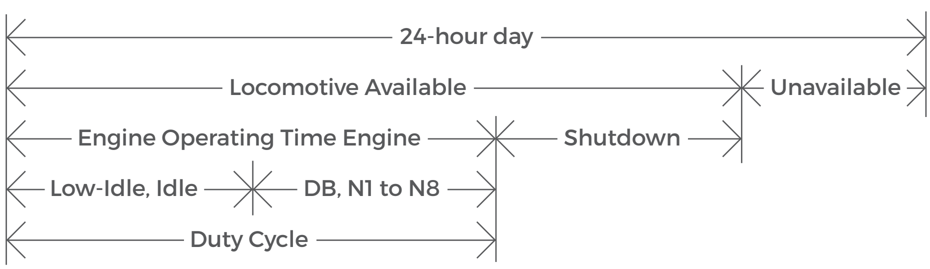
Locomotive Prime Movers: The diesel engine is the prime mover of choice for locomotives in operation on Canadian railways. Combustion takes place in a diesel engine by compressing the fuel and air mixture until auto-ignition occurs. It has found its niche as a result of its fuel-efficiency, reliability, ruggedness, and installation flexibility. Two diesel prime mover installation arrangements are currently in use:

Medium-speed diesel engine: This engine is installed in versions from 8 to 16 cylinders at up to 4,400 hp, with an operating speed of 800 to 1,100 rpm.

Multiple 'GenSet' diesel engines: This "stand alone" generating set (GenSet) is each powered by a 700 hp industrial diesel engine driving separate generators, which are linked electronically to produce up to 2,100 traction horsepower, with an operating speed up to 1,800 rpm. For switching locomotive applications, the advantage of this arrangement is that individual GenSet engines can be started or stopped according to the power required.

Locomotive Remanufacture: The "remanufacture" of a locomotive is a process in which all of the power assemblies of a locomotive engine are replaced with freshly manufactured (containing no previously used parts) or refurbished power assemblies or those inspected and qualified. Inspecting and qualifying previously used parts can be done in several ways, including such methods as cleaning, measuring physical dimensions for proper size and tolerance, and running performance tests to ensure that the parts are functioning properly and according to specifications. Refurbished power assemblies could include some combination of freshly manufactured parts, reconditioned parts from other previously used power assemblies, and reconditioned parts from the power assemblies that were replaced. In cases where all of the power assemblies are not replaced at a single time, a locomotive will be considered to be "remanufactured" (and therefore "new") if all power assemblies from the previously new engine had been replaced within a 5-year period. *(This definition for remanufactured locomotives is taken from the U.S. Federal Register Volume 63, No. 73 April 16, 1998 / Rules and Regulations for the Environmental Protection Agency (USEPA) 40 CFR Parts 85, 89 and 92 (Emission Standards for Locomotives and Locomotive Engines).*

Locomotive Utilization Profile: This is the breakdown of locomotive activity within a 24-hour day (based on yearly averages).



The elements in the above diagram constitute, respectively:

Locomotive Available: This is the time, expressed in percent of a 24-hour day, that a locomotive could be used for operational service. Conversely, **Unavailable** is the percentage of the day that a locomotive is being serviced, repaired, remanufactured, or stored. Locomotive available time plus unavailable time equals 100 percent.

Engine Operating Time: This is the percentage of Locomotive Available time that the diesel engine is turned on. Conversely, **Engine Shutdown** is the percentage of Locomotive Available time that the diesel engine is turned off.

Idle: This is the percent of the operating time that the engine is operating at **idle** or **low-idle** setting. It can be further segregated into Manned Idle (when an operating crew is on-board the locomotive) and Isolate (when the locomotive is unmanned).

Duty Cycle: This is the profile of the different locomotive power settings (Low-Idle, Idle, Dynamic Braking, or Notch levels 1 through 8) as percentages of Engine Operating Time.

Railway Productivity Units:

Gross Tonne-Kilometres (GTK): This term refers to the product of the total weight (in tonnes) of the trailing tonnage (both loaded and empty railcars) and the distance (in kilometres) the freight train travelled. It excludes the weight of locomotives pulling the trains. Units can also be expressed in gross ton-miles (GTM).

Revenue Tonne-Kilometres (RTK): This term refers to the product of the weight (in tonnes) of revenue commodities handled and the distance (in kilometres) transported. It excludes the tonne-kilometres involved in the movement of railway materials or any other non-revenue movement. The units can also be expressed in revenue ton-miles (RTM).

Passenger-Kilometres per Train-Kilometre: This term is a measure of intercity train efficiency, which is the average of all revenue passenger kilometres travelled divided by the average of all train kilometres operated.

Revenue Passenger-Kilometres (RPK): This term is the total of the number of revenue passengers multiplied by the distance (in kilometres) the passengers were transported. The units can also be expressed in revenue passenger-miles (RPM).

Terminology of Diesel Locomotive Emissions

Emission Factors (EFs): An emission factor is the average mass of a product of combustion emitted from a particular locomotive type for a specified amount of fuel consumed. The EF units are grams, or kilograms, of a specific emission product per litre of diesel fuel consumed (g/L).

Emissions of Criteria Air Contaminant (CAC): CAC emissions are by-products of the combustion of diesel fuel that impact on human health and the environment. The principal CAC emissions are:

Nitrogen Oxides (NO_x): These result from high combustion temperatures. The amount of NO_x emitted is a function of peak combustion temperature. NO_x reacts with hydrocarbons to form ground-level ozone in the presence of sunlight which contributes to smog formation.

Carbon Monoxide (CO): This toxic gas is a by-product of the incomplete combustion of fossil fuels. Relative to other prime movers, it is low in diesel engines.

Hydrocarbons (HC): These are the result of incomplete combustion of diesel fuel and lubricating oil.

Particulate Matter (PM): This is residue of combustion consisting of soot, hydrocarbon particles from partially burned fuel and lubricating oil and agglomerates of metallic ash and sulphates. It is known as primary PM. Increasing the combustion temperatures and duration can lower PM. It should be noted that NO_x and PM emissions are interdependent such that technologies that control NO_x (such as retarding injection timing) result in higher PM emissions, and conversely, technologies that control PM often result in increased NO_x emissions.

Sulphur Oxides (SO_x): These emissions are the result of burning fuels containing sulphur compounds. For LEM reporting, sulphur emissions are calculated as SO_2. These emissions can be reduced by using lower sulphur content diesel fuel. Reducing fuel sulphur content will also typically reduce emissions of sulphate-based PM.

Emissions of Greenhouse Gases (GHG)

In addition to CACs, GHG emissions are also under scrutiny due to their accumulation in the atmosphere and contribution to global warming. The GHG constituents produced by the combustion of diesel fuel are listed below:

Carbon Dioxide (CO_2): This gas is by far the largest by-product of combustion emitted from engines and is the principal GHG, which due to its accumulation in the atmosphere, is considered to be the main contributor to global warming. It has a Global Warming Potential of 1.0. CO_2 and water vapour are normal by-products of the combustion of fossil fuels.

Methane (CH_4): This is a colourless, odourless, and flammable gas, which is a by-product of incomplete diesel combustion. Relative to CO_2, it has a Global Warming Potential of 25.

Nitrous Oxide (N_2O): This is a colourless gas produced during combustion that has a Global Warming Potential of 298 (relative to CO_2).

The sum of the constituent GHGs expressed in terms of their equivalents to the Global Warming Potential of CO_2 is depicted as $CO_{2eq.}$. This is calculated by multiplying the volume of fuel consumed by the emission factors of each constituent, then, in turn, multiplying the product by the respective Global Warming Potential, and then summing them. See Appendix F for conversion values pertaining to diesel fuel combustion.

Emissions Metrics: The unit of measurement for the constituent emissions is grams per brake horsepower-hour (g/bhp-hr).

This is the amount (in grams) of a particular constituent emitted by a locomotive's diesel engine for a given amount of mechanical work (brake horsepower) over one hour for a specified duty cycle. This measurement allows a ready comparison of the relative cleanliness of two engines, regardless of their rated power.

RAC LEM Protocol: This is the collection of financial and statistical data from RAC members and the RAC database (where data is systematically stored for various RAC applications). Data from the RAC database, which is used in this report, include freight traffic revenue tonne kilometres and gross tonne kilometres, intermodal statistics, passenger traffic particulars, fuel consumption, average fuel sulphur content and locomotive inventory. The Class I railways' Annual Reports and Financial and Related Data submissions to Transport Canada also list much of this data.

Appendix F
Conversion Factors Related to Railway Emissions

Emission Factors (in grams or kilograms per litre of diesel fuel consumed)

Emission Factors for the Criteria Air Contaminants (NO_x, CO, HC, PM, SO_x) in g/L are found in Table 10.

Emission Factors for Sulphur Dioxide (SO_2) for 2013:

Freight Railways (15.0 ppm sulphur in fuel)	0.000025 kg / L

Emission Factors for Greenhouse Gases:

Carbon Dioxide	CO_2	2.69000 kg / L
Methane	CH_4	0.00015 kg / L
Nitrous Oxide	N_2O	0.00110 kg / L
Hydrofluorocarbons*	HFC	
Perfluorocarbons*	PFC	
Sulphur hexafluoride*	SF_6	
$CO_{2eq.}$ † of all six GHGs		3.02155 kg / L
Global Warming Potential for	CO_2	1
Global Warming Potential for	CH_4	25
Global Warming Potential for	N_2O	298

* Not present in diesel fuel

† Sum of constituent Emissions Factors multiplied by their Global Warming Potentials

Conversion Factors Related to Railway Operations

Imperial gallons to litres	4.5461
US gallons to litres	3.7853
Litres to Imperial gallons	0.2200
Litres to US gallons	0.2642
Miles to kilometres	1.6093
Kilometres to miles	0.6214
Metric tonnes to tons (short)	1.1023
Tons (short) to metric tonnes	0.9072
Revenue ton-miles to Revenue tonne-kilometres	1.4599
Revenue tonne-kilometres to Revenue ton-miles	0.6850

Metrics Relating Railway Emissions and Operations

Emissions in this report are displayed both as an absolute amount and as ‘intensity,’ which is either a ratio that relates a specific emission to productivity or units of work performed. An example of emissions intensity metrics is the ratio NO_x per 1,000 RTK; which is the mass in kilograms of NO_x emitted per 1,000 revenue tonne-kilometres of freight hauled.

Appendix G
Abbreviations and Acronyms used in the Report

Abbreviations of Units of Measure

bhp	Brake horsepower
g	Gram
g/bhp-hr	Grams per brake horsepower hour
g/GTK	Grams per gross tonne-kilometre
g/L	Grams per litre
g/RTK	Grams per revenue tonne-kilometre
hr	Hour
kg/1,000 RTK	Kilograms per 1,000 revenue tonne-kilometres
km	Kilometre
kt	Kilotonne
L	Litre
L/hr	Litres/hour
lb	Pound
ppm	Parts per million

Abbreviations of Emissions and Related Parameters

CAC	Criteria Air Contaminant
CO_2	Carbon Dioxide
$CO_{2eq.}$	Carbon Dioxide equivalent of all six Greenhouse Gases
CO	Carbon Monoxide
EF	Emissions Factor
GHG	Greenhouse Gas
HC	Hydrocarbons
NO_x	Nitrogen Oxides
PM	Particulate Matter
SO_x	Sulphur Oxides
SO_2	Sulphur Dioxide
TOMA	Tropospheric Ozone Management Areas

Abbreviations used in Railway Operations

AESS	Automated Engine Start-Stop
APU	Auxiliary Power Unit
COFC	Container-on-Flat-Car
DB	Dynamic Brake
DMU	Diesel Multiple Unit
EMU	Electric Multiple Unit
GTK	Gross tonne-kilometres
LEM	Locomotive Emissions Monitoring
MOU	Memorandum of Understanding
N1, N2 ...	Notch 1, Notch 2... Throttle Power Settings
RDC	Rail Diesel Car
RPK	Revenue Passenger-Kilometres
RPM	Revenue Passenger-Miles
RTK	Revenue Tonne-Kilometres
RTM	Revenue Ton-Miles
TOFC	Trailer-on-Flat-Car
ULSD	Ultra-low Sulphur Diesel Fuel

Acronyms of Organizations

AAR	Association of American Railroads
ALCO	American Locomotive Company
CCME	Canadian Council of the Ministers of the Environment
CN	Canadian National Railway
CP	Canadian Pacific
EC	Environment Canada
ESDC	Engine Systems Development Centre of CAD Railway Industries Ltd.
GE	General Electric Transportation Systems
GM/EMD	General Motors Corporation Electro-Motive Division.
MLW	Montreal Locomotive Works
MPI	Motive Power Industries
NRE	National Railway Equipment Co.
OEM	Original Equipment Manufacturer
RAC	Railway Association of Canada
TC	Transport Canada
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VIA	VIA Rail Canada