Port Metro Vancouver Land Side Air Emissions Inventory

Phase One: Burrard Inlet and Roberts Bank

Executive Summary

December 2008







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ACKNOWLEDGEMENTS

The inventory estimates were made possible with the completion of specific, activity based questionnaires for over 50 port related facilities that are represented in this emissions assessment. In many cases, completion of a facility questionnaire was accomplished with the participation of several terminal representatives. In addition, feedback was also provided by many of these representatives during the quality assessment phase of the project.

PROJECT TEAM

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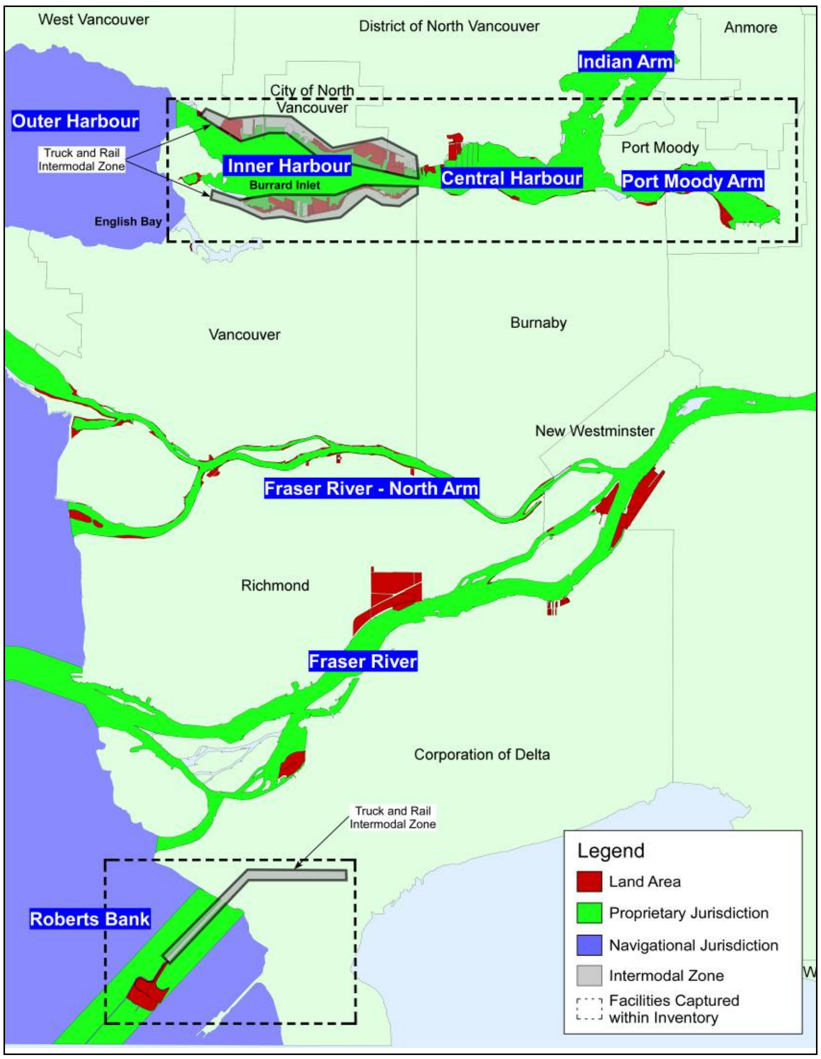
EXECUTIVE SUMMARY

Port Metro Vancouver commissioned SENES Consultants Limited (SENES) to complete a port landside emissions inventory of common air contaminants, greenhouse gases and air toxics in December of 2006. This effort complements the 'waterside' 2005-2006 BC Ocean-Going Vessel Emissions Inventory, completed in 2007 by the B.C. Chamber of Shipping. The landside inventory includes a baseline for the 2005 activity year, with backcast and forecast estimates in five-year increments. This inventory report, 'Phase I', accounts for the landside activities of 51 port-related facilities, including those on and off port property along Vancouver's Inner Harbour, Central Harbour, Roberts Bank, Port Moody and Indian Arms only; additional landside activities on the north and south arms of the Fraser River will be accounted for separately. Figure 1 provides a graphical representation of Port Metro Vancouver (the port), along with the geographical boundaries used for the Phase I assessment. The majority of the port's current operations occur within the Phase I boundaries used for the landside emissions inventory (LEI).

Figure 1: Port Metro Vancouver Operations and Emissions Inventory Boundaries



The LEI was assessed using an activity based approach, which is consistent with current best practices in North America. As part of the assessment process, detailed activity information was collected for each facility, capturing data for the three main sources of landside emissions:

- cargo handling equipment
- rail locomotives
- trucks

Fleet operational data that affect emissions, such as number and type of equipment, engine age, fuel consumption and usage intensity were gathered through use of a survey questionnaire and personal interviews.

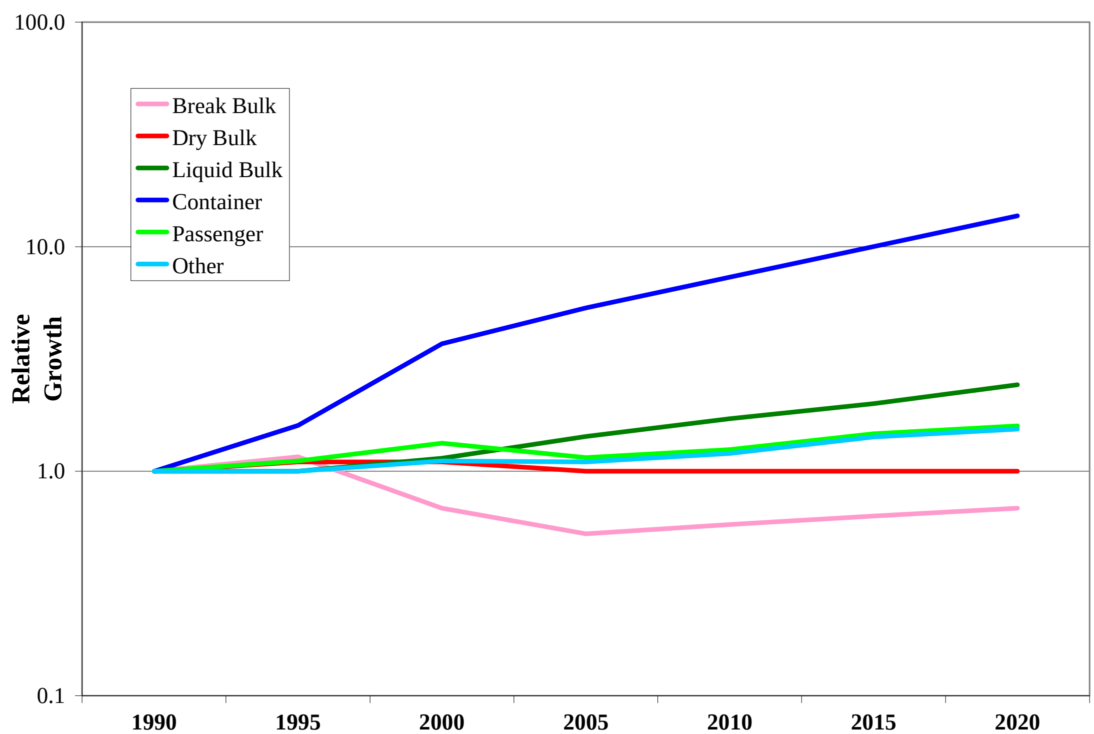
There are three intermodal zones with significant port-related truck and rail activity that include areas on and off port property, yet are clearly associated with the port and the flow of commodities to and from the marine facilities. As shown in Figure 1, these areas and related activities were included in the LEI. The common air contaminant (CAC) and greenhouse gas (GHG) emissions estimates for 2005 are shown in Table 1 for Cargo Handling Equipment (CHE), Rail and Trucking. The fuel estimates include all types of fuels used at the port, although the majority is diesel.

Table 1: Port Metro Vancouver Phase I LEI for 2005: By Source Group

	Annual Air Contaminants Emissions (tonnes) and Fuel Consumption (kilolitres)										
Source Group	**NO_x**	**SO_x**	**CO**	**HC**	**PM_{10}**	**$PM_{2.5}$**	**NH_3**	**CO_2**	**CH_4**	**N_2O**	**Fuel**
CHE	405.8	23.0	713.6	48.9	33.5	32.5	0.7	41,877	3.4	4.0	16,115
Rail	329.0	3.4	49.6	18.6	6.0	5.9	0.0	13,813	0.8	5.6	5,059
Trucking	137.4	1.2	127.8	13.3	4.2	3.7	0.5	13,957	1.6	0.9	5,942
TOTAL	**872.2**	**27.6**	**891.0**	**80.8**	**43.8**	**42.1**	**1.2**	**69,647**	**5.7**	**10.4**	**27,116**

Additional inventory estimates were completed for the years 1990 – 2000 (backcast) and 2010 – 2020 (forecast), in five-year increments. These additional years were selected to provide an estimate of past and projected future trends in emission levels. Figure 2 shows the growth rates by major commodity type handled at the port. Container throughput was very low in 1990 and has grown considerably since that time. In contrast, break bulk throughput peaked in 1995 and is expected to remain lower than the 1995 level through 2020.

Figure 2: Port Relative Growth Rates by Commodity



It should be noted that the projected growth rates may not be experienced due to the current downturn in the global economy (in particular for container traffic).

The scope of work for the LEI included assessment of emission reduction initiatives that have been carried out or are firmly planned by either the port or one or more facility operators. Eight distinct initiatives were assessed, although it was clear that several of the port facilities were planning additional efforts. These additional efforts did not have sufficient related information to support a detailed assessment of emissions during the LEI data collection phase. Therefore, the estimated effect of emission reduction initiatives, as shown in this report, should not be considered inclusive of all the efforts that have been or are currently being carried out. The eight initiatives assessed include the following: low sulphur diesel for CHE, catalytic converters for select CHE equipment, diesel oxidization catalysts for select CHE equipment, electronic control systems for select CHE equipment, implementation of a port container truck licensing program, use of a 20% biodiesel mix for select CHE equipment, replacement of select CHE cranes with hybrid units and use of electric forklifts.

The emission reduction initiatives affected some but not necessarily all of the air contaminants assessed in the LEI. For example, use of low sulphur (on road) diesel and emission control technologies were estimated to have a lowering effect on some of the CACs, but not the GHGs. In contrast, three initiatives were found to lower fuel consumption and all air emissions. A select summary of the trends determined for several air contaminants of interest are provided on the following pages. For each air contaminant, three common charts are presented:

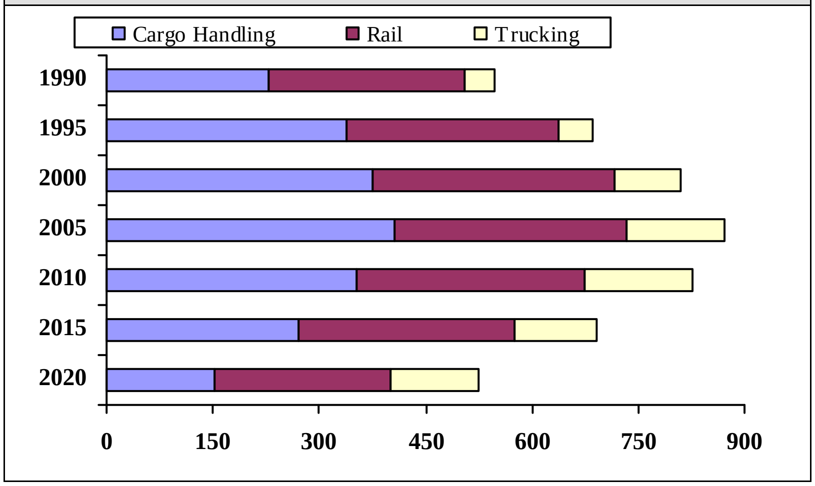
- *Annual Emissions by Source Group* illustrates the annual baseline (2005), backcast (1990 – 2000) and forecast (2010 – 2020) emission estimates by the three major source groups.
- *Effect of Reduction Initiatives* showcases the improvement in emissions due to implementation of the eight initiatives. The improvement was determined by comparing emission estimates to the Business as Usual (BAU) case. The BAU case accounts for technology and fuel improvements according to defined schedules over time, mostly driven by regulatory changes; therefore in most cases the Reduction Initiatives effectively accelerate technological and regulatory improvements that are expected.
- *Contribution by Fuel Type* examines the expected shift in relative fuel quantities by 2020. The five major fuel types were assessed: 20% Biodiesel mix (b20), on-road diesel (on), non-road diesel (nr), gasoline and propane.

In general, the LEI assessment shows that regulatory standards for engine emission rates and fuel composition will have a very significant reducing effect over time for the common air contaminants of particular concern (NO_x, SO_x, HC, CO and PM). The port and facility reduction measures are in addition to these BAU reductions that have been realistically captured in the port emissions assessment.

Nitrogen Oxides (NO_x)

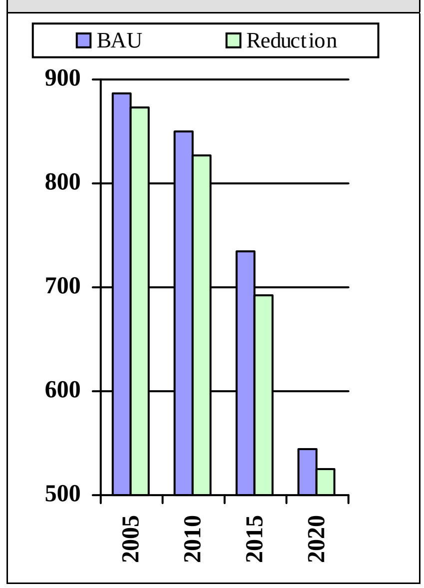
Nitrogen oxide emissions are largely composed of nitric oxide (NO) and nitrogen dioxide (NO_2). The term NO_x is commonly used for these two chemical species since they readily convert from one form to the other in the atmosphere. NO_x emissions are caused by the high temperature combustion of fossil fuels, amongst other processes.

Annual NO_x Emissions by Source Group (Tonnes)
2005 Total: 872 Tonnes

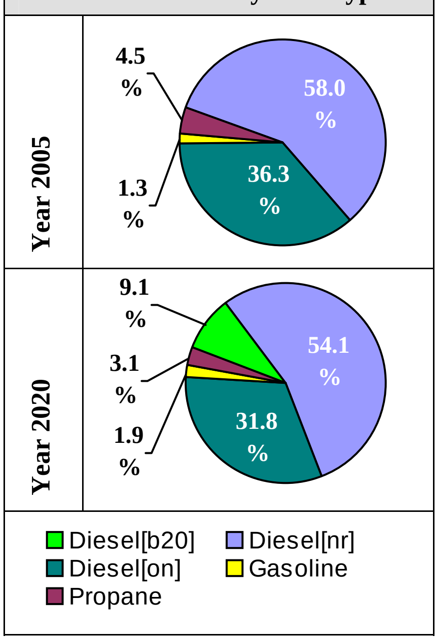


NO_x emissions from landside port related activity were estimated to peak around 2005, with a gradual decline expected over the next two decades. Even in light of significant growth, emissions are expected to decrease as improved engine technologies and emission controls propagate throughout the equipment fleets. Cargo handling equipment in particular will experience much lower emission rates as on-road engine technologies are introduced into the non-road sector. Trucking emissions will also decline, but not to the same degree as CHE, since the technology base is more mature. Rail locomotives tend to have a longer service life and will experience lower fleet turnover rates and thus a lower reduction in associated emissions over time.

Effect of Reduction Initiatives



NOx Contribution by Fuel Type



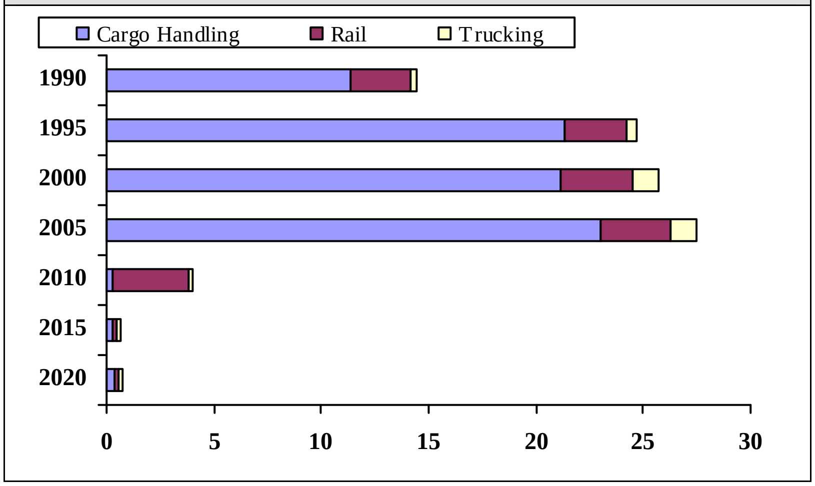
Future (planned) emission reduction initiatives were determined to have the highest impact for the year 2015. Initiatives taken were found to have a lowering effect on emissions for each year assessed.

Consumption of diesel fuel is the primary contributor to total port related landside emissions and this is not expected to change in the future. The use of biodiesel has minimal impacts upon NO_x emissions.

Sulphur Oxides (SO_x)

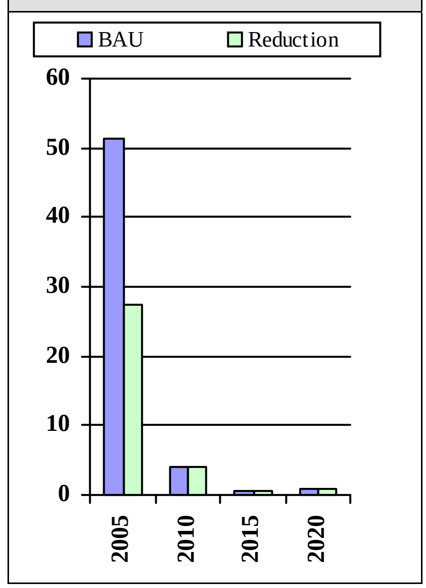
Sulphur oxide (SO_x) emissions are produced from the combustion of sulphur-bearing fossil fuels. SO_x are almost entirely in the form of sulphur dioxide (SO_2), which can be oxidized in the atmosphere to produce sulphates, which are a component of suspended particulate matter. In general, emissions of SO_x from transportation have been steadily declining due to improvements in fuel quality (lower sulphur content).

Annual SO_x Emissions by Source Group (Tonnes)
2005 Total: 27 Tonnes



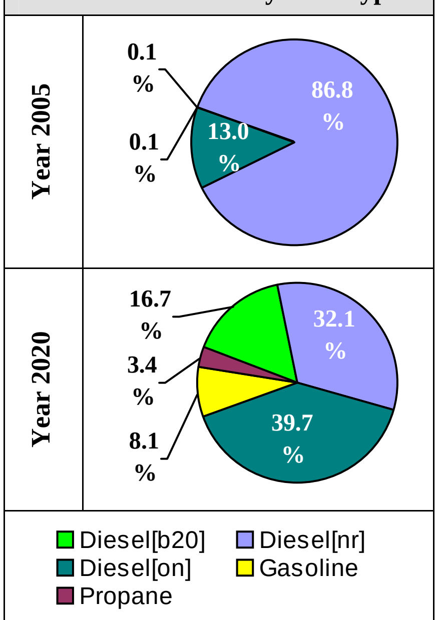
SO_x emissions at the port related facilities are dominated by cargo handling equipment and rail sources, which commonly use non-road fuels of relatively high sulphur content (when compared to on-road fuels). In all future years, SO_x emissions will dramatically decline, due to Canadian sulphur in fuels regulations.

Effect of Reduction Initiatives



Port related facilities have significantly reduced SO_x emissions through the voluntary use of lower sulphur fuels in cargo handling equipment. As illustrated in the adjacent *Effects of Reduction Initiatives* chart, replacement of non-road diesel with on-road diesel resulted in a very large decrease in total emissions in 2005. The use of lower sulphur fuel lowered the estimated baseline emissions by nearly 50%, compared to emissions that would have otherwise occurred.

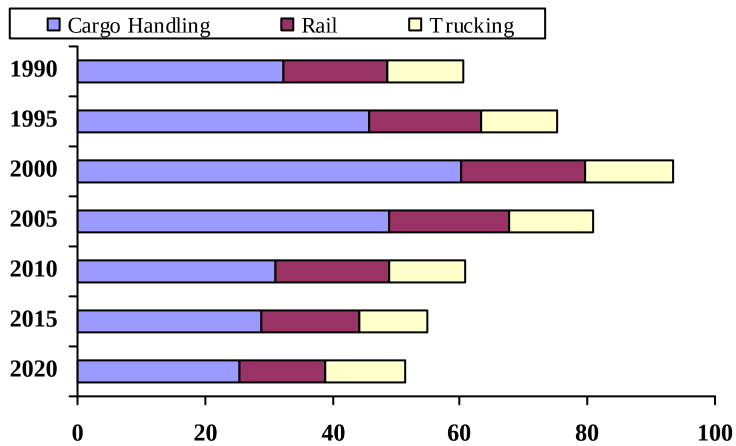
SOx Contribution by Fuel Type



All diesel fuels used in the forecast years will contain relatively low sulphur levels, including b20 bio-diesel, which is a blend of bio-diesel (with virtually no sulphur) with on-road or non-road diesel.

Hydrocarbons (HC)

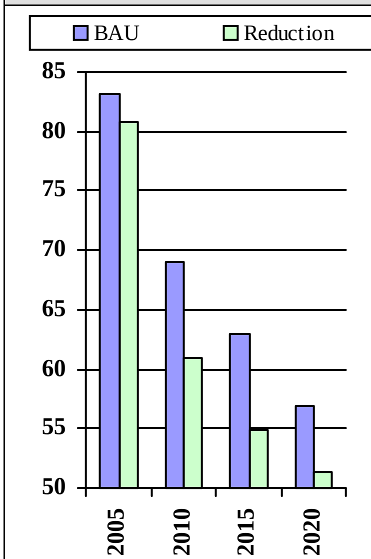
Annual HC Emissions by Source Group (Tonnes)
2005 Total: 81 Tonnes



Hydrocarbon (HC) emissions are caused by the incomplete combustion of fossil fuels, which was accounted for in the LEI. Other sources of HC were not included (such as storage and handling of fuels). HC compounds can react with NO_x in the atmosphere to form ground-level ozone.

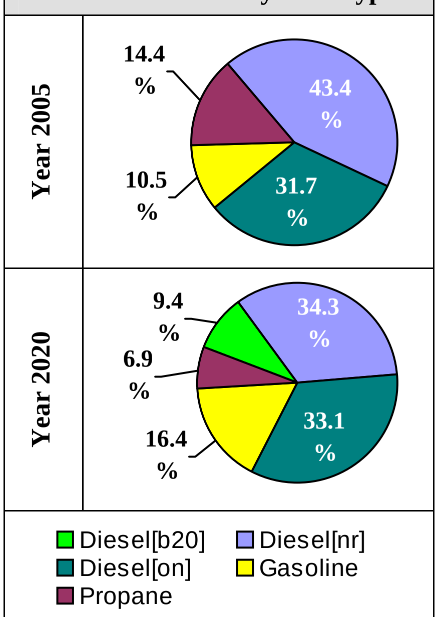
HC emissions from port related landside activities were estimated to peak at or near the year 2000 and are expected to decline over the next two decades. Cargo handling equipment in particular will experience the largest drop in emissions as lower emission rates from all equipment types and fuel sources are expected to occur. Established regulatory engine standards for HC emissions target both exhaust emissions from un-burnt fuel and evaporation from equipment fuel tanks.

Effect of Reduction Initiatives



The *Effect of Reduction Initiatives* shows that the accelerated adoption of reduction technologies through programs undertaken by port related facilities are expected to significantly reduce emissions over the next decade, beyond the improvements associated with the gradual introduction of new equipment. Although much of the decrease is associated with non-diesel CHE, truck and rail emissions will also experience reductions. These additional reductions are not as significant, since diesel powered equipment are generally not high HC emitters. As illustrated in *Contribution by Fuel Type*, gasoline and propane fuels contribute a significant portion of the total HC emissions, even though their consumption is far lower than that of diesel. The relatively high HC emissions are due to the volatile nature of these fuels.

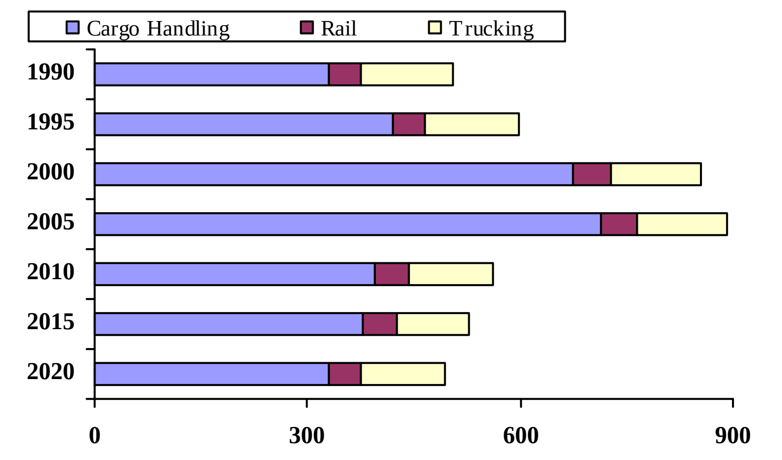
HC Contribution by Fuel Type



Carbon Monoxide (CO)

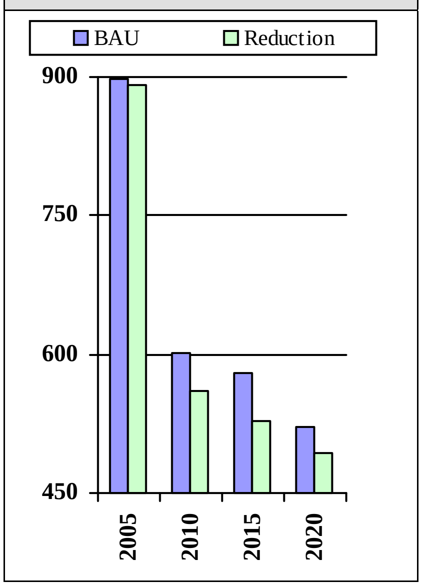
Carbon monoxide (CO) emissions are caused by the incomplete combustion of fossil fuels. Emissions from on-road transportation have declined over the last two decades to the point where outdoor CO emissions do not have the same level of concern they once had.

Annual CO Emissions by Source Group (Tonnes)
2005 Total: 891 Tonnes

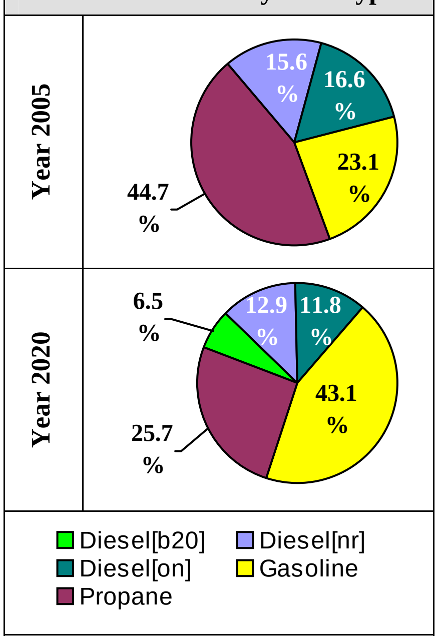


CO emissions from port related landside activities were estimated to peak in or near 2005 and are expected to decline over the next two decades. Cargo handling equipment in particular will see the largest drop in emissions as much lower emission rates from propane powered equipment are expected. Numerous propane forklifts are used at the port and they tend to experience a high replacement rate due to intensity of use. Although CO emission rates due to gasoline consumption are also projected to decline, they are not expected to fall as quickly as with the other fuels, resulting in a higher projected portion of total CO emissions by 2020 (see *Contribution by Fuel Type*). At present, gasoline CHE do not experience a high replacement rate, due to a lower intensity of use.

Effect of Reduction Initiatives



CO Contribution by Fuel Type



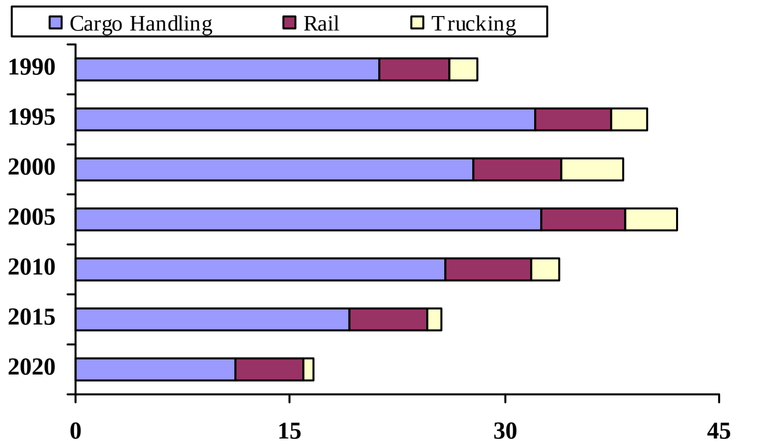
Truck and rail emissions are also expected to decline, but not to the same degree as CHE. Diesel trucks and locomotives are generally low CO emitters.

Emission reduction initiatives at the port related facilities are expected to cause a decrease in total emissions for all forecast inventory years.

Particulate Matter ($PM_{2.5}$)

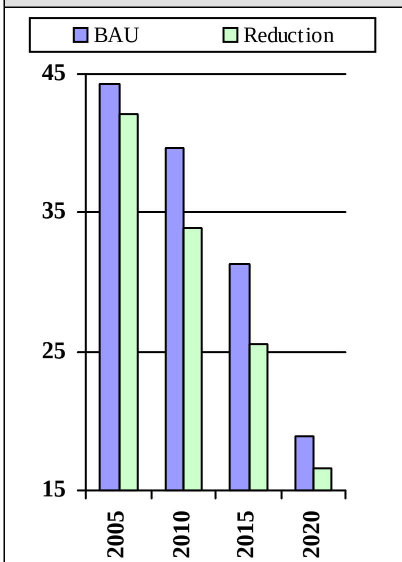
Suspended particulate matter (PM) is caused by the combustion of fuels as well as the re-suspension of dust and other materials due to wind erosion or other disturbances. PM is commonly assessed as PM_{10} (particles of diameter 10 micrometres or less) and $PM_{2.5}$ (particles of diameter 2.5 micrometres or less). The majority of combustion related emissions are within the $PM_{2.5}$ size range. Only combustion related emissions of PM were included in the LEI.

Annual $PM_{2.5}$ Emissions by Source Group (Tonnes)
2005 Total: 42 Tonnes



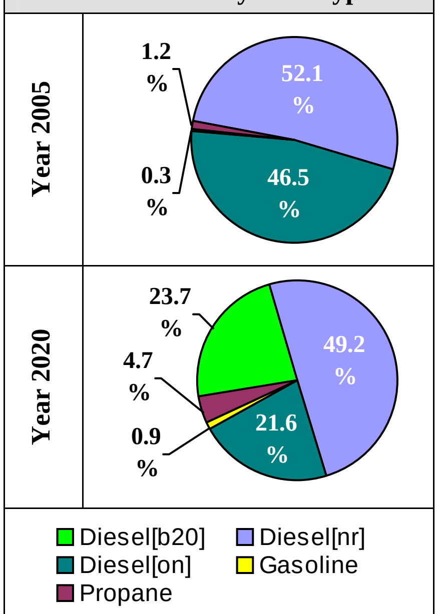
As with the other common air contaminants assessed in the LEI, cargo handling equipment is the largest contributor to total emissions of $PM_{2.5}$. CHE and truck emissions are projected to decline considerably in the next two decades, due to both improvements in engine emissions controls and fuel quality (sulphur content). Total rail emissions are not expected to change significantly in future years, as growth in total activity will counter act the expected engine technology improvements.

Effect of Reduction Initiatives



Emission reduction initiatives resulted in lower $PM_{2.5}$ emissions from the port related facilities for the baseline and all forecast years. Much of the future initiatives involve purchase and use of newer engine (or hybrid) technologies for CHE.

Contribution by Fuel Type

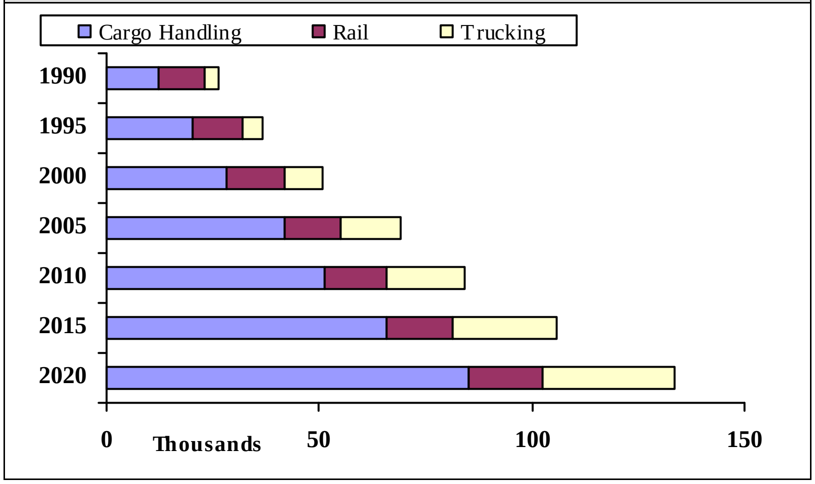


As shown in *Contribution by Fuel Type*, virtually all of the $PM_{2.5}$ included in the LEI is due to combustion of diesel and therefore most of the estimated total can be considered diesel particulate matter – DPM. Sulphur content of diesel affects engine emission rates of $PM_{2.5}$ and therefore much of the projected decrease in emissions is due to the introduction of cleaner diesel locally.

Carbon Dioxide (CO_2)

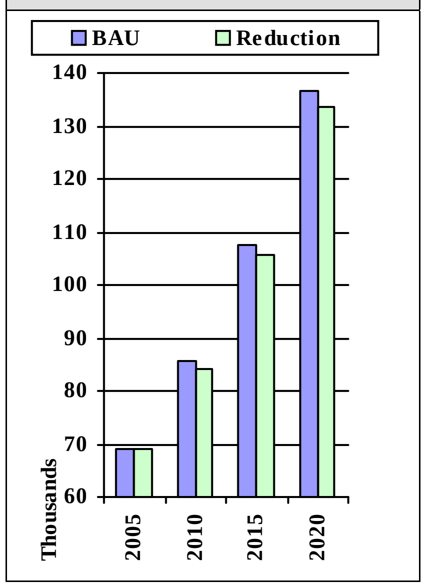
CO_2 emissions are not considered a near-source health concern, but have significance at the global level due to their global warming potential (GWP). Although other GHGs are released and have been assessed, CO_2 levels are much higher and dominate the total GWP that can be associated with the port related activities.

Annual CO_2 Emissions by Source Group (Tonnes)
2005 Total: 69,647 Tonnes

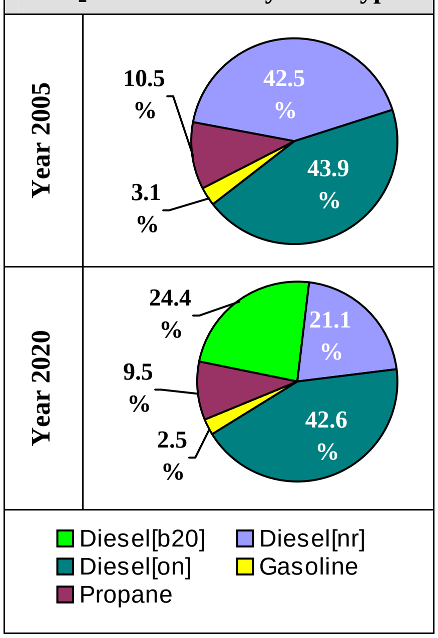


Annual Emissions by Source Group shows that CO_2 emissions have increased in step with the steady growth experienced by the port. As with the other air contaminants included in the LEI, cargo handling equipment contributes the greatest portion of total landside emissions, simply because CHE consumes the greatest amounts of fuel within the inventory boundaries. Cleaner fuels and emission controls that will be gradually introduced into the equipment fleets during future years will have virtually no effect on fuel consumption and CO_2 emission rates. The only notable decrease in CO_2 emission rates accounted for in the forecasts are those associated with the adoption of hybrid technologies and the switch from propane forklifts to electric units.

Effect of Reduction Initiatives



CO_2 Contribution by Fuel Type



Use of biodiesel at the facilities has the potential to reduce the effective CO_2 emissions, due to its renewable nature. As shown in *Emission Fraction by Fuel Type*, a large amount of biodiesel is expected to be consumed by 2020. The assessment of carbon neutrality that could be associated with bio-diesel use was beyond the scope of this project. Instead, the actual tailpipe CO_2 emissions from combustion of bio-diesel were assessed and accounted for in the LEI, similar to combustion of regular diesel. For this reason, the *effective* CO_2 emissions for the LEI may be considered lower than that presented here.

Some degree of caution is warranted for the CO_2 forecasts, since equipment fuel efficiency improvements and logistical improvements at the facilities are expected to occur. However, the potential improvements in efficiency have not yet been accounted for and documented in a way that would support their use in emission inventory forecast generation. For these reasons, the CO_2 forecast estimates provided in this report may be more conservative (over-estimated) when compared to estimates for other air contaminants that have been subject to government regulation, such as NO_x, SO_x and PM.

CONCLUDING REMARKS

Port Metro Vancouver is committed to sustainable operations and development, mindful of economic, social and environmental impacts. This includes a commitment to continuous improvement in terms of reducing emissions from port-related operations that contribute to air quality and climate change. Through the Air Action Program, Port Metro Vancouver is collaborating with other ports, industry and government agencies to develop a data baseline, promote efficiency, implement technologies and support regulatory changes to reduce air emissions. Reducing emissions from port-related activities including ships, trucks, trains and terminal equipment, as well as industrial processes are a key component of sustainable port operations.

The development of a detailed port emissions inventory constitutes an important tool for environmental management, allowing port and facility managers to understand the sources of emissions and to assess the benefits of different programs and strategies. A database inventory tool was developed to provide a clear linkage between activities and emissions for current and expected future operations. The developed LEI allows for reporting in a complete and transparent manner, while supporting the Port's commitment to sustainable operations and development.