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Railway Association of Canada

Locomotive Emissions Monitoring / Report

2022

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* In December 2021, CP announced the acquisition of Kansas City Southern (KCS). In March 2023, the United States Surface Transportation Board (STB) authorized the acquisition, and the combination of CP and KCS was completed on April 14, 2023 to create a combined Canadian Pacific Kansas City Limited (CPKC). This report is limited to Canadian Pacific's (CP) standalone activities and operations from January 1st through December 31st of 2022. In addition, unless indicated otherwise or the context otherwise requires, does not report on the climate initiatives of the combined CPKC.

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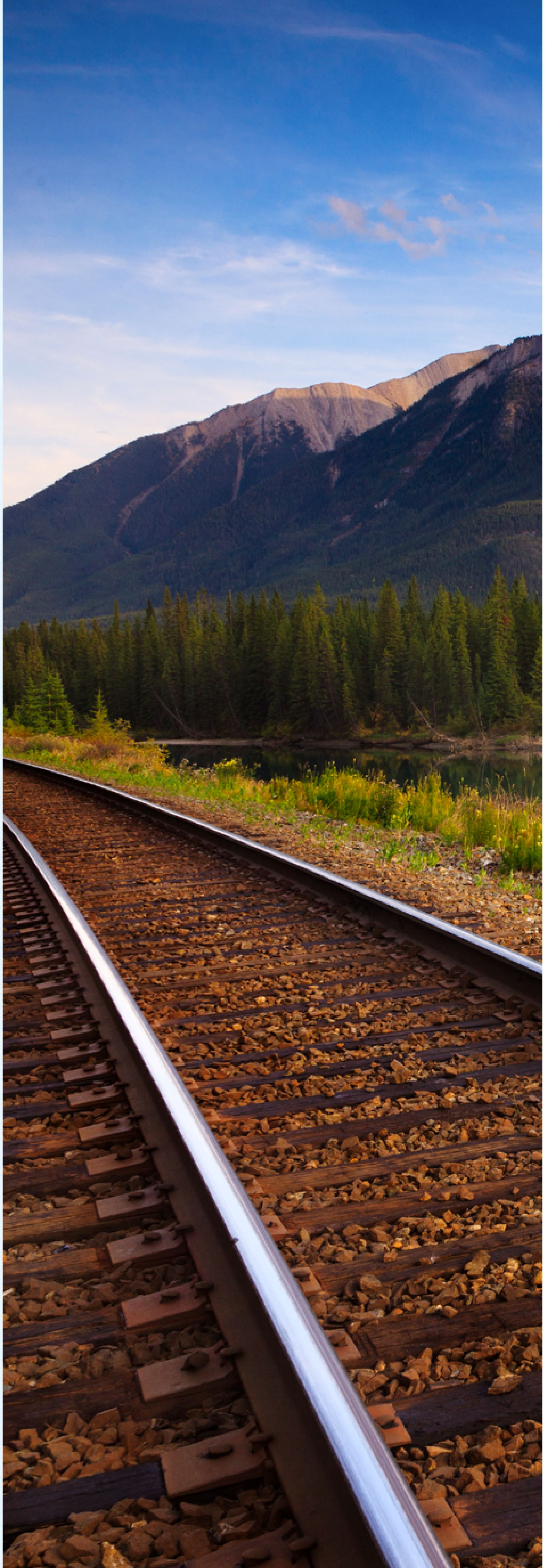

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REVIEW NOTICE

This report has been reviewed and approved by the Technical Review and Management Committees of the *2018–2022 Memorandum of Understanding between Transport Canada and the Railway Association of Canada for Reducing Locomotive Emissions*.

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Executive Summary

INTRODUCTION

The Locomotive Emissions Monitoring Program (LEM) data filing for 2022 has been completed in accordance with the terms of the 2018–2022 Memorandum of Understanding (referred hereafter as "the MOU") signed on March 21, 2019, 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 fifth and final report prepared under this MOU, though it is based on reporting for the LEM program governed by MOUs dating back to 1995.

As stated in the MOU, the RAC encourages its members to make every effort to reduce the GHG emissions intensity from railway operations. The MOU's GHG emissions intensity targets for 2018–2022, which uses 2017 as a baseline year, are included in the table below.

Under the MOU, the RAC continues to encourage CAC emissions reductions and conformance with appropriate CAC emission standards for those locomotives not covered by the *Locomotive Emissions Regulations* (LER), which came into force on June 9, 2017. Reporting by the RAC of CAC emissions as agreed under the MOU and included in this LEM report do not fulfil any member reporting requirements under the LER.

2018–2022 MOU RESULTS

This report highlights that, despite challenges related to the COVID-19 pandemic, Class 1 freight and intercity passenger operations have reduced their GHG emissions intensities over the course of the MOU period. Canadian Class 1 freight railways have reduced GHG emissions intensities by 6.99%, exceeding the 6% MOU reduction target. Total regional & shortline emissions intensity increased during the MOU period by 1.48%. The initial effects of the COVID-19 pandemic on ridership (both personal and business travel) caused GHG emissions intensities to increase for intercity passenger railways. However, as ridership continued to recover through 2021 and 2022, and train operations (number of trains and length of trains) were adjusted to match demand, intercity passenger railways experienced a significant decrease in GHG emissions intensities. Intercity passenger railways achieved 77.94% progress towards their MOU target, however, GHG emissions intensities remained above the record level achieved in 2019.

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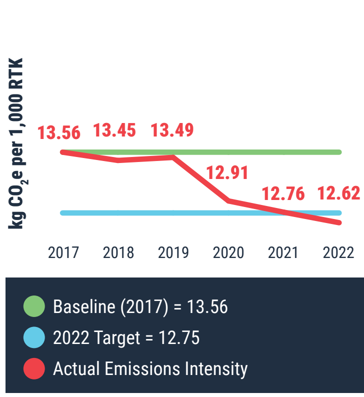
2018–2022 MOU Results

Railway Operation	Productivity Units	Baseline 2017	2022	2022 Target	Change from 2017–2022	% of Target Achieved	Target Achieved?
Class I Freight	kg CO_2e per 1,000 RTK	13.56	12.62	12.75 (6% reduction)	-6.99%	116%	YES
Intercity Passenger*	kg CO_2e per passenger-km	0.098	0.093	0.092 (6% reduction)	-4.68%	78%	NO
Regional & Shortline	kg CO_2e per 1,000 RTK	14.08	14.29	13.66 (3% reduction)	1.48%	increase since 2017	NO

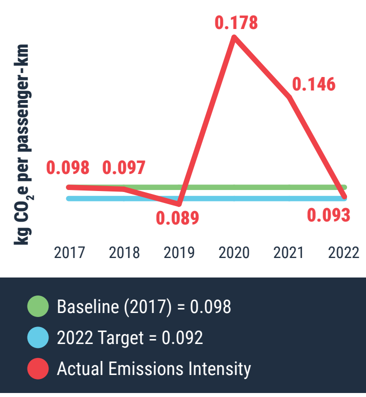
Note: GHG emissions for all years have been calculated based on the emission factors and global warming potentials in the 2024 National Inventory Report (the 2024 National Inventory Report contains the GHG emissions factors for 1990-2022). Historical values have been updated.

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

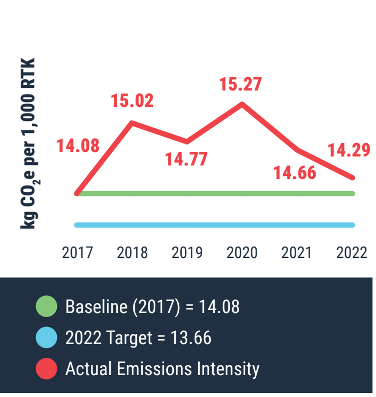
Class 1 Freight



Intercity Passenger*



Regional & Shortline



As seen in the table and figures above, Class 1 freight GHG emissions intensity decreased by 6.99% from 2017 to 2022 — exceeding the MOU target of a 6% reduction. Intercity passenger GHG emissions intensity (i.e., kg carbon dioxide equivalent (CO_2e) per passenger-km) decreased by 4.68% from 2017 to 2022. The deviation in 2020 from the improving trend was due to a significant decrease in ridership throughout the COVID-19 pandemic, while passenger railways continued to maintain essential services. During the same time frame, passenger fuel consumption also decreased, however, the drastic decrease in ridership still caused emissions intensity to approximately double from 2019 to 2020. In 2022, passenger train operations were properly adjusted to meet demand. Compared to the pre-pandemic period, there were fewer and slightly shorter trains. This enabled emissions intensity to return to levels experienced before the pandemic.

Turning to regional & shortline railways, despite an improving trend since 2020, regional & shortline emissions intensity increased by 1.48% from 2017 to 2022. Since regional & shortline railways are less diversified than Class 1 freight railways (both geographically and in the products they transport), they are typically more vulnerable to economic volatility, resulting in greater year-over-year variation. In addition, RAC's regional & shortline membership changes over time, impacting GHG emissions intensity from one year to the next.

2018–2022 MOU ACHIEVEMENTS

As this is the final reporting year of the 2018-2022 MOU between the Railway Association of Canada and Transport Canada, this section highlights major achievements made during the reporting period.

Railways invested over $12 billion into their Canadian networks between 2018-2022 and continued to reduce their emissions through investments in fleet renewal/modernization, fuel saving technologies, operational efficiencies, and use of low carbon fuels. Railways and their partners also made progress in their various partnerships as well as pilot projects in alternative propulsion.

The portion of the Canadian locomotive fleet compliant with emissions standards increased from 67.9% in 2017 to 84.4% in 2022. Reflective of the significant investments made by the rail industry to advance emission reductions.

CP[1] initiated its demonstration Hydrogen Locomotive Program to advance industry knowledge in real-world operations and to generate critical industry knowledge to inform future commercialization and development.

To advance ambitious long-term goals, CN announced plans for a battery-electric locomotive trial project to advance understanding of alternative propulsion technology and opportunities.

Both freight Class 1s began testing various renewable fuel blend rates in pursuit of achieving their climate targets. Renewable fuels are a critical component to further emission reductions.

The Southern Railway of British Columbia Ltd. (SRY) is continuing its collaboration with University of British Columbia – Okanagan on advancing the research and understanding of hydrogen and fuel cell/battery hybrid system with a focus on technology innovations adapted to locomotives used in switching applications. Operational testing of 100% biodiesel (B100) at SRY was also launched to advance renewable fuels knowledge.

VIA Rail's Fleet Renewal Program initiated the deployment of new energy efficient Tier 4 locomotives. VIA Rail also launched a pilot project to test an application using artificial intelligence, called EcoRail, to further advance opportunities to improve fuel efficiency.

Collaboration is required to advance decarbonization of the rail sector. With the shared goal of reducing emissions, the RAC and Transport Canada jointly supported the Rail Pathways Initiative, which consisted of two phases. Phase 1, completed in 2020, catalogued ongoing and potential activities related to rail sector decarbonization that are led by industry and government, or collaborations between the private and public sectors. This provided an important inventory of existing initiatives. Phase 2, published in 2022, developed a comprehensive assessment framework for assessing the decarbonization pathways available to the rail industry, and then assessed a shortlist of renewable fuel and alternative propulsion technology options while providing a better understanding of the decarbonization roadmap for rail.

The Government of Canada is committed to tackling climate change by reducing greenhouse gas emissions, while simultaneously fostering economic growth through sustainable jobs and clean industrial practices. To this end, Canada pledged to cut its GHG emissions by 40–45 percent below 2005 levels by 2030, ultimately striving for net-zero emissions by 2050. This

1 This report is limited to Canadian Pacific's (CP) standalone activities and operations, and does not report on the climate initiatives of the combined CPKC.

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commitment is supported by initiatives such as the Strengthened Climate Plan, the Hydrogen Strategy, and the 2030 Emissions Reduction Plan (led by Environment and Climate Change Canada), which provide practical pathways for emission reductions across all sectors of the economy.

2022 KEY FINDINGS

Impacts of COVID-19

Canadian railways faced major challenges during the MOU period due to the COVID-19 pandemic. Despite these challenges, railways kept trains running, providing essential services to Canadians. As a consequence of changes to railway operations and passenger ridership, performance and emissions data diverges significantly from historical trends throughout the MOU period.

While some impacts were temporary, there is the potential of lasting impacts on Canada's passenger railways, as passenger railways experienced significant decreases in ridership. Specifically, the initial effect of the COVID-19 pandemic caused intercity passenger traffic to significantly decrease to 1.15 million in 2020 from 5.05 million the previous year. Although there has been some improvement since then, intercity ridership had not yet returned to pre-pandemic levels by the end of the MOU period. By 2022, total intercity passenger traffic across all carriers reached 3.36 million passengers, marking a recovery to 66.5% of 2019 ridership.

Railway Traffic

	2017	2022	Change from 2017–2022
GTK (billion)	823.45	822.62	-0.1%
RTK (billion)	435.46	438.73	0.8%
Intermodal Tonnage (million)	39.13	41.22	5.3%
Intercity Passengers (million)	4.65	3.36	-27.6%
Commuter Passengers (million)	79.35	27.83	-64.9%

FREIGHT TRAFFIC

- **Gross Tonne-Kilometres (GTK):** In 2022, the railways handled 822.62 billion GTK of traffic compared to 823.45 billion GTK in 2017, representing a decrease of 0.1%. GTK traffic was 23.0% higher than it was in 2005, the reference year, having increased at an average rate of 1.2% per year.[2] Class 1 GTK traffic accounted for 94.7% of the total GTK hauled in 2022.

- **Revenue Tonne-Kilometres (RTK):** In 2022, the railways handled 438.73 billion RTK of traffic compared to 435.46 billion RTK in 2017, representing an increase of 0.8%. RTK traffic was 24.3% higher than it was in 2005, the reference year, having increased at an average rate of 1.3% per year. Of the freight RTK traffic handled in 2022, Class 1 freight railways were responsible for 94.6% of the total traffic.

- **Intermodal Traffic:** Intermodal tonnage increased by 5.3% to 41.22 million tonnes in 2022 from 39.13 million tonnes in 2017. Overall, intermodal tonnage comprising both container-on-flat-car and trailer- on-flat-car traffic for railways in Canada has risen 33.7% since 2005, equating to an average growth rate of 1.7% per year.

2 Growth rates are calculated using the compound annual growth rate (CAGR) formula.

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PASSENGER TRAFFIC

Passenger rail traffic in 2022 continued to be impacted by the COVID-19 pandemic since it began in 2020. While the number of intercity rail and commuter passengers continued increasing in 2022 (after a sharp decline in 2020), both intercity and commuter rail ridership were significantly lower in 2022 than they were pre-pandemic.

- While commuter ridership continued to recover in 2022, rail traffic decreased from 79.35 million passengers in 2017 to 27.83 million in 2022, a decrease of 64.9%.[3]
- Following closures during the COVID-19 pandemic, tourist and excursion railways were able to provide passenger services in 2022.

Fuel Consumption

	Million litres		Change from 2017–2022
	2017	2022	
Total	2,157.98	2,018.61	-6.5%
Total Freight Operations	2,039.28	1,919.98	-5.9%
Class 1 Freight	1,864.83	1,750.57	-6.1%
Regional & Shortline	114.15	113.24	-0.8%
Yard Switching and Work Train	60.30	56.17	-6.9%
Passenger Operations	118.70	98.63	-16.9%

- Fuel consumed by railway operations in Canada decreased by 6.5%, from 2,157.98 million litres in 2017 to 2,018.61 million litres in 2022.
- Of the total fuel consumed by all railway operations, Class 1 freight train operations (excluding yard switching) consumed 86.7% and regional & shortlines consumed 5.6%. Yard switching and work train operations consumed 2.8%, and passenger operations accounted for 4.9%.
- For total freight operations, overall fuel consumption in 2022 was 1,919.98 million litres, 5.9% below the 2017 level of 2,039.28 million litres.
- For total freight operations, fuel consumption per productivity unit (litres per 1,000 RTK) in 2022 was 4.38 litres per 1,000 RTK, a decrease of 6.6% from 2017 and 26.7% from 2005.
- For total passenger operations, overall fuel consumption in 2022 was 98.63 million litres, 16.9% below the 2017 level of 118.70 million litres.

Locomotive Fleet

	2017	2022	Change from 2017–2022
Total Locomotives	3,177	3,715	16.9%
Line Haul Freight	2,349	2,861	21.8%
Class 1	2,064	2,555	23.8%
Regional	117	162	38.5%
Shortline	168	144	-14.3%
Freight Yard Switching and Work Train	576	602	4.5%
Passenger	252	252	0.0%
Intercity	84	79	-6.0%
Commuter	126	155	23.0%
Tourist/Excursion	42	18	-57.1%

3 The COVID-19 pandemic caused a reduction in travel and increase in teleworking, resulting in a significant decrease in the number of commuters and commuter railways' fuel consumption (also impacting total passenger rail fuel consumption).

The reported number of diesel-powered locomotives and diesel multiple units (DMUs) in active service in Canada operated by MOU signatory railways totaled 3,715 in 2022 versus 3,177 in 2017, an increase of 16.9%.[4]

For line haul freight operations in 2022, 2,555 locomotives were operated by Class 1s, 162 by regional railways, and 144 by shortlines. A further 602 locomotives were used in freight yard switching and work train operations. A total of 252 locomotives and DMUs were used in 2022 to support passenger railway operations in Canada, of which 79 were for intercity passenger services, 155 for commuter railway services, and 18 for tourist and excursion services.

LOCOMOTIVES MEETING EMISSION STANDARDS

In 2022, 84.4% of the active fleet met emission standards (as set out under the LER or the United States Environmental Protection Agency (US EPA) Regulations).[5] This is a significant improvement compared to 2017, when 67.9% of the fleet met an emission standard. A total of 84 locomotives were added to the locomotive fleet in 2022, including 11 non-Tier, seven Tier 0, 21 Tier 0+, five Tier 1, 25 Tier 1+, five Tier 2+, nine Tier 3, and one Tier 4; and 63, mostly non- and lower-Tier locomotives, were retired. In addition, 203 locomotives were remanufactured: two to non-Tier, 40 to Tier 0+, 52 to Tier 1+, 51 to Tier 2+, and 58 to Tier 3.

LOCOMOTIVES EQUIPPED WITH ANTI-IDLING DEVICES

The number of locomotives in 2022 equipped with a device to minimize unnecessary idling, such as an automatic engine stop-start (AESS) system or auxiliary power unit (APU), was 3,355, which represents 90.3% of the fleet, compared to 3,034 in 2021 (84.1% of the 2021 fleet) and 2,195 in 2017 (69.1% of the total in-service fleet).[6]

Tropospheric Ozone Management Areas (TOMA)

TOMAs are geographically-defined areas in which governments, stakeholders, and other interested parties work together to improve local air quality and manage air pollutant concentrations. Of the total GHGs emitted by the railway sector in 2022, 2.6% occurred in the Lower Fraser Valley of British Columbia, 13.2% in the Québec City-Windsor Corridor, and 0.2% in the Saint John area of New Brunswick. Estimated NO_x emissions for each TOMA were at the same ratios as GHGs.

4 The active fleet is reported as it existed on December 31st of each year. As the data represents the fleet on one particular day in the calendar year, significant year-over-year fluctuations are possible.
5 Ibid.
6 Ibid.

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1. Introduction

This report contains the Locomotive Emissions Monitoring (LEM) data filing for 2022 in accordance with the terms of the Memorandum of Understanding (MOU) signed on March 21, 2019, between the Railway Association of Canada (RAC) and Transport Canada (TC) concerning voluntary arrangements to limit greenhouse gas (GHG) emissions and criteria air contaminant (CAC) emissions from locomotives operating in Canada.

Transportation is Canada's second largest source of GHG emissions. In 2022, the transportation sector emitted 196 Mt of CO_2e, accounting for 27.7% of Canada's total GHG emissions.[7] The majority of transportation GHGs are attributed to light-duty and heavy-duty on-road vehicles. Canadian railways accounted for less than 1% of Canada's total GHG emissions and less than 4% of transportation GHGs, which is less than light-duty vehicles (40%), heavy-duty vehicles (21%), and the pipeline transport sector (5%).[8] To meet Canada's commitment to reduce GHGs by 40–45 percent below 2005 levels by 2030 and reach net-zero by 2050, the transport sector must make a significant contribution.

Railways have played and will continue to play a key role in contributing to Canada's climate targets. Since 2005, freight railways have reduced their GHG intensity by 26.7%. During the same timeframe, railways have experienced a 24.3% increase in revenue traffic. Passenger railways continue to invest in training, technology and equipment to reduce emissions, while contributing to emissions reductions by providing a sustainable transportation option for commuters and intercommunity travelers. Canada's railways will continue to contribute to national emissions reductions through investments in innovative solutions to increase efficiency and sustainability.

The 2018-2022 MOU between Transport Canada and the RAC is the fourth MOU signed by the RAC and the federal government since 1995. The MOU established a framework through which the RAC, its MOU signatory member companies (as listed in Appendix A), and TC committed to address GHG and CAC emissions produced by locomotives in Canada. The MOU, which can be found on the RAC website, includes measures, targets, and actions that will further reduce GHG and CAC emissions intensities from rail operations to help protect the environment and health of Canadians and address climate change. This is the fifth and final report prepared under the 2018-2022 MOU.

Data for this report was collected via a survey sent to each RAC member. 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 carbon dioxide equivalent (CO_2e), the key constituents of which are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). CAC emissions include nitrogen oxides (NO_x), particulate matter (PM_{10}), carbon monoxide (CO), hydrocarbons (HC), and sulphur oxides (SO_x). The SO_x emitted is a function of the sulphur content of diesel fuel and is expressed as SO_2. The survey and calculation methodology are available upon request to the RAC.

7 Source: Canada's National Inventory Report, 1990–2022: Greenhouse Gas Sources and Sinks in Canada, Environment and Climate Change Canada, 2024, Table ES-1 and Table 3-7.
8 Ibid.

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1.1 OVERVIEW OF REPORT

This report provides an overview of 2022 rail performance including traffic, fuel consumption, fleet inventory, and GHG and CAC emissions. Also included are sections on partnerships and initiatives being undertaken or examined by the sector to reduce fuel consumption and emissions.

1.2 GHG COMMITMENTS

As stated in the MOU, the RAC encourages its members to improve their GHG emissions intensity from railway operations and sets GHG emissions targets for 2022. The 2017 baseline data and actual annual emissions (expressed as kilograms of CO_2e per productivity unit) are outlined in the following table.

Data is presented from 2018 to 2022. For historical comparison purposes, the year 2005[9] has been set as the reference year and has also been included. LEM statistics from 1990 to 2021 can be found in previously completed LEM Reports available from the RAC upon request. Unless otherwise specified, metric units are used and quantities are expressed to two significant figures, while percentages are expressed to the number of significant digits reflected in the table. Data in US (imperial) units are available upon request to the RAC.

In addition, this report contains winter and summer data on the fuel consumed and emissions produced by railways operating in three designated Tropospheric Ozone Management Areas (TOMA): the Lower Fraser Valley in British Columbia, the Québec City-Windsor Corridor, and the Saint John area in New Brunswick.

GHG Emissions Intensity and MOU Results by Railway Operation

Railway Operation	Productivity Units	Baseline 2017	2018	2019	2020	2021	2022	2022 Target	Change from 2017–2022	Change from 2021–2022	% of Target Achieved	Target Achieved?
Class I Freight	kg CO_2e per 1,000 RTK	13.56	13.45	13.49	12.91	12.76	12.62	12.75 (6% reduction)	-6.99%	-1.12%	116%	YES
Intercity Passenger*	kg CO_2e per passenger-km	0.098	0.097	0.089	0.178	0.146	0.093	0.092 (6% reduction)	-4.68%	-36.27%	78%	NO
Regional & Shortline	kg CO_2e per 1,000 RTK	14.08	15.02	14.77	15.27	14.66	14.29	13.66 (3% reduction)	1.48%	-2.55%	increase since 2017	NO

Note: GHG emissions for all years have been calculated based on the emissions factors and global warming potentials in the 2024 National Inventory Report (the 2024 National Inventory Report contains the GHG emissions factors for 1990-2022). Historical values have been updated.

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

GREENHOUSE GAS POLLUTION PRICING ACT

The Government of Canada passed the *Greenhouse Gas Pollution Pricing Act* in 2018, based on the consensus that greenhouse gas (GHG) emissions contribute to global climate change. In March 2021, Canada's Supreme Court deemed reducing GHG emissions a matter of national concern when it found the Act to be constitutional. The landmark decision allows provinces to design their own GHG pricing systems so long as they align with the federal government's outcome-based targets. Existing pricing regimes, such as in Québec and British Columbia, may stay in place, but the federal tax will apply for provinces that do not meet the standard or do not have a mechanism in place.

9 Starting with the 2020 LEM Report, 2005 has been set as the reference year, as it aligns with the Government of Canada's climate targets, among other merits. In all previous reports, 1990 was set as the reference year.

ENHANCED 2030 AND 2050 TARGETS

At the 2021 Leaders Summit on Climate, hosted by the United States on Earth Day (April 22, 2021), the Government of Canada raised its climate ambition and committed to reducing GHG emissions by 40–45 percent from 2005 levels by 2030 and reaching net-zero by 2050. In July 2021, the Minister of Environment and Climate Change, the Honourable Jonathan Wilkinson, formally submitted Canada's enhanced Nationally Determined Contribution (NDC) to the United Nations. Canada's NDC submission outlines a series of investments, regulations, and measures that the country is taking in pursuit of its ambitious target. It includes input from provincial, territorial, and Indigenous partners. These actions are also detailed in a new publication, entitled "Canada's Climate Actions for a Healthy Environment and a Healthy Economy."

CANADA NET-ZERO EMISSIONS ACCOUNTABILITY ACT

The Canadian Net-Zero Emissions Accountability Act, which became law on June 29, 2021, enshrines in legislation Canada's commitment to achieve net-zero GHG emissions by 2050, and provides a framework of accountability and transparency to deliver on it. The Act also establishes a requirement to set national emissions reduction targets for 2035, 2040, and 2045, ten years in advance, to be supported by a science-based emissions reduction plan outlining the measures and strategies the Government of Canada will take to achieve the target along with progress reports on the plan's ongoing implementation. Decarbonizing the transportation sector will be a crucial step in achieving these ambitious targets.

1.3 CAC COMMITMENTS

As stated in the MOU, Transport Canada has developed regulations to control CAC emissions under the *Railway Safety Act*. The *Locomotive Emissions Regulations* (LER) came into force on June 9, 2017, and apply to railway companies that the federal government regulates.[10] The Canadian regulations are aligned with the United States Environmental Protection Agency (US EPA) emissions regulations (*Title 40 of the Code of Federal Regulations of the United States, Part 1033*).

Prior to the implementation of the Canadian regulations, the RAC encouraged all members to conform to the US EPA emission standards and to adopt operating practices aimed at reducing CAC emissions. The RAC continues to encourage its members, including those not covered by the LER, to improve their CAC emissions performance. Through this Memorandum, the RAC continued to report on annual CAC emissions, in a manner and format that is agreeable to all parties, with a view to leverage the data railways provide under the regulations. CAC reporting under the MOU does not fulfill reporting requirements under the LER.

10 Baseline and some historical CAC performance reflected in this report predates the *Locomotive Emissions Regulations* for CACs. The *Locomotive Emissions Regulations* came into force on June 9, 2017. https://laws-lois.justice.gc.ca/PDF/SOR-2017-121.pdf

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2. Emissions Reduction Initiatives

In 2022, Canadian railways continued to invest in new technologies and improve operational practices to reduce locomotive emissions. In 2022, railways invested $2.4 billion in their Canadian networks, bringing the total to more than $21.5 billion over the past ten years. This section of the report highlights how Canadian railways lowered their emissions through investments in fleet renewal/modernization, fuel saving technologies, operational efficiencies, and use of low carbon fuels. In addition, pilot projects in alternative fuels and propulsion and partnerships that will drive emissions reductions in the coming years are also discussed.

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OF THE MOST FUEL-EFFICIENT LOCOMOTIVES CURRENTLY AVAILABLE WERE ACQUIRED BY CN IN 2022

OVER THE LAST FEW YEARS, CP INVESTED APPROXIMATELY **$514M** IN ITS LOCOMOTIVE MODERNIZATION AND RETROFITTING PROGRAM

43%

RECORDED IMPROVEMENT IN CP'S FUEL EFFICIENCY FROM 1990 TO 2022

2.1 FLEET RENEWAL/ MODERNIZATION

In 2022, CN's fleet renewal approach included purchasing 53 of the most fuel efficient high-horsepower locomotives currently available. CN also received the first 10 units out of a multi-year modernization program, where existing locomotives from the CN fleet are upgraded with the latest technology, extending their life, and enhancing fuel efficiency. All new and modernized locomotives are equipped with energy management systems, data telemetry systems as well as distributed power functionality to help maximize locomotive operating effectiveness and fuel efficiency.

Over the last few years, CP[11] invested approximately $514M in its locomotive modernization and retrofitting program. Since 2012, more than 400 of CP's active line-haul locomotives have been upgraded, resulting in an estimated annual fuel savings of nearly 12 million litres, which corresponds to about 35,000 metric tonnes of GHG emissions saved each year. CP recorded a 2022 fuel efficiency of 0.955 U.S. gallons of locomotive fuel per 1,000 gross ton-miles (GTMs), an improvement of 43 percent relative to 1990.

11 This report is limited to Canadian Pacific's (CP) standalone activities and operations, and does not report on the climate initiatives of the combined CPKC.

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The rollout of VIA Rail's new fleet of trains for the Québec City-Windsor corridor also reached a new critical milestone in 2022 when it welcomed the first passengers on board. The fleet offers an unparalleled, fully accessible, and barrier-free travel experience and is one of North America's most environmentally friendly fleets. The Corridor's new fleet of locomotives meet Tier 4 emissions standards which allows for an 85-95% reduction in particulate matter and Nitrogen Oxide emissions and hence significantly contribute to improving air quality.

VIA Rail also continued to make improvements to its existing fleet by upgrading two additional F40PH (GPA30) locomotives to meet Tier 0 emissions standards.[12]

Genesee & Wyoming Inc. continued its efforts to reduce GHGs by upgrading locomotives to Tier 0+ and purchased more APUs and AESS.

West Coast Express (WCE) continued to progress with the refurbishment of the WCE locomotives from Tier 1 engines to Tier 3 engines. WCE will receive its first two refurbished locomotives in 2023, with all work expected to be completed by 2026. Once these refurbishments are complete, CAC (criteria air contaminants) emissions should be reduced by 48 per cent, based on US EPA standards.

VIA RAIL'S NEW FLEET OF TRAINS FOR THE QUÉBEC CITY-WINDSOR CORRIDOR REACHED A CRITICAL MILESTONE IN 2022 WHEN IT WELCOMED ITS FIRST PASSENGERS ON BOARD

12 VIA Rail upgraded the locomotives to meet CDN/40 CFR 1033 Tier 0 standards, which is referred to as "Tier 0+" in the rest of the LEM report.

ISBN: 978-1-927520-21-5

2.2 FUEL SAVING TECHNOLOGIES

CP installed Wabtec's Trip Optimizer™ technology on more than 400 high-horsepower locomotives, equipping more than 50% of its high-horsepower fleet with this fuel-saving technology. Trip Optimizer™ is a sophisticated locomotive cruise control optimized for fuel economy, taking into account factors such as train length, weight and track grade to determine the optimal speed profile for a given segment of track. CP enhanced its use of Trip Optimizer systems in 2019 to include pacing technology to drive deeper fuel efficiency and system fluidity improvements. Pacing technology accounts for a specific train's location in relation to other trains operating within the same area of the network. The system detects opportunities to reduce train speed in certain areas along the right-of-way to minimize wait times at stations, thus facilitating continued progression at the optimum speed to deliver on time, in the most fuel-efficient manner possible.

CN continues to install fuel-efficient technologies and utilize data analytics to optimize the efficiency of its fleet. These innovative technologies allow CN to continuously improve train handling, braking performance, and overall fuel efficiency, therefore, improving carbon efficiency in the years to come. Technologies include:

1. CN's Horsepower Tonnage Analyzer uses data from the system to optimize a train horsepower-tonnage ratio for efficiency.

2. Energy management system to regulate speed and compute the most fuel-efficient manner to handle the train.

3. Distributed Power to remotely control locomotives and improve braking performance, train handling and fuel efficiency.

4. Locomotive Telemetry System to collect data to improve performance of fuel saving initiatives.

CN achieved an all-time record fuel efficiency of 0.867 U.S. gallons of locomotive fuel consumed per 1,000 GTMs in 2022, which was a 2% improvement from 2021 efficiency.

In 2022, VIA Rail completed a pilot project through the Innovative Solutions Canada Testing Stream in collaboration with Transport Canada and start-up RailVision Analytics to test EcoRail, an artificial intelligence-enabled software.

EcoRail monitors driving behavior between station stops to determine improvements that will reduce fuel consumption. The software analyzes several variables, including the equipment being used, the season, and the schedule, to recommend the most fuel-efficient train handling behavior without affecting travel time. The initial six month testing with locomotive engineers in VIA Rail's simulators confirmed a potential reduction of up to 15% in fuel consumption and associated GHG emissions.

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2.3 OPERATIONAL EFFICIENCIES

In 2022, CN continued to implement projects related to its locomotive emissions and energy efficiency strategy.[13] This includes fuel efficiency training for locomotive crews. Additionally, installation of Energy Management System (EMS) in new and modernized locomotives and improvements to the integration between CN in-house-built Horsepower Ton Analyzer (HPTA) and EMS system.

CN's recommitment to a disciplined scheduled operating plan, with a focus on velocity, helped to increase network fluidity, reducing unplanned train stops across the network and helping to enhance related gains in fuel efficiency.

CP has implemented a precision scheduled railroading (PSR) operating approach. PSR focuses on operational efficiency and fuel efficiency metrics to drive performance improvements.

2.4 LOW CARBON FUELS

Railways make use of renewable fuels such as biodiesel blends up to 5% (B5) and hydrogenation-derived renewable diesel (HDRD) blends up to 30%. The majority of North American engine manufacturers endorse up to a B5 biodiesel blend. Some important caveats to note include:

- biodiesel and HDRD have slightly lower energy density than fossil diesel;[14]
- fuel providers are not always required to disclose exact blend levels, therefore railways do not have precise visibility on exact blend levels; and
- locomotive performance may be adversely impacted with higher renewable fuel content and manufacturer warranties may be voided.

Canadian railways continue to work collaboratively with a variety of partners to explore the opportunities and challenges of increasing the use of low carbon fuels in locomotives.

CN is actively working with its fuel suppliers and locomotive manufacturers and is focused on testing and exploring the greater use of sustainable renewable fuel blends, beyond regulated amounts, in its locomotives, to achieve its target. CN continued its partnership with Progress Rail and Chevron REG to test high-level renewable fuel blends including both biodiesel and renewable diesel in support of their sustainability goals. Trials and qualifications of up to 100% bio-based diesel fuel, important steps in reducing GHG emissions from CN's existing locomotive fleet, have continued to progress. In 2022, the use of renewable fuels in CN's fleet saved 138,442 tonnes of CO_2e.

In 2022, CP prepared to initiate in 2023 a multi-year biodiesel trial out of its Golden, B.C. railyard to evaluate fuel performance in the challenging terrain of the Canadian Rockies and during periods of cold weather.

138,442 TONNES

OF CO_2e WERE SAVED IN 2022 IN CN'S FLEET FROM THE USE OF RENEWABLE FUELS

13 CN Climate Action Plan. https://www.cn.ca/-/media/files/delivering-responsibly/delivering-resp-2022-en.pdf
14 HDRD has approximately two to four percent lower energy density than fossil diesel.

ISBN: 978-1-927520-21-5

2.5 ALTERNATIVE PROPULSION

CP built a demonstration of North America's first line-haul hydrogen-powered locomotive using fuel cells and batteries to power the locomotive's electric traction motors. Hydrogen fuel cells supported by battery technology are being integrated into existing locomotive platforms to power the electric traction motors. With over 30,000 diesel-electric locomotives in freight service across North America today, a solution to retrofit the locomotive power plant with a combination of hydrogen fuel cells and battery technologies is critical to reducing the carbon footprint of the freight rail sector.

In 2022, CP advanced production on three hydrogen locomotive conversions and installation of hydrogen production and fueling facilities. This industry-leading project is demonstrating the technical performance in real-world operations and generating critical industry knowledge and experience that is informing future commercialization and development activities. CP's Hydrogen Locomotive Program passed a significant milestone in 2022 by completing the first successful movement and freight service testing on the initial hydrogen locomotive.

IN 2022 CP COMPLETED THE FIRST SUCCESSFUL MOVEMENT AND FREIGHT SERVICE TESTING ON THE INITIAL HYDROGEN LOCOMOTIVE

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2.6 PARTNERSHIPS

Partnerships between and among industry, governments, academia, and others will play a critical role in developing policy and technological solutions for continued decarbonization of the rail sector in Canada.

Transport Canada and Change Energy Services Low Carbon-Intensity Diesel Report

Transport Canada engaged Change Energy Services to undertake a research project to explore the use of low carbon-intensity diesel fuels in Canada's rail sector through a review of relevant literature and published data, as well as direct interviews with industry representatives. The project concluded in 2022. The project's final report[15] included an analysis of the rail sector's potential demand for diesel out to 2050, impacts of increased low-carbon fuel use under future scenarios, challenges associated with increasing low-carbon fuel use in the sector, and opportunities and tactical initiatives that could address those challenges.

Using historical data from the 2018 and 2019 LEM reports, Change Energy Services projected plausible levels of locomotive composition, railway activity, and diesel consumption in Canada to 2050 for freight, intercity/tourist, and commuter railways. Based on expected growth in Canada's locomotive fleet, the report illustrated that the railway sector in Canada could require nearly one-third more diesel by 2050 than it uses today, or 700-750 million litres more.

Change Energy Services also modeled a scenario to illustrate how the rail sector may reduce emissions by increasing its low-carbon fuel use. The analysis illustrated that by 2050 the rail sector may consume nearly 1.5 billion litres of low-carbon diesel, representing nearly half the fuel demand of the sector. The report assumes that the other half of the sector's energy demand will be met by some other decarbonizing solution (e.g., electrification, hydrogen) or petrochemical diesel in 2050.

The report will help inform TC and RAC's discussions on a renewed Memorandum of Understanding for reducing locomotive emissions, and consideration of opportunities to increase the use of low-carbon fuels in the sector.

Transport Canada and High Frequency Rail Project

The Government of Canada's High Frequency Rail project would transform intercity passenger rail in the Quebec City to Windsor Corridor, bringing faster, more frequent, and reliable service to travelers.

In Budget 2022, the Government of Canada allocated $396.8 million over two years, starting in 2022-23, to Transport Canada and Infrastructure Canada to advance HFR through the Procurement phase of the project, scheduled to end in 2024 — taking it into the Co-Development phase.

The HFR project supports many priorities of the MOU, including the vision for green and innovative transportation in Canada, and the improvement the GHG and CAC emissions intensity of the rail sector, by supporting the construction of electrified rail tracks.

Natural Resources Canada—Lignin-Derived Diesel Fuel

Through Natural Resources Canada, CanmetENERGY-Ottawa completed a project in Fall 2022 to develop a process to produce lignin-derived diesel fuel as a potential drop-in low carbon biofuel. Lignin is present in softwoods, hardwoods, grasses, and other plants. It is a waste product as a residue from chemical pulp mills and from agriculture that can be converted into a drop-in replacement for diesel. Results to date have demonstrated that

15 To receive a copy of the report please contact TC.RailDecarbonization-DecarbonisationFerroviaire.TC@tc.gc.ca.

ISBN: 978-1-927520-21-5

100% lignin-derived diesel met 9 locomotive diesel specifications from CGSB-3.18-2010 and the same 9 from CGSB-3.517-2020.[16]

The low cloud point of 100% lignin-derived diesel (-36 °C by ASTM D5773) indicates that it has fairly good low-temperature operability. The specifications not met were for electrical conductivity, lubricity, and derived cetane number. These properties could be brought to standard by using fuel additives that are commonly used in ultra-low sulphur diesel, and a cetane enhancer additive that would boost the ignition quality of 100% lignin-derived diesel (from 39.1 to 40). These results indicate that the lignin-derived diesel that was produced is suitable for use in diesel locomotives at any blend up to and including 100% and would be compatible with existing infrastructure.

Commercial hydrogenation-derived renewable diesel (HDRD or hydrotreated vegetable oil—HVO) employs many of the same feedstocks as biodiesel. The hydrocarbons are chemically identical to some of the molecules found in petroleum diesel fuel. Considered to be a 'drop-in' fuel, it is compatible with existing infrastructure and locomotives; however, some OEMs have placed limits on the amount of HDRD that can be included when blended with petroleum diesel fuels.

Natural Resources Canada—Hydrogen Strategy

Natural Resources Canada released Canada's Hydrogen Strategy in 2020,[17] which continues to complement the strengthened climate plan, as the Strategy is working to position Canada's ports as hosts for early deployment hubs of fuel cell equipment, with marine, rail, and on-road vehicles that could share hydrogen infrastructure at scale, and companies such as Alstom are exploring hydrogen rail demonstration.[18]

Environment and Climate Change Canada And California Environmental Protection Agency Memorandum of Cooperation

On June 9, 2022, the Government of Canada and the Government of the State of California signed a cooperative arrangement to advance their shared climate action and nature protection goals. The Memorandum of Cooperation between the Government of Canada and the Government of the State of California Concerning Climate Action and Nature Protection (MOC) signals Canada and California's intent to work together on their respective policies and regulations aimed at reducing pollution, adapting to climate change and conserving nature. The MOC is part of a broader Canada-California Climate Action and Nature Protection Partnership launched by California Governor Gavin Newsom and Canadian Prime Minister Justin Trudeau in June 2022.

The MOC is intended to remain valid for a period of 5 years (2022-2027) and designates Environment and Climate Change Canada (ECCC) and the California Environmental Protection Agency (CalEPA) as the implementing agencies of the MOC.

Transport Canada—Innovation Centre

The Innovation Centre's Rail RD&D group undertakes research and development activities to support the rail industry's adoption of new technologies that reduce the emissions of greenhouse gases and criteria air contaminants. The projects are designed to help the rail industry address technical challenges and build knowledge about how to operate new technologies safely. Projects undertaken in this program are selected through a consultation process that includes recommendations from federal government, academia, and the railway industry.

16 In September 2021, the CAN/CGSB-3.18-2010 standard was withdrawn, and standard CAN/CGSB-3.517-2020 may be used for applications that were formerly covered by CAN/CGSB-3.18-2010.

17 Progress report available: https://natural-resources.canada.ca/climate-change/canadas-green-future/the-hydrogen-strategy/hydrogen-strategy-for-canada-progress-report/25678

18 Alstom's Coradia iLint, the world's first hydrogen-powered passenger train, will demonstrate green traction in Quebec (https://www.alstom.com/press-releases-news/2023/2/alstoms-coradia-ilint-worlds-first-hydrogen-powered-passenger-train-will-demonstrate-green-traction-quebec)

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Policy, market, and technology trends are positioning hydrogen and battery technologies as key parts of the solution for decarbonizing the rail sector. To this end, Innovation Centre has focused more attention on work that informs the development of codes and standards to ensure a safe environment for hydrogen and battery locomotive operations. Major initiatives in this space include (1) a grant to CSA group to support their development of technical specifications for hydrogen fuel cell and battery locomotives. These specifications provide guidance about appropriate risk assessment approaches for this equipment, operational parameters, and inspection and maintenance protocols. (2) Internally, Innovation Centre continued its work from 2021 with the National Research Council of Canada on building a detailed risk register associated with hydrogen and battery components in locomotives.

Research results from 2022 conducted internally by Innovation Centre and its research partners are described below:

- TC continued its initiative to examine the risks and hazards associated with hydrogen fuel cell and battery powered locomotives by initiating Phase II of their Hydrogen and Battery Locomotives Risks and Hazards project.
    - Phase I of the project was completed in 2021 and included a literature review of risks and hazards (online report), assessment of the risks and hazards (online report), and a review of existing codes and standards (online report).
    - The second phase built on the original analysis by documenting hazards associated with hydrogen and battery locomotives, estimating their risks, and evaluating risk mitigation technologies.
    - As part of Phase II, an overview of batteries for locomotives is being prepared. It will include information about common operational or manufacturing issues that can cause battery failures and an overview of the risks and hazards associated with them.
    - A report is planned to be published with findings of Phase II in 2024.
- Launched a literature review and physical experiments with hydrogen/diesel blends to evaluate overall feasibility for locomotive use and potential changes in greenhouse gas and criteria air contaminant emissions compared to diesel. This study used heavy-duty compression ignition engines operating at typical locomotive engine load conditions in a laboratory. The final report is available online at the Innovation Centre reports page.
- TC has completed two testing projects with NRCan: to develop (1) lignin-derived renewable diesel (online report) and (2) a means of addressing CAC emissions with dual NO_x-PM catalytic converters (online report).
- TC has completed a testing project with VIA Rail Canada to validate the usefulness of RailVision Analytics' product service known as 'EcoRail', which is a tool for operators that provides in-cab fuel efficiency and performance insights. The project involved providing training, technical support, oversight services, and consultation with operators to ensure that EcoRail was compatible with VIA's network data. Testing of the tool in VIA Rail's simulators confirmed a potential reduction of up to 15% in fuel consumption and associated GHG emissions.

Transport Canada also supports the development of technologies for reducing emissions through the Clean Transportation System - Research and Development Program. This is a grant program; projects are selected through a competitive process and funded to carry out research and demonstration testing work. The rail projects that received grant funding in 2021 and continued through 2022 are described below. Results from these projects are expected in 2023.

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1. **Ballard Power Systems:** The project is a feasibility study to assess the viability of replacing diesel generators with hydrogen fuel cell (HFC) power generators to manage the train's auxillary power demands, i.e. lighting, heating, power. The purpose is to study the technical feasibility and potential benefits, in order to form a potential future demonstration project.

2. **Canadian Nuclear Laboratories (CNL):** CNL is conducting a high-level quantitative risk assessment of the use of hydrogen as a fuel in freight trains. Hydrogen detection and mitigation measures, and relevant regulations, codes and standards are being assessed to develop appropriate risk mitigation strategies where required. To further support this work, CNL is creating a quantitative risk assessment tool designed to be used for case studies. This forms a part of CNL's in-kind contributions to the project. The analysis from this work will help to determine fatalities per year for a given hydrogen installation. The project engaged industrial partners to provide operational data and feedback to support the risk assessment.

3. **CSA Group:** The CSA Group is one of the largest standards development organization in North America. CSA Group is developing technical specifications for hydrogen fuel cell and battery-powered locomotives:

   - CSA TS-602:2—Railway Applications—Rolling Stock—Onboard Lithium-ion Traction Batteries (Published: CSA TS-602:23)

   - CSA TS-601 related to hydrogen fuel cells[19]

   Participating members of these working groups include railway companies, manufacturers of locomotives and fuel cells, academia, and National Research Council of Canada. In another part of this project, CSA Group carried out a project to identify codes and standards from international sources that could be used to inform safe design and operation of hydrogen fuel cell and battery-powered locomotives. The product of this work is a roadmap for developing a more robust codes and standards ecosystem and identify gaps where North American homegrown standards may be needed.

4. **Southern Railway of British Columbia (SRY) Limited:** SRY Limited has initiated a pilot project to transition one diesel locomotive engine to 100% biodiesel-power, also known as "B100." The test locomotive is used in SRY's day-to-day freight rail operations in Southern British Columbia. The project is examining train performance and emission reductions.

5. **University of British Columbia:** Is investigating the technical feasibility of a hydrogen-powered locomotive pilot project by analyzing the technical parameters, operational constraints, and safety risks as well as mitigation strategies for the fuel cell and battery retrofits to be utilized in the locomotive. A techno-economic analysis and life cycle costing of the retrofits is being conducted in order to examine the economic viability of the hydrogen-powered locomotive, along with a study of the environmental sustainability and social acceptability of the retrofits. The project is also working on a multi-criteria decision support system for future hydrogen-powered locomotive projects considering their technical, economic, environmental, and social aspects.

19 Hegazi, M., Wong, D., Aitken, H., Hoffrichter, A. (2024). Advancing the Use of Hydrogen and Electrification in the Rail Industry. Canadian Standards Association, Toronto, ON.

CN—Collaboration with the Université de Montréal

CN is continuing its academic-industry partnership with Université de Montréal for development of operations research and machine learning models to enhance operational planning. Through optimized planning of how CN operates, they expect to benefit from reduction in equipment movements and an improvement in in-train aerodynamics, both of which contribute to possible reduction of carbon emissions. These models are being evaluated, to prove and maximize their potential to drive business impact.

CN—Progress Rail and Chevron Renewable Energy Group to Test High-Level Renewable Fuel Blends

CN's partnership with Progress Rail and Chevron Renewable Energy Group continued to advance in 2022. Together, CN is testing high-level renewable fuel blends including both biodiesel and renewable diesel in support of its sustainability goals. See 2.4 Low Carbon Fuels.

CN—Working with Supply Chain Partners to Reduce End-to-End Emissions

CN is building important partnerships on the journey toward decarbonization by closely working with its customers and supply chain partners, including ports, to reduce supply chain emissions. The greater use of combined modes and allowing each mode to be used for the portion of the trip to which it is best suited (such as trucking for short distances and rail for the long haul), is reducing transportation costs and end-to-end emissions across the entire supply chain.

CP—Engaging Customers on Climate-Related Benefits of Shipping by Rail

CP increased engagement with stakeholders on climate actions by releasing a web-based Carbon Emissions Calculator for use by current and prospective rail customers. This tool is designed to provide users with the ability to calculate and compare an estimate of the GHG emissions related to transportation of freight by CP's rail services versus heavy haul trucking alternatives.

CP—Partnering with Ballard Power Systems on Hydrogen Locomotives

CP is partnering with Ballard Power Systems to employ Ballard fuel cell modules in CP's Hydrogen Locomotive Program. This program is intended to spur innovation, demonstrate leadership and encourage supply chain collaboration to expedite fuel cell technology for the freight transportation sector. In 2022, plans to expand the scope of this program through the purchase of eight additional 200 kW fuel cell modules were announced. CP's Hydrogen Locomotive Program receives funding support from Emissions Reduction Alberta (ERA). See 2.5 Alternative Propulsion.

2.7 RAIL PATHWAYS INITIATIVE—PHASE 2

The Pathways Initiative is a partnership between the RAC and its members, Transport Canada, Pollution Probe, and the Delphi Group. In 2021, Phase 2 of the Rail Pathways Initiative launched with an objective of creating a roadmap to rail decarbonization based on emerging low-carbon technologies. This entailed developing a framework for assessing GHG reduction opportunities in Canada's rail sector and creating a strategy to apply it to inform decision-making on decarbonization in the years and decades ahead. The technologies shortlisted for assessment included biodiesel (B20), HDRD-30, battery electric, catenary electric, and hydrogen fuel cell technology.

Phase 2 was published in December 2022.[20] The final report delivered an assessment of the short-listed technologies and included a series of recommendations to inform potential next steps.

20 Rail Pathways Initiative Phase 2 Final Report https://www.railcan.ca/wp-content/uploads/2022/12/Rail-Pathways-Decarbonization-Roadmap.pdf

ISBN: 978-1-927520-21-5

The final report recommends:

1. Completion of technology assessments every 2–5 years to update shared knowledge.

2. Renewal of the MOU between Transport Canada and the RAC.

3. Establishment of a Rail Decarbonization Committee to lead on setting targets, tracking progress, overseeing assessments, identifying areas for government support, proposing actions, and engaging with U.S. counterparts.

4. Creation of a Project Manager function to support the Rail Decarbonization Committee.

5. Establish a joint government-industry program to support and realize the decarbonization opportunities identified in the Rail Pathways Initiative reports.

Knowledge gained through this initiative will serve to inform future developments and advancements in rail decarbonization.

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3. Traffic Data

3.1 FREIGHT TRAFFIC HANDLED

As shown in Table 1 and Figure 1, freight traffic in 2022 decreased relative to 2021, but has grown since 2005. Traffic handled by Canadian railways totaled 822,62 billion gross tonne-kilometres (GTK) compared to 833.21 billion GTK in 2021, a decrease of 1.3%. The 2022 GTK represents an increase of 23.0% from the reference year of 2005. Revenue traffic in 2022 decreased to 438.73 billion revenue tonne-kilometres (RTK) from 442.97 billion RTK in 2021, a decrease of 1.0%. When compared to 352.91 billion RTK in 2005, this represents an increase of 24.3%. Since 2005, the average annual growth rates for GTK and RTK were 1.2% and 1.3% respectively.

Table 1: Total Freight Traffic, 2005, 2013–2022 (billion tonne-kilometres)

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
GTK											
Class 1	628.09	695.58	754.24	752.30	722.33	778.86	820.67	824.53	807.01	793.87	779.42
Regional & Shortline	40.45	39.62	39.19	42.09	44.07	44.59	43.98	39.45	39.75	39.33	43.20
Total	668.54	735.19	793.43	794.39	766.40	823.45	864.66	863.98	846.76	833.21	822.62
RTK											
Class 1	328.24	371.77	399.47	394.10	383.47	411.22	433.45	432.38	430.39	421.23	415.03
Regional & Shortline	24.67	24.23	23.01	23.98	25.05	24.25	22.27	22.68	21.29	21.73	23.70
Total	352.91	396.00	422.49	418.08	408.53	435.46	455.72	455.06	451.67	442.97	438.73
Ratio RTK/GTK*	**0.53**	**0.53**	**0.53**	**0.52**	**0.53**	**0.53**	**0.53**	**0.53**	**0.53**	**0.53**	**0.53**

* A higher RTK/GTK ratio may be indicative of greater asset utilization efficiency. However, this ratio may be influenced by non-efficiency factors such as a change in the composition of a railway's commodity portfolio (for example, increasing share of carloads of relatively lighter goods leading to a lower RTK/GTK ratio).

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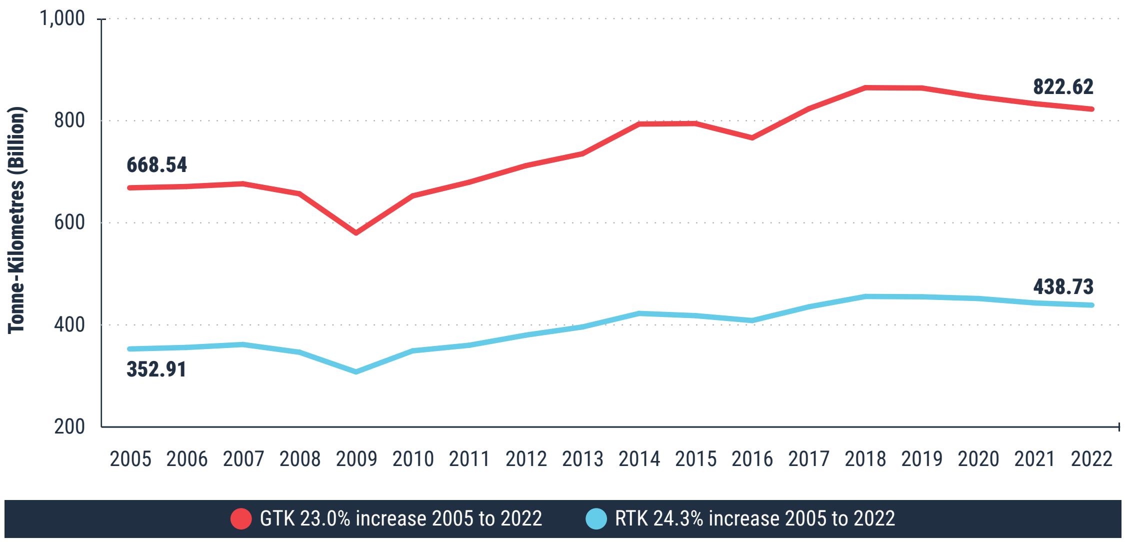
Figure 1: Total Freight Traffic, 2005–2022



In 2022, Class 1 GTK traffic decreased by 1.8% to 779.42 billion from 793.87 billion in 2021 (Table 1) and accounted for 94.7% of the total GTK hauled. Class 1 RTK traffic decreased by 1.0% in 2022 to 415.03 billion from 421.23 billion in 2021 and accounted for 94.6% of the total RTK.

Of the total freight traffic in 2022, regional & shortlines were responsible for 43.20 billion GTK (or 5.3%) and 23.70 billion RTK (or 5.4%). In 2022, regional & shortline railways experienced a 9.1% increase in RTK compared to 2021 and an increase of 9.8% of their GTK traffic.

3.1.1 Freight Carloads by Commodity Grouping

The total 2022 freight carloads for 11 commodity groups are shown in Figure 2 and Table 2 below.

Figure 2: Canadian Rail Originated Carloads By Commodity Grouping, 2022

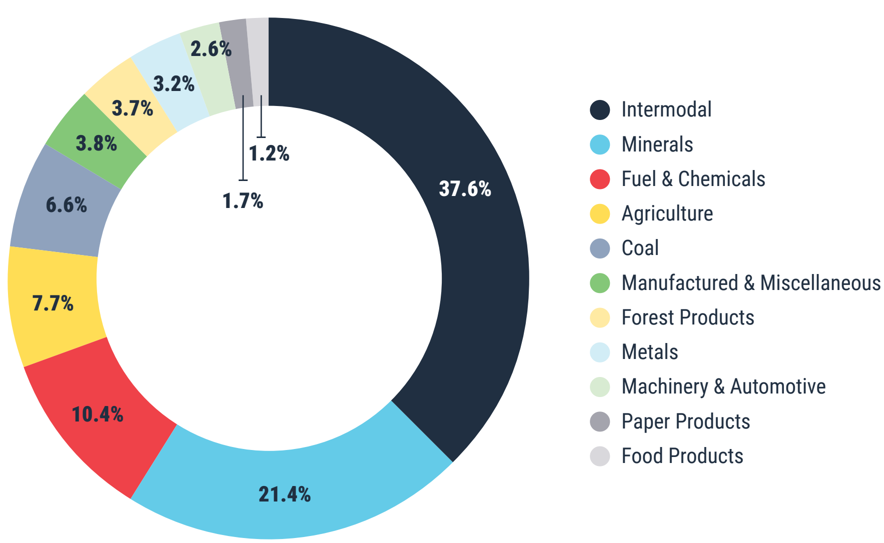


Table 2: Canadian Rail Originated Freight Carloads by Commodity Grouping, 2005, 2021–2022

	2005	2021	2022	2005–2022	2021–2022
Agriculture	416,473	483,085	413,939	-0.6%	-14.3%
Coal	353,197	321,232	352,549	-0.2%	9.7%
Minerals	657,410	1,105,311	1,145,610	74.3%	3.6%
Forest Products	433,138	198,714	196,436	-54.6%	-1.1%
Metals	295,022	168,593	172,511	-41.5%	2.3%
Machinery & Automotive	235,480	126,451	138,403	-41.2%	9.5%
Fuel & Chemicals	469,655	565,748	558,806	19.0%	-1.2%
Paper Products	333,830	97,884	92,140	-72.4%	-5.9%
Food Products	44,169	79,547	65,990	49.4%	-17.0%
Manufactured & Miscellaneous	65,629	180,944	203,449	210.0%	12.4%
Intermodal	769,936	1,955,771	2,012,003	161.3%	2.9%
Total	**4,073,939**	**5,283,280**	**5,351,835**	**31.4%**	**1.3%**

The impact of the COVID-19 pandemic, along with ongoing supply chain issues, affected freight carloads during the MOU period. From 2021 to 2022, the number of carloads increased for six commodity groups (led by a 12.4% increase in manufactured & miscellaneous goods and a 9.5% increase in machinery & automotive) and the number of carloads decreased for five commodity groups (led by a 17.0% reduction in food products and a 14.3% reduction in agricultural products). Despite the fluctuations across commodity groups, and a 1.0% decrease in total revenue tonne-kilometres (see Table 1), total freight carloads increased by 1.3%.[21]

3.1.2 Intermodal Traffic

Of the total freight carloads in 2022, intermodal made up the largest share at 37.6%, as illustrated in Figure 2 and Table 2 above. The number of intermodal carloads handled by railways in Canada increased to 2,012,003 from 1,955,771 in 2021, an increase of 2.9%. In 2022, intermodal tonnage increased by 0.5% to 41.22 million tonnes from 41.01 million tonnes in 2021.[22]

Overall, since 2005, intermodal tonnage, comprising both container-on-flat-car and trailer-on-flat-car traffic, has risen by 33.7%, equating to an average annual growth of 1.7% as illustrated in Figure 3.

21 Growth in carloads may differ from growth in revenue tonne-kilometres due to changes in average carload weight and/or average length of haul.
22 Source: Statistics Canada, Monthly Railway Carloading Survey.

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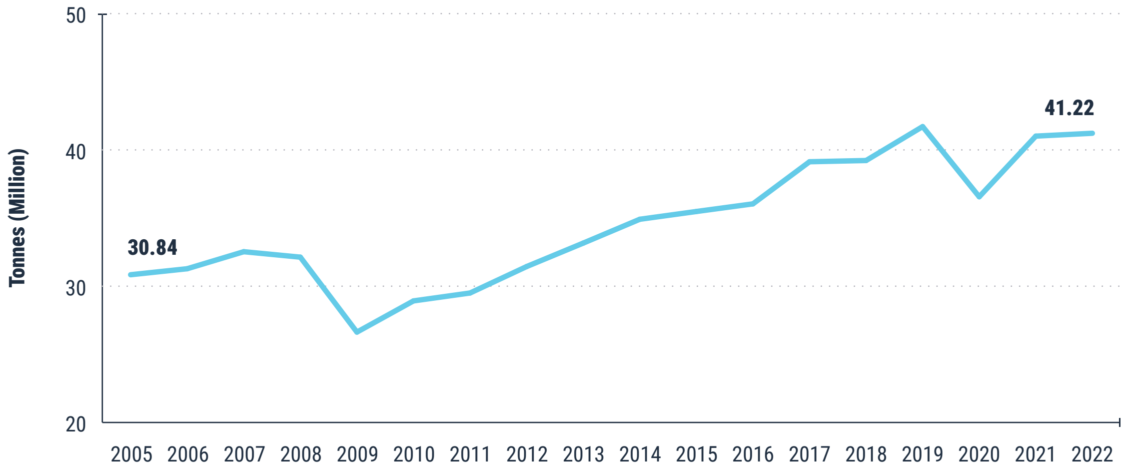
Figure 3: Intermodal Tonnage, 2005–2022



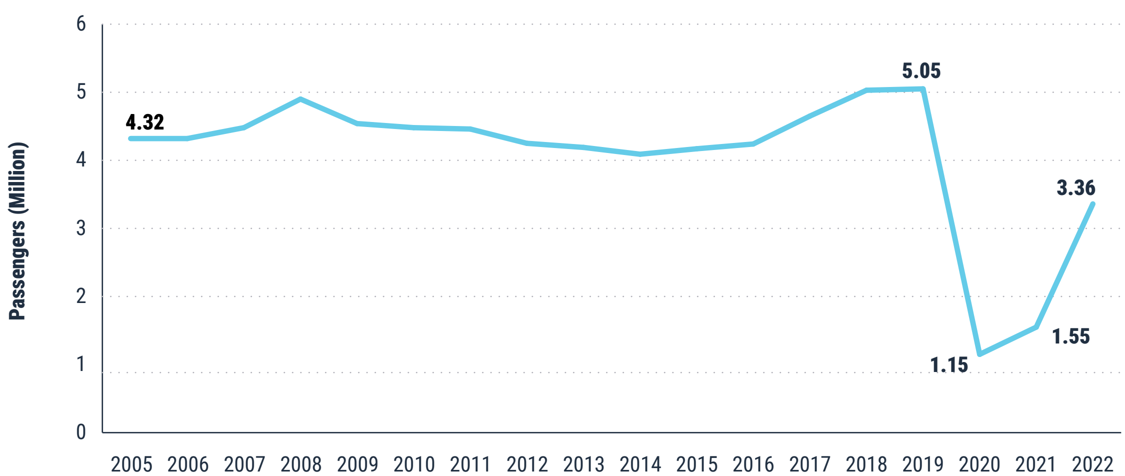
33.7% increase 2005 to 2022

3.2 PASSENGER TRAFFIC HANDLED

3.2.1 Intercity Passenger Services

Intercity passenger traffic in 2022 totaled 3.36 million passengers, compared to 1.55 million passengers in 2021, an increase of 116.2%, and a 22.2% decrease from 4.32 million passengers in 2005 (Figure 4).

Figure 4: Intercity Rail Passenger Traffic, 2005–2022



22.2% decrease 2005 to 2022*

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

Revenue passenger-kilometres (RPK) for intercity passenger traffic totaled 1,222.77 million. This is an increase of 128.5% compared to 535.20 million in 2021 and 17.4% decrease from 1,479.61 million in 2005 (Figure 5).

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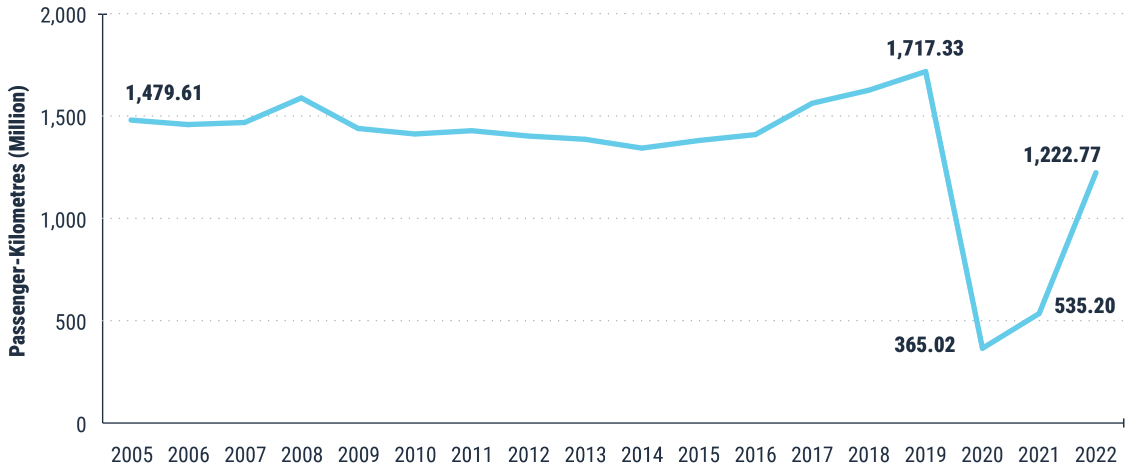
Figure 5: Intercity Rail Revenue Passenger-Kilometres, 2005–2022

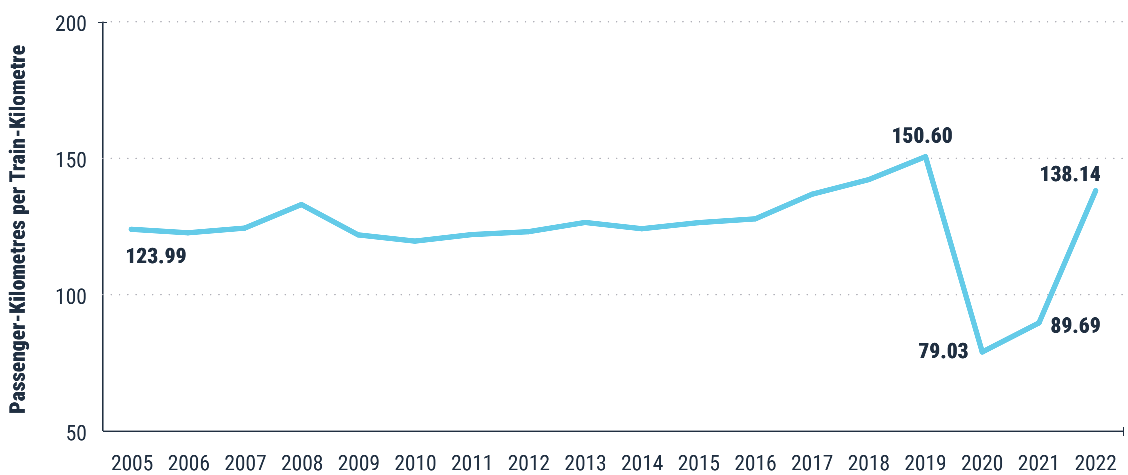


17.4% decrease 2005 to 2022*

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

Intercity train efficiency is expressed in terms of average passenger-kilometres (km) per train-km. As shown in Figure 6, intercity rail train efficiency in 2022 was 138.14 passenger-km per train-km, 89.69 in 2021, and 123.99 in 2005. As a percentage, train efficiency in 2022 was 11.4% above that in 2005, but still below the pre-pandemic efficiency high of 150.6 passenger-km per train-km in 2019. Lower intercity rail train efficiencies resulted from fewer passengers per train during COVID-19 restrictions and a reduction in overall travel. However, as seen in Figure 6, since the initial steep decline in 2020, intercity rail efficiency has improved each year with a continued increase in ridership.

Figure 6: Intercity Rail Train Efficiency, 2005–2022



11.4% increase 2005 to 2022*

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

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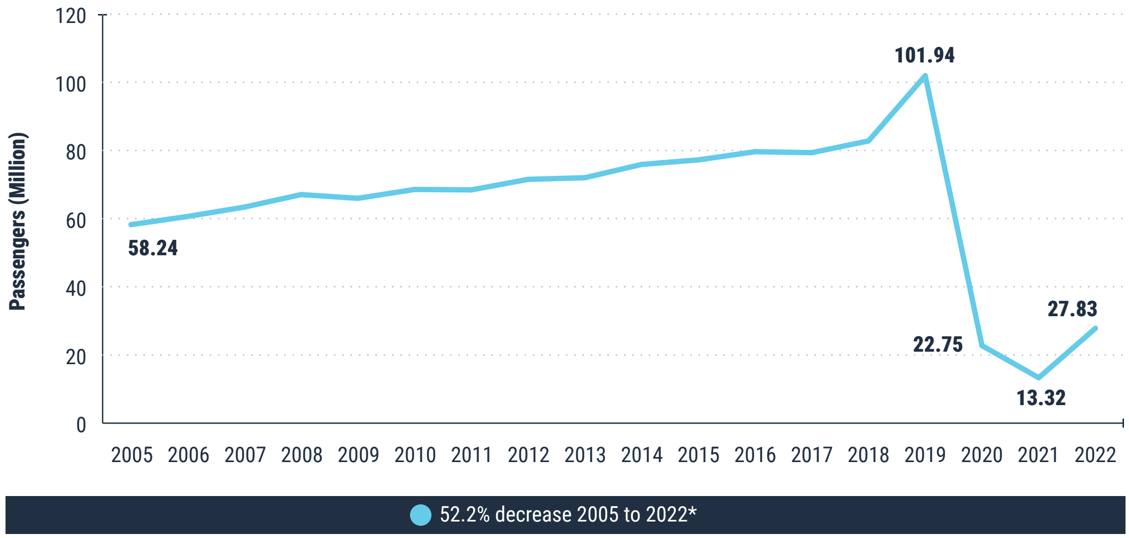
3.2.2 Commuter Rail

In 2022, commuter rail passengers totaled 27.83 million (Figure 7). This is up from 13.32 million in 2021, an increase of 108.9%.[23] Despite this recent increase, as seen in Figure 7, overall commuter traffic has decreased 52.2% below the 2005 base year level of 58.24 million passengers. The commuter operations in Canada using diesel locomotives and/or diesel multiple units (DMUs) are exo serving the Montreal-centred region (previously Réseau de transport metropolitain), Capital Railway serving Ottawa,[24] Metrolinx serving the Greater Toronto Area, and West Coast Express serving the Vancouver-Lower Fraser Valley region.

Figure 7: Commuter Rail Passengers, 2005–2022



* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

3.3.3 Tourist and Excursion Services

Tourist and excursion services were significantly impacted by COVID-19. Following closures in 2020, tourist and excursion railways continued to reopen for passenger service in 2022.

23 The significant decrease in commuters since 2019 is due to an unprecedented drop in ridership on commuter rail services, as a consequence of the COVID-19 pandemic.

24 Capital Railway's DMUs were not in operation in 2022 due to construction of the expanded passenger rail service.

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4. Fuel Consumption Data

Total rail sector fuel consumption in 2022 was 2,018.61 million litres, a 0.7% decrease from 2021 and an 8.6% decrease from 2005. In 2022, freight operations consumed 1,919.98 million litres of fuel, an 8.9% decrease from 2,107.90 in 2005. Over this same period (2005–2022), freight traffic (RTKs) increased by 24.3%, resulting in a 26.7% improvement in freight fuel efficiency. Passenger rail operations increased fuel consumption by 33.5% in 2022 compared to 2021, to accommodate a recovery in ridership levels since the onset of the COVID-19 pandemic.

Over the MOU period (2018–2022), total fuel consumption decreased from 2,157.98 million litres of fuel in 2017 to 2,018.61 million litres in 2022, a decrease of 6.5%.

Fuel consumption was slightly lower in 2022 compared to 2021. Of the total fuel consumed by all railway operations, Class 1 and regional & shortline operations consumed 92.3%, yard switching and work train operations consumed 2.8%, and passenger operations accounted for 4.9%. For total freight train operations fuel consumption, Class 1 railways accounted for 91.2%, regional & shortlines 5.9%, and yard switching and work trains 2.9%.

Table 3: Canadian Rail Operations Fuel Consumption, 2005, 2013-2022 (million litres)

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Class 1 Freight	1,893.19	1,849.57	1,918.27	1,852.98	1,732.20	1,864.83	1,949.92	1,950.71	1,857.42	1,796.77	1,750.57
Regional & Shortline	140.13	101.72	108.91	105.45	101.83	114.15	111.88	111.99	108.69	106.56	113.24
Yard Switching	67.85	41.77	62.02	52.97	46.95	50.29	51.56	51.71	46.81	47.07	49.43
Work Train	6.73	10.30	10.80	11.35	10.84	10.01	7.10	9.94	8.41	9.04	6.73
Total Freight Operations	2,107.90	2,003.36	2,100.00	2,022.75	1,891.82	2,039.28	2,120.46	2,124.35	2,021.34	1,959.44	1,919.98
Intercity*	64.05	46.17	44.89	46.98	47.93	51.02	52.77	51.05	21.74	26.15	38.07
Commuter*	35.31	48.61	49.67	60.50	59.43	64.46	65.74	79.53	47.85	47.28	57.28
Tourist/ Excursion*	1.74	2.25	2.61	2.65	2.79	3.22	3.22	4.30	0.00	0.46	3.28
Total Passenger Operations*	101.10	97.03	97.16	110.13	110.15	118.70	121.72	134.89	69.60	73.89	98.63
Total Rail Operations	**2,209.00**	**2,100.39**	**2,197.17**	**2,132.88**	**2,001.97**	**2,157.98**	**2,242.19**	**2,259.24**	**2,090.94**	**2,033.33**	**2,018.61**

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

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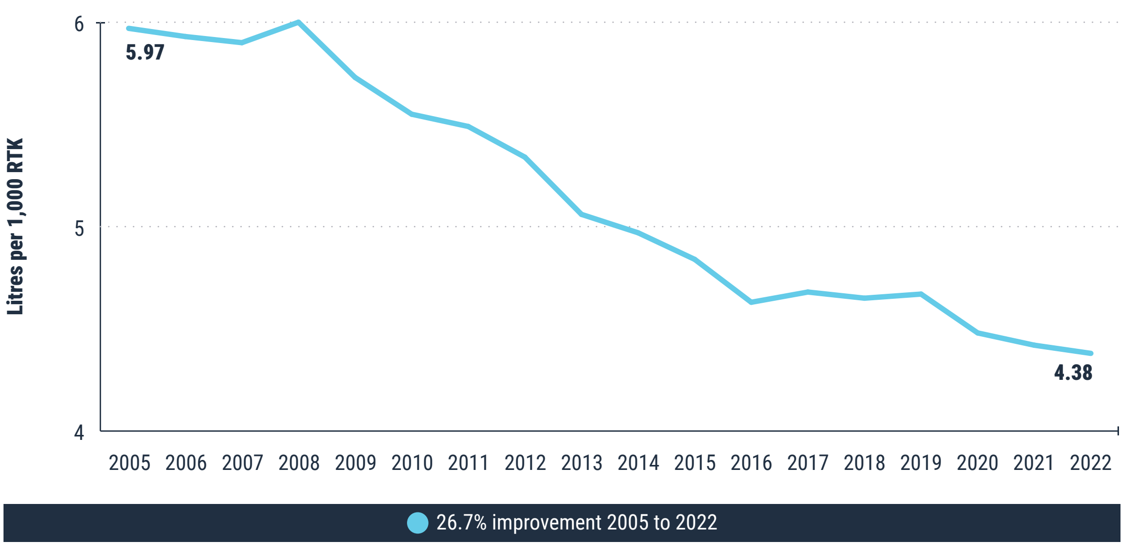
4.1 FREIGHT OPERATIONS

Fuel consumption in 2022 for all freight train, yard switching, and work train operations was 1,919.98 million litres, a decrease of 2.0% from the 1,959.44 million litres consumed in 2021 and a decrease of 8.9% from the 2005 level of 2,107.90 million litres. Based on total traffic moved by railways in Canada, measured in revenue tonne-kilometres, in 2022 railways moved one tonne of freight approximately 228.5 kilometres on just one litre of fuel.

The amount of fuel consumed per 1,000 RTK can be used as a measure of freight traffic fuel efficiency. As shown in Figure 8, the value in 2022 for overall rail freight traffic was 4.38 litres per 1,000 RTK. This value is a 1.1% decrease from the 4.42 L/1,000 RTK in 2021 and 26.7% below (i.e., improved efficiency) the 2005 level of 5.97 L/1,000 RTK. The improvement since 2005 shows the ability of Canadian freight railways to accommodate traffic growth while reducing fuel consumption per unit of work.

Figure 8: Freight Fuel Efficiency, 2005–2022



Member railways have implemented many practices to improve fuel efficiency over the years. Improved fuel efficiency has been achieved primarily by replacing older locomotives with modern, fuel-efficient locomotives that meet emission standards, investing in fuel saving technologies, and efficient asset utilization. Additionally, operating practices and various strategies that reduce fuel consumption have been implemented. Section 2 presented initiatives that are being undertaken by the railways, including details on partnerships with government, academia, equipment manufacturers, fuel providers, and other industry stakeholders to continue the transition to a more sustainable future.

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4.2 PASSENGER SERVICES

Overall passenger rail fuel consumption—that is the sum of intercity, commuter, and tourist and excursion train operations—totaled 98.63 million litres in 2022, an increase of 33.5% from the 73.89 million litres consumed in 2021. The increase in passenger rail fuel consumption is largely due to growth in intercity and commuter rail operations (where ridership more than doubled) and the reopening of tourist and excursion train operations since the onset of the COVID-19 pandemic. The breakdown and comparison with previous years is provided in Table 3.

Intercity passenger rail fuel consumption increased by 45.6% from 26.15 million litres in 2021 to 38.07 million litres in 2022. Fuel consumption for commuter rail increased by 21.2% from 47.28 million litres in 2021 to 57.28 million litres in 2022. Lastly, tourist and excursion rail fuel consumption increased by 610.2% to 3.28 million litres in 2022 from 0.46 in 2021.

4.3 DIESEL FUEL PROPERTIES

The sulphur content of railway diesel fuel in Canada is regulated by the *Sulphur in Diesel Fuel Regulations* at 15 parts per million (ppm). Renewable fuel content for diesel fuel sold and imported in Canada was also regulated by the *Renewable Fuels Regulations until the end of 2022,*[25] mandating at least 2% biodiesel and/or HDRD content. In 2022, some provinces, such as Ontario, British Columbia, and Manitoba required a minimum renewable fuel content above 2% for diesel.[26]

For details on low-carbon fuels, see sections 2.4 Low-Carbon Fuels and 2.6 Partnerships.

25 After which it was replaced by the Clean Fuel Regulations.
26 In 2022, diesel biofuel blending policies required 4% in British Columbia, 5% in Manitoba, and 4% in Ontario.

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5. Locomotive Inventory

5.1 FLEET OVERVIEW

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

Table 4: Canadian Locomotive Fleet Summary, 2022

	Locomotives	Share of Fleet
Line Haul: Class 1	2,555	68.8%
Line Haul: Regional	162	4.4%
Line Haul: Shortline	144	3.9%
Freight Yard Switching and Work Train	602	16.2%
Total Freight Operations	3,463	93.2%
Passenger Locomotives	234	6.3%
Passenger DMUs	18	0.5%
Total Passenger Operations	252	6.8%
Total Rail Operations	3,715	100.0%

Note: numbers include all active fleet equipment.

5.2 LOCOMOTIVES MEETING EMISSION STANDARDS

Locomotives operated by federally regulated railways are subject to the emission standards set out under the *Locomotive Emissions Regulations* (LER), which came into force on June 9, 2017. These emission standards align with US EPA emission standards. The RAC's member railways that are not federally regulated will continue to be encouraged to meet the emission standards.

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- and lower-tier locomotives.

Table 5 shows the total number of in-service locomotives meeting emission standards[27] compared to the total number of active freight and passenger locomotives. Because the locomotive fleet as reported under the LER and in the LEM Report is based on a snapshot of the locomotive fleet on December 31 of a given year, year-to-year variations are to be expected.

27 The emission standards include the following Tier levels: Tier 0, Tier 0+, Tier 1, Tier 1+, Tier 2, Tier 2+, Tier 3, and Tier 4 (see Appendix D).

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Table 5: Locomotives in Canadian Fleet Meeting Emission Standards, 2005, 2013–2022

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of freight and passenger locomotives meeting an emission standard	888	1,631	1,538	1,266	1,267	2,157	2,995	2,982	3,108	2,989	3,136
Number of freight and passenger locomotives in Canadian Fleet	2,986	3,063	2,700	2,400	2,318	3,177	3,782	3,840	3,756	3,606	3,715
Percentage of locomotives meeting an emission standard	29.7%	53.2%	57.0%	52.8%	54.7%	67.9%	79.2%	77.7%	82.7%	82.9%	84.4%

Note 1: Canada's *Locomotive Emissions Regulations* came into force on June 9, 2017. Prior to this date, locomotives in Canada were not subject to regulations but were encouraged to meet US EPA emission standards under the MOU.

Note 2: Not all locomotives need to meet emission standards. Provincially regulated railways are not subject to the *Locomotive Emissions Regulations*; and not all locomotives of federally regulated railways are subject to the Regulations. Exceptions include: steam- and electric-powered locomotives; locomotives manufactured prior to 1973 that have not been upgraded; and locomotives with less than 1,006 horsepower. Only new locomotives, not active existing locomotives, are required to meet emission standards. Locomotives become new when they are freshly manufactured, remanufactured, upgraded or imported.

In 2022, 84.4% of the fleet (3,136 locomotives of 3,715) met emission standards (set-out under the LER or the US EPA regulations).

Table 6 provides an overview of the 2022 locomotive fleet and includes details about the total number of locomotives meeting each tier level, including those that have been added, retired, and remanufactured in 2022. It also presents the number of locomotives with anti-idling devices.

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Table 6: Locomotive Fleet Breakdown by Tier Level, 2022

	Locomotives		Locomotives with anti-idling devices	Added	Retired	Remanufactured
Tier Level*	Number	% of fleet				
Elec/Steam/Other	6	0.2%	–	–	–	–
No Tier	573	15.4%	317	11	36	2
Tier 0	184	5.0%	159	7	10	–
Tier 0+	775	20.9%	725	21	4	40
Tier 1	31	0.8%	31	5	–	–
Tier 1+	675	18.2%	671	25	11	52
Tier 2	142	3.8%	135	–	2	–
Tier 2+	523	14.1%	511	5	–	51
Tier 3	502	13.5%	502	9	–	58
Tier 4	304	8.2%	304	1	–	–
Total	**3,715**	**100.00%**	**3,355**	**84**	**63**	**203**

* See Appendix D for additional information regarding tier levels.

In 2022, 84 locomotives were added to the Canadian fleet, including 11 No Tier, seven Tier 0, 21 Tier 0+, five Tier 1, 25 Tier 1+, five Tier 2+, nine Tier 3 locomotives, and one Tier 4. A total of 203 locomotives were remanufactured (upgraded); two to No Tier, 40 to Tier 0+, 52 to Tier 1+, 51 to Tier 2+, and 58 to Tier 3; and 63, mostly non-tier-level and lower-tier-level locomotives, were retired.

Anti-idling devices on locomotives reduce emissions by ensuring that locomotive engines are shut down during periods of inactivity, reducing engine activity and therefore emissions. The number of locomotives in 2022 equipped with a device to minimize unnecessary idling, such as an AESS system or APU, was 3,355, which represents 90.3% of the fleet, compared to 3,034 in 2021 (84.1% of the 2021 fleet).

6. Locomotive Emissions

6.1 GREENHOUSE GASES

6.1.1 Emission Factors for Greenhouse Gases

The emission factors (EFs) and global warming potentials used to calculate GHGs emitted from diesel locomotive engines (i.e., CO_2, CH_4, and N_2O) are the same factors used by ECCC to create the National Inventory Report 1990–2022: Greenhouse Gas Sources and Sinks in Canada, which is submitted annually to the United Nations Framework Convention on Climate Change (UNFCCC).[28]

Table 7 presents the 2022 GHG EFs for diesel locomotives.

The methodology document describing the calculation of GHG and CAC EFs referenced in the sections below is available upon request to the RAC.

Table 7: GHG Emission Factors for Diesel Locomotives, 2022

	Emission Factors (kg/L)	Global Warming Potential
CO_2	2.6805	1
CH_4	0.000149	25
N_2O	0.001029	298
CO_2e	2.990867	Not Applicable

Note: Hydrofluorocarbons (HFC), Perfluorocarbons (PFC), and Sulphur hexafluoride (SF6) are not present in diesel fuel.

Source: National Inventory Report 1990–2022: Greenhouse Gas Sources and Sinks in Canada, Environment and Climate Change Canada, 2024. The 2024 National Inventory Report contains the GHG emissions factors for 1990–2022.

6.1.2 Greenhouse Gas Emissions

Over the MOU reporting period, GHG emissions produced by RAC members decreased from 6,454.24 kilotonnes (kt) in 2017 to 6,037.39 kt in 2022. Representing an absolute emission decrease of 6.5%. GHG emissions decreased 0.7% year-over-year and were 8.6% below 2005 levels.

Table 8 displays the GHG emissions produced in 2005 and annually since 2013; Figure 9 presents the annual trend graphically. The GHG emissions for years prior to 2013 are available upon request to the RAC.

28 National Inventory Report 1990–2022: Greenhouse Gas Sources and Sinks in Canada, Environment and Climate Change Canada, 2024. The 2024 National Inventory Report contains the GHG emissions factors for 1990-2022.

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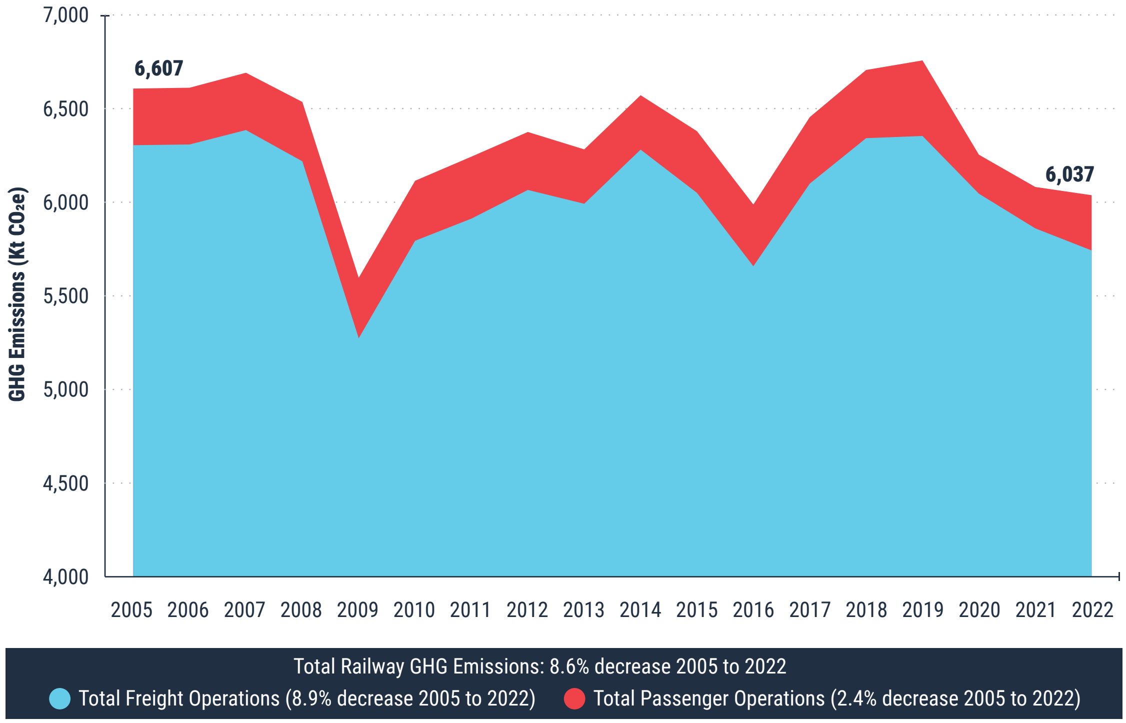
Table 8: GHG Emissions by Railway Service in Canada, 2005, 2013–2022 (kilotonnes)

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Line Haul Freight											
CO_2	5,450.31	5,230.42	5,433.86	5,249.57	4,916.11	5,304.66	5,526.65	5,529.07	5,270.18	5,101.87	4,995.94
CH_4	7.57	7.27	7.55	7.30	6.83	7.37	7.68	7.68	7.32	7.09	6.94
N_2O	623.50	598.35	621.62	600.54	562.39	606.84	632.23	632.51	602.89	583.64	571.52
CO_2e	6,081.39	5,836.04	6,063.03	5,857.41	5,485.34	5,918.87	6,166.57	6,169.26	5,880.40	5,692.60	5,574.41
Yard Switching and Work Train											
CO_2	199.91	139.58	195.20	172.41	154.91	161.64	157.25	165.27	148.03	150.41	150.55
CH_4	0.28	0.19	0.27	0.24	0.22	0.22	0.22	0.23	0.21	0.21	0.21
N_2O	22.87	15.97	22.33	19.72	17.72	18.49	17.99	18.91	16.93	17.21	17.22
CO_2e	223.06	155.74	217.80	192.37	172.85	180.36	175.45	184.40	165.17	167.82	167.99
Total Freight Operations											
CO_2	5,650.22	5,370.00	5,629.06	5,421.98	5,071.03	5,466.30	5,683.90	5,694.33	5,418.21	5,252.28	5,146.50
CH_4	7.85	7.46	7.82	7.53	7.05	7.60	7.90	7.91	7.53	7.30	7.15
N_2O	646.37	614.31	643.95	620.26	580.11	625.33	650.22	651.42	619.83	600.85	588.75
CO_2e	6,304.45	5,991.78	6,280.83	6,049.78	5,658.18	6,099.22	6,342.02	6,353.66	6,045.57	5,860.42	5,742.39
Total Passenger Operations*											
CO_2	271.00	260.09	260.45	295.20	295.25	318.17	326.28	361.56	186.55	198.05	264.38
CH_4	0.38	0.36	0.36	0.41	0.41	0.44	0.45	0.50	0.26	0.28	0.37
N_2O	31.00	29.75	29.79	33.77	33.78	36.40	37.33	41.36	21.34	22.66	30.24
CO_2e	302.38	290.21	290.60	329.38	329.44	355.01	364.06	403.43	208.15	220.98	294.99
Total Rail Operations											
CO_2	5,921.23	5,630.10	5,889.51	5,717.19	5,366.28	5,784.47	6,010.18	6,055.90	5,604.76	5,450.33	5,410.88
CH_4	8.23	7.82	8.18	7.94	7.46	8.04	8.35	8.42	7.79	7.57	7.52
N_2O	677.37	644.07	673.74	654.03	613.89	661.73	687.55	692.78	641.17	623.50	618.99
CO_2e	6,606.83	6,281.99	6,571.44	6,379.16	5,987.62	6,454.24	6,706.08	6,757.09	6,253.72	6,081.41	6,037.39

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

Note: GHG emissions for all years have been calculated based on the emission factors and global warming potentials in the 2024 National Inventory Report (the 2024 National Inventory Report contains the GHG emissions factors for 1990–2022). Historical values have been updated.

Figure 9: GHG Emissions, 2005–2022



The MOU sets out targets to be achieved in 2022 for GHG emissions intensities by category of railway operation (Class 1 freight, regional & shortline freight, and intercity passenger). Table 9 shows the 2022 GHG emissions intensity levels for these categories, as well as for commuter rail.

Table 9: GHG Emissions Intensities by Railway Service in Canada, 2005, 2013–2022

	2005	2013	2014	2015	2016	2017 (MOU Baseline)	2018	2019	2020	2021	2022	2022 (Target)
Total Freight Operations (kg CO_2e/1,000 RTK)**	17.86	15.13	14.87	14.47	13.85	14.01	13.92	13.96	13.38	13.23	13.09	No Target
Class 1 Freight (kg CO_2e/1,000 RTK)	17.25	14.88	14.36	14.06	13.51	13.56	13.45	13.49	12.91	12.76	12.62	12.75
Regional & Shortline Freight (kg CO_2e/1,000 RTK)	16.99	12.56	14.15	13.15	12.16	14.08	15.02	14.77	15.27	14.66	14.29	13.66
Intercity Passenger (kg CO_2e/P assenger-km)*	0.129	0.100	0.100	0.102	0.102	0.098	0.097	0.089	0.178	0.146	0.093	0.092
Commuter Rail (kg CO_2e/Passenger)*	1.81	2.02	1.96	2.34	2.23	2.43	2.37	2.33	6.29	10.62	6.16	No Target

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

** Includes yard switching and work train GHG emissions.

Note: GHG emissions for all years have been calculated based on the emissions factors and global warming potentials in the 2024 National Inventory Report (the 2024 National Inventory Report contains the GHG emissions factors for 1990–2022). Historical values have been updated.

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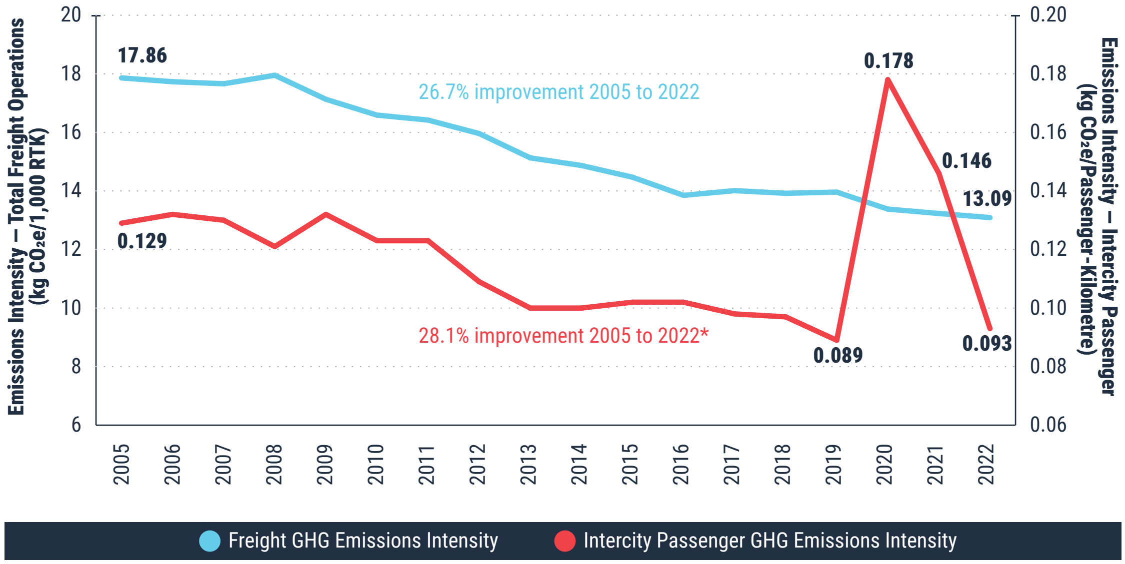
The GHG emissions intensities for total freight traffic (which includes yard switching and work train operations) decreased in 2022 by 1.1% to 13.09 kg CO_2e/1,000 RTK from 13.23 kg CO_2e/1,000 RTK in 2021. Since 2005, the GHG emissions intensity for total freight has decreased 26.7% from 17.86 kg CO_2e/1,000 RTK. Class 1 freight saw a 1.1% decrease in GHG emissions intensity from 12.76 kg CO_2e/1,000 RTK in 2021 to 12.62 kg CO_2e/1,000 RTK in 2022. Regional & shortline freight emissions intensity decreased from 14.66 kg CO_2e/1,000 RTK in 2021 to 14.29 kg CO_2e/1,000 RTK in 2022. In 2022, emissions intensity for intercity passenger rail decreased by 36.3% to 0.093 kg CO_2e/1,000 RTK compared to 2021. Commuter rail operations decreased emissions intensity by 42.0% to 6.16 kg CO_2e/1,000 RTK in 2022, which was largely a result of increased ridership.

Figure 10 shows the trend in GHG emissions intensities for freight and intercity passenger rail, since 2005.

Figure 10: GHG Emissions Intensities, 2005–2022



* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

6.2 CRITERIA AIR CONTAMINANTS

6.2.1 Emission Factors for Criteria Air Contaminant Emissions

Criteria Air Contaminant (CAC) emissions factors (EF) for 2022 have been calculated in grams per litre (g/L) of fuel consumed for NO_x, PM_{10}, CO, HC, and SO_2 for each category of operation (i.e., line haul freight, yard switching and work train, and passenger operations). CAC EFs for line haul freight and for yard switching and work train operations remained relatively unchanged from 2021 (no change greater than 1%, either positive or negative). In passenger operations, EFs for CO and SO_2 remained unchanged while EFs decreased for NO_x (-4.43%), PM_{10} (-4.83%), and HC (-6.22%). The CAC EFs are estimated based on the active fleet on December 31 of each year.

The EFs to calculate emissions of SO_x (calculated as SO_2) are based on the sulphur content of the diesel fuel. The CAC EFs are listed in Table 10 for 2005 and 2013–2022. EFs for years prior to 2013 are available upon request to the RAC.

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Table 10: CAC Emission Factors for Diesel Locomotives, 2005, 2013–2022 (g/L)

Year	NO_x	PM_{10}	CO	HC	SO_2
Line Haul Freight					
2022	31.76	0.63	6.98	1.21	0.02
2021	31.67	0.63	6.98	1.21	0.02
2020	32.97	0.66	6.99	1.29	0.02
2019	34.17	0.69	6.99	1.34	0.02
2018	34.56	0.78	7.02	1.54	0.02
2017	34.79	0.72	7.04	1.46	0.02
2016	38.17	0.78	7.05	1.54	0.02
2015	39.50	0.81	7.13	1.68	0.02
2014	41.40	0.90	7.07	1.81	0.02
2013	44.41	1.01	7.05	2.00	0.02
2005	56.12	1.54	6.97	2.56	2.25
Yard Switching and Work Train					
2022	55.42	1.10	7.35	3.17	0.02
2021	54.96	1.10	7.35	3.16	0.02
2020	55.34	1.13	7.35	3.23	0.02
2019	57.32	1.18	7.35	3.34	0.02
2018	56.15	1.15	7.35	3.27	0.02
2017	69.14	1.50	7.35	4.01	0.02
2016	65.68	1.46	7.35	3.92	0.02
2015	68.38	1.48	7.35	3.96	0.02
2014	68.93	1.50	7.35	3.99	0.02
2013	68.79	1.50	7.35	4.01	0.02
2005	69.88	1.64	7.35	4.06	2.25
Total Passenger Operations					
2022	40.40	0.84	7.03	1.58	0.02
2021	42.45	0.88	7.03	1.68	0.02
2020	40.87	0.85	7.03	1.64	0.02
2019	45.13	0.92	7.03	1.77	0.02
2018	40.87	0.85	7.03	1.64	0.02
2017	56.34	1.15	7.03	2.19	0.02
2016	54.05	1.11	7.03	2.12	0.02
2015	48.96	1.00	7.03	1.91	0.02
2014	54.58	1.14	7.03	2.18	0.02
2013	51.64	1.06	7.03	2.03	0.02
2005	71.44	1.58	7.03	2.64	2.25

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6.2.2 Criteria Air Contaminant Emissions

Table 11 displays the CAC emissions produced annually by locomotives in operation in Canada for the reference year (2005) and annually from 2013 to 2022, namely NO_x, PM_{10}, CO, HC, and SO_2. The values presented are for both absolute amounts and intensities per productivity unit. The emissions and intensities for years before 2013 are available upon request to the RAC.

Looking at NO_x, as shown in Table 11, emissions in 2022 for total railway operations was 66.30 kt, down 0.3% from 66.50 kt in 2021. Freight operations accounted for 94.0% 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 0.14 kg per 1,000 RTK in 2022, a 0.7% decrease from 2021 and a 58.0% decrease since 2005.

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Table 11: Locomotive CAC Emissions, 2005, 2013–2022 (kilotonnes, unless otherwise specified)

Year	NO_x	PM_{10}	CO	HC	SO_2 (tonnes)
Line Haul Freight					
2022	59.20	1.17	13.01	2.26	45.93
2021	60.28	1.20	13.29	2.31	46.91
2020	64.83	1.30	13.73	2.53	48.46
2019	70.49	1.42	14.41	2.77	50.84
2018	71.25	1.61	14.48	3.18	50.81
2017	68.84	1.43	13.93	2.89	48.77
2016	70.01	1.42	12.94	2.82	45.20
2015	77.35	1.59	13.96	3.28	48.27
2014	83.92	1.82	14.34	3.66	49.96
2013	86.65	1.98	13.76	3.90	48.09
2005	114.12	3.13	14.18	5.21	4,580.20
Yard Switching and Work Train					
2022	3.11	0.06	0.41	0.18	1.38
2021	3.08	0.06	0.41	0.18	1.38
2020	3.02	0.06	0.40	0.17	1.34
2019	3.53	0.07	0.45	0.21	1.52
2018	3.32	0.07	0.43	0.20	1.45
2017	4.17	0.09	0.44	0.24	1.49
2016	3.80	0.08	0.42	0.23	1.42
2015	4.40	0.10	0.47	0.25	1.59
2014	5.02	0.11	0.54	0.29	1.79
2013	3.58	0.08	0.38	0.21	1.28
2005	5.21	0.12	0.55	0.30	168.00
Total Freight Operations[1]					
2022	62.31	1.23	13.42	2.44	47.32
2021	63.36	1.26	13.71	2.49	48.29
2020	67.85	1.36	14.13	2.71	49.80
2019	74.02	1.49	14.86	2.98	52.36
2018	74.58	1.68	14.91	3.38	52.26
2017	73.01	1.52	14.37	3.13	50.26
2016	73.80	1.51	13.36	3.05	46.63
2015	81.75	1.69	14.43	3.54	49.85
2014	88.94	1.93	14.87	3.95	51.76
2013	90.23	2.05	14.14	4.11	49.37
2005	119.33	3.25	14.73	5.52	4,748.19

Table 11: Locomotive CAC Emissions, 2005, 2013–2022 (kilotonnes, unless otherwise specified)

Year	NO_x	PM_{10}	CO	HC	SO_2 (tonnes)
Total Passenger Operations*					
2022	3.98	0.08	0.69	0.16	2.43
2021	3.14	0.06	0.52	0.12	1.82
2020	2.84	0.06	0.49	0.11	1.72
2019	6.09	0.12	0.95	0.24	3.32
2018	6.56	0.13	0.85	0.25	2.97
2017	6.63	0.14	0.83	0.26	2.90
2016	5.89	0.12	0.77	0.23	2.69
2015	5.33	0.11	0.77	0.21	2.69
2014	5.24	0.11	0.68	0.21	2.37
2013	4.95	0.10	0.67	0.19	2.12
2005	7.18	0.16	0.71	0.26	226.29
Total Rail Operations[2]					
2022	66.30	1.32	14.12	2.60	49.75
2021	66.50	1.32	14.23	2.61	50.11
2020	70.70	1.42	14.62	2.82	51.51
2019	80.11	1.62	15.81	3.22	55.68
2018	81.14	1.81	15.76	3.63	55.23
2017	79.64	1.66	15.20	3.38	53.16
2016	79.70	1.63	14.13	3.28	49.31
2015	87.08	1.80	15.20	3.75	52.54
2014	94.18	2.04	15.55	4.16	54.12
2013	95.19	2.16	14.82	4.30	51.50
2005	126.50	3.41	15.43	5.78	4,974.49
Total Freight Emissions Intensity (kg/1,000 RTK)					
2022	0.1420	0.0028	0.0306	0.0056	0.00011
2021	0.1430	0.0028	0.0309	0.0056	0.00011
2020	0.1502	0.0030	0.0313	0.0060	0.00011
2019	0.1627	0.0033	0.0327	0.0065	0.00012
2018	0.1636	0.0037	0.0327	0.0074	0.00011
2017	0.1677	0.0035	0.0330	0.0072	0.00012
2016	0.1807	0.0037	0.0327	0.0075	0.00011
2015	0.1955	0.0040	0.0345	0.0085	0.00012
2014	0.2105	0.0046	0.0352	0.0094	0.00012
2013	0.2279	0.0052	0.0357	0.0104	0.00012
2005	0.3381	0.0092	0.0417	0.0156	0.01345

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

[1] Total Freight Operations = Line Haul Freight + Yard Switching and Work Train

[2] Total Rail Operations = Total Freight Operations + Total Passenger Operations

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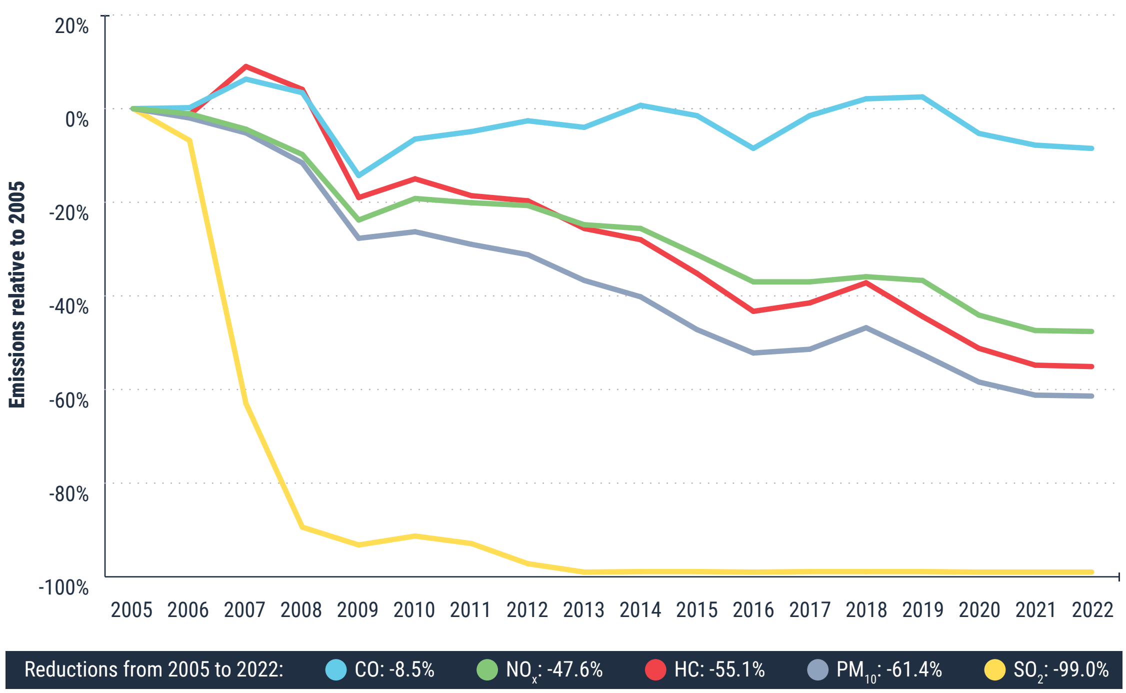
Figure 11 shows the reductions in CAC emissions from total railway operations in Canada, since 2005. Despite a general increase in traffic over this time, CAC emissions have decreased for CO (-8.5%), NO_x (-47.6%), HC (-55.1%), PM_{10} (-61.4%), and SO_2 (-99.0%).

Within the methodology for calculating CAC emissions, the CO emission factors are constant across tier levels (see Table 10). As a result, fleet modernization through the acquisition of higher-tiered locomotives does not affect the calculated CO emissions. The reduction in CO emissions is primarily driven by the reduction in locomotive diesel fuel consumption. Methodology available upon request.

Similarly, within the methodology for calculating SO_2 emissions, since 2013, the SO_2 emission factor has been constant as Canadian railways have been using ultra-low sulphur diesel (ULSD). As a result, the reductions in SO_2 since 2013 are driven by reductions in locomotive diesel fuel consumption.

Figure 11: CAC Emissions, 2005–2022



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7. Tropospheric Ozone Management Areas

Tropospheric Ozone Management Areas (TOMA) are geographically defined areas in which governments, stakeholders, and other interested parties work together to improve local air quality and manage air pollutant concentrations. The three TOMAs include the Lower Fraser Valley in British Columbia, the Québec City-Windsor Corridor, and the Saint John area in New Brunswick.

Tropospheric ozone is a greenhouse gas and atmospheric pollutant that contributes to global warming and is harmful to human health, agriculture, and ecosystems. Tropospheric ozone is the product of the reaction of several precursor pollutants in the atmosphere. Conventional railway activities, including diesel combustion, contribute to tropospheric ozone.

The following Tropospheric Ozone Management Areas are of interest both from an air quality and rail activity perspective.

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 Québec City-Windsor 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 Québec City-Windsor 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-Gatineau, Montréal, Trois- Rivières, and Québec City.

TOMA NO. 3

The Saint John TOMA is represented by two counties in southern New Brunswick—Saint John County and Kings County. The area covers 4,944.67 km^2.

7.1 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 and as a percentage of total railway CO_2e. Table 13 shows NO_x emissions in the TOMA regions as a percentage of the total NO_x emissions for all rail operations.

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Table 12: TOMA Percentage of Total Fuel Consumption and GHG Emissions, 2005, 2013–2022

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lower Fraser Valley, B.C.	3.2	2.9	2.2	2.3	2.5	2.4	2.3	2.4	2.3	2.4	2.6
Québec City-Windsor Corridor	17.4	14.2	14.1	14.1	14.0	13.8	13.0	13.5	11.5	12.3	13.2
Saint John, N.B.	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2

Table 13: TOMA Percentage of Total NO_x Emissions, 2005, 2013–2022

	2005	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lower Fraser Valley, B.C.	3.2	2.9	2.3	2.3	2.5	2.4	2.3	2.4	2.3	2.4	2.6
Québec City-Windsor Corridor	17.9	14.2	14.1	14.1	14.0	13.8	13.0	13.5	11.5	12.3	13.2
Saint John, N.B.	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2

The emissions of GHGs for the TOMA regions were calculated using the respective GHG emission factors as discussed in Section 6.1 and the fuel consumption data available for each TOMA region.

The CAC emission factors and emissions for the TOMA regions were calculated based on the total fuel usage for each region. The emission factors for each CAC presented for these three regions is a weighted average of the calculated line haul freight, yard switching and work train, and passenger operation EFs, as presented in Section 6.2.1, and based on the reported 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. Once these weighted CAC emission factors were derived, the emissions for each CAC were calculated by multiplying the EFs by the fuel usage for each TOMA region.

7.2 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.
- Summer (five months): May to September, inclusively.

The division of traffic in the TOMA regions 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. For TOMA No. 1, it was assumed that 50% of the fuel consumption for B.C. tourism operators was applicable to this region. The 2022 traffic, fuel consumption, and emissions data in the seasonal periods for each railway are summarized in Table 14.

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Table 14: Tropospheric Ozone Management Areas, 2022

		TOMA No.1 Lower Fraser Valley, B.C.			TOMA No.2 Québec City-Windsor Corridor			TOMA No.3 Saint John Area, New Brunswick		
		Seasonal Split			Seasonal Split			Seasonal Split		
		Total 100%	Winter 58%	Summer 42%	Total 100%	Winter 58%	Summer 42%	Total 100%	Winter 58%	Summer 42%
Traffic (Million GTK)										
CN		15,299	8,873	6,425	57,953	33,613	24,340	589	341	247
CP		6,070	3,521	2,549	21,639	12,551	9,089	–	–	–
Regional & Shortline		190	110	80	1,266	734	532	1,376	798	578
Total Freight Traffic		21,559	12,504	9,055	80,858	46,898	33,961	1,965	1,139	825
Fuel Consumption (Million Litres) Freight Fuel Rate (L/1,000 GTK) = 2.33[1]										
Total Freight Fuel Consumption		50.32	29.18	21.13	188.72	109.46	79.26	4.59	2.66	1.93
Passenger Fuel Consumption										
Intercity Passenger		0.41	0.24	0.17	22.23	12.89	9.34	–	–	–
Tourism/Excursion		1.51	0.88	0.64	–	–	–	–	–	–
Commuter		0.84	0.49	0.35	56.44	32.74	23.71	–	–	–
Total Passenger Fuel Consumption		2.77	1.60	1.16	78.67	45.63	33.04	0.00	0.00	0.00
Total Rail Fuel Consumption		53.09	30.79	22.30	267.40	155.09	112.31	4.59	2.66	1.93
Emissions										
Emission Factors (g/L)[2]		Kilotonnes/Year			Kilotonnes/Year			Kilotonnes/Year		
CACs	NO_x 32.84	1.74	1.01	0.73	8.78	5.09	3.69	0.15	0.09	0.06
CACs	PM_{10} 0.65	0.03	0.02	0.01	0.17	0.10	0.07	0.00	0.00	0.00
CACs	CO 6.99	0.37	0.22	0.16	1.87	1.08	0.79	0.03	0.02	0.01
CACs	HC 1.29	0.07	0.04	0.03	0.34	0.20	0.14	0.01	0.00	0.00
CACs	SO_2 0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
GHGs[3]	CO_2 2,680.50	142.30	82.53	59.76	716.76	415.72	301.04	12.29	7.13	5.16
GHGs[3]	CH_4 3.73	0.20	0.11	0.08	1.00	0.58	0.42	0.02	0.01	0.01
GHGs[3]	N_2O 306.64	16.28	9.44	6.84	81.99	47.56	34.44	1.41	0.82	0.59
GHGs[3]	CO_2e 2,990.87	158.77	92.09	66.68	799.75	463.85	335.89	13.71	7.95	5.76

1 The 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). In 2022, the Freight Fuel Rate was 2.33 litres per 1,000 GTK.

2 The emission factors used in the emissions calculations are a weighted average of the overall freight, yard and passenger emission factors based on the quantity of freight and passenger fuel used.

3 The emission factors for each GHG include their respective global warming potentials (CO_2:1; CH_4:25; N_2O:298).

8. Summary and Conclusions

The 2022 Locomotive Emissions Monitoring Report highlights the successful collaboration between the RAC and TC to advance initiatives that reduced locomotive emissions throughout the 2018-2022 reporting years. Canadian railways continued to improve their emissions performance through investments in fleet renewal/modernization, fuel saving technologies, operational efficiencies, and use of low carbon fuels. Furthermore, railways are looking ahead and establishing partnerships with government, academia, and industry stakeholders to advance the development of alternative propulsion and other zero-emissions technologies in support of the transition to a more sustainable future.

GHG emissions reductions over the course of the MOU period progressed towards the MOU targets. As with the previous MOU (2011–2017), commuter railways did not have an intensity target but continued to report on performance and efforts to reduce GHG emissions intensity. Similarly, as with previous MOUs, CAC emissions were reported, and the RAC continues to encourage its members to improve their CAC emissions performance.

The rail industry's performance against the GHG emissions targets for 2022 are set out in the following table, which includes the 2017 baseline data and annual emissions from 2018 to 2022 (expressed as kilograms of CO_2e per productivity unit).

GHG Emissions Intensity and MOU Results by Railway Operation

Railway Operation	Productivity Units	Baseline 2017	2018	2019	2020	2021	2022	2022 Target	Change from 2017–2022	Change from 2021–2022	% of Target Achieved	Target Achieved?
Class I Freight	kg CO_2e per 1,000 RTK	13.56	13.45	13.49	12.91	12.76	12.62	12.75 (6% reduction)	-6.99%	-1.12%	116%	YES
Intercity Passenger*	kg CO_2e per passenger-km	0.098	0.097	0.089	0.178	0.146	0.093	0.092 (6% reduction)	-4.68%	-36.27%	78%	NO
Regional & Shortline	kg CO_2e per 1,000 RTK	14.08	15.02	14.77	15.27	14.66	14.29	13.66 (3% reduction)	1.48%	-2.55%	increase since 2017	NO

Note: GHG emissions for all years have been calculated based on the emissions factors and global warming potentials in the 2024 National Inventory Report (the 2024 National Inventory Report contains the GHG emissions factors for 1990–2022). Historical values have been updated.

* Starting in 2020, passenger rail performance metrics have been significantly impacted by the COVID-19 pandemic.

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Class 1 freight GHG emissions intensity decreased by 6.99% from 2017 to 2022 — exceeding the MOU target of a 6% reduction. Intercity passenger GHG emissions intensity decreased by 36.27% from 2021 to 2022, and by 4.68% from 2017 to 2022; making progress beyond the pre-pandemic normal. Overall, intercity passenger operations made 77.94% progress towards the MOU target over the course of the MOU period. Regional & shortline emissions intensity decreased from 2021 to 2022 by 2.55%, but over the course of the MOU period the intensity had increased overall by 1.48% from 2017 to 2022.

GHG emissions intensity for total freight operations (including yard switching and work train) decreased by 6.57% over the MOU period.[29]

Absolute GHG emissions from all railway operations in Canada totaled 6,037.39 kt in 2022, which is a decrease of 0.7% from 6,081.41 kt in 2021 and a 6.5% decrease over the course of the MOU period.

Absolute CAC emissions from all railway operations decreased, with total locomotive NO_x emissions decreasing 0.3% to 66.30 kt in 2022 from 66.50 kt in 2021 and decreasing by 16.76% over the course of the MOU period. The total freight NO_x emissions intensity improved by 0.7% to 0.14 kg/1,000 RTK in 2022 from 2021, a 58.0% improvement from 2005 levels (at 0.34 kg/1,000 RTK) and a 15.29% decrease over the course of the MOU period.

In 2022, Canadian railways added 84 locomotives to the fleet: 11 No Tier, seven Tier 0, 21 Tier 0+, five Tier 1, 25 Tier 1+, five Tier 2+, nine Tier 3, and one Tier 4. In addition, 203 locomotives were remanufactured (upgraded): two to No Tier, 40 to Tier 0+, 52 to Tier 1+, 51 to Tier 2+, and 58 to Tier 3. Non-tier-level and lower-tier-level locomotives continue to be retired, and in 2022, 63 locomotives were taken out of active duty. Including 2022, a total of 635 locomotives have been removed from active duty over the course of the MOU period (mostly no- and low-tier). Over the same period, 191 Tier 3 and 175 Tier 4 locomotives have been added to the fleet.

The Canadian fleet totaled 3,715 locomotives in 2022, of which 3,136 locomotives (84.4%) met an emission standard (not all locomotives in Canada are required to meet emission standards). This is an increase when compared to 2017, where 67.9% of the fleet met an emission standard. The number of locomotives equipped with APUs or AESS systems to minimize unnecessary idling totaled 3,355, or 90.3% of the in-service fleet. This represents a significant increase when compared to 2017, where only 69.1% of the total fleet were equipped with APUs or AESS systems.

Through continued progress on emissions reduction initiatives and partnerships, along with federal initiatives (e.g., Strengthened Climate Plan, Hydrogen Strategy, Clean Fuel Regulations, *Greenhouse Gas Pollution Pricing Act*, etc.), Canadian railways and the Government of Canada will continue their efforts to reduce GHG emissions in the railway sector.

This report meets the filing requirements for the 2022 reporting year.

29 Emissions intensity for total freight operations is not shown in the table, as the freight sector as a whole does not have a singular MOU target.

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Appendix A

RAC Member Railways Participating in the 2018–2022 MOU by Province

Railway	Province(s) of Operation
Agawa Canyon Railroad	Ontario
Alberta Prairie Railway Excursions	Alberta
Cartier Railway (Arcelor Mittal Infrastructure Canada s.e.n.c.)	Québec
Barrie-Collingwood Railway	Ontario
Battle River Railway	Alberta
BCR Properties	British Columbia
Big Sky Rail Corp.	Saskatchewan
Boundary Trail Railway Co.	Manitoba
Canadian National Railway	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia, Northwest Territories
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
Chemin de fer Arnaud Québec	Québec
Compagnie du Chemin de Fer Lanaudière Inc.	Québec
Essex Terminal Railway Company	Ontario
Exo	Québec
Goderich-Exeter Railway Company Ltd.	Ontario
Great Canadian Railtour Company Ltd.	British Columbia, Alberta
Great Western Railway Ltd.	Saskatchewan
Hudson Bay Railway	Manitoba, Saskatchewan
Huron Central Railway Inc.	Ontario
Keewatin Railway Company	Manitoba
Knob Lake and Timmins Railway	Québec, Newfoundland and Labrador
Last Mountain Railway	Saskatchewan
Metrolinx (GO Transit)	Ontario
New Brunswick Southern Railway Company Ltd.	New Brunswick
Nipissing Central Railway Company	Ontario, Québec
Ontario Northland Transportation Commission	Ontario, Québec
Ontario Southland Railway Inc.	Ontario
Orangeville Brampton Railway	Ontario
Ottawa Valley Railway	Ontario, Québec
Prairie Dog Central Railway	Manitoba
Québec Gatineau Railway Inc.	Québec
Québec Iron Ore Inc.	Québec
Québec North Shore and Labrador Railway Company Inc.	Québec, Newfoundland and Labrador
Roberval and Saguenay Railway Company	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
St. Lawrence & Atlantic Railroad (Québec) Inc.	Québec
St. Paul & Pacific Northwest	British Columbia
Toronto Terminals Railway Company Limited	Ontario
Train Touristique de Charlevoix Inc.	Québec
Trillium Railway Co. Ltd.	Ontario
Tshiuetin Rail Transportation Inc.	Québec, Newfoundland and Labrador
VIA Rail Canada Inc.	British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia
West Coast Express Ltd.	British Columbia
White Pass and Yukon Route Railroad	Yukon, British Columbia

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Appendix B-1

2022 Locomotive Fleet—Freight Train Line Haul Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
				GM/EMD					
GP35	No Tier	16-645E	2500	1960–1969	2	0	0	0	2
GP38-2	No Tier	645E	2000	1960–1969	0	0	2	2	2
GP38-2	No Tier	16-645E	2000	1973–1979	0	0	4	4	4
GP38-2	No Tier	16-645E	2000	1970–1972	0	0	4	4	4
GP38-2	No Tier	645E	2000	1973–1979	0	0	2	2	2
GP38-2	No Tier	16V-645E	2000	1960–1969	0	0	1	1	1
GP38-2	No Tier	16V-645E	2000	1973–1979	0	0	2	2	2
GP38-2	No Tier	16-645E	2000	1960–1969	0	0	8	8	8
GP38-3	No Tier	16-645E	2000	1960–1969	0	0	1	1	1
GP38-3	No Tier	645E	2000	1970–1972	0	0	2	2	2
GP38-3	No Tier	645E	2000	1960–1969	0	0	6	6	6
GP40	No Tier	16-645E3	3000	1960–1969	0	0	1	1	1
GP40-2	No Tier	16V-645E3B	3000	1973–1979	10	0	0	0	10
GP40-2	No Tier	16-645E3B	3000	1960–1969	0	0	3	3	3
GP40-2	No Tier	16-645E3B	3000	1970–1972	0	0	3	3	3
GP40-2	No Tier	645E	3000	1973–1979	0	0	1	1	1
GP40-2LW	No Tier	16-645EB	3000	1973–1979	0	0	1	1	1
GP40-2LW	No Tier	16-645E3	3000	1973–1979	0	0	1	1	1
GP40-2W	No Tier	16-645E3	3000	1973–1979	0	0	4	4	4
GP40-3	No Tier	16-645E3	3000	1960–1969	0	0	3	3	3
GP40-3M	No Tier	16-645E3	3000	1960–1969	0	0	3	3	3
GP40-3M	No Tier	16-645E3	3000	1970–1972	0	0	1	1	1
GP9	No Tier	645E	2000	1950–1959	0	1	0	1	1
GP9	No Tier	16V-645C	1800	1950–1959	0	0	1	1	1
GP9	No Tier	16V-645C	1800	1973–1979	0	0	7	7	7
GP9	No Tier	16V-645C	1800	1960–1969	0	0	2	2	2
GR418/GP9	No Tier	16V-645C	1800	1960–1969	0	0	2	2	2
RM-1 SLUG	No Tier	NA	0	1960–1969	0	0	1	1	1
RM-1 SLUG	No Tier	NA	0	1970–1972	0	0	1	1	1
RM-1 SLUG	No Tier	NA	0	1960–1969	0	0	1	1	1
RM1 - SLUG	No Tier	NA	0	1960–1969	0	0	1	1	1
RM1-SLUG	No Tier	NA	0	1970–1972	0	0	3	3	3
SD38-2	No Tier	16V-645 or 16V-645E	2000	1970–1972	0	0	1	1	1
SD38-2	No Tier	16V-645 or 16V-645E	2000	1973–1979	0	0	1	1	1

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2022 Locomotive Fleet—Freight Train Line Haul Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
SD38AC	No Tier	16V-645 or 16V-645E	2000	1970–1972	0	0	1	1	1
SD40	No Tier	645	3000	1970–1972	0	1	0	1	1
SD40-2	No Tier	16-645E3C	3000	1980–1989	2	0	0	0	2
SD40-2	No Tier	16V-645E3B	3000	1973–1979	4	0	1	1	5
SD40-2	No Tier	645E3	3000	1970–1972	0	2	0	2	2
SD40-2	No Tier	16V-645E3	3000	1960–1969	0	0	1	1	1
SD40-2	No Tier	16-645E3	3000	1980–1989	11	0	0	0	11
SD40-2	No Tier	16-645E3B	3000	1960–1969	0	0	1	1	1
SD40-2	No Tier	16-645E3	3000	1970–1972	0	0	3	3	3
SD40-2	No Tier	16-645E3B	3000	1980–1989	20	0	1	1	21
SD40-2	No Tier	16-645E3B	3000	1973–1979	9	0	1	1	10
SD40-2	No Tier	16-645E3	3000	1973–1979	20	0	0	0	20
SD40-2	No Tier	16V-645E3B	3000	1980–1989	6	0	1	1	7
SD40-2	No Tier	16V-645E	2000	1970–1972	0	0	1	1	1
SD40-2	No Tier	645E	3000	1973–1979	0	6	1	7	7
SD40-2F	No Tier	16-645E3	3000	1980–1989	3	0	0	0	3
SD40-3	No Tier	16-645E3B	3000	1960–1969	0	0	1	1	1
SD40-3	No Tier	16V-645E3B	3000	1960–1969	5	0	0	0	5
SD40-3	No Tier	16-645E3B	3000	1973–1979	0	0	2	2	2
SD40-3	No Tier	16-645E3B	3000	1970–1972	0	0	4	4	4
SD40-3	No Tier	16V-645E3B	3000	1970–1972	1	0	0	0	1
SD70ACe	No Tier	16-710G3B-ES	4375	2000–2009	0	2	0	2	2
SD70ACe	No Tier	16-710G3B-ES	4375	2010–2019	0	9	0	9	9
GP38-2	Tier 0	16-645E	2000	1970–1972	0	0	2	2	2
GP40-2	Tier 0	16V-645E3B	3000	1973–1979	20	0	0	0	20
SD40-2	Tier 0	16V-645E3B	3000	1973–1979	14	0	0	0	14
SD40-2	Tier 0	16-645E3B	3000	1973–1979	1	0	0	0	1
SD40-2	Tier 0	16-645E3	3000	1980–1989	9	0	0	0	9
SD40-2	Tier 0	16-645E3	3000	1973–1979	1	0	0	0	1
SD40-2	Tier 0	16V-645E3B	3000	1980–1989	4	0	0	0	4
SD40-2	Tier 0	16-645E3B	3000	1980–1989	1	0	0	0	1
SD60	Tier 0	16V-710G3	3800	1980–1989	34	0	0	0	34
SD60-3	Tier 0	16-710G3	3800	1980–1989	7	0	0	0	7
SD60M	Tier 0	710G3A	3800	1990–1999	0	4	0	4	4
SD60M	Tier 0	16-710G3	3800	1980–1989	1	0	0	0	1
SD60M	Tier 0	710G3A	3800	1980–1989	0	3	0	3	3
SD70I	Tier 0	16V-710G3B	4000	1990–1999	3	0	0	0	3
SD75I	Tier 0	710G3C	4300	1990–1999	0	5	0	5	5
SD75I	Tier 0	16V-710G3C	4300	1990–1999	24	0	0	0	24

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2022 Locomotive Fleet—Freight Train Line Haul Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
SD9043MAC	Tier 0	16-710G3C-ES	4300	1990–1999	3	0	0	0	3
GP38	Tier 0+	EMD 645E	2000	1973–1979	0	2	0	2	2
GP38-2	Tier 0+	16-645E	2000	1973–1979	0	0	4	4	4
GP38-2	Tier 0+	645E	2000	1980–1989	0	2	0	2	2
GP38-2	Tier 0+	16-645E	2000	1970–1972	0	0	2	2	2
GP38-2	Tier 0+	645E	2000	1973–1979	0	4	4	8	8
GP382	Tier 0+	EMD 645E	2000	1960–1969	0	7	0	7	7
GP382	Tier 0+	EMD 645E	2000	1970–1972	0	1	0	1	1
GP39-2C	Tier 0+	12-645E3	2300	1970–1972	0	0	2	2	2
GP40	Tier 0+	645	3000	1973–1979	0	2	0	2	2
GP40-2	Tier 0+	645E	3000	1973–1979	0	4	0	4	4
GP40-2	Tier 0+	16V-645E3B	3000	1973–1979	27	0	0	0	27
GP40-2	Tier 0+	645E	3000	1960–1969	0	1	0	1	1
GP40-3	Tier 0+	16-645E3C	3000	1960–1969	2	0	0	0	2
GP40-3M	Tier 0+	16-645E3B	3000	1980–1989	0	0	1	1	1
GP40-3M	Tier 0+	16-645E3B	3000	1970–1972	0	0	1	1	1
GP40-3M	Tier 0+	16-645E3B	3000	1973–1979	0	0	1	1	1
SD-50	Tier 0+	645	3600	1980–1989	0	3	0	3	3
SD30C-ECO	Tier 0+	12-710G3B	3000	1973–1979	25	0	0	0	25
SD30C-ECO	Tier 0+	12-710G3B	3000	1980–1989	22	0	0	0	22
SD30C-ECO	Tier 0+	12-710G3B	3000	1970–1972	2	0	0	0	2
SD40-2	Tier 0+	16-645E3B	3000	1980–1989	7	0	0	0	7
SD40-2	Tier 0+	16V-645E3B	3000	1980–1989	16	0	0	0	16
SD40-2	Tier 0+	16-645E3	3000	1980–1989	3	0	0	0	3
SD40-2	Tier 0+	16V-645E3B	3000	1973–1979	37	0	0	0	37
SD40-2	Tier 0+	16-645E3B	3000	1973–1979	1	0	2	2	3
SD40-2F	Tier 0+	16-645E3B	3000	1980–1989	5	0	0	0	5
SD40-3	Tier 0+	16-645E3B	3000	1980–1989	7	0	0	0	7
SD40-3	Tier 0+	16V-645E3B	3000	1960–1969	14	0	0	0	14
SD40-3	Tier 0+	645E3B	3000	1970–1972	0	2	0	2	2
SD40-3	Tier 0+	16-645E3	3000	1980–1989	3	0	0	0	3
SD40-3	Tier 0+	16V-645E3B	3000	1970–1972	3	0	0	0	3
SD50	Tier 0+	645	3600	1980–1989	0	1	0	1	1
SD60	Tier 0+	16-710G3A	3800	1980–1989	27	0	0	0	27
SD60	Tier 0+	16V-710G3	3800	1980–1989	43	0	0	0	43
SD60-3	Tier 0+	16-710G3A	3800	1980–1989	3	0	0	0	3
SD60M	Tier 0+	16-710G3A	3800	1980–1989	4	0	0	0	4
SD70I	Tier 0+	16V-710G3B	4000	1990–1999	19	0	0	0	19
SD75I	Tier 0+	16V-710G3C	4300	1990–1999	119	0	0	0	119

2022 Locomotive Fleet—Freight Train Line Haul Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
SD70M	Tier 1	710G3C	4000	2000–2009	0	5	0	5	5
SD70ACU	Tier 1+	16-710G3C	4300	1990–1999	60	0	0	0	60
SD70MAC	Tier 1+	16-710G3C	4000	1990–1999	0	0	3	3	3
SD70-ACE	Tier 2	710	4400	2010–2019	0	5	0	5	5
SD70M-2	Tier 2	16V-710G3C	4300	2000–2009	22	0	0	0	22
SD70M-2	Tier 2	16V-710G3C	4300	2010–2019	34	0	0	0	34
SD-70ACe	Tier 2+	16-710G3C-ES	4375	2000–2009	0	5	0	5	5
SD70ACE	Tier 2+	16V-710G3C	4400	1990–1999	0	0	4	4	4
SD70M-2	Tier 2+	16V-710G3C	4300	2000–2009	72	0	0	0	72
SD70M-2	Tier 2+	16V-710G3C	4300	2010–2019	46	0	0	0	46
SD-70ACe	Tier 3	16-710G3C-ES	4375	2000–2009	0	5	0	5	5
SD70ACE	Tier 3	16V-710G3C	4300	2010–2019	4	0	0	0	4
SD70ACe	Tier 3	16-710G3C-ES	4375	2000–2009	0	1	0	1	1
SD70ACe	Tier 3	16-710G3B-ES	4375	2000–2009	0	2	0	2	2
SD70ACe	Tier 3	16-710G3B-ES	4375	2010–2019	0	5	0	5	5
GM/EMD Sub-Total					842	90	119	209	1,051
GE									
AC4400CM	No Tier	16-7FDL	4400	2000-2009	0	6	0	6	6
B23-7	No Tier	7FDL12	2000	1973-1979	0	0	2	2	2
Dash 8-40CM	No Tier	7FDL16	4000	1990-1999	0	0	3	3	3
Dash-9 44CW	No Tier	16-7FDL	4400	1990-1999	0	2	0	2	2
C44-9W	Tier 0	7FDL-16	4400	2000-2009	1	0	0	0	1
C40-8	Tier 0+	7FDL-16	4000	1990-1999	6	0	0	0	6
C40-8	Tier 0+	7FDL-16	4000	1980-1989	14	0	0	0	14
AC4400CW	Tier 1	7FDL16	4400	2000-2009	0	26	0	26	26
AC4400CM	Tier 1+	16-7FDL	4400	2000-2009	0	6	0	6	6
AC4400CW	Tier 1+	7FDL16	4400	1990-1999	90	0	0	0	90
AC4400CW	Tier 1+	7FDL16	4400	2000-2009	171	0	0	0	171
AC44C6M	Tier 1+	7FDL-A16	4400	1990-1999	9	0	0	0	9
AC44C6M	Tier 1+	7FDL-A16	4400	2000-2009	1	0	0	0	1
AC44CWM	Tier 1+	7FDL16	4400	1990-1999	171	0	0	0	171
C44-9W	Tier 1+	7FDL-16	4400	2000-2009	85	0	0	0	85
C44-9W	Tier 1+	7FDL-16	4400	1990-1999	60	0	0	0	60
ES44AC	Tier 2	GEVO12	4360	2010-2019	0	6	0	6	6
ES44DC	Tier 2	GEVO-12	4400	2000-2009	22	0	0	0	22
ES44DC	Tier 2	GEVO-12	4400	2010-2019	3	0	0	0	3
ES44AC	Tier 2+	GEVO-12	4365	2000-2009	198	0	0	0	198
ES44AC	Tier 2+	GEVO-12	4365	2010-2019	61	0	0	0	61

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2022 Locomotive Fleet—Freight Train Line Haul Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
ES44DC	Tier 2+	GEVO-12	4400	2010-2019	31	0	0	0	31
ES44DC	Tier 2+	GEVO-12	4400	2000-2009	67	0	0	0	67
ES44AC	Tier 3	GEVO-12	4400	2010-2019	371	0	0	0	371
ES44AC	Tier 3	GEVO-12	4365	2010-2019	30	0	0	0	30
ES44AC	Tier 3	GEVO12	4400	2010-2019	53	0	0	0	53
ET44AC	Tier 3	ES44AC	4400	2010-2019	1	0	0	0	1
ES44AC	Tier 4	GEVO-12	4400	2010-2019	3	0	0	0	3
ET44AC	Tier 4	GEVO-12	4400	2010-2019	222	0	0	0	222
ET44AC	Tier 4	ET44AC	4400	2010-2019	5	0	0	0	5
ET44AC	Tier 4	GEVO-12	4400	2020-2022	38	0	0	0	38
GE Sub-Total					1,713	46	5	51	1,764
MLW									
RS-18	No Tier	12V-251	1800	1950-1959	0	0	6	6	6
MLW Sub-Total					0	0	6	6	6
NRE									
SD40-3	Tier 0+	645E3	3000	1970-1972	0	1	0	1	**1**
SD40-3	Tier 0+	645E3B	3000	1970-1972	0	6	0	6	6
NRE Sub-Total					0	7	0	7	7
EMCC									
SD70M-2	Tier 2+	16V-710G3B	4000	2000-2009	0	0	12	12	12
EMCC Sub-Total					0	0	12	12	12
Wabtec									
AC44C6M	Tier 1+	16-7FLDA	4500	2020-2022	0	19	0	19	19
Wabtec Sub-Total					0	19	0	19	19
Other									
1750HP	No Tier	567	1800	1950-1959	0	0	2	2	2
Other Sub-Total					0	0	2	2	2
Total Mainline Freight					**2,555**	**162**	**144**	**306**	**2,861**

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Appendix B-2

2022 Locomotive Fleet—Freight Yard Switching & Work Train Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
GM/EMD									
Cab slug	Elec/ Steam/ Other	NA	0	1950-1959	0	0	2	2	2
SLUG	Elec/ Steam/ Other	NA	0	2000-2009	0	0	1	1	1
SLUG	Elec/ Steam/ Other	NA	0	1980-1989	0	0	1	1	1
FP9A	No Tier	16-645C	1750	1950-1959	2	0	0	0	2
FP9A-3	No Tier	16-645E	1750	1950-1959	1	0	0	0	1
GP35	No Tier	16V-567D3A	2500	1960-1969	0	0	1	1	1
GP38	No Tier	645	2000	1960-1969	0	1	0	1	1
GP38	No Tier	16-645E	2000	1970-1972	1	0	0	0	1
GP38	No Tier	16-645E	2000	1960-1969	1	0	0	0	1
GP38-2	No Tier	16-645E	2000	1960-1969	1	0	1	1	2
GP38-2	No Tier	16V-645E	2000	1970-1972	11	0	0	0	11
GP38-2	No Tier	16V-645E	2000	1973-1979	32	0	17	17	49
GP38-2	No Tier	16-645E	2000	1980-1989	55	0	0	0	55
GP38-2	No Tier	16-645E	2000	1970-1972	0	0	1	1	1
GP38-3	No Tier	16-645E	2000	1970-1972	3	0	0	0	3
GP38-3	No Tier	16-645E	2000	1980-1989	3	0	0	0	3
GP38-3	No Tier	16-645E	2000	1960-1969	1	0	0	0	1
GP38-3	No Tier	16-645E	2000	1973-1979	1	0	0	0	1
GP38AC	No Tier	16-645E	2000	1970-1972	4	0	0	0	4
GP40-2	No Tier	16V-645E3	3000	1973-1979	0	0	9	9	9
GP40-3	No Tier	16-645E3	3000	1960-1969	0	0	2	2	2
GP9	No Tier	16V-567	1750	1950-1959	0	0	2	2	2
GP9	No Tier	16V-645	1700	1960-1969	0	0	1	1	1
GP9	No Tier	16V-567	1750	1960-1969	0	0	1	1	1
GP9	No Tier	16V-645C	2000	1950-1959	0	0	1	1	1
GP9	No Tier	567C	1750	1950-1959	0	3	0	3	3
GP9	No Tier	16V-645	2000	1950-1959	0	0	2	2	2
GP9	No Tier	16V-645	1750	1950-1959	0	0	2	2	2

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2022 Locomotive Fleet—Freight Yard Switching & Work Train Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
GP9 master	No Tier	16V-567	1750	1950-1959	0	0	5	5	5
GP9-3	No Tier	16-567C	1750	1950-1959	0	0	2	2	2
GP9-RM	No Tier	16V-645C	1800	1950-1959	66	0	0	0	66
MP15	No Tier	12V-645	1500	1973-1979	0	0	1	1	1
MP15	No Tier	12V-645	1500	1980-1989	0	0	3	3	3
MP1500	No Tier	12V-567	1500	1973-1979	0	0	3	3	3
SD35-3	No Tier	16V-645E	2500	1960-1969	0	0	1	1	1
SD40-2	No Tier	16-645-E3B	3000	1980-1989	0	0	1	1	1
SD40-2	No Tier	16-645E3B	3000	1970-1972	0	0	3	3	3
SD40-2	No Tier	16V-645E3	3000	1973-1979	0	0	4	4	4
SW-12	No Tier	567	3600	1960-1969	0	1	0	1	1
SW1000RS	No Tier	8V-645	1000	1960-1969	0	0	2	2	2
SW14	No Tier	12V-567	1400	1950-1959	0	0	1	1	1
SW1500	No Tier	12-645E	1500	1970-1972	0	0	2	2	2
SW900	No Tier	8-567C	900	1950-1959	1	0	0	0	1
SW900	No Tier	8V-567	900	1960-1969	0	0	1	1	1
SW900	No Tier	8V-645C	1000	1950-1959	0	0	1	1	1
SW900RS	No Tier	8V-567	900	1950-1959	0	0	8	8	8
SW900RS	No Tier	8V-567	900	1960-1969	0	0	1	1	1
GP15-1	Tier 0	12-645E	1500	1973-1979	0	0	3	3	3
GP38-2	Tier 0	16-645E	2000	1973-1979	16	0	0	0	16
GP38-2	Tier 0	16-645E	2000	1980-1989	3	0	0	0	3
GP38-2	Tier 0	16V-645E	2000	1973-1979	2	0	0	0	2
GP38AC	Tier 0	16-645E	2000	1970-1972	1	0	0	0	1
FP9B-3	Tier 0+	16-645E	1750	1950-1959	1	0	0	0	1
GP20C-ECO	Tier 0+	8-710G3B	2000	1950-1959	130	0	0	0	130
GP38-2	Tier 0+	16V-645E	2000	1970-1972	7	0	0	0	7
GP38-2	Tier 0+	16-645E	2000	1973-1979	27	0	2	2	29
GP38-2	Tier 0+	16-645E	2000	1970-1972	4	0	0	0	4
GP38-2	Tier 0+	16-645E	2000	1980-1989	56	0	0	0	56
GP38-2	Tier 0+	16V-645E	2000	1973-1979	43	0	0	0	43
GP38-3	Tier 0+	16-645E	2000	1980-1989	6	0	0	0	6
GP382	Tier 0+	645E	2000	1970-1972	10	0	0	0	10
GP382	Tier 0+	645E	2000	1973-1979	3	0	0	0	3
GP38AC	Tier 0+	16-645E	2000	1970-1972	8	0	0	0	8

2022 Locomotive Fleet—Freight Yard Switching & Work Train Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Class 1	Regional	Shortline	Total Regional & Shortline	Total Freight Fleet
GP39-2C	Tier 0+	12-645E3	2300	1970-1972	0	0	2	2	2
GP40-3	Tier 0+	645E3B	3000	1973-1979	1	0	0	0	1
GP40-3	Tier 0+	645E3B	3000	1970-1972	1	0	0	0	1
SD38-2	Tier 0+	16V-645E	2000	1973-1979	3	0	0	0	3
GM/EMD Sub-Total					505	5	90	95	600
ALCO									
RS-18	No Tier	12V-251-B	1800	1950-1959	0	0	1	1	**1**
S-13	No Tier	Inline 6 251	1000	1950-1959	0	0	1	1	1
ALCO Sub-Total					0	0	2	2	2
Yard Switching & Work Train Total					**505**	**5**	**92**	**97**	**602**

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Appendix B-3

2022 Locomotive and DMU Fleet—Passenger Train Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Intercity	Commuter	Tourist/ Excursion	Total
GM/EMD								
F40-PH	No Tier	16V-645E3B	3000	1973-1979	2	0	0	2
F40-PH-2D	No Tier	16-645E3C	3000	1980-1989	47	0	0	47
F40PHR	No Tier	16-645E3B	3000	1973-1979	0	0	2	2
GMD-1	No Tier	12V-567C	1200	1950-1959	0	0	1	1
GP9	No Tier	16V-645	1750	1950-1959	0	0	1	1
GP9	No Tier	16V-567C	1750	1950-1959	0	0	1	1
F59-PH	Tier 0	710	3000	1990-1999	0	8	0	8
F59-PHI	Tier 0	710	3000	1990-1999	0	4	0	4
GP40-0	Tier 0	645E3B	3000	1960-1969	0	0	1	1
GP40-1	Tier 0	645E3B	3000	1960-1969	0	0	2	2
GP40-2	Tier 0	645E3B	3000	1960-1969	0	0	1	1
GP40-2LW	Tier 0	645E3B	3000	1973-1979	0	0	5	5
F40-PH-2D	Tier 0+	16-645E3C	3000	1980-1989	5	0	0	5
F40PHR	Tier 0+	16-645E3B	3000	1973-1979	0	0	1	1
GP38-2	Tier 0+	645E	2000	1980-1989	3	0	0	3
F59-PH	Tier 2	12V-710G3	3000	1980-1989	0	10	0	10
F59-PHI	Tier 2	12V-710G3	3000	1990-1999	0	11	0	11
GM/EMD Sub-Total					57	33	15	105
GE								
70 ton	No Tier	Cummins 1710	660	1940-1949	0	0	1	1
P42DC	No Tier	7FDL16	4250	2000-2009	21	0	0	21
GE Sub-Total					21	0	1	22
Motive Power								
MP36PH-3C	Tier 0	645E3B	3600	2000-2009	0	1	0	1
MP40PH-3C	Tier 2	16V-710G3C	4000	2010-2019	0	29	0	29
MP40PH-3C	Tier 2+	16V-710G3C	4000	2000-2009	0	27	0	27
MP40PH-3C	Tier 3	16V-710G3C	4000	2010-2019	0	10	0	10
MP40PHT-T4-AC	Tier 4	Twin QSK 60 T4 -16 cyl	5400	2010-2019	0	16	0	16
MP40PHTC-T4-DC	Tier 4	Twin QSK 60 T4 -16 cyl	5400	2010-2019	0	1	0	1
Motive Power Sub-Total					0	84	0	84

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2022 Locomotive and DMU Fleet—Passenger Train Operations

Model	US EPA Tier Level	Engine	HP	Year of Manufacture	Intercity	Commuter	Tourist/ Excursion	Total
Bombardier								
ALP45-DP	Tier 3	3512C HD	4200	2010-2019	0	20	0	20
Bombardier Sub-Total					0	20	0	20
Cummins								
DMU A-Car	Tier 4	QSK19R	760	2010-2019	0	12	0	12
DMU C-Car	Tier 4	QSK19R	760	2010-2019	0	6	0	6
Cummins Sub-Total					0	18	0	18
Siemens								
Charger	Tier 4	16V-QSK95	4200	2020-2022	1	0	0	1
Siemens Sub-Total					1	0	0	1
Dubs								
4-4-0	Elec/Steam/Other	Other	0	1880-1889	0	0	1	1
Dubs Sub-Total					0	0	1	1
ALCO								
04/04/00	Elec/Steam/Other	Steam	600	1880-1889	0	0	1	1
ALCO Sub-Total					0	0	1	1
Passenger Operations Total					**79**	**155**	**18**	**252**

Appendix C

RAILWAYS OPERATING IN TROPOSPHERIC OZONE MANAGEMENT AREAS

TOMA Region No. 1: Lower Fraser Valley, British Columbia

CN

Division:	Pacific
Subdivisions:	Rawlison, Yale

CP

Division:	Pacific
Subdivisions:	Cascade, Mission, Page, Westminster

Other

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

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TOMA Region No. 2: Québec City-Windsor 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

Division:	Canada Québec
Subdivisions:	Adirondack, Adirondack CMQ, Lacolle, Moosehead West, Newport North, Outremont Spur, Sherbrooke, St Luc Branch, Vaudreuil, Winchester
Division:	Canada Ontario
Subdivisions:	Belleville, Brockville, Dunnville spur, Galt, Hamilton, Havelock, Mactier, Montrose, Nephton, North Toronto, Stamford, Stevensville Spur, Waterloo, Windsor

Other

Essex Terminal Railway	All
Goderich—Exeter Railway	All
Québec Gatineau Railway	All
Southern Ontario Railway	All
St-Lawrence & Atlantic (Canada)	All
Trillium	All
VIA Rail Canada	Part
GO Transit (Metrolinx)	All
exo	All
Capital Railway	All

TOMA Region No. 3: Saint John Area, New Brunswick

CN

District:	Champlain
Subdivisions:	Denison, Sussex

Other

New Brunswick Southern	All

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Appendix D

LOCOMOTIVE EMISSION STANDARDS

Locomotive Emissions Regulations

THE LOCOMOTIVE EMISSIONS REGULATIONS

- Came into force on June 9, 2017 and were published in Canada Gazette, Part II on June 28, 2017.
- Were developed by Transport Canada under the *Railway Safety Act* subsection 47.1(2).
- Align with existing regulations in the U.S. (i.e., *Title 40 of the U.S. Code of Federal Regulations (CFR), Part 1033* administered by the U.S. Environmental Protection Agency (EPA)).
- Limit emissions of criteria air contaminants (CACs), including, nitrogen oxides (NO_x), particulate matter (PM), hydrocarbons (HC), and carbon monoxide (CO), as well as smoke.
- Apply to railway companies that operate under federal jurisdiction in Canada and the locomotives that they operate.

The *Locomotive Emissions Regulations* require railways companies to:

- meet emission standards for new locomotives;
- carry out emissions testing;
- follow labelling and anti-idling requirements;
- keep records; and
- file reports with Transport Canada.

More information on the *Locomotive Emissions Regulations* can be found on the Transport Canada website at: https://tc.canada.ca/en/rail-transportation/rail-safety/regulations/overview-locomotive-emissions-regulations

More information on the U.S. regulations can be found on the U.S. EPA website at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-locomotives

EMISSION STANDARDS

Based on the type of locomotive (line haul or switch locomotive) and the year of original manufacture, new locomotives are required to meet the increasingly stringent tier of standards for NO_x, PM, HC and CO emissions, as well as smoke opacity. Locomotives are required to meet the applicable tier of standards for their entire useful life and, in certain cases, for their entire service life.

The U.S. first started regulating emissions from locomotives in 2000 under 40 CFR Part 92. These regulations included emission standards for 3 Tier levels (Tier of standards): Tier 0, Tier 1, and Tier 2.

The U.S. regulations were updated in 2008 under 40 CFR Part 1033. These are the current regulations, which set out emission standards for 5 Tier levels (Tier of standards): Tier 0, Tier 1, Tier 2, Tier 3 and Tier 4. Note: Tier 0, Tier 1, and Tier 2 are sometimes referred to as Tier 0+, Tier 1+, and Tier 2+ as these current emission standards under 40 CFR Part 1033 are more stringent than those under the older emission standards under 40 CFR Part 92.

The emission standards under the *Locomotive Emissions Regulations* are identical to the current emission standards set out in the U.S. regulations under 40 CFR Part 1033.

The *Locomotive Emissions Regulations* incorporate by reference specific tables, footnotes and paragraphs of 40 CFR Part 1033, which set out the emission standards and can be found online at: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-U/part-1033?toc=1

The older emission standards, under the U.S. regulations 40 CFR Part 92, typically no longer apply, unless a locomotive is covered by an EPA certificate that sets out family emission limits (FELs), as family emission limits (FELs) are valid for the locomotive's service life. The older emission standards, are set out in section 92.8 of 40 CFR Part 92 and can be found online at: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-U/part-1033/appendix-Appendix%20I%20to%20Part%201033

A railway company's fleet can contain locomotives that:

- meet the current emission standards;
- meet the older emission standard; and
- do not meet any emission standards.

When reporting on Tier of standards for regulatory reporting, there are 9 Tier of standards options:

Tier of standards for regulatory reporting	Description	Tier of standards for LEM reporting
CDN/40 CFR 1033 Tier 0	Meets the current Canadian emission standards or the current U.S. emission standards under Title 40 CFR Part 1033. This Tier of standards is sometimes referred to as Tier 0+.	Tier 0+
CDN/40 CFR 1033 Tier 1	Meets the current Canadian emission standards or the current U.S. emission standards under Title 40 CFR Part 1033. This Tier of standards is sometimes referred to as Tier 1+.	Tier 1+
CDN/40 CFR 1033 Tier 2	Meets the current Canadian emission standards or the current U.S. emission standards under Title 40 CFR Part 1033. This Tier of standards is sometimes referred to as Tier 2+.	Tier 2+
CDN/40 CFR 1033 Tier 3	Meets the current Canadian emission standards or the current U.S. emission standards under Title 40 CFR Part 1033.	Tier 3
CDN/40 CFR 1033 Tier 4	Meets the current Canadian emission standards or the current U.S. emission standards under Title 40 CFR Part 1033.	Tier 4
40 CFR 92—Tier 0	Meets the older emission standards in the U.S. emission standards under Title 40 CFR Part 92.	Tier 0
40 CFR 92—Tier 1	Meets the older emission standards in the U.S. emission standards under Title 40 CFR Part 92.	Tier 1
40 CFR 92—Tier 2	Meets the older emission standards in the U.S. emission standards under Title 40 CFR Part 92.	Tier 2
No Tier	Does not meet any emission standards.	No Tier

For further information on the *Locomotive Emissions Regulations*, please contact Transport Canada's Rail Safety Directorate:

- Telephone: 613-998-2985, 1-844-897-7245 (toll-free)
- Email: RailSafety@tc.gc.ca

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Appendix E

GLOSSARY OF TERMS

Terminology Pertaining To Railway Operations

CLASS 1 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 1 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 truck and rail modes.

LOCOMOTIVE ACTIVE FLEET
Refers to all locomotives, owned or leased, being used by a railway company for its railway operations in Canada. Not included in the active fleet are locomotives put in storage or removed as a result of being scrapped, sold or destroyed.

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.

LOCOMOTIVE REMANUFACTURE
The “remanufacture” of a locomotive is a process in which all 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 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* (US EPA) 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 % 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,

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repaired, remanufactured, or stored. Locomotive available time plus unavailable time equals 100%.

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 % 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_2e. 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 Table 7 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 1 railways' Annual Reports and Financial and Related Data submissions to Transport Canada also list much of this data.

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Appendix F

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

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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 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
LER	*Locomotive Emissions Regulations*
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

ABBREVIATIONS OF EMISSIONS AND RELATED PARAMETERS

CAC	Criteria Air Contaminant
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent of all six Greenhouse Gases
CO	Carbon Monoxide
EF	Emission 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

ACRONYMS OF ORGANIZATIONS

AAR	Association of American Railroads
ALCO	American Locomotive Company
CGSB	Canadian General Standards Board
CN	Canadian National Railway
CP	Canadian Pacific
ECCC	Environment and Climate Change Canada
GE	General Electric Transportation Systems
GM/EMD	General Motors Corporation Electro-Motive Division
MLW	Montreal Locomotive Works
OEM	Original Equipment Manufacturer
RAC	Railway Association of Canada
TC	Transport Canada
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
VIA	VIA Rail Canada

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Appendix H

CALCULATIONS METHODOLOGY

Data Collection

RAC members complete an annual statistical survey that forms the basis of the yearly LEM reports. The survey collects information pertaining to (but not limited to):

TRAFFIC DATA:

- Freight railways: revenue tonne-kilometres; gross tonne-kilometres; carloads by commodity.

- Passenger railways: number of passengers; passenger-kilometres; train kilometres; average length of journey; average number of passengers per train.

FUEL CONSUMPTION DATA:

- Fuel consumed across four service categories: line haul service; yard switching service; work train service; and passenger service.

LOCOMOTIVE INVENTORY:

- For each locomotive in the railway's fleet, details on: manufacturer, model, EPA tier level, engine, horsepower, year of original manufacture, anti-idle devices, and service type (line haul; yard).

Data Analysis

Internally, the RAC aggregates the information to produce industry statistics. In many cases, information is aggregated either by type of railway (Class 1; regional & shortline; intercity passenger; commuter passenger; and tourist/excursion passenger), by service (line haul, yard, work train, etc.), or by region (TOMAs).

Data on GHG emission factors are from Environment and Climate Change Canada, and data on CAC emission factors are from the United States Environmental Protection Agency.

Data Review

RAC's calculations are submitted to a consultant for a Quality Assurance / Quality Control process to validate the calculations. Afterwards, a report draft is submitted to a Technical Review Committee consisting of railway and government representatives to further review and approve the data calculations.