Rolling Towards a Cleaner Future:

The Development of Canadian Locomotive Emissions Regulations

Issue Brief

December 2010

Executive Summary

The purpose of this paper is to frame consultations with stakeholders as the Government of Canada develops railway emissions regulations for criteria air contaminants under the *Railway Safety Act*.

On October 21, 2006, the Government of Canada published a Notice of Intent to develop regulations to reduce human-made criteria air contaminant and greenhouse gas emissions. These regulations would establish nationally consistent emission standards to address all major sources of air emissions in Canada, including all modes of transportation, the industrial sectors and from consumer and commercial products.

With respect to the rail sector, the Minister of Transport will develop and implement new emissions regulations, under the *Railway Safety Act*, following the end of the current Memorandum of Understanding with the rail industry in 2010. Transport Canada intends to develop these regulations in alignment with those of the U.S. Environmental Protection Agency and implement them in 2011.

The transportation sector is a substantial emitter of criteria air contaminants. Canada's transportation sector generated over 54 per cent of all nitrogen oxides (NO_x) emissions in 2008. Of this, rail transportation was responsible for about 9 per cent of all transportation-related NO_x emissions.

The *Railway Safety Act* (R.S.C. 1985 (4th Supp.), c. 32) provides the legislative basis for developing regulations governing rail safety, security and some aspects of the environmental impacts of rail operations in Canada. The Act provides the Minister of Transport with the power to develop regulations, rules and standards that apply to federally regulated railroads. Railway companies operating interprovincially or internationally automatically fall under federal jurisdiction, while railway companies that operate solely within the boundaries of a single province may fall outside the jurisdiction of the *Railway Safety Act* unless they have been declared by Parliament to be for the general advantage of Canada or are an integral part of an existing federal undertaking. As of August 2010, a total of 32 railways operate under federal jurisdiction.

In 2007, there were close to 437 railway operations (companies that use rail equipment on tracks) in Canada. Canadian National Railway and Canadian Pacific Railway have about 75 per cent of the total rail track in Canada, typically measured in route-kilometres. About 60 short line and regional railways accounted for 23 per cent of the route-kilometres and other terminal and switching railways accounted for the remaining 2 per cent. In terms of fuel consumption, the Class 1 railways (Canadian National, Canadian Pacific and VIA Rail) used over 94 per cent of the total railway fuel consumed.

Most North American railways are freight operations that use diesel electric locomotive technology. While there is diversity in operational practices and institutional structure related to North American railways, railway technical standards are highly integrated. The North American rail industry is expected to be diesel-based for at least the medium-term future.

Canadian railways have voluntarily managed locomotive emissions in Canada since 1995, under two Memoranda of Understanding. The first Memorandum of Understanding was between the Railway Association of Canada, on behalf of the Canadian railways, and Environment Canada, and was in effect from 1995 to 2005. The second was between the Railway Association of Canada, Environment

Canada and Transport Canada. It was signed in 2007 and will remain in effect through December 31, 2010. During the period of these agreements, industry has taken measures that helped to reduce its criteria air contaminants, NO_x emissions in particular. As a result of the initiatives taken during the first Memorandum of Understanding, NO_x intensity was significantly reduced. Over its period, railway activity grew by 25 per cent, while NO_x emissions decreased by 3 per cent.

This paper seeks to stimulate discussion and feedback from stakeholders on the design of a Canadian regulatory regime for criteria air contaminant emissions from locomotives. Transport Canada will accept written submissions until February 14, 2011. All views and comments will be considered and will be posted online at www.tc.gc.ca/locomotive-emissions.

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1 Background

More and more Canadians are aware of the impact of local air contaminants on our health and air quality in our communities. Summer smog advisories in our cities are frequent reminders of the harm air pollutants can cause.

Whenever fuel is burnt, emissions are released into the air, impacting human health and the environment. These emissions include criteria air contaminants that can lead to smog and acid rain, such as nitrogen oxides (NO_x) and particulate matter (PM). That is why the Government of Canada is developing federal regulations to limit and reduce these emissions in order to protect the health of Canadians and our environment.

The Minister of Transport will develop and implement new emissions regulations, under the *Railway Safety Act*, to take effect when its current Memorandum of Understanding with the rail industry ends. Developing these regulations will be done in two phases:

1. Regulations aligned with those of the U.S. Environmental Protection Agency will be developed to limit the release of criteria air contaminants from the rail sector, to be implemented in 2011.
2. Regulations to limit the release of greenhouse gases will be developed in step with the U.S. Environmental Protection Agency.

Before Transport Canada undertakes the first phase of this plan and develops new criteria air contaminant emissions regulations, it will consult with stakeholders. This issue brief presents relevant facts and issues, and should help inform these discussions. In it, you will find:

- a summary of Canadian railway industry activity;
- a summary of how the Canadian railways have worked to reduce emissions under the terms of two Memoranda of Understanding;
- an explanation of locomotive emissions reduction regulations in force in the U.S. and elsewhere;
- an explanation of how Canada's locomotive emissions regulations will be developed; and
- annexes with additional information.

1.1 Canada's Railway Industry

Canada's railway system moves over 300 million tonnes of cargo and millions of passengers each year. Canada's rail sector includes:

- two major Class 1 freight railways (Canadian National Railway and Canadian Pacific);
- several short line and regional railways;
- intercity passenger railways (primarily VIA Rail, which is also a Class 1 railway);
- several commuter railways serving major Canadian municipalities;
- numerous industrial railways; and
- a number of tourist or recreational railway operations.[1]

An interactive map of Canada's railway system and operators is on Natural Resources Canada's Website.

In 2007, there were close to 437 railway operations in Canada.[2] Transport Canada's 2009 Annual Report shows that Canadian National and Canadian Pacific have about 75 per cent of the total rail track in Canada, typically measured in route-kilometres.[3] About 60 short line and regional railways have 23 per cent of the route-kilometres and other terminal and switching railways have the remaining 2 per cent. Class 1 railways used over 94 per cent of total railway fuel consumed.[4]

1.1.1 Freight Railways

Canadian National and Canadian Pacific dominate the railway freight sector. Canadian National has 33,000 route-kilometres of track in eight Canadian provinces and 16 U.S. states,[5] while Canadian Pacific operates nearly 21,300 km of track in six Canadian provinces and the U.S. Northeast and Midwest regions.[6] In 2008, they operated 1,942 of the total 2,193 locomotives used to move freight[7] and earned $9.87 billion in gross revenue compared to regional and short line freight railways' earnings of $0.55 billion.[8]

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1 Canadian Class 1 railways are those that realized gross revenues that exceed a threshold of 250 million dollars for the provision of Canadian railway services for two consecutive calendar years. The three Canadian Class 1 railways are Canadian National, Canadian Pacific and VIA Rail Canada. Source: *Carriers and Transportation and Grain Handling Undertakings Information Regulations*, P.C. 1996-1060, 1 July, 1996, SOR/96-334.

2 Appendix E: Profile of Railway Companies as of November 2007, Railway Safety Act Review Secretariat, *Stronger Ties: A Shared Commitment to Railway Safety,* Review of the Railway Safety Act**,** pp. 202-207.

3 Table RA1, Transport Canada, *Transportation in Canada 2009*.

4 Table RA6, Transport Canada, *Transportation in Canada 2009*.

5 Canadian National Railway, "Quick Facts & Figures."

6 Canadian Pacific*, 2008 Corporate Profile and Fact Book*, p. 11.

7 Appendix B-1, Railway Association of Canada, *Locomotive Emissions Monitoring Program,* 2008.

8 Table EC71, Transport Canada, *Transportation in Canada 2009*.

In addition, three major U.S. Class 1 freight railroads — the Burlington Northern Santa Fe Railway Company, CSX Transportation Inc. and the Norfolk Southern Railway — operate short distances within Canada. These lines connect with their rail networks in the U.S.

Freight railways use three types of locomotives: line-haul, yard switcher and road switcher. Since yards and terminals are often in urban areas, switch locomotives are used more in urban areas than are line-haul locomotives. Switch locomotives are often older than line-haul locomotives.

- **Line-haul locomotives** haul freight and passenger cars on railway tracks between yards and terminals. These are high-powered units that travel many kilometres per year and spend much of their operating time at high power levels.

- **Yard switcher locomotives** are used in yards and terminals to “switch” blocks of cars and assemble trains for line-haul. Locomotives used for this purpose do not need high-power engines and they spend much of their time with engines at idle.

- **Road switcher locomotives** are used on mainlines to pick up and deliver cars at source and destination locations. They move fewer kilometres per year, spend more time with the engine at idle, and operate at lower power levels than line-haul locomotives.

There are about 60 short line and regional railways operating over 16,000 km of track within Canada. Some regional railways are large self-contained mining railways (e.g. Cartier Mining Company and Quebec North Shore and Labrador) and some are principally industrial railways (e.g. Roberval Saguenay).

Much of the short line railway track, approximately 8,300 km, was spun off from Canadian National and Canadian Pacific to smaller operators during the mid- to late-1990s. These smaller railways provide a vital link between many regional industries and either of the two Canadian Class 1 freight railways.

1.1.2 Passenger Railways

Canada’s passenger railways fall into three broad categories. These are Class 1 passenger railways (of which there is only one: VIA Rail), smaller passenger rail operations and commuter railways.

VIA Rail

VIA Rail is a Canadian crown corporation, which carried nearly 94 per cent of the 4.9 million intercity rail passengers travelling within Canada during 2008.[9] In the same year, VIA Rail earned $288 million.[10] While VIA Rail owns and operates its own fleet of locomotives and rail cars, it owns very little track so enters into agreements to operate mainly over Canadian National track. In 2008, VIA Rail operated 503 scheduled trains per week over 12,366 km of track and served approximately 450 communities. The average passenger trip was 332 kilometres. The average passenger load factor was 59 per cent, yielding a productivity of 141 passenger-kilometres per train-kilometre.[11] While most passenger trips take place within a high-density corridor between Quebec City and Windsor, Ontario, VIA Rail also operates eastern and western long-haul services and a number of remote and regional services.

Smaller passenger rail operations

While VIA Rail carries 94 per cent of intercity rail passengers, smaller companies also provide vital or tourist services. They include:

- the Ontario Northland Railway, which provides service into Northern Ontario from Toronto;
- the Tshiuetin Rail Transportation Inc., which provides service to First Nations communities in Northern Quebec and Labrador; and
- the White Pass and Yukon Route, which provides tourist and passenger service between Skagway, Alaska, and Carcross, Yukon.

Commuter railways

Commuter rail passengers in 2008 totalled 67.05 million.[12] The largest commuter rail operations in Canada using diesel engine technology include:

- GO Transit operating in the Greater Toronto Area;
- l'Agence Métropolitaine de Transport operating in the Montreal area;
- Capital Railway operating in Ottawa; and
- West Coast Express operating in the greater Vancouver region.

Of these four commuter rail services, only the Capital Railway operates under federal jurisdiction.

9 Railway Association of Canada, *2009 Railway Trends*, p. 10.
10 Table EC71, Transport Canada, *Transportation in Canada 2009*.
11 Railway Association of Canada, *Locomotive Emissions Monitoring Program*, 2008.
12 Railway Association of Canada, *Locomotive Emissions Monitoring Program*, 2008.

1.1.3 Locomotive Supply Industry

Electro-Motive Diesel (formerly known as GM EMD) and GE produce most of North America's locomotives. While both companies are based in the U.S., Electro-Motive Diesel builds locomotive bodies and assembles locomotives in London, Ontario.

A new locomotive may cost between U.S.$2.5 million[13] and U.S.$5.5 million,[14] has a life expectancy of 25 to 40 years or more, and can be remanufactured (major engine overhauls at intervals that vary according to its use and engine power, but nominally 1.2 million km) many times over its lifetime.

The North American locomotive market is somewhat U.S.-centred for three main reasons:

1. Most locomotives are made according to U.S. standards in and for the U.S. rail system.
2. Recent years have seen increased cross-border movement, requiring Canadian and Mexican locomotives to meet U.S. standards.
3. The U.S. has 225,000 route-kilometres of track compared to Canada's 48,000 route-kilometres and Mexico's 26,000 route-kilometres.

Many companies in Canada, the U.S. and Mexico supply and manufacture replacement parts for locomotives. These include high-wear diesel engine parts, traction motors, alternators and generators. In the past, much of the locomotive remanufacturing in Canada was done in-house by the railway companies at their major locomotive repair shops. Today, much of this work is contracted out to private companies, some of which have taken over former railway locomotive maintenance facilities. For example:

- Alstom's Montreal remanufacturing centre was once Canadian National's Point Sainte Charles shop,
- CAD Railway Industries Ltd. in Lachine, Quebec, has a five-year, $100-million contract to rebuild 53 VIA Rail F-40 passenger locomotives,
- NRE-ALCO Locomotive of Canada provides remanufacturing services near Capreol, Ontario;
- OEM Remanufacturing in Edmonton, Alberta, remanufactures locomotive engine components; and
- Railpower Technologies Corp. in Brossard, Quebec, rebuilds old locomotives into hybrid yard switching and multi-genset yard and road switching locomotives. Its

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13 Peter Eggleton and Robert Dunn, *Present and Future Canadian Railway Activity and Emissions Profile*, prepared for the Railway Association of Canada, July 2005.

14 VIA Rail news release, "VIA receives first environmentally enhanced F-40 locomotive from CAD Railway Industries," July 2009.

switching locomotive products use small U.S. Environmental Protection Agency Tier 2- or Tier 3-compliant diesel engines.[15]

For more information on the basics of locomotive engine operation, see Annex A.

1.1.4 North American Integration

A highly integrated North American rail industry makes transporting goods across rail networks owned by different railways more efficient. Companies operating on integrated rail networks build track to a standard "gauge" and maintained to similar minimum standards. Loaded rail cars are usually pulled by locomotives owned and operated by the owner of the track they operate on, but North American integration allows railways to interchange or hand off cars and locomotives that meet industry standards to other railways to complete a journey. The standards for rail cars are published by the Association of American Railroads, whose members include all major U.S., Canadian and Mexican freight railways. Almost all locomotives used by North American railway companies are built to U.S. manufacturing standards and new equipment is certified for service only after successfully passing performance tests.

Interchange agreements between railways allow the safe and efficient interchange and use of cars on another railway's tracks. More locomotives are being interchanged now because of Canadian National and Canadian Pacific operations on both the U.S. and Canadian side of the border — and locomotives used extensively in the U.S. must conform to their federal standards.

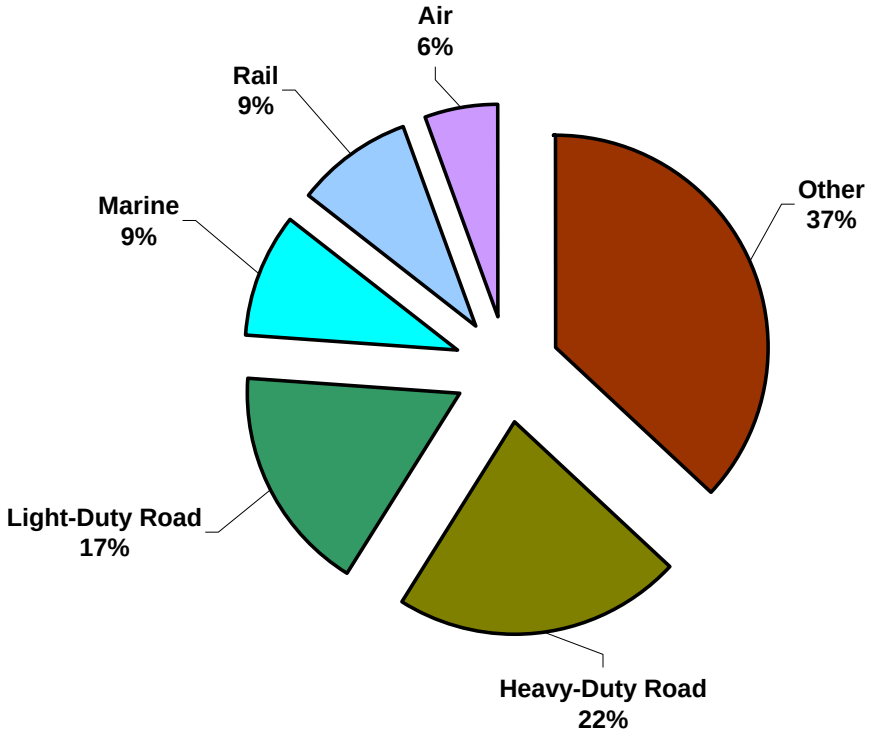
1.2 Railway Emissions in Canada

Each year, Environment Canada produces an inventory of criteria air contaminant emissions in Canada. The transportation sector generated over 54 per cent of all NO_x emissions in 2008.[16] Within transportation, the surface modes produce almost half of the NO_x emissions. This includes light-duty passenger vehicles, heavy-duty trucks, and rail. Figure 1 illustrates the NO_x emissions of all modes in Canada.

[15] Refer to Section 3.1.1 for an explanation of U.S. Environmental Protection Agency engine emission Tier levels.

[16] Environment Canada, National Pollutant Release Inventory, *2008 Air Pollutant Emission Summary*.

Figure 1: Transportation NO_x Emissions in Canada, 2008



"Light-Duty Road" includes light-duty gasoline and diesel vehicles, and trucks and motorcycles.
"Heavy-Duty Road" includes heavy-duty diesel vehicles and heavy-duty gasoline trucks.
"Other" includes off-road diesel and gasoline sources.

Source: *2008 Air Pollutant Emission Summary*, Environment Canada's National Pollutant Release Inventory.

Rail transportation produces about 9 per cent of all transportation-related NO_x emissions. In 2008, Canadian railways produced close to 5 per cent of Canada's total NO_x emissions.

1.2.1 Locomotive Emissions of Criteria Air Contaminants

Locomotive criteria air contaminant emissions are by-products of burning diesel fuel, and they impact human health and the environment. The principal criteria air contaminant emissions are described below.

- **Nitrogen oxides** (NO_x) include the gases nitrogen oxide (NO) and nitrogen dioxide (NO_2). NO_x is formed primarily from the liberation of nitrogen from the air during combustion processes. NO emitted during combustion quickly oxidizes to NO_2 in the atmosphere. NO_2 dissolves in water vapour in the air to form acids and interacts with other gases and particles in the air to form particles known as nitrates and other products that may be harmful to people and their environment.

- **Particulate matter** (PM) is airborne particles in solid or liquid form that may be classified as primary or secondary, depending on the compounds and processes

involved during its formation. The size of PM particles largely determines how much environmental and health damage they can cause.

- **Sulphur dioxide** (SO_2) belongs to a family of sulphur oxide gases (SOx). It is formed from the sulphur in raw materials such as coal, oil and metal-containing ores when they are burned or refined. SO_2 dissolves in water vapour in the air to form acids, and interacts with other gases and particles in the air to form particles known as sulphates and other products that can be harmful to people and their environment.

- **Volatile organic compounds** (VOCs) are gases and vapours such as diesel fumes and solvents that contain carbon (but not carbon dioxide, carbon monoxide, methane or chlorofluorocarbons).

- **Carbon monoxide** (CO) is a colourless, odourless, tasteless and poisonous gas. It is a product of incomplete combustion of hydrocarbon-based fuels.

NO_x and VOCs react in sunlight to produce ground-level ozone, which can significantly impact human health. Exposure to ozone has been linked to pre-mature mortality and a range of health markers such as hospital admissions and asthma symptom days.[17] Since NO_2, a component of NO_x, is linked to nose, throat and lung effects, it has been the focus of air quality standard development. A map of the total NO_x emissions density in Canada for 2005 is available on Environment Canada's Website.

Many studies have linked PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema and to some forms of heart disease.[18] Groups most at risk are the elderly, children and people with respiratory problems. The indirect impacts smog has on health and safety include reduced visibility, and less quality of life for those directly subjected to it. A map of the total PM emissions density in Canada for 2005 from all sources is available on Environment Canada's Website.

[17] Environment Canada, *Criteria Air Contaminants and Related Pollutants: Ground Level O_3*.
[18] Environment Canada, *Criteria Air Contaminants and Related Pollutants: Particulate Matter (PM)*.

2 Past and Current Initiatives to Reduce Railway Emissions in Canada

The Canadian government and the railway industry have taken steps to reduce rail sector emissions in Canada. One of the key federal activities has been entering into voluntary agreements with the railroad industry.

2.1 Memoranda of Understanding with the Rail Sector

Canadian railways have managed locomotive emissions in Canada since 1995, under two Memoranda of Understanding. The first Memorandum of Understanding was between the Railway Association of Canada on behalf of the Canadian railways and Environment Canada, and was in effect from 1995 to 2005. The second was between the Railway Association of Canada, Environment Canada and Transport Canada. It was signed in 2007, and will remain in effect through December 31, 2010.

2.1.1 Memorandum of Understanding for 1995-2005

The first Memorandum of Understanding set a voluntary cap on NO_x locomotive emissions of 115,000 tonnes per year. This cap was based on best estimates of the rail sector's total yearly NO_x emissions at the end of 1989 and projected traffic growth.

Under the terms of this agreement, the Railway Association of Canada agreed to:

- take the actions needed to avoid exceeding the voluntary cap;
- collect the data required to calculate yearly estimates of NO_x emissions between January 1, 1990, and December 31, 2005; and
- deliver an annual report to Environment Canada with details of railway activity, emissions and relevant activities.

The annual report[19] included data such as:

- yearly gross tonne-kilometres;
- revenue tonne-kilometres;
- passenger-kilometres;
- total fuel consumption; and
- estimates for emissions of NO_x, hydrocarbons (HC), SO_x, PM, CO and CO_2.

[19] See the Railway Association of Canada Website for copies of its annual *Locomotive Emissions Monitoring Program* reports dating back to 2001.

These are provided as aggregate national values, as well as for three separate geographic areas of Canada, referred to as Tropospheric Ozone Management Areas, which are of interest both from an air quality and from a rail activity perspective. Tropospheric Ozone Management Area fuel consumption and emissions data are broken down further by winter and summer months.

The annual reports also included:

- updated information on the locomotive fleet, such as year of manufacture, horsepower, engine model, duty type and railway company;
- a summary of new operating procedures or technologies introduced to reduce NO_x emissions;
- the emissions control systems, hardware or techniques installed during an engine rebuild program that would affect NO_x emissions;
- any new emissions performance data or emissions factors for locomotives;
- significant changes in diesel fuel properties and any new data on locomotive engine emission sensitivity to fuel quality or alternative fuels; and
- descriptions of other emissions reduction initiatives, operating procedures or changes in service or duty cycles that would significantly affect emissions.

2.1.2 Results Achieved Under the 1995-2005 Memorandum of Understanding

Under the 1995-2005 Memorandum of Understanding, the rail industry reduced its NO_x emission intensity. The annual reports detailed the criteria air contaminant and greenhouse gas emission estimates for the rail industry and outlined measures the industry had taken to reduce emission intensities. These measures included:

- increasing overall awareness of best practices and efficiencies;
- making changes to locomotive and car equipment;
- changing operational practices;
- improving infrastructure; and
- adopting relevant emerging technologies.

During the first Memorandum of Understanding, the industry reduced NO_x emissions intensity. The 2005 *Locomotive Emissions Monitoring Program* report[20] itemized the following list of initiatives:

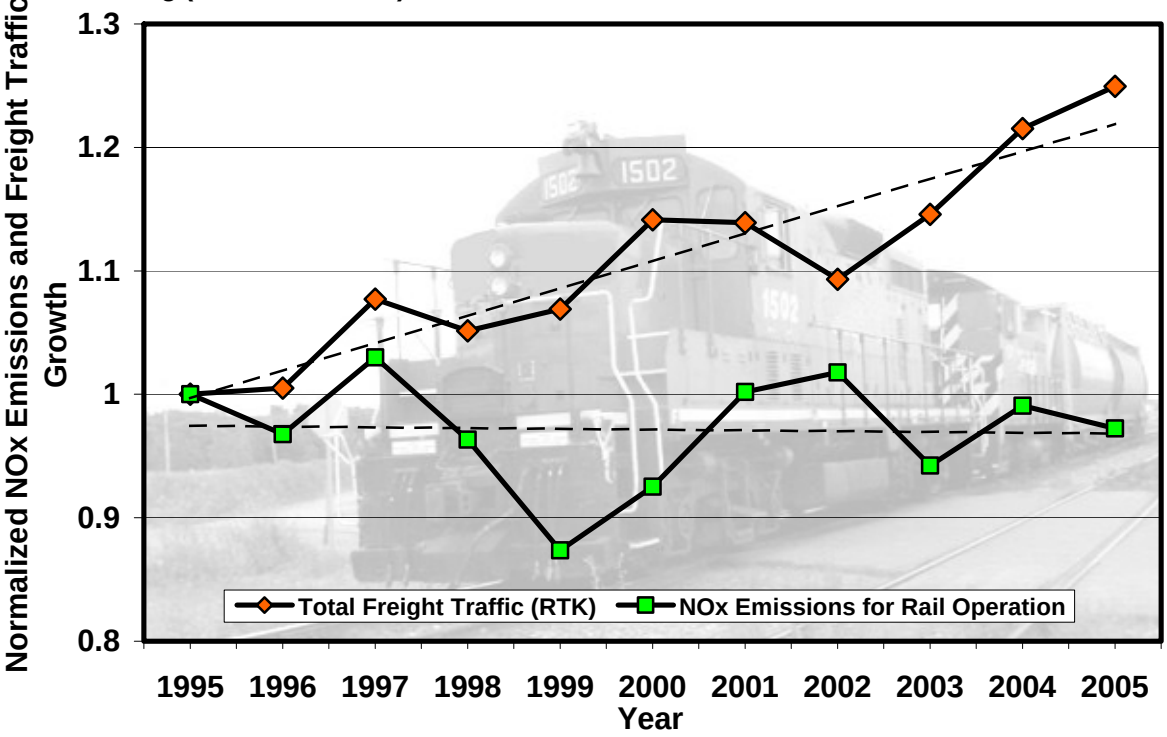
- Fleet renewal
- Low idle
- Automatic stop/start systems
- Passenger train layover systems
- Passenger train operations

[20] Railway Association of Canada, *Locomotive Emissions Monitoring Program*, 2005.

- Freight car productivity improvement
- Longer trains
- Remote power
- Consolidation of cars with similar destination into blocks
- Train pacing and braking strategies
- Crew training and incentives
- Improved track structures
- Rail lubrication
- Fuel additives
- Co-production
- Government programs, such as Transport Canada's Freight Sustainability Demonstration Program
- Monitoring emissions reduction technologies under development

Figure 2 shows the per cent change in railway activity and NO_x emissions from 1995 to 2005. Over the period, railway activity grew by 25 per cent, while NO_x emissions decreased by 3 per cent.

Figure 2: NO_x Emissions and Railway Activity Growth Under the 1995-2005 Memorandum of Understanding (Index 1995 = 1.0)

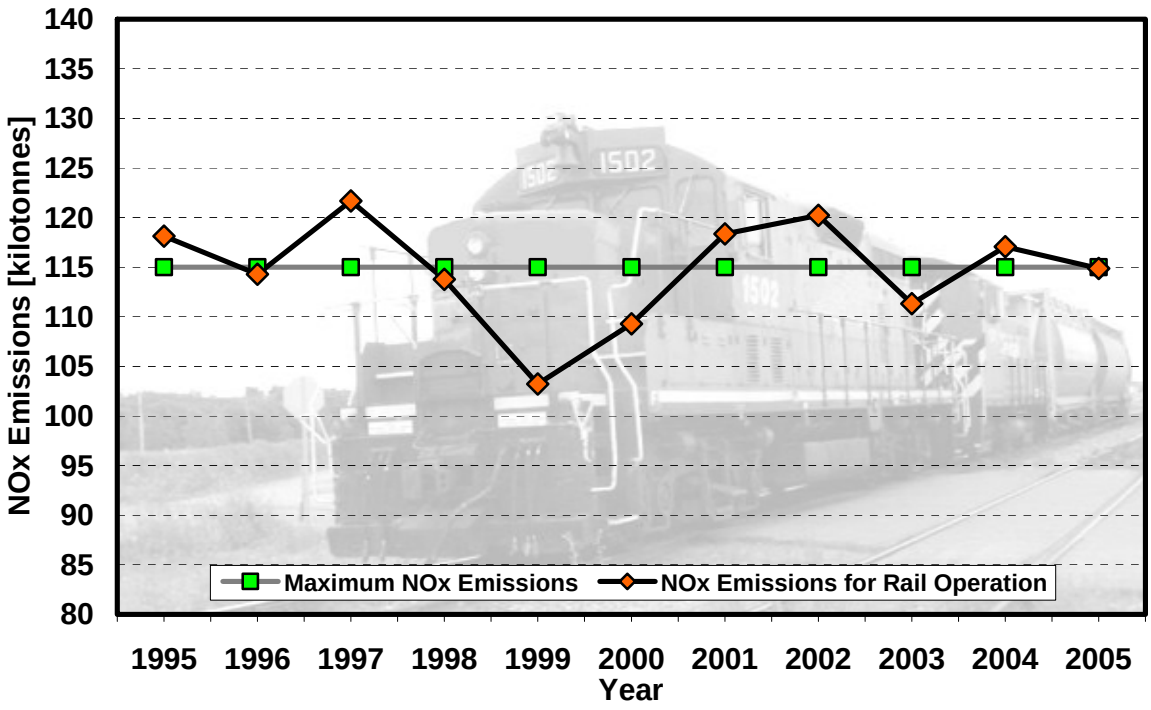


"RTK" stands for revenue tonne-kilometers, which refers to the product of the weight (in tonnes) of revenue commodities handled and the distance (in kilometers) transported.

Source: Railway Association of Canada, *Locomotive Emissions Monitoring Program* reports: 2002, 2003, 2008.

But, the Memorandum of Understanding called for a cap on total emissions, not simply lowering their intensity. Annual emissions are shown in Figure 3, which plots the actual annual emissions and the associated straight-line trend from the baseline year in 1995 to the conclusion of the agreement in 2005. The average yearly NO_x emissions over the 10-year period of the agreement (1995-2005) were in line with the agreed voluntary threshold (114.47 kilotonnes versus 115.0 kilotonnes).

Figure 3: Annual NO_x Emissions Under the 1995-2005 Memorandum of Understanding



Source: Railway Association of Canada, *Locomotive Emissions Monitoring Program* reports: 2002, 2003, 2008.

2.1.3 Memorandum of Understanding for 2006-2010

When the 1995-2005 Memorandum of Understanding ended, a second was signed in 2007, between the Railway Association of Canada, Environment Canada and Transport Canada, which remains in effect until December 31, 2010. This agreement has an expanded scope, which references both criteria air contaminant emissions, of which NO_x is one component, and greenhouse gas emissions.

Under the terms of the new 2006-2010 Memorandum of Understanding, the Railway Association of Canada agreed to encourage its members to:

- conform to all U.S. Environmental Protection Agency criteria air contaminant emission standards related to locomotive equipment; and
- adopt other operating practices that will reduce criteria air contaminant emissions.

Canadian National, Canadian Pacific, VIA Rail and GO Transit have made a four-part commitment that Transport Canada expects will further reduce criteria air contaminants from levels achieved under the first Memorandum of Understanding:

1. Acquire only new and freshly manufactured locomotives that meet all applicable U.S. Environmental Protection Agency emission standards, during the life of the Memorandum of Understanding. This means that any additions to their locomotive fleets will at least meet the U.S. Environmental Protection Agency Tier 2 emission standards.
2. Retire from service a total of 130 medium-horsepower locomotives (2,000 to 3,000 horsepower) built between 1973 and 1999. This represents approximately 5.5 per cent of Canada's total 2005 fleet of 2,363 locomotives. That total excludes switchers, slugs, diesel multiple units, electric multiple units, self-propelled rail diesel cars, historic and steam locomotives. Please note that retired locomotives are often sold or traded, and might not be removed completely from service.
3. Upgrade all high-horsepower locomotives (those above 3,000 horsepower output) to meet U.S. Environmental Protection Agency emission standards when they are remanufactured.
4. Beginning in 2010, upgrade any medium-horsepower locomotives manufactured after 1972 to meet the U.S. Environmental Protection Agency Tier 0 emission standards when remanufactured.

Canadian railway companies have also committed to meet a set of operations-specific greenhouse gas emissions intensity targets by 2010. These include separate targets for Class 1 freight operations, intercity passenger, commuter rail, and regional and short line railways.

2.1.4 Results Under the 2006-2010 Memorandum of Understanding

The 2008 *Locomotive Emissions Monitoring Program* report indicates the progress that rail operators in Canada are making to meet their 2010 greenhouse gas emission intensity targets (see Table 1).

Table 1: Railway Association of Canada's Progress to Meet 2010 Greenhouse Gas Emission Intensity Targets

Railway Operation	Units of CO_2-equivalent emissions	2006 Level	2007 Level	2008 Level	2010 Target
Class 1 Freight	kg / 1,000 revenue tonne-km	17.79	17.32	**17.61**	16.98
Regional & Short Lines	kg / 1,000 revenue tonne-km	15.10	15.21	**15.80**	15.38
Intercity Passenger	kg / passenger-km	0.13	0.13	**0.12**	0.12
Commuter Rail	kg / passenger	1.74	1.71	**1.74**	1.46

The rail industry has also taken measures to help reduce its criteria air contaminant (and particularly NO_x) emissions. Results of the four-part commitment made by Canadian National, Canadian Pacific, VIA Rail and GO Transit include the following:

1. 227 new locomotives that meet U.S. Environmental Protection Agency Tier 2 standards were acquired by the Canadian rail sector by the end of 2008.
2. 125 medium-horsepower 1993-1999 era locomotives were retired during the first three years of the agreement.
3. 25 high-horsepower locomotives were upgraded to U.S. Environmental Protection Agency Tier 0 standards by the end of 2008.
4. 19 medium-horsepower locomotives were upgraded to U.S. Environmental Protection Agency Tier 0 emission standards by the end of 2008.

The 2008 *Locomotive Emissions Monitoring Program* report listed the initiatives that were explored to help improve greenhouse gas emission levels and criteria air contaminant emission intensity across Canada's entire rail industry:

Equipment-related initiatives

- Locomotive fleet renewal
- Tier 2 engine retrofits
- Fleet upgrading and maintenance
- Low idle
- Engine anti-idling systems
- Low and ultra-low sulphur diesel fuel
- Freight car technology improvements
- Longer trains
- Remote power
- Passenger train layover systems
- Intercity passenger train equipment initiatives
- Commuter rail equipment modifications
- Fuel additives
- Alternate fuels

Operations-related initiatives

- Crew training and incentives
- Manual shutdown of locomotive engines
- Consolidation of cars with similar destination into blocks
- Train pacing and braking strategies
- Commuter train coach door management

Infrastructure-related initiatives

- Improved track structures
- Rail lubrication
- Top-of-rail friction control
- Co-production

3 Regulatory Initiatives in Other Countries

Reviewing the regulations already in effect in other countries will help us develop Canadian regulations. The approach of the U.S. Environmental Protection Agency is particularly relevant. The U.S. has had criteria air contaminant emissions regulations in place since 1997, which phase in a set of increasingly strict controls on engine emissions from railway locomotives. The European Commission has been phasing in similar legislative controls since 1997 as well (see Section 3.3).

Many countries are taking positive steps to control criteria air contaminant emissions from the railway sector, and several have already developed regulations to manage the reduction of these pollutants; however, not all are relevant to the Canadian context. For instance, China and Japan's criteria air contaminant emission standards for off-road diesel engines apply only to engines with outputs of up to 560 kilowatts (750 horsepower). Most of Canada's locomotives, on the other hand, have engines with outputs of 1,492 kilowatts (2,000 horsepower).

3.1 U.S. Environmental Protection Agency Rule on Criteria Air Contaminants

3.1.1 U.S. Environmental Protection Agency Standards

Section 213 (a)(5) of Title II of the U.S. *Clean Air Act* gives the U.S. Environmental Protection Agency the authority to set emission standards for locomotives, to achieve the greatest degree of reduction in emissions by applying available technologies.

The U.S. Environmental Protection Agency regulations aimed at reducing rail sector criteria air contaminant emissions establish a layered set of standards, referred to as "Tiers," for two types of locomotives:

- **line-haul locomotives** defined as having a rated power of more than 2,300 horsepower; and
- **switch locomotives** defined as having a rated power of 2,300 horsepower or less.

The Tier standards set out the maximum levels in grams of emission per brake horsepower-hour of output (g/bhp-hr), of NO_x, PM, HC, and CO that line-haul and switch locomotives can emit. The Tier standards generally apply to all locomotives, although there are some exceptions, such as locomotives powered by steam engines. The U.S. Environmental Protection Agency also exempts some locomotives owned or operated by Class 3 freight railways that have less than 500 to 1,500 employees, depending on the type of operation. Class 3 railways are defined by the U.S. Surface Transportation Board

as having a total operating revenue of $20 million per year or less.[21] The U.S. Environmental Protection Agency does not, however, exempt locomotives owned or operated by Class 3 railway companies that are owned by large parent companies.

The first U.S. locomotive emission standards were set in regulations signed in 1997, but which did not come into effect until 2000. They defined three sets of emission levels (Tiers 0, 1 and 2) that relate to the original date of a locomotive's manufacture and that must be met any time its engine is subsequently remanufactured. Tables 2 and 3 present the Tier standards for each type of operation, as published in the 1997 rule.

Table 2: U.S. Environmental Protection Agency Tier 0-2 Line-Haul Locomotive Emission Standards (1997 Rule)

Tier	Year Manufactured	Effective Date	HC g/bhp-hr*	CO g/bhp-hr*	NO_x g/bhp-hr*	PM g/bhp-hr*
Tier 0	1973-2001	2000	1.00	5.0	9.5	0.60
Tier 1	2002-2004	2000	0.55	2.2	7.4	0.45
Tier 2	2005 and later	2000	0.30	1.5	5.5	0.20

*g/bhp-hr = grams of emission per brake horsepower-hour

Table 3: U.S. Environmental Protection Agency Tier 0-2 Switch Locomotive Emission Standards (1997 Rule)

Tier	Year Manufactured	Effective Date	HC g/bhp-hr*	CO g/bhp-hr*	NO_x g/bhp-hr*	PM g/bhp-hr*
Tier 0	1973-2001	2000	2.1	8.0	14.0	0.72
Tier 1	2002-2004	2000	1.2	2.5	11.0	0.54
Tier 2	2005 and later	2000	0.6	2.4	8.1	0.24

*g/bhp-hr = grams of emission per brake horsepower-hour

The U.S. Environmental Protection Agency issued a second set of regulations for locomotive emissions in 2008.[22] These strengthen existing standards and establish two additional Tiers. The five Tiers are:

- more stringent Tier 0 (also called Tier 0+) standards to come into effect in 2010;[23]
- more stringent Tier 1 (also called Tier 1+) standards to come into effect in 2010;
- more stringent Tier 2 (also called Tier 2+) standards to come into effect in 2013;
- Tier 3 standards to come into effect in 2011 for switch locomotives, and 2012 for line-haul locomotives; and
- Tier 4 emission standards, which will apply to locomotives manufactured in 2015 or later.

[21] Surface Transportation Board, "FAQs."

[22] Both the 1997 and 2008 rules can be found online in the "Locomotives" section of the U.S. Environmental Protection Agency Website.

[23] Locomotives manufactured in 2008 and 2009 may have to meet the applicable Tier 0 or Tier 1 standard if certified systems are available.

Tables 4 and 5 summarize the revised Tiers 0 to 4 emission levels[24] for line-haul and switch locomotives.

Table 4: U.S. Environmental Protection Agency Tier 0-4 Line-Haul Locomotive Emission Standards (2008 Rule)

Tier	Year Manufactured	Effective Date	HC g/bhp-hr*	CO g/bhp-hr*	NO_x g/bhp-hr*	PM g/bhp-hr*
Tier 0+	1973-1992	2010	1.00	5.0	8.0	0.22
Tier 1+	1993-2004**	2010	0.55	2.2	7.4	0.22
Tier 2+	2005-2011	2013	0.30	1.5	5.5	0.10
Tier 3	2012-2014	2012	0.30	1.5	5.5	0.10
Tier 4	2015 or later	2015	0.14	1.5	1.3	0.03

*g/bhp-hr = grams of emission per brake horsepower-hour

**Certain locomotives, defined within the U.S. Environmental Protection Agency rule, originally manufactured from 1993 to 2001 are subject to the Tier 0+ standard instead of the Tier 1+ standard.

Table 5: U.S. Environmental Protection Agency Tier 0-4 Switch Locomotive Emission Standards (2008 Rule)

Tier	Year Manufactured	Effective Date	HC g/bhp-hr*	CO g/bhp-hr*	NO_x g/bhp-hr*	PM g/bhp-hr*
Tier 0+	1973-2001	2010	2.10	8.0	11.8	0.26
Tier 1+	2002-2004	2010	1.20	2.5	11.0	0.26
Tier 2+	2005-2010	2013	0.60	2.4	8.1	0.13
Tier 3	2011-2014	2011	0.60	2.4	5.0	0.10
Tier 4	2015 or later	2015	0.14	2.4	1.3	0.03

*g/bhp-hr = grams of emission per brake horsepower-hour

While the emission levels of the Tier 0 through Tier 3 standards may be reached through better engine design, reaching Tier 4 levels will most likely require using additional exhaust gas treatment technologies.[25]

The 2008 U.S. Environmental Protection Agency regulations have also introduced new measures to limit locomotive idling on a national scale. They require that Automatic Engine Stop/Start systems be installed on all newly built Tier 3 and Tier 4 locomotives and on certain existing locomotives according to the remanufacturing standards that apply. The U.S. Environmental Protection Agency also encourages the use of additional idle reduction technologies (along with the required Automatic Engine Stop/Start), by allowing reductions in idle emissions to be factored into the overall engine emissions during the engine certification process.

[24] Tier 0 through Tier 2 are denoted as Tier 0+ through Tier 2+ in these tables to signify increased stringency as established by the U.S. Environmental Protection Agency 2008 rule.

[25] For additional information on Tier 4 technologies, consult Section 4.3 of the U.S. Environmental Protection Agency's *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder*.

To learn more about these regulations, visit the U.S. Environmental Protection Agency Website.

Impact of Criteria Air Contaminant Standards on Fuel Consumption

While altering the combustion process of the locomotive diesel engine can reduce the by-products of fuel combustion (i.e. NO_x, PM, and the other criteria air contaminants) that are regulated by the U.S. Environmental Protection Agency, such changes can also impact the engine's fuel efficiency. The extent of this impact will depend on the method used.

For example, retarding the start of fuel injection within the cylinder can reduce NO_x emissions from a diesel engine to Tier 0 levels, but can also increase fuel consumption by 0.8-2.5 per cent,[26] if not addressed through other means such as increasing the pressure ratio of the turbocharger.[27] Some remanufacturers offer Tier 0 certified "kits" that do not increase fuel consumption, depending on the locomotive type and make.[28]

According to the U.S. Environmental Protection Agency, using a diesel particulate filter, which filters or "traps" the PM[29] to meet the Tier 4 PM standard, may increase fuel consumption by up to 1 per cent.[30] This increase is due to the pumping work required to force exhaust through the filter's small openings.

On the other hand, some Tier 1-compliant locomotives do not consume more fuel, and some Tier 2 locomotives currently on the market have been shown to improve fuel consumption by nearly 3 per cent.[31]

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[26] Section 3.3, "Emission Reduction Technologies," of the U.S. Environmental Protection Agency's *Locomotive Emission Standards Regulatory Support Document* for the 1997 Locomotive Emissions Final Rulemaking.

[27] Peter Eggleton, *Technology to Meet EPA Locomotive Emissions Standards Without Fuel Penalty*, 2003.

[28] Peter Eggleton, *Technology to Meet EPA Locomotive Emissions Standards Without Fuel Penalty*, 2003.

[29] In its most basic form, a diesel particulate filter is a device that "traps" PM emissions by forcing the exhaust stream though small openings.

[30] Section 5.4, "Operating Costs for Freshly Manufactured Tier 4 Engines," of the U.S. Environmental Protection Agency's *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder*.

[31] Peter Eggleton, *Technology to Meet EPA Locomotive Emissions Standards Without Fuel Penalty*, 2003.

3.2 Criteria Air Contaminant Initiatives Outside North America

In recent years, the European Commission has been phasing in criteria air contaminant emissions control regulations for off-road mobile equipment. The first regulations came into force on December 16, 1997, but did not apply to railway locomotive engines.

Standards applying to locomotive engines, termed "European Commission Stage III," were enacted on April 21, 2004. The Stage III emission limits that would apply to comparable locomotives in Canada are summarized in Table 6.

Table 6: European Commission Stage III Standards for Locomotive Engines

Net Power (kW)	Effective in Year	CO (g/kWh)	HC (g/kWh)	HC+NO_x (g/kWh)	NO_x (g/kWh)	PM (g/kWh)
560-2000	2009	3.5	0.5	-	6.0	0.200
> 2000	2009	3.5	0.4	-	7.4	0.200
> 130	2012	3.5	-	4	-	0.025

Source: European Union Publications Office, *Official Journal of the European Union* (L series), "Directive 2004/26/EC of the European Parliament and of the Council of 21 April 2004," pp. 6, 7, 16 and 17.

The Union Internationale des Chemins de fer (UIC), a non-profit international trade association, also set emission levels for locomotive engines owned by member railways in a two-stage standard published in April of 2002. However, since UIC standards are less strict than the European Commission Stage III standards, we do not include them in this document.

3.2.1 European versus U.S. Locomotive Emission Standards

Despite comparable emission limits, it is not easy to compare European and U.S. standards. Reasons include the fact that Europe has high-speed rail lines and many electrified rail lines,[32] while the North American rail network depends almost exclusively on diesel powered locomotives; that passenger trains play a more important role in Europe than they do in North America; and that freight operation plays a bigger role in North America as opposed to in Europe.[33]

[32] Close to 50 per cent of European rail lines are electrified, according to the European Commission report, *EU Energy and Transport in Figures: Statistical Pocketbook 2009*.

[33] Railway Association of Canada, *Locomotive Emissions Monitoring Program*, 2007; European Commission, *EU Energy and Transport in Figures: Statistical Pocketbook 2009*.

4 Developing Railway Emissions Regulations in Canada

This section outlines the context and process through which the Canadian railway emissions regulations will be developed.

4.1 Canada's Clean Air Regulatory Agenda

On October 21, 2006, the Government of Canada published a Notice of Intent, signalling its plans to develop regulations to reduce air emissions. These regulations would set nationally consistent emission standards to address all major sources of air emissions in Canada, including all modes of transportation, industry, and consumer and commercial products.

Section 7.3(b) of the Notice of Intent deals specifically with the rail transportation sector, and states:

> *(b) Rail: The Minister of Transport, with the Minister of the Environment, will support a MOU with the Railway Association of Canada that is consistent with U.S. EPA air pollution standards and ensures that the rail industry continues to improve its GHG emissions performance during the period 2006-2010. The Minister of Transport will develop and implement new regulations, under the* Railway Safety Act*, to take effect following the end of the MOU in 2010.*[34]

Developing these regulations will be done in two phases. First, regulations aligned with those of the U.S. Environmental Protection Agency will be developed to limit the release of criteria air contaminants from the rail sector, to be implemented in 2011. Secondly, regulations for greenhouse gas emissions will be developed in step with the U.S. Environmental Protection Agency. The timing of the implementation of greenhouse gas regulations has yet to be determined.

The focus of these preliminary consultations is on the development of criteria air contaminant emissions regulations.

4.2 Regulating via the Railway Safety Act

The *Railway Safety Act* (R.S.C. 1985 (4th Supp.), c. 32) gives Transport Canada the authority to develop regulations governing rail safety, security and some aspects of the environmental impacts of rail operations in Canada.

[34] *Canada Gazette*, Part I, October 21, 2006, p. 3356.

4.2.1 Applicability of the Act

As with any Act, the *Railway Safety Act* carefully defines who can be regulated under its authority. An understanding of these definitions is important to understanding the challenge inherent in developing Canadian regulations in line with those developed by the U.S. Environmental Protection Agency under different legislation.

In the U.S. regulations, while there are provisions that apply to locomotive owners and operators[35] or railways, the Tier standards for criteria air contaminants, discussed above in Section 3.1.1, apply generally to locomotive manufacturers and remanufacturers.[36] It is clear that the general intent of these regulations is to achieve emissions reductions by setting equipment performance standards to be met by those that directly develop and design the equipment.

By contrast, the *Railway Safety Act* permits the development of regulations, rules and standards that apply to federally regulated railway companies, as defined by the *Canada Transportation Act*. According to this definition, a federally regulated railway company is a person, with a valid Certificate of Fitness,[37] constructs or operates a railway — which includes track, bridges, rolling stock, etc. Therefore, the regulated parties under the *Railway Safety Act* do not have direct control over the design of the equipment used on their locomotives to meet equipment performance standards. However, compliance with equipment performance standards can be defined as a condition to be met before a locomotive can be added to a railway company's fleet.

Railway companies operating interprovincially or internationally automatically fall under federal jurisdiction, while railway companies that operate solely within the boundaries of a single province may fall outside the jurisdiction of the *Railway Safety Act* unless they have been declared by Parliament to be for the general advantage of Canada or are an integral part of an existing federal undertaking. As of August 2010, a total of 32 railways operate under federal jurisdiction.

4.3 Canada's Regulatory Process

Stakeholders are vital to Canada's regulatory development process. The federal government is committed to giving stakeholders and the public an opportunity to participate in developing or modifying regulations and regulatory programs. The process of making and amending regulations in Canada, as governed by the *Statutory Instruments Act* (R.S.C. 1985, c. S-22), includes consultation, review by the Department of Justice, publication across Canada, review by Cabinet, and final publication and promulgation.

35 U.S. Environmental Protection Agency, 40 CFR 1033, Subpart I.
36 U.S. Environmental Protection Agency, 40 CFR 1033.10.
37 Canada, *Canada Transportation Act*, S.C. 1996, c. 10, s. 87.

4.3.1 Preliminary Consultations

Transport Canada will solicit the views of a wide range of stakeholders including the rail industry, other levels of government, non-governmental organizations and the public. The information we receive will be considered when drafting the proposed regulations. The Consultation Paper and Issue Brief form the basis for the preliminary consultation discussions.

4.3.2 Cost-Benefit Analysis

Transport Canada will perform a cost-benefit analysis to determine the costs and benefits associated with the regulations. The costs will be estimated by projecting the incremental cost of technologies applied as a direct result of the regulations. See Annex C for additional information on the department's methodology and related assumptions used to forecast locomotive emissions.

4.3.3 Pre-Publication of Draft Regulations

Once developed, the Minister of Transport will submit the proposed regulations to the Governor in Council for approval. They will then be published in the *Canada Gazette*, Part I. Pre-publication in Part I of the *Canada Gazette* gives interested groups and people a final opportunity to review and comment on a proposed regulation at the last stages of the process.

4.3.4 Formal Notice and Comment Period

A formal notice period begins once the draft regulations are published in Part I of the *Canada Gazette*. All stakeholders then have 90 days to submit formal comments on the proposed regulations.

4.3.5 Approvals and Final Publication

The final regulations will be formalized, taking into consideration all comments received, when the comment period ends. The final regulations will be published in the *Canada Gazette*, Part II for enactment. It is expected that final regulations will come into force in 2011.

5 Preliminary Consultations

Stakeholder views and concerns will play an important role because they will inform and help shape these Canadian regulations over the course of the regulatory process. While the Consultation Paper and Issue Brief serve to inform stakeholders of facts and issues relevant to this process, they should also initiate a wider discussion of stakeholder views and opinions.

The Government of Canada invites you to comment on all aspects of regulating criteria air contaminant emissions from locomotives. We welcome your views on the:

- broad policy issues involved in regulating Canadian railways;
- technical issues involved in aligning with the U.S. Environmental Protection Agency emission standards; and
- policy and administrative issues involved in preparing and implementing regulations under the *Railway Safety Act*.

General comments and feedback that bear on these regulations are also welcome and will be considered.

5.1 Consultation Submissions

Please submit written submissions by February 14, 2011 to Transport Canada.

Electronic submissions will be accepted by email at:

locomotive-emissions-locomotives@tc.gc.ca

Electronic submissions will be accepted in any accessible document format, such as Microsoft Word or OpenOffice Writer.

Hard-copy submissions may be sent to:

Director General, Environmental Policy
Transport Canada
330 Sparks Street
Place de Ville, Tower C
Ottawa ON K1A 0N5

Please note that all submissions will be posted on Transport Canada's Website at www.tc.gc.ca/locomotive-emissions.

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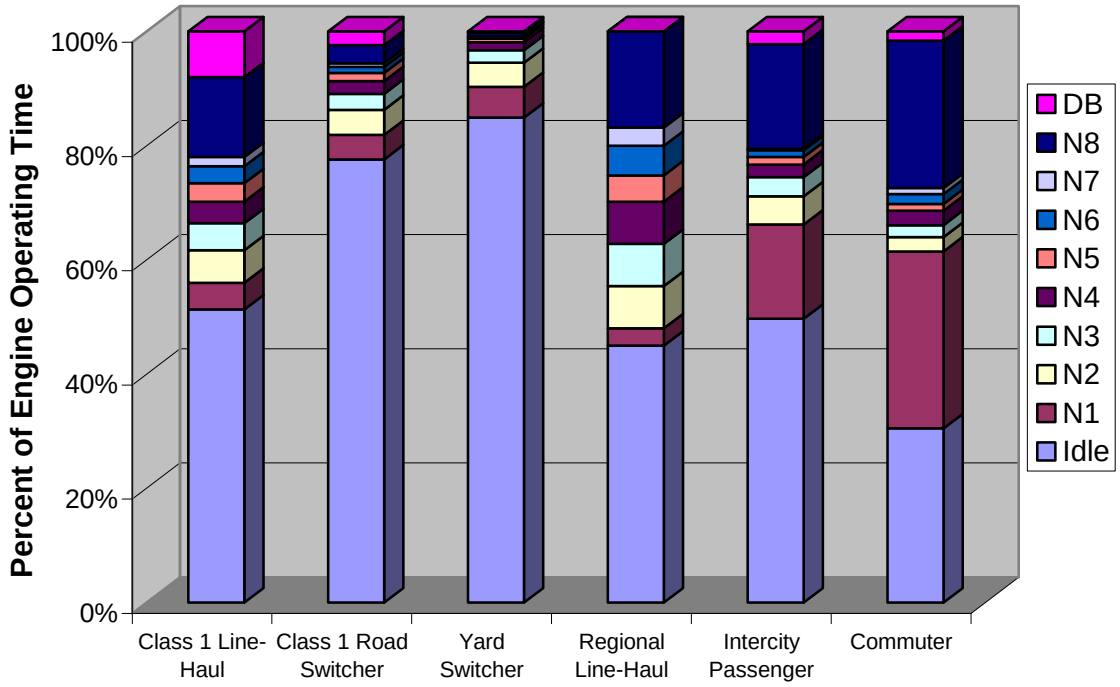
ANNEX A
Locomotive Engine Operation: The Basics

Most North American railways use diesel electric locomotives. The diesel engine powers an onboard electric generator that, in turn, powers traction motors. This allows the diesel engine to operate at optimal speed for any given traction force and train speed combination required to haul a given train over varying terrain. It also allows the locomotive to apply non-friction braking forces by having the traction motors act as generators and dissipating the electricity generated in resistor grids on the locomotive.

Switch locomotives have historically used the same technology as line-haul locomotives but at lower power capacities. Due to the stop-and-go nature of their operations, switch locomotives have more frequent power level changes and braking applications.

The amount of time spent at different power levels while operating is called a locomotive's duty cycle. The Railway Association of Canada defined the duty cycle shown in Figure 4, for the three activities of Class 1 railways and for regional line-haul, intercity passenger and commuter services. The locomotive control settings involve increasing power at increasing "Notch" settings from Notch 1 (N1) through Notch 8 (N8). An idle setting provides auxiliary power, but no power to the traction motors. In the dynamic brake (DB) setting, the engine provides power to the resistance bank cooling fans and other auxiliaries.

Figure 4: Locomotive Duty Cycle by Service Type



Source: Railway Association of Canada, *Locomotive Emissions Monitoring Program*, 2008.

Figure 4 shows the differences between the six duty cycles as defined by the Railway Association of Canada. Please note that:

- the two switching locomotive duty cycles spend between 78 and 85 per cent of engine operating time idling;
- the commuter passenger rail duty cycle contains the lowest idle time component (approximately 30 per cent) and splits most of the balance of the operating time between N1 and N8;
- the intercity passenger rail duty cycle is about half idle time and both the Notch 1 and Notch 8 percentages are much lower than commuter operations; and
- While both the Class 1 and regional line-haul duty cycles spend similar amounts of time in the highest power setting, the regional line-haul duty cycle includes more time spent in intermediate power settings and less time idling than the Class 1 line-haul duty cycle. Also, the Class 1 line-haul duty cycle spends eight per cent of operating time in dynamic braking while the regional line-haul operations do not use dynamic braking at all.

ANNEX B

List of Railways Holding Federal Certificates of Fitness

Railway Company	Decision No. / Order No.	Issue Date
6970184 Canada Ltd.**	33-R-2009	Jan. 30, 2009
Arnaud Railway Company	54-R-1997	Feb. 12, 1997
BNSF Railway Company*	70-R-2010	Feb. 26, 2010
Canadian National Railway Company	601-R-2008	Dec. 3, 2008
Canadian Pacific Railway Company	396-R-2007	Aug. 9, 2007
City of Ottawa carrying on business as Capital Railway	283-R-2007	June 6, 2007
CSX Transportation Inc.*	602-R-2006	Oct. 31, 2006
Eastern Maine Railway Company	404-R-1997	June 30, 1997
Essex Terminal Railway Company	218-R-1997	Apr. 21, 1997
Goderich-Exeter Railway Company Limited	17-R-2008	Jan. 17, 2008
Great Canadian Railtour Company Ltd.	27-R-2007	Jan. 17, 2007
Hudson Bay Railway Company	230-R-2001	May 9, 2001
International Bridge and Terminal Company, The	399-R-1997	June 27, 1997
Kelowna Pacific Railway Company	110-R-2000	Feb. 18, 2000
Kettle Falls International Railway Company	673-R-2004	Dec. 10, 2004
Maine Central Railroad Company and Springfield Terminal Railway Company	617-R-1997	Oct. 28, 1997
Minnesota, Dakota & Western Railway Company	398-R-1997	June 27, 1997
Montreal, Maine & Atlantic Railway, Ltd. and the Montreal, Maine & Atlantic Canada Co.	561-R-2005	Sept. 9, 2005
National Railroad Passenger Corporation (Amtrak)*	391-R-1997	June 26, 1997
Nipissing Central Railway Company	448-R-1997	July 11, 1997
Norfolk Southern Railway Company*	600-R-1996	Dec. 19, 1996
Okanagan Valley Railway Company	531-R-1998	Oct. 30, 1998
Pacific and Arctic Railway and Navigation Company/British Columbia Yukon Railway Company/British Yukon Railway Company Limited carrying on business as or proposing to carry on business as White Pass & Yukon Route	666-R-1997	Nov. 25, 1997
Quebec North Shore & Labrador Railway Company	563-R-2007	Nov. 2, 2007
RaiLink Canada Ltd.	325-R-2006	June 5, 2006
St. Lawrence & Atlantic Railroad (Québec) Inc.	567-R-1998	Nov. 24, 1998
Sydney Coal Railway Inc.	2009-R-437	Sept. 14, 2009
Toronto Terminals Railway Company Limited, The	81-R-2008	Feb. 26, 2008
Tshiuetin Rail Transportation Inc.	190-R-2005	Apr. 1, 2005
Union Pacific Railroad Company*	371-R-1997	June 16, 1997
VIA Rail Canada Inc.	446-R-2008	Aug. 29, 2008
Wabush Lake Railway Company, Limited	55-R-1997	Feb. 12, 1997

*American Class 1 rail operators with networks that extend into Canada.
**McNeil Spur connecting with Canadian Pacific and operating between Saskatchewan and Alberta.

Source: Canadian Transportation Agency, "Federal Railway Companies."

ANNEX C
Locomotive Emissions Modeling and Related Assumptions

To determine the benefits of the proposed regulations, we will forecast locomotive emissions for the period lasting from 2011 to 2020:

1) assuming a business-as-usual scenario in which there are no voluntary agreements or regulations; and
2) assuming that Canada's regulations align with the locomotive emissions requirements of the U.S. Environmental Protection Agency.

We will use the Total Railway Emissions for Canada model, which was developed by Environment Canada in 2005, and later modified by Transport Canada to incorporate the most recent U.S. Environmental Protection Agency locomotive emission standards. This model uses a "bottom-up" approach. It projects the fleet make-up and assigns emission factors to individual locomotives. This is consistent with how annual locomotive emissions data are prepared by the Railway Association of Canada for the *Locomotive Emissions Monitoring Program* reports. The Total Railway Emissions for Canada model methodology is also similar to the methodology used by the U.S. Environmental Protection Agency to forecast locomotive emissions.

Our locomotive emissions forecasts will be based on:

1) **Fleet Profile:** Start with detailed information about the current Canadian locomotive fleet: For each locomotive, the Tier standard it currently meets, if any, and its original date of manufacture must be known.
2) **Fleet Turnover:** Remove and add locomotives to the fleet in each future year based on assumptions regarding the expected age of locomotive retirement and growth of the overall fleet.
3) **Fleet Emission Profile:** Assign an emission rate associated with its U.S. Environmental Protection Agency Tier-level standards to each locomotive in the fleet.
    - For the business-as-usual scenario, the relevant standard for each new locomotive would be associated with the level of technology that would be used in the absence of a voluntary agreement or regulations. See "Assumptions for the Business-as-Usual Scenario," below.
    - For the regulations scenario, the standard for each new locomotive would be the one required by the regulations (aligned to the U.S. Environmental Protection Agency locomotive emissions requirements).
4) **Quantification of Benefits:** Forecast the environmental impact of the regulations using the quantified benefits associated with the change in criteria air contaminant emissions between the two scenarios.

Assumptions for the Business-as-Usual Scenario

Forecasting locomotive emissions in the absence of regulations is a challenge since there is some uncertainty in projecting the fleet's characteristics, such as the environmental performance of locomotives. Therefore, we made a number of assumptions to forecast the locomotives Canadian railways would purchase and use in the years to come. These key assumptions are:

Assumption #1: The North American market for freshly manufactured locomotives is well integrated. As a result, freshly manufactured locomotives currently purchased by both Canadian and U.S. railways will meet the same U.S. Environmental Protection Agency emission standards (see box below).

Assumption #2: There are many remanufacturers in Canada that are not subject to the U.S. Environmental Protection Agency requirements. In the absence of regulations, it is assumed that railways will have the option, in some instances, to remanufacture their locomotives without having to meet any particular U.S. Environmental Protection Agency emission standard.

Assumption #3 a): The growth rate of Class 1 freight operators in the rail industry, measured in revenue tonne-kilometres, is projected to be 3 per cent from 2008 to 2010; 2.5 per cent from 2011 to 2015; and 2 per cent from 2016 to 2020. We assume that this growth will be met by purchasing new Tier 2-compliant locomotives.

Assumption #3 b): We expect the growth rates of VIA Rail and short line operations in Canada to be roughly in line with Class 1 freight growth. However, due to the significant gap between carrying capacity and current loads for both VIA Rail and short lines, we do not expect that either will exceed current carrying capacity in the foreseeable future.

The U.S. Environmental Protection Agency prohibits locomotive manufacturers and remanufacturers to sell locomotives that do not meet one of 5 discrete Tiers of emission standards, based on the locomotive's original year of manufacture:

Line-Haul Locomotives	Switch Locomotives
Tier 0: 1973-1992	**Tier 0:** 1973-2001
Tier 1: 1993-2004	**Tier 1:** 2002-2004
Tier 2: 2005-2011	**Tier 2:** 2005-2010
Tier 3: 2012-2014	**Tier 3:** 2011-2014
Tier 4: 2015 or later	**Tier 4:** 2015 or later