SNC·LAVALIN

TP15255 E

EAST COAST/GREAT LAKES PORTS 2010 EMISSIONS INVENTORY STUDY

Final Report
Contract Number: T8125-110138/002/XSB

Prepared for:

Transportation Development Centre
Of Transport Canada
26th Floor, 330 Sparks Street
Ottawa, On, K1A 0N5

Prepared by:

The Environment & Water business unit of SNC-Lavalin Inc.

May 2014

SNC-LAVALIN INC.
8648 Commerce Court
Burnaby, British Columbia
Canada V5A 4N6
Tel.: 604-515-5151
Fax: 604-515-5150

TP15255 E

EAST COAST/GREAT LAKES PORTS 2010 EMISSIONS INVENTORY STUDY

Final Report
Contract Number: T8125-110138/002/XSB

Prepared for:

Transportation Development Centre
Of Transport Canada
26th Floor, 330 Sparks Street
Ottawa, On, K1A 0N5

Prepared by:

The Environment & Water business unit of SNC-Lavalin Inc.

May 2014

Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

Un sommaire français se trouve avant la table des matières.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP15255 E	2. Project No. B61B	3. Recipient's Catalogue No.
4. Title and Subtitle East Coast/Great Lakes Ports 2010 Emissions Inventory Study		5. Publication Date May 2014
		6. Performing Organization Document No.
7. Author(s) The Environment & Water business unit of SNC-Lavalin Inc.		8. Transport Canada File No.
9. Performing Organization Name and Address SNC-LAVALIN INC. 8648 Commerce Court Burnaby, British Columbia V5A 4N6		10. PWGSC File No.
		11. PWGSC or Transport Canada Contract No. T8125-110138/002/XSB
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) Place de Ville, Tower C 330 Sparks Street, 26th Floor Ottawa, Ontario K1A 0N5		13. Type of Publication and Period Covered Final
		14. Project Officer E. Radloff
15. Supplementary Notes (Funding programs, titles of related publications, etc.)		

16. Abstract

Port emission inventories of energy consumption, criteria air contaminants, greenhouse gases and select air toxics were developed for the fourteen ports on the east coast and Great Lakes regions of Canada. The inventories are activity-based, accounting for the marine and landside activities at the ports of Belledune, Halifax, Hamilton, Montreal, Oshawa, Quebec, Saguenay, Saint John, Sept-Iles, St. John's, Thunder Bay, Toronto, Trois-Rivières and Windsor.

A consistent methodology was applied, consistent with Canada's Port Emissions Inventory Protocol that was first developed in 2009 and updated as part of the project work. A port inventory software called the Port Emissions Inventory Tool (PEIT), also developed for Transport Canada in 2009, was updated and used to develop the emission estimates. PEIT utilizes an MS Excel data questionnaire that is populated by the port and port terminal staff, identifying the equipment fleets, activity rates and fuels consumption for the source groups marine vessels, rail locomotives, onroad vehicles, cargo handling equipment and administration. The inventories were developed for calendar year 2010, with forecasts out to 2025 in five year increments.

The study is complemented by a similar inventory exercise completed for Canada's four west coast ports of Port Alberni, Metro Vancouver, Nanaimo and Prince Rupert.

17. Key Words port emission inventory, criteria air contaminants, greenhouse gases, air toxics, Port Emission Inventory Tool (PEIT), protocol	18. Distribution Statement Digital Copy

19. Security Classification (of this publication) Unclassified	20. Security Classification (of this page) Unclassified	21. Declassification (date) —	22. No. of Pages xxv, 116, apps	23. Price Shipping/ Handling

CDT/TDC 79-005
Rev. 96

Canada

Transports Canada | Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada: TP15255 E

2. N° de l'étude: B61B

3. N° de catalogue du destinataire:

4. Titre et sous-titre: Etude d'inventaire des émissions (2010) pour les ports de la côte Est et des Grands Lacs

5. Date de la publication: Mai 2014

6. N° de document de l'organisme exécutant:

7. Auteur(s): L'unité d'exploitation Environnement et eau de SNC-Lavalin Inc.

8. N° de dossier - Transports Canada:

9. Nom et adresse de l'organisme exécutant:
SNC-LAVALIN INC.
8648 Commerce Court
Burnaby, British Columbia
V5A 4N6

10. N° de dossier - TPSGC:

11. N° de contrat - TPSGC ou Transports Canada: T8125-110138/002/XSB

12. Nom et adresse de l'organisme parrain:
Centre de développement des transports (CDT)
Place de Ville, tour C
330, rue Sparks, 26e étage
Ottawa (Ontario)
K1A 0N5

13. Genre de publication et période visée: Finale

14. Agent de projet: E. Radloff

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

16. Résumé

Les inventaires des émissions portuaires résultant de la consommation énergétique, des principaux contaminants atmosphériques, des gaz à effet de serre et des polluants atmosphériques toxiques ont été dressés pour les quatorze ports de la côte est et pour les régions des Grands Lacs du Canada. Ces inventaires sont dressés en fonction des activités et tiennent compte des activités côtés mer et terre des ports de Belledune, d'Halifax, d'Hamilton, de Montréal, d'Oshawa, de Québec, de Saguenay, de Saint John, de Sept Îles, de St. John's, de Thunder Bay, de Toronto, de Trois Rivières et de Windsor.

La méthodologie appliquée était uniforme et conforme au protocole de l'inventaire des émissions des ports du Canada élaboré en 2009 et mis à jour dans le cadre de ce projet. Un logiciel appelé « Outil d'inventaire des émissions portuaires » (OIEP) a aussi été développé en 2009 pour Transports Canada, puis mis à jour et utilisé pour obtenir des estimations des émissions. L'OIEP utilise un questionnaire en format MS Excel qui est alimenté en données par le personnel des ports et des terminaux portuaires. Les données portent sur le parc d'équipement, les taux d'activités, la consommation de carburant des bâtiments par catégories de sources d'émission, les locomotives, les véhicules routiers, l'équipement de manutention de la cargaison et l'administration. Les inventaires ont été élaborés pour l'année civile de 2010 et présentent des prévisions pour les émissions, par période de cinq ans, et ce' jusqu'en 2025.

Dans le cadre de cette étude, un exercice d'inventaire semblable a été effectué pour les quatre ports de la côte ouest : Port Alberni, Metro Vancouver, Nanaimo et Prince Rupert.

17. Mots clés: inventaire des émissions portuaires, principaux contaminants atmosphériques, gaz à effet de serre, polluants atmosphériques toxiques, outil d'inventaire des émissions portuaires (OIEP), protocole.

18. Diffusion: Copie numérique

19. Classification de sécurité (de cette publication): Non classifiée

20. Classification de sécurité (de cette page): Non classifiée

21. Déclassification (date): —

22. Nombre de pages: —

23. Prix: Port et manutention

ACKNOWLEDGEMENTS

Assistance and data was provided from each of Canada's 14 port authorities in Eastern Canada/Great Lakes. Additionally, data was provided by many port terminal representatives at each of the ports. These terminal representatives are too numerous to name individually. The cooperation and assistance of the port and terminal representatives is gratefully acknowledged as an essential component of this study.

Individuals who played a particular role in development of the port inventory are identified below.

INVENTORY PROJECT TEAM

TRANSPORT CANADA	Ernst Radloff, Senior Development Officer
	Fiona Beaudoin, Programs Directorate
ENVIRONMENT CANADA	Richard Holt, Transportation Division (Pacific)
GREEN MARINE	David Bolduc, Executive Director
SNC-Lavalin:	Bryan McEwen, Project Manager
	John Lindner, Air Quality Specialist
	John Fišera, Data Systems Specialist
	Cameron Wallace, GIS Analyst
	Richard Iannone, Air Quality Specialist
	Jenny Vieira, Air Quality Specialist
	David Allard, Air Quality Specialist
Belledune Port Authority:	Wynford Goodman, Director of Operations
Halifax Port Authority:	Patrick Henderson, Environmental Engineer
Hamilton Port Authority:	Marilyn Baxter, Environmental Manager
Montreal Port Authority:	Lyne Martin, Environment Director (retired)
	Claude Deschambault, Environment Director
Oshawa Port Authority:	Shannan Hewak, Administrative Assistant
	Donna Taylor, Chief Executive Officer
Quebec Port Authority:	Nancy Hudon, Environment Director

INVENTORY PROJECT TEAM (Cont'd)

Saguenay Port Authority:	Carl Laberge, Director, Marketing and Projects
Saint John (NB) Port Authority:	John McCann, VP Operations, Infrastructure & Harbour Master
	Andrew Somerville, Manager, Operations & Logistics
Sept-Iles Port Authority:	Manon D'Auteuil, Director, Engineering & Sustainable Development
St. John's (NL) Port Authority:	Paul Sheppard, Port Technologist
Thunder Bay Port Authority:	Chris Heikkinen, Communications & Research Coordinator
	Guy Jarvis, Director, Engineering & Harbour Master
Toronto Port Authority:	Michael Riehl, Deputy Harbour Master and Manager of Customer Relations
Trois-Rivières Port Authority:	Michel Parent, Director of Operations
Windsor Port Authority:	Peter Berry, Harbour Master

EXECUTIVE SUMMARY

The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) was contracted by Transport Canada (TC) to complete a 2010 activity and emissions inventory for the East Coast / Great Lakes (EC/GL) ports identified under the Canada Marine Act (1998, 2008): Ports of Belledune, Halifax, Hamilton, Montreal, Oshawa, Quebec, Saguenay, Saint John, Sept-Iles, St. John's, Thunder Bay, Toronto, Trois-Rivières, and Windsor. The inventory is based on the four primary port-related source groups: Marine Vessels; Cargo Handling Equipment (CHE); Rail and Onroad Vehicles; and additionally accounts for Administration sources. The inventory includes all of the activities of the ports' tenants as well as ship movements within the respective harbours.

A port emissions inventory is a semi-formalized process based on early port assessment work done for the largest U.S. ports (notably the ports of L.A. and Long Beach in California), Port Metro Vancouver in Canada and related guidance provided by the U.S. EPA as early as 2006. To harmonize Canadian efforts, TC developed the Port Emission Inventory Protocol in 2009, which was updated during this project to reflect current data and methodologies. While early port inventory work focused on criteria air contaminants (CACs), recent port inventories such as the 2010 Port Metro Vancouver Landside Emissions Inventory have included a greater focus on greenhouse gases (GHGs) and energy consumption to broadly consider opportunities for emissions reduction and improvements in efficiency. The EC/GL inventory has a similar focus and allows for the development of energy/emissions metrics to identify and track environmental performance over time.

As an activity-based inventory, all fuels and energies consumed by the emission sources within each Port Boundary are included, in addition to CACs, GHGs and select air toxics of interest. Forecasts were prepared for 2015, 2020 and 2025, accounting for expected commodity growth as well as documented fuel and emission regulations for the sector. Notably, this includes the 2012 implementation of an Emissions Control Area (ECA) for the East Coast of North America. The inventory was completed with use of TC's Port Emissions Inventory Tool (PEIT), which has been in development in Canada since 2008. PEIT uses terminal level data questionnaires that are completed by terminal representatives (with assistance from SNC-Lavalin) and imported to a database.

PEIT greatly simplifies development of a port emissions inventory. As shown in Figure 0-1, the model accounts for each of the emission source groups, with allocation to the principal boundaries of interest.

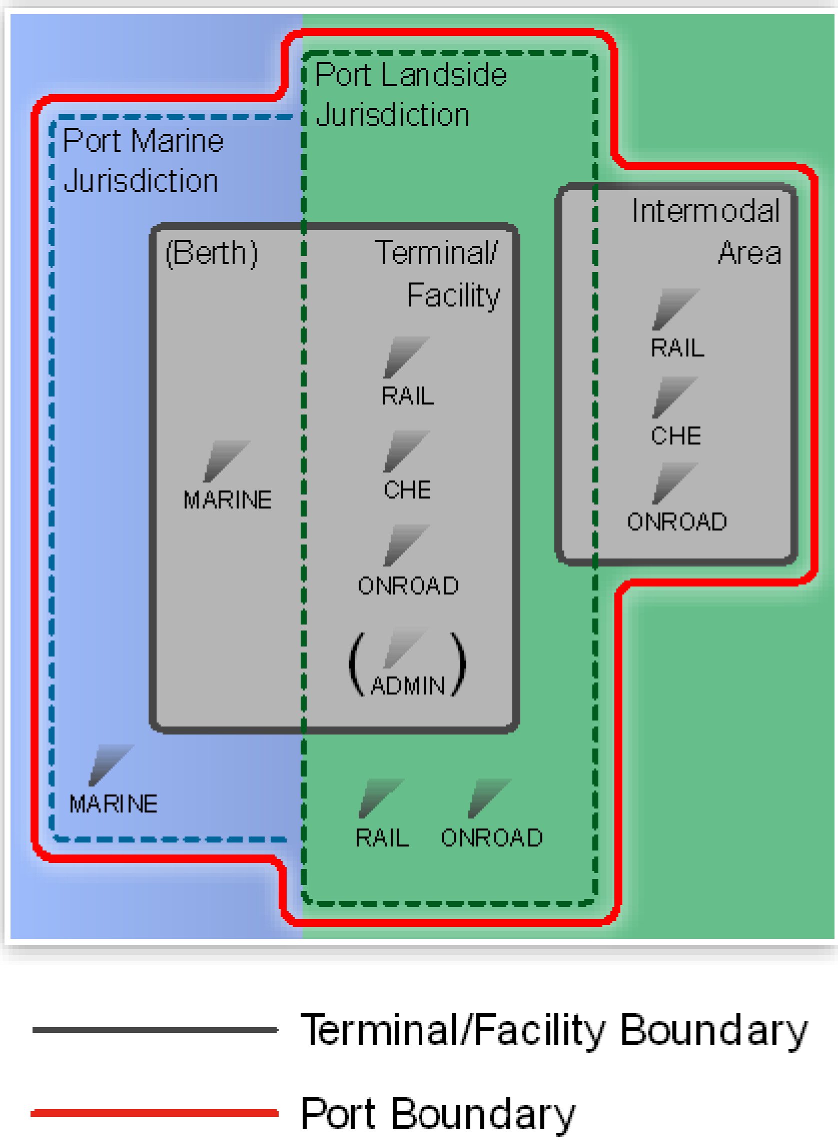


Figure 0-1: Representation of the Port Emission Inventory Boundaries

This study is complemented by a similar study completed for Canada's four West Coast ports (Nanaimo, Port Alberni, Metro Vancouver and Prince Rupert). Together, these reports provide a complete 2010 baseline for all 18 of Canada's official ports. The 2010 EC/GL Ports Emissions Inventory is summarized in Figure 0-2 by port, source group, and major commodity type, respectively.

Figure 0-2: 2010 EC/GL Ports Emission Estimates to the Port Boundary, by Port, Source Group and Commodity Type (tonnes)

The Port of Saint John (NB) accounts for approximately half of the 2010 VOC emissions. The primary source of these VOCs is fugitive emissions from vessels transporting fossil fuels, which spend a significant amount of time within the Port of Saint John marine boundary.

Marine sources (ships) dominate the EC/GL port emissions estimates. In part, this is due to broader water side boundaries applied to the ports than those on the landside. A flexible approach involving port representatives was used to determine the waterside and landside boundaries for each Port Boundary definition. 11 of the 14 ports chose the landside boundary to coincide with the terminal grounds. The Ports of Hamilton, Montreal, and Toronto identified a larger landside area to incorporate much of the rail and truck movements in the immediate vicinity of the marine terminals. The 2010 emissions estimates are re-expressed to the "Terminal/Facility Boundary" in Figure 0-3. These estimates relate to the port terminals alone, without including ship, rail and truck movements to/from the terminals. With the smaller boundaries applied, marine sources still dominate the totals.

Figure 0-3: 2010 EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Port, Source Group and Commodity Type (tonnes)

Emissions associated with the Port of Montreal are higher than the other EC/GL ports. This is logical, since the Port of Montreal is Canada's largest port in eastern Canada, by annual commodity throughput. Montreal does not have the highest throughput for all commodities however, with several ports having higher Breakbulk, Bulk Solid, and Bulk Liquid throughput. Figure 0-4 provides a summary of annual commodity throughput for each port during 2010, including cruise ship passengers.

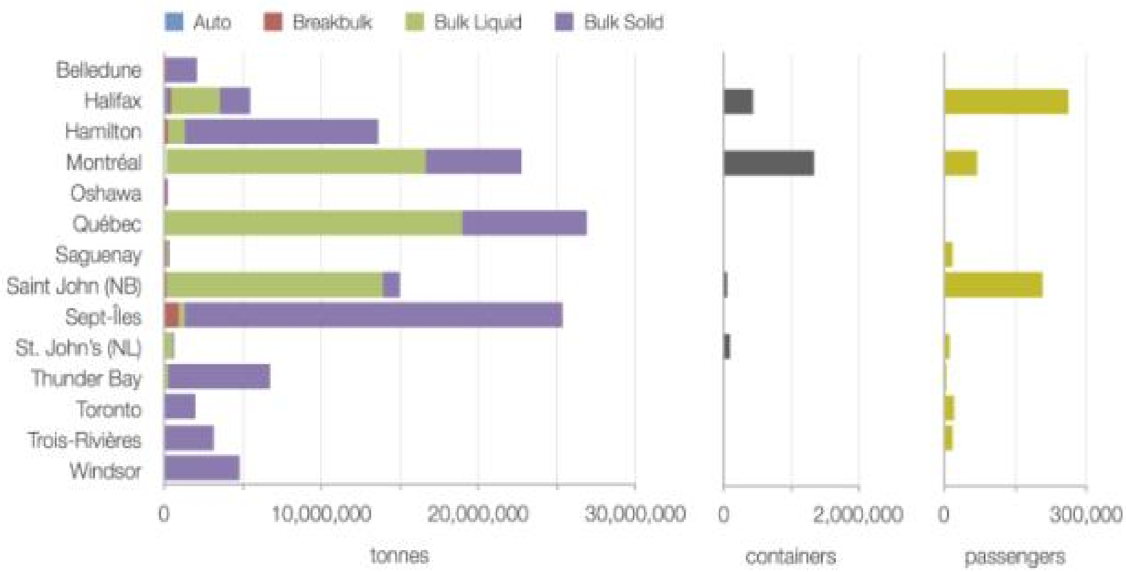


Figure 0-4: Commodity Throughput Handled at EC/GL Ports in 2010

Forecasts were developed for the EC/GL port inventory by accounting for the expected commodity growth for each in 2015, 2020 and 2025. The ports are expected to grow significantly in throughput by 2025, especially for the containers and bulk solid commodity types. The forecast inventories are shown in Tables 0-1 and 0-2 for the Port Boundary and Terminal/Facility Boundary, respectively.

Table 0-1: Forecast EC/GL Emission Estimates to the Port Boundary, by Year (tonnes)

Inventory year	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
2010	5,139	3,584	968	2,628	445	410	6	478,433
2015	5,542	224	1,003	2,752	162	149	7	570,241
2020	5,342	236	913	2,822	157	144	7	601,543
2025	4,754	249	912	2,924	159	145	7	636,382

Table 0-2: Forecast EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Year (tonnes)

Inventory year	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
2010	3,487	2,644	774	2,519	323	298	4	370,722
2015	3,814	170	791	2,633	120	111	5	447,025
2020	3,667	180	696	2,699	114	105	5	473,560
2025	3,291	191	688	2,796	114	104	5	502,683

The forecast emissions to the Port Boundary are shown in Figures 0-5 to 0-8 for NO_x, SO_x, $PM_{2.5}$ and CO_2e, respectively. These figures show that while GHG emissions for the ports are expected to increase with the port growth, increase in the CACs is limited due to expected improvements in fuel quality and engine/emissions technologies, in line with domestic and international regulations.

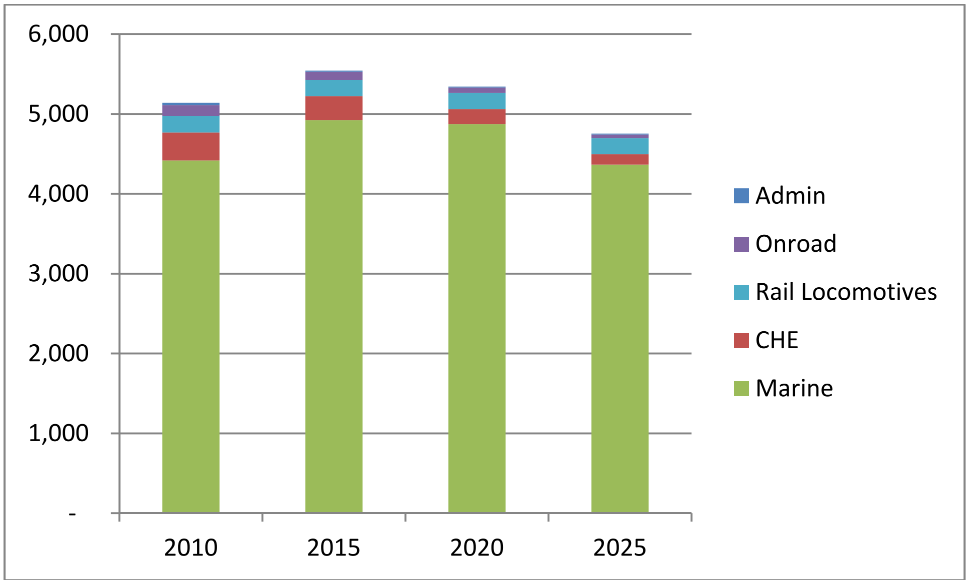


Figure 0-5: EC/GL Ports NO_x Emission Estimates to the Port Boundary (tonnes)

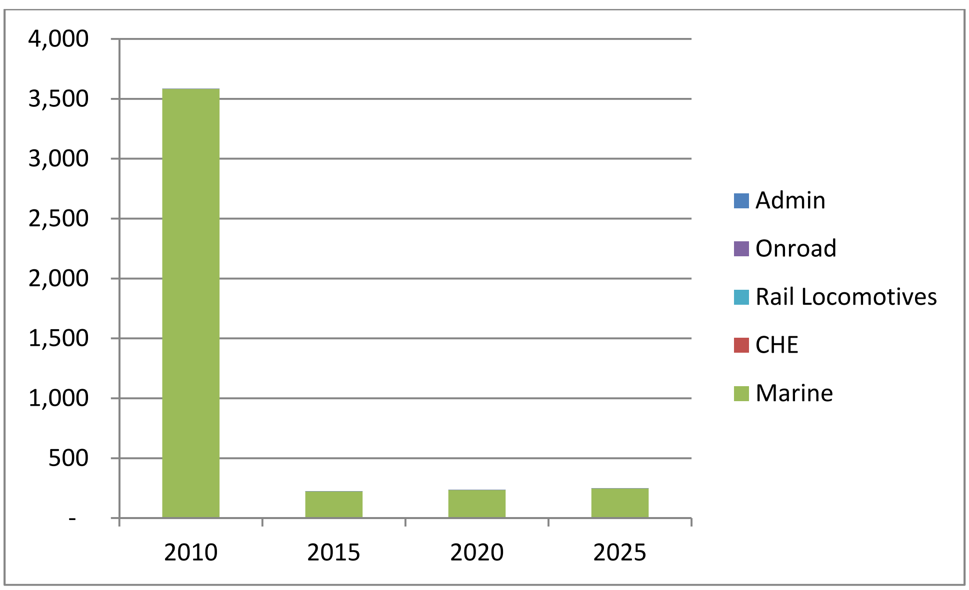


Figure 0-6: EC/GL Ports SO_x Emission Estimates to the Port Boundary (tonnes)

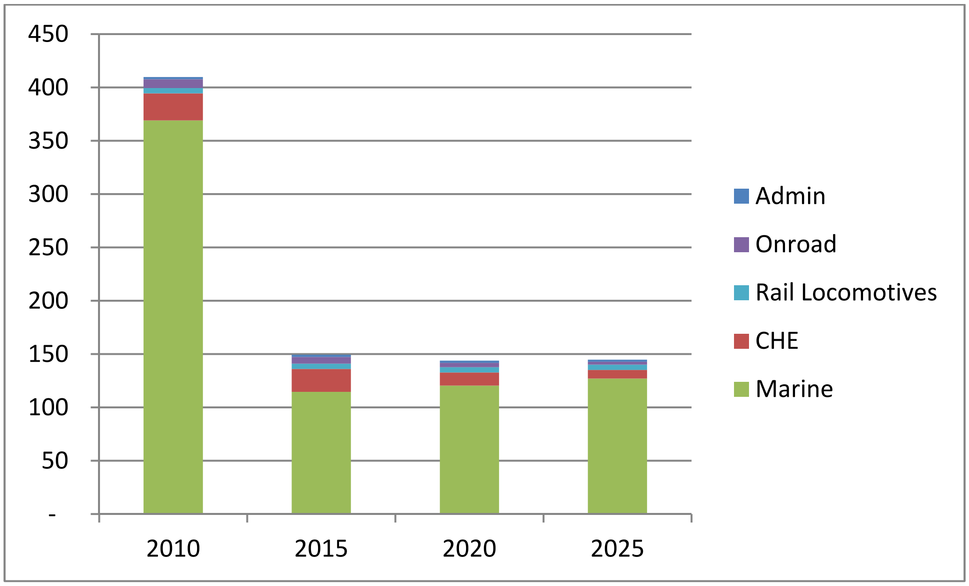


Figure 0-7: EC/GL Ports $PM_{2.5}$ Emission Estimates to the Port Boundary (tonnes)

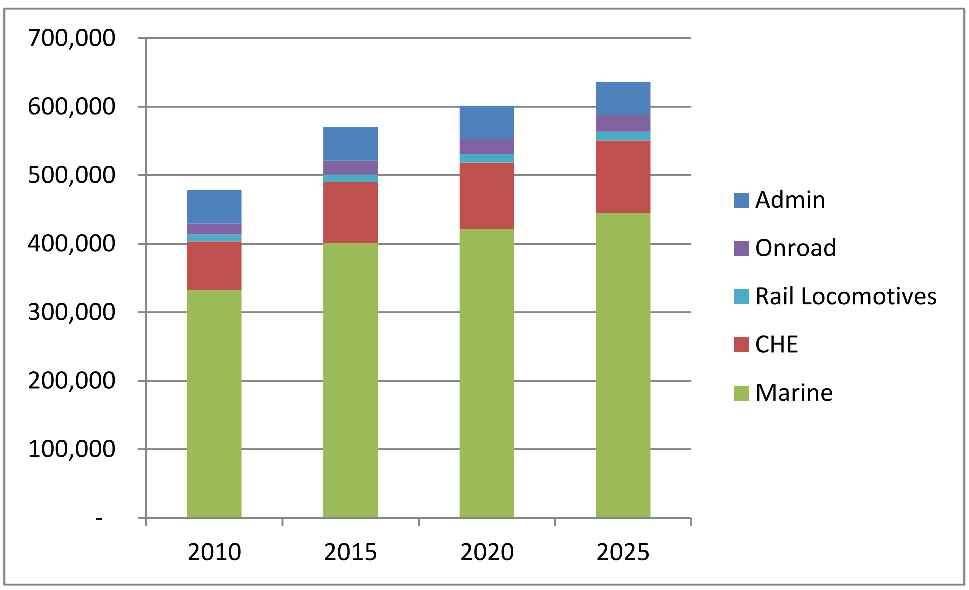


Figure 0-8: EC/GL Ports CO_2e Emission Estimates to the Port Boundary (tonnes)

Commodity-based emission intensities were developed from the EC/GL ports inventory by identifying terminal emissions for a particular commodity and applying a tonnage- or TEU-based weighting. In other words, annual emissions to the Terminal/Facility Boundary divided by the annual throughput, for those terminals that deal exclusively in one commodity type. These values can be considered *key performance indicators* (KPIs) for the EC/GL ports. The values determined for containerized goods, which are inclusive of all sources (including Admin) and energies are as follows:

- 48 kg/TEU CO_2e
- 0.48 kg/TEU NO_x
- 0.32 kg/TEU SO_x
- 0.04 kg/TEU $PM_{2.5}$

These KPIs are representative of container handling on the EC/GL as a whole and not specifically for one terminal. Similar indicators were determined for breakbulk handling and a number of specific bulk solid goods (e.g., iron ore, grains, etc). The KPIs can be used to identify the total footprint of moving goods from source to destination, when combined with distance-based indicators for a particular mode of transportation (e.g., kg/tonne-km). However, it is suggested that the KPIs are also valuable for the EC/GL ports and terminals to benchmark and track environmental performance. As such, port- or terminal-specific KPIs can be used.

Although significant emission reduction initiatives have been developed at the EC/GL ports, reducing energy consumption and GHG emissions remains a considerable challenge. The PEIT model and the port inventories are consistent with current best-practices for emissions assessment in the port/marine sector and additionally are consistent with Transport Canada's Port Emissions Inventory Protocol. A great deal of developmental work has been conducted by Transport Canada on both the Protocol and the PEIT software since 2008. The completion of an EC/GL Port Inventory along with a West Coast Port Inventory (described in a separate Transport Canada report) provides Canadian government with a thorough understanding of the activities, energies and emissions associated with the trade of goods through Canada's 18 official ports.

RÉSUMÉ

Transports Canada (TC) a confié au secteur Environnement et eau de SNC-Lavalin Inc. (SNC-Lavalin) la tâche de dresser un inventaire des activités et des émissions en 2010 dans les ports de la côte Est et des Grands Lacs mentionnés dans la *Loi maritime du Canada* (1998, 2008) : les ports de Belledune, Halifax, Hamilton, Montréal, Oshawa, Québec, Saguenay, Saint John, Sept-Îles, St. John's, Thunder Bay, Toronto, Trois-Rivières et Windsor. L'inventaire est basé sur les quatre principaux groupes de sources liés aux ports : les navires, l'équipement de manutention de cargaison, le chemin de fer et les véhicules routiers. De plus, il englobe les sources des administrations. L'inventaire comprend toutes les activités menées par les locataires des ports, ainsi que les déplacements des navires à l'intérieur des ports respectifs.

L'inventaire des émissions d'un port est un processus semi-officiel fondé sur le travail d'évaluation des ports préalablement effectué pour les plus grands ports des États-Unis (notamment, les ports de Los Angeles et de Long Beach, en Californie) et le port Metro Vancouver, au Canada; l'inventaire s'appuie également sur l'orientation en la matière fournie par la United States Environmental Protection Agency dès 2006. Pour harmoniser les efforts déployés au Canada, TC a élaboré en 2009 le Protocole de l'inventaire des émissions des ports, lequel a été mis à jour dans le cadre du présent projet afin de refléter les données et les méthodes actuelles. Les premiers travaux d'inventaire des émissions des ports étaient centrés sur les principaux contaminants atmosphériques (PCA); les inventaires de ports récents, comme l'Inventaire des émissions côté terre du port Metro Vancouver de 2010, sont davantage axés sur les gaz à effet de serre (GES) et la consommation d'énergie, ce qui permet d'évaluer les possibilités de réduction des émissions et d'amélioration de l'efficacité dans un contexte élargi. L'inventaire de la côte Est et des Grands Lacs, dont l'orientation est la même, permet d'établir des mesures de l'énergie et des émissions en vue de connaître le rendement en matière environnementale au fil du temps et d'en faire le suivi.

Comme il s'agit d'un inventaire basé sur les activités, l'ensemble du carburant et de l'énergie consommés par les sources d'émission à l'intérieur des limites de chacun des ports sont pris en compte, en plus des PCA, des GES et de certains toxiques atmosphériques d'intérêt. Des prévisions ont été établies pour 2015, 2020 et 2025, en prenant en considération l'augmentation attendue des marchandises ainsi que les règlements documentés en matière de carburant et d'émissions pour ce secteur. Notamment, cela inclut la mise en œuvre, en 2012, d'une zone de contrôle des émissions pour la côte Est de l'Amérique du Nord. L'inventaire a été effectué au moyen de l'Outil de l'inventaire des émissions des ports (OIEP) de TC, que l'on peaufine au Canada depuis 2008. L'OIEP est alimenté par des questionnaires portant sur les

données à l'échelle du terminal qui sont remplis par des représentants du terminal (avec l'aide de SNC-Lavalin), puis importés dans une base de données.

L'OIEP simplifie grandement la préparation d'un inventaire des émissions des ports. Comme l'illustre la figure 0-1, on tient compte, avec l'OIEP, de chacun des groupes de sources d'émissions et des principales délimitations d'intérêt.

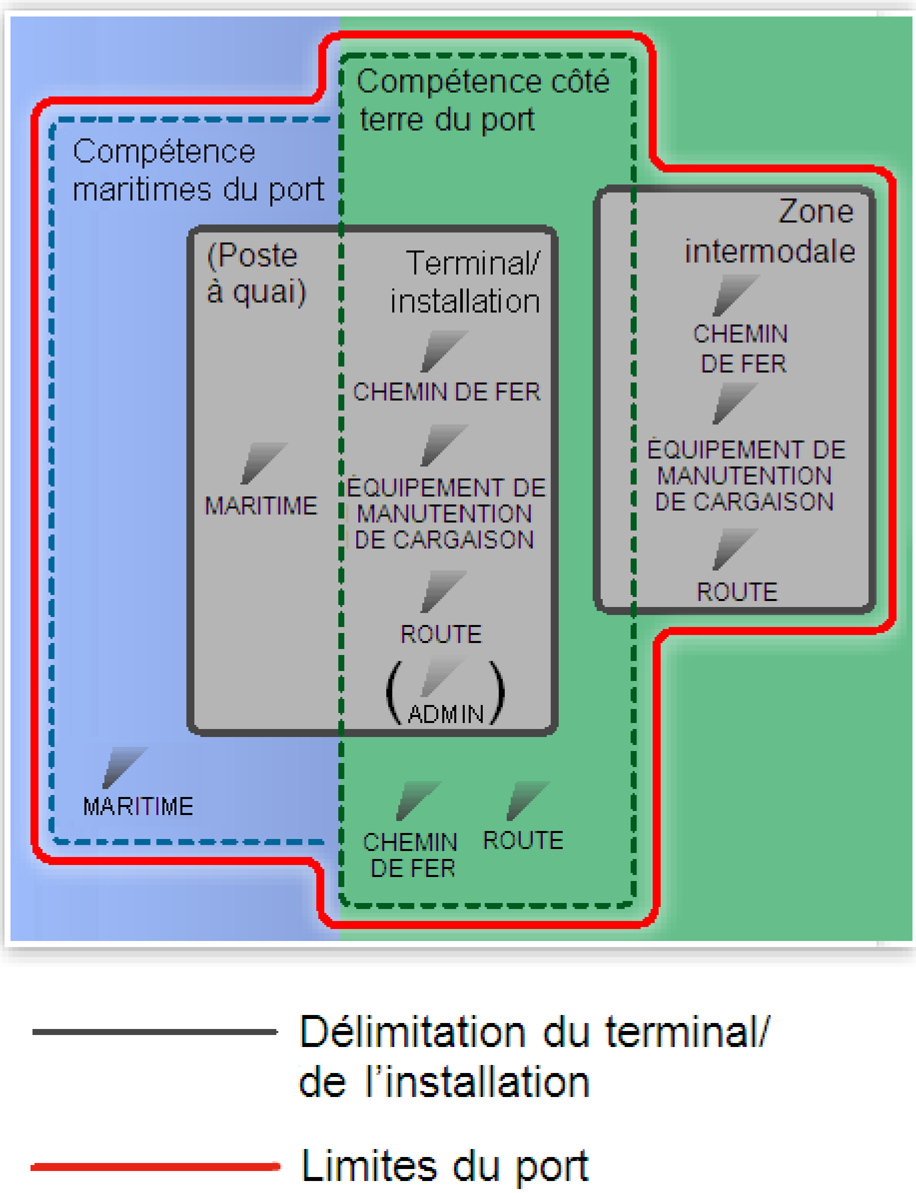


Figure 0-9 : Représentation des délimitations en lien avec l'inventaire des émissions des ports

À la présente étude s'ajoute une recherche similaire sur les quatre ports de la côte Ouest du Canada (Nanaimo, Port Alberni, Metro Vancouver et Prince-Rupert). Réunis, ces rapports procurent une base de référence de 2010 complète pour l'ensemble des 18 ports officiels du Canada. Les données figurant dans l'inventaire de 2010 des émissions des ports de la côte Est et des Grands Lacs sont résumées dans la figure 0-2, présentées en fonction du port, du groupe de sources et du type principal de marchandises, respectivement.

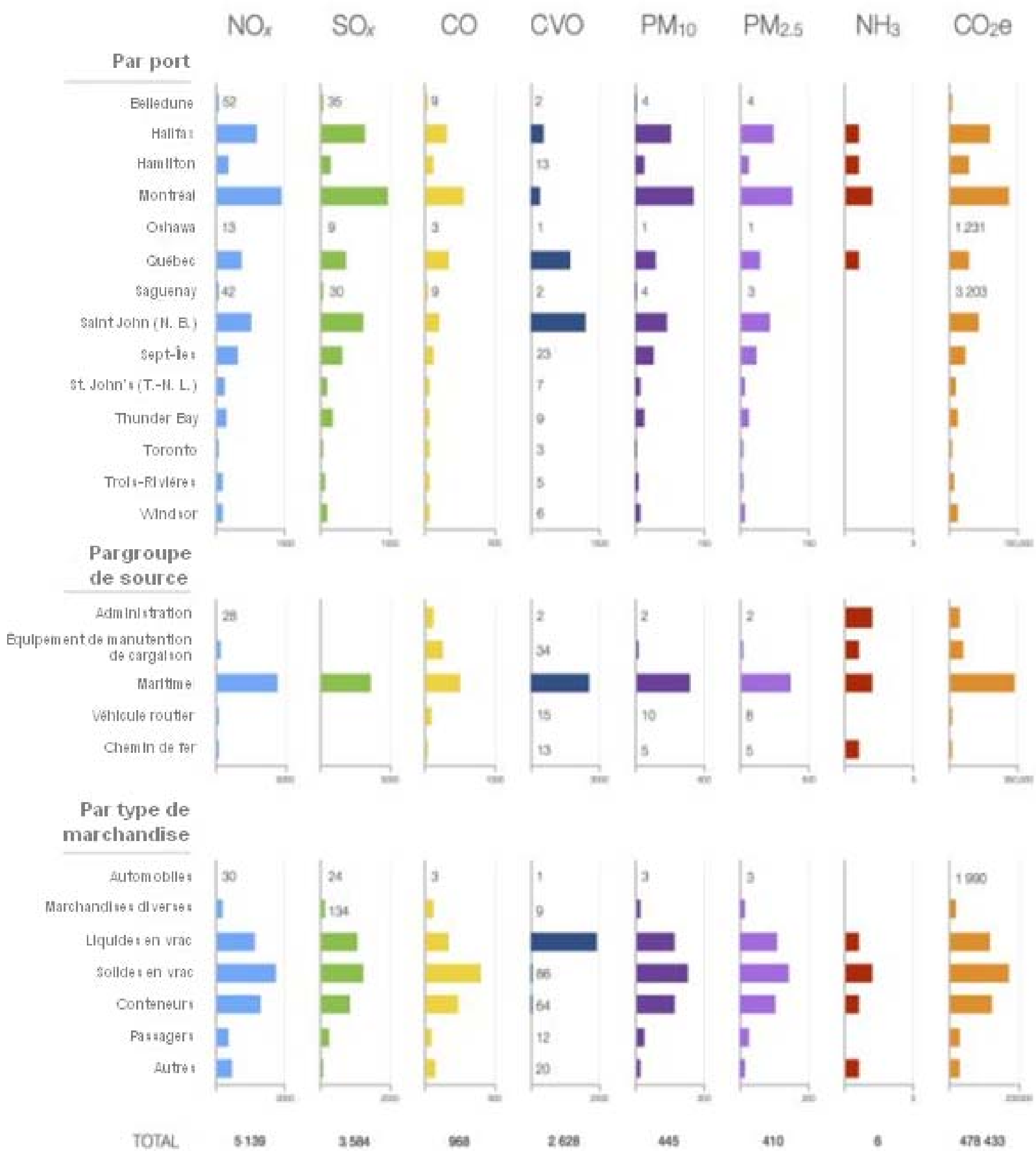


Figure 0-10 : Estimation des émissions de 2010 pour les ports de la côte Est et des Grands Lacs selon les délimitations du port, en fonction du port, du groupe de sources et du type de marchandise (tonnes)

Le port de Saint John (N.-B.) est la source d'environ la moitié des émissions de composés organiques volatils (COV) produites en 2010. Ces COV proviennent principalement des émissions fugitives des navires transportant des combustibles fossiles, qui passent un temps considérable dans les limites maritimes du port de Saint John.

Les sources maritimes (navires) dominent les estimations d'émissions des ports de la côte Est et des Grands Lacs. Cette situation s'explique en partie par le fait que les limites riveraines sont plus étendues, dans le cas des ports, que celles du côté terre. On a eu recours à une approche souple faisant appel aux représentants des ports pour déterminer les limites riveraines et terrestres ayant servi à définir les délimitations de chaque port. Les représentants de 11 des 14 ports ont décidé que les limites terrestres coïncideraient avec les terrains du terminal. Aux ports de Hamilton, de Montréal et de Toronto, on a déterminé une plus grande zone côté terrestre de manière à inclure une bonne partie des mouvements ferroviaires et des déplacements de camions à proximité des terminaux portuaires. Les estimations des émissions de 2010 sont reformulées dans la figure 0-3 en fonction des délimitations des terminaux et des installations. Ces estimations ne visent que les terminaux portuaires, sans inclure le mouvement de navires, de wagons ou de camions en direction des terminaux ou en partance de ceux-ci. Même si l'on applique des délimitations plus restrictives, les sources maritimes dominent encore dans les résultats totaux.

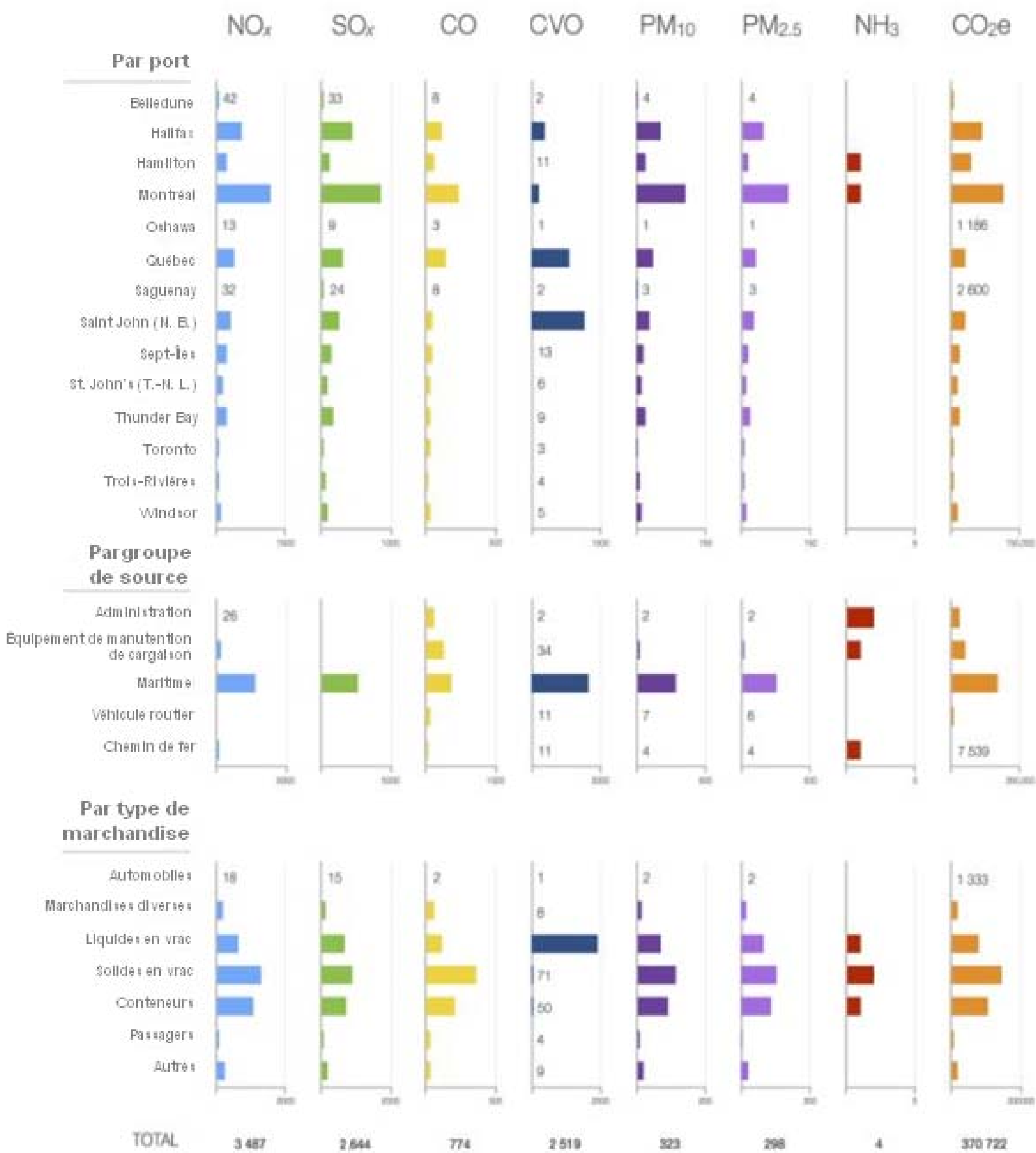


Figure 0-11 : Estimation des émissions de 2010 pour les ports de la côte Est et des Grands Lacs selon les délimitations des terminaux et des installations, en fonction du port, du groupe de sources et du type de marchandise (tonnes)

Les émissions associées au port de Montréal sont plus élevées que dans le cas des autres ports de la côte Est et des Grands Lacs. Ce résultat est logique puisque le port de Montréal est le plus grand de l'est du Canada en ce qui concerne la capacité annuelle en marchandises. Le port de Montréal n'a toutefois pas la plus grande capacité pour toutes les marchandises puisque plusieurs ports ont une plus grande capacité en ce qui concerne les marchandises diverses, les solides en vrac et les liquides en vrac. La figure 0-4 présente un résumé de la capacité annuelle en termes de marchandises de chaque port en 2010, incluant les passagers de navires de croisière.

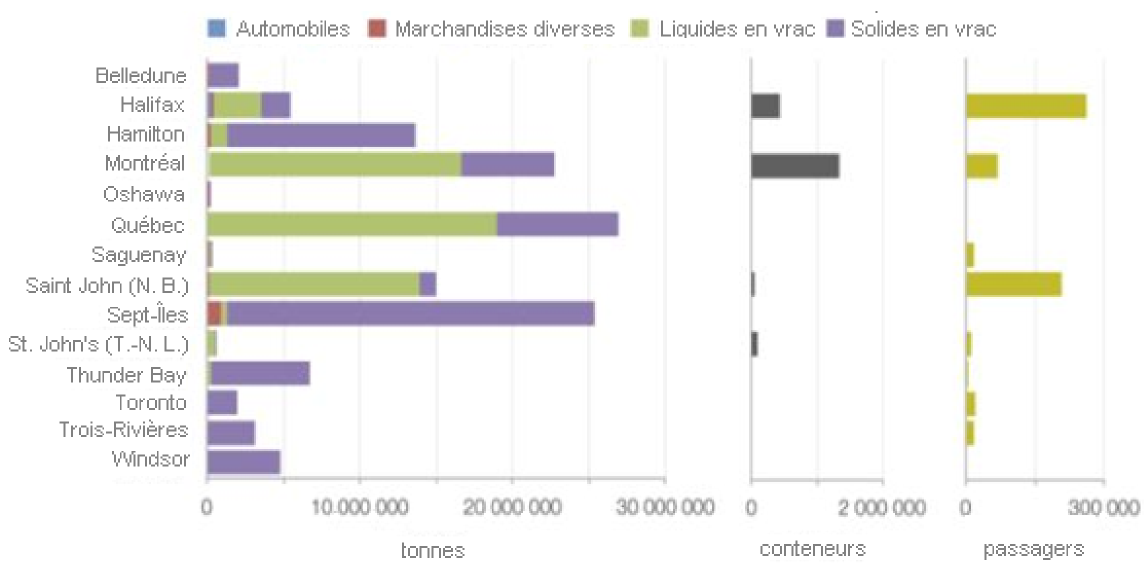


Figure 0-12 : Capacité en marchandises dans les ports de la côte Est et des Grands Lacs en 2010

Les prévisions calculées aux fins de l'inventaire des ports de la côte Est et des Grands Lacs tiennent compte de l'augmentation attendue des marchandises pour chaque tranche d'années : 2015, 2020 et 2025. On s'attend à ce que la marchandise transitant dans les ports enregistre des augmentations considérables d'ici 2025, plus particulièrement les conteneurs et les liquides en vrac. Les inventaires prévisionnels sont illustrés dans les tableaux 0-1 et 0-2 en lien avec la délimitation du port et la délimitation du terminal/de l'installation, respectivement.

Tableau 0-3 : Prévision des émissions des ports de la côte Est et des Grands Lacs selon la délimitation du port, par année (tonnes)

Année d'inventaire	NO_x	SO_x	CO	COV	PM_{10}	$PM_{2,5}$	NH_3	Équivalent-CO_2
2010	5 139	3 584	968	2 628	445	410	6	478 433
2015	5 542	224	1 003	2 752	162	149	7	570 241
2020	5 342	236	913	2 822	157	144	7	601 543
2025	4 754	249	912	2 924	159	145	7	636 382

Tableau 0-4 : Prévision des émissions des ports de la côte Est et des Grands Lacs selon la délimitation du terminal/de l'installation, par année (tonnes)

Année d'inventaire	NO_x	SO_x	CO	COV	PM_{10}	$PM_{2,5}$	NH_3	Équivalent-CO_2
2010	3 487	2 644	774	2 519	323	298	4	370 722
2015	3 814	170	791	2 633	120	111	5	447 025
2020	3 667	180	696	2 699	114	105	5	473 560
2025	3 291	191	688	2,796	114	104	5	502 683

Les émissions prévues en lien avec la délimitation du port sont présentées dans les figures 0-5 à 0-8 en ce qui concerne les $NO_{x,}$ les SO_x, les matières particulaires ($PM_{2,5}$) et les équivalents-CO_2, respectivement. Selon les données obtenues, bien que l'on s'attende à ce que les émissions de GES des ports augmentent sous l'effet de l'expansion du port, l'augmentation des PCA sera limitée grâce aux améliorations prévues concernant la qualité du carburant et les technologies liées aux moteurs et aux émissions, conformément à la réglementation nationale et internationale.

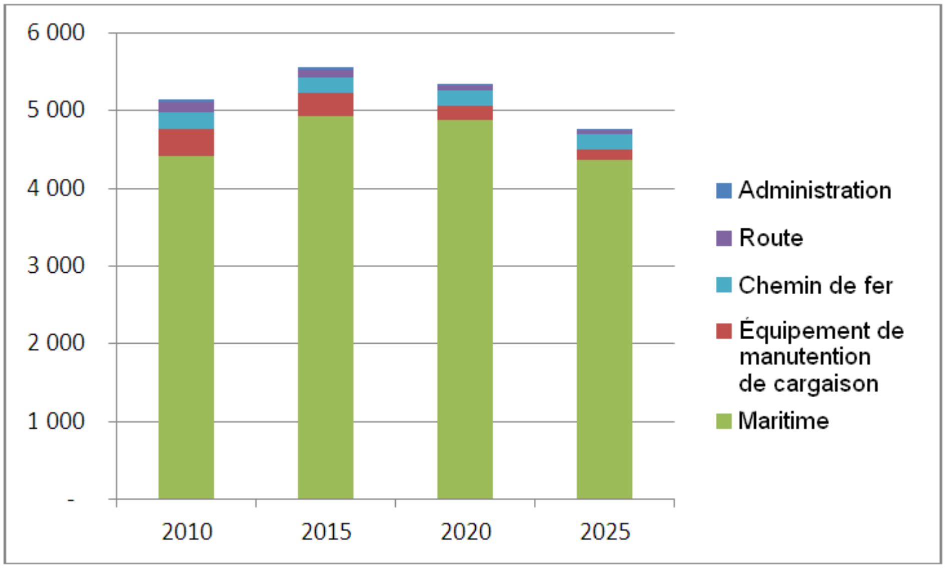


Figure 0-13 : Estimation des émissions de NO_x des ports de la côte Est et des Grands Lacs par année, selon la délimitation du port (tonnes)

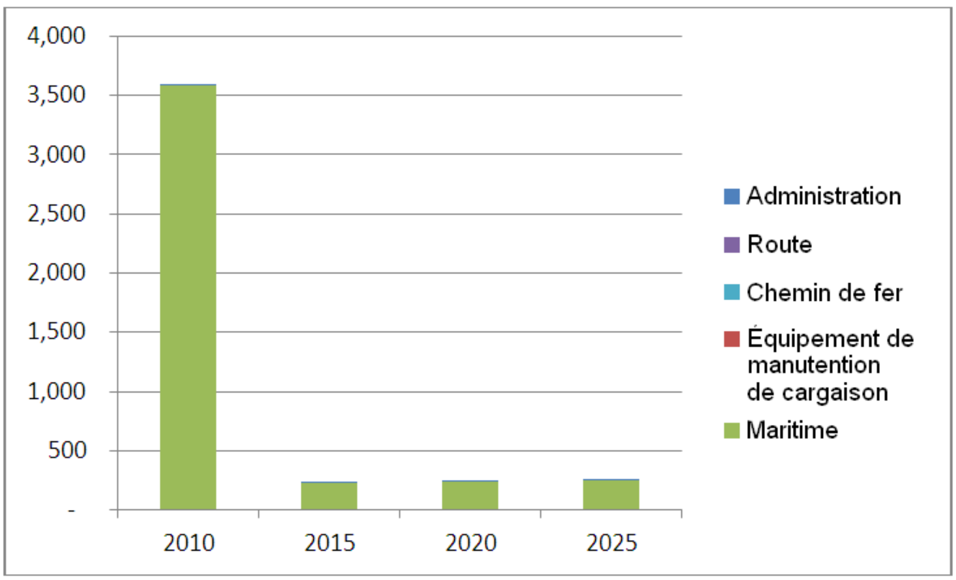


Figure 0-14 : Estimation des émissions de SO_x des ports de la côte Est et des Grands Lacs par année, selon la délimitation du port (tonnes)

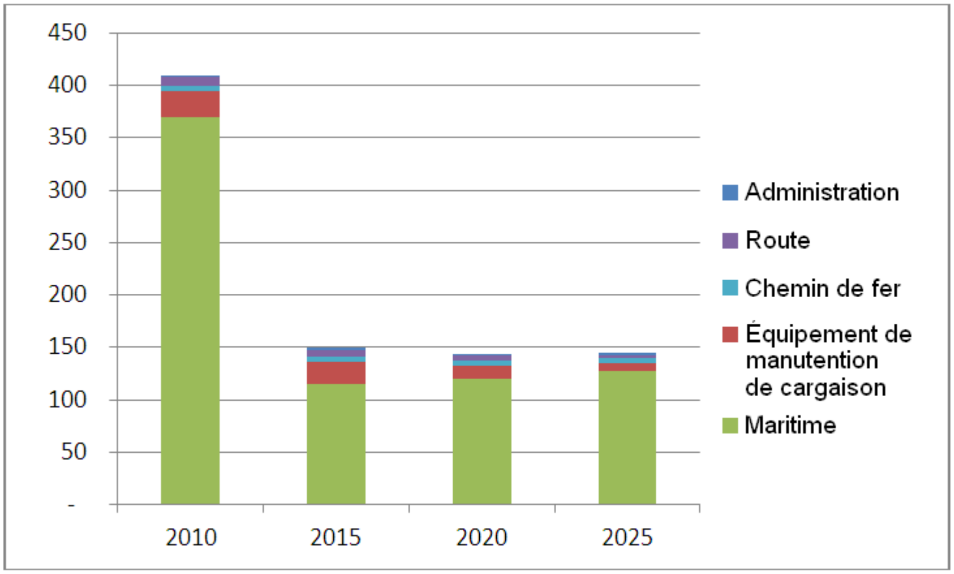


Figure 0-15 : Estimation des émissions de $PM_{2,5}$ des ports de la côte Est et des Grands Lacs par année, selon la délimitation du port (tonnes)

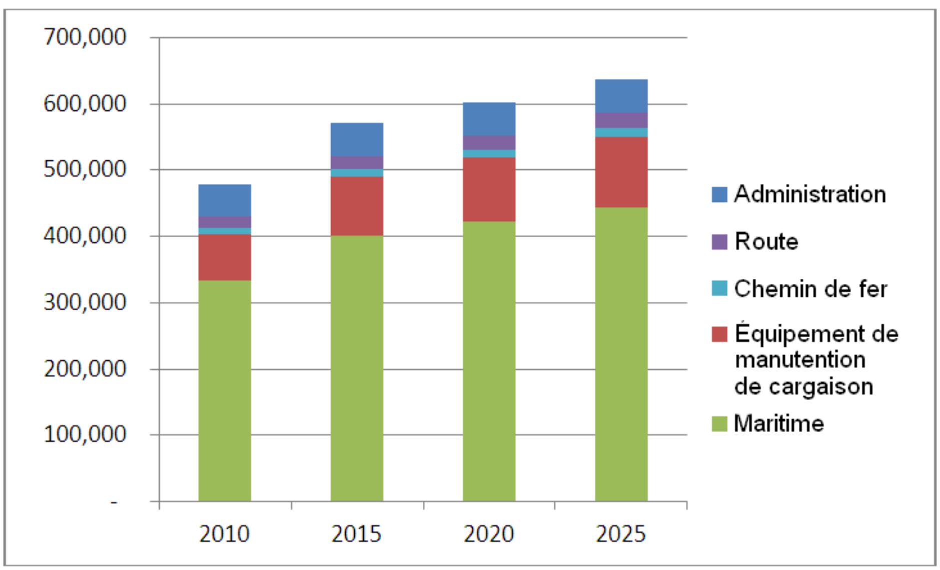


Figure 0-16 : Estimation des émissions d'équivalents-CO_2 des ports de la côte Est et des Grands Lacs par année, selon la délimitation du port (tonnes)

L’intensité des émissions selon les marchandises a été établie à partir de l’inventaire des ports de la côte Est et des Grands Lacs en déterminant les émissions du terminal associées à une marchandise donnée et en appliquant une méthode de pesée basée sur le tonnage ou l’équivalent vingt pieds (EVP). En d’autres mots, il s’agit du total des émissions annuelles du terminal ou des installations divisé par la capacité annuelle, dans le cas des terminaux qui ne traitent qu’un type de marchandise. Ces valeurs peuvent être considérées comme des *indicateurs de rendement clés* (IRC) pour les ports de la côte Est et des Grands Lacs. Les valeurs établies pour les marchandises se trouvant dans des conteneurs, incluant toutes les sources (y compris l’administration) et les formes d’énergie sont les suivantes :

- 48 kg/EVP d’équivalents-CO_2;
- 0,48 kg/EVP de $NO_{x;}$
- 0,32 kg/EVP de $SO_{x;}$
- 0,04 kg/EVP de $PM_{2,5.}$

Ces IRC reflètent la manutention de conteneurs dans l’ensemble des ports de la côte Est et des Grands Lacs, et non dans un terminal en particulier. Des indicateurs similaires ont été établis pour la manutention de marchandises diverses et un certain nombre de marchandises solides en vrac (p. ex., le minerai de fer, le grain). Les IRC peuvent être utilisés pour déterminer l’empreinte complète des marchandises pendant leur déplacement de leur point d’origine à leur destination en les associant à des indicateurs basés sur la distance pour un moyen de transport donné (p. ex., kg/tonne-km). Toutefois, il a aussi été suggéré que les IRC pouvaient être utiles aux ports et aux terminaux de la côte Est et des Grands Lacs pour établir des points de référence et faire le suivi de leur rendement en matière d’environnement. Des IRC propres à un port ou à un terminal peuvent être utilisés à cette fin.

Bien que des initiatives importantes de réduction des émissions aient été élaborées dans les ports de la côte Est et des Grands Lacs, réduire la consommation d’énergie et les émissions de GES demeure un défi de taille. Le modèle de l’OIEP et les inventaires des ports sont en accord avec les meilleures pratiques existantes en matière d’évaluation des émissions dans le secteur maritime et portuaire; de plus, ils sont conformes au Protocole de l’inventaire des émissions des ports de Transports Canada, qui a effectué des travaux considérables pour l’élaboration du protocole et du logiciel de l’OIEP depuis 2008. La réalisation de l’inventaire des ports de la côte Est et des Grands Lacs et de l’inventaire des ports de la côte Ouest (lequel est décrit dans un rapport distinct de Transports Canada) permet au gouvernement du Canada de bien comprendre les activités, les sources d’énergie et les émissions associées au commerce de marchandises dans les 18 ports officiels du Canada.

TABLE OF CONTENTS

APPENDICES

Page

IN-TEXT FIGURES

Page

IN-TEXT FIGURES (Cont'd)

IN-TEXT TABLES

Page

IN-TEXT TABLES (Cont'd)

Page

IN-TEXT TABLES (Cont'd)

Page

IN-TEXT TABLES (Cont'd)

TABLE OF ABBREVIATIONS

CAC	Criteria air contaminants
CHE	Cargo handling equipment
CH_4	Methane
CN	Canadian National (Rail)
CO	Carbon monoxide
CO_2	Carbon dioxide
CPR	Canadian Pacific Rail
DPM	Diesel particulate matter
EC	Environment Canada
EC/GL	East Coast/Great Lakes
ECA	Emissions control area
EPA	Environmental Protection Agency (US)
ERI	Emission reduction initiative
GHG	Greenhouse gas
GJ	Gigajoule (10^9 joules)
GWP	Global warming potential
HAP	Hazardous air pollutants
IPCC	Intergovernmental Panel on Climate Change
KPIs	Key performance indicators
kWh	Kilowatt-hour
NH3	Ammonia

TABLE OF ABBREVIATIONS (Cont'd)

NO_x	Nitrogen oxides
N_2O	Nitrous oxide
OGV	Ocean going vessel
PAH	Polycyclic aromatic hydrocarbons
PEIT	Port Emissions Inventory Tool
PM	Particulate matter
PMV	Port Metro Vancouver
ppm	Parts per million
RAC	Railway Association of Canada
RTG	Rubber-tired gantry (crane)
SNC-Lavalin	The Environment & Water business unit of SNC-Lavalin Inc.
SO_x	Sulphur oxides
TC	Transport Canada
TEU	Twenty-foot equivalent
VOCs	Volatile organic compounds

1.0 INTRODUCTION

The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) was contracted by Transport Canada (TC) to complete a 2010 activity and emissions inventory for the East Coast/Great Lakes (EC/GL) ports identified under the Canada Marine Act: Ports of Belledune, Halifax, Hamilton, Montreal, Oshawa, Quebec, Saguenay, Saint John, Sept-Iles, St. John's, Thunder Bay, Toronto, Trois-Rivières, and Windsor (1). The inventory is based on the four primary source groups: Marine Vessels; Cargo Handling Equipment (CHE); Rail and Onroad Vehicles; and additionally accounts for Administration sources at the port authorities and the tenant terminals. In addition to a 2010 inventory, forecasts were prepared for 2015, 2020, and 2025, accounting for expected commodity growth at the ports as well as documented fuel and emission regulations for the sector. The inventory was completed by updating and using TC's Port Emissions Inventory Tool (PEIT), which is an MS ACCESS oriented database linked to MS EXCEL data sheets that are completed for each port terminal and port authority.

The goal of the project is to provide a comprehensive accounting of the equipment, activities, fuels consumed, and emissions released for each of the ports. The inventories will facilitate effective air quality management by exploring the potential for emission reduction initiatives. To this end, past and planned (future) emission reduction initiatives at the ports were quantified during the project.

This inventory benefits from previous work completed for Environment Canada. Marine activities and emission estimates for the EC/GL were available from Canada's 2010 National Marine Inventory (2). Although port ship call data were obtained from each of the 14 port authorities, the National Inventory data were used to evaluate and complement the port data. As the port authority data contained higher spatial resolution than the National Marine Inventory data for several of the eastern ports, Canada's National Marine Emissions Inventory Tool (MEIT, V4.0) was updated as part of this study to better reflect the actual vessel movements in harbour areas.

The inventory includes activities, energy consumption, and emissions allocated to five main source groups, including:

- Marine Vessels – ocean going vessels as well as harbour vessels such as tugboats.
- CHE – dockside equipment used to move cargo.
- Onroad Vehicles – Highway Vehicles and Facility Vehicles used on and off terminal grounds.

- Rail – Facility Locomotives and Provincial/National Locomotives used on and off terminal grounds.
- Admin – building and compound energy use and emissions.

The inventory does not include the activities and emissions associated with the processing of goods (e.g., lumber or steel production/processing). As well, fugitive emissions associated with the storing and handling of goods at port terminals are not included (e.g., volatile organic compounds [VOC] releases from tanks, dust emissions from coal stockpiles). These emissions are addressed through other initiatives, such as Canada's National Pollutant Release Inventory (NPRI).

The energy and emissions included in the inventory are as follows:

- Energy:
  - Electricity, natural gas, propane, gasoline, and diesel.
- Criteria Air Contaminants (CACs):
  - Nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM, as total PM, PM_{10} and $PM_{2.5}$, as well as elemental, organic and sulphate fractions), and ammonia (NH_3).
- Greenhouse Gases (GHGs):
  - Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
  - Equivalent carbon dioxide (CO_2e).
- Air Toxics:
  - Diesel particulate matter (DPM), benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic aromatic hydrocarbons (PAHs), metals, dioxins/furans, and additional hazardous air pollutants (HAPs).

Contrary to previous port emission inventories developed in Canada, fugitive emissions of VOCs from ships were included to the emission estimates. While the great majority of emissions in the inventory relate to combustion sources, fugitive VOC emissions from ships constitute a large portion of the total VOCs released from ships. These estimates are consistent with MEIT and the 2010 National Marine Inventory. They largely relate to ship loading or unloading of fuels at berth. As noted above, additional fugitive VOC emissions that may be released from the storage of fuels at the terminals are not included. The fugitive marine VOC estimates should be considered preliminary and are not as well detailed (or accurate) as the combustion estimates. This is further discussed in Appendix I.

The CO_2e amounts are consistent with the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (3). As such, 1, 21 and 310 are applied for the global warming potential (GWP) of CO_2, CH_4 and N_2O, respectively.

1.1 Reporting Protocols

Activity and emissions reporting for the project is consistent with the Transport Canada Ports Emissions Inventory Protocol (4) (Protocol). Most importantly, the Protocol establishes two emission inventory (EI) boundaries of significance to the project, as defined below:

a) Terminal/Facility Boundary – a port terminal or facility property that is directly managed by a port or port tenant. This boundary is usually defined by clear features, including the facility gate. Any marine berths that are part of the Terminal/Facility are included.

b) Port Boundary – all landside and waterside areas managed by the port where port related marine, CHE, rail or truck activity may occur. This boundary includes the port marine jurisdiction and all port landside property. Some of which may be privately held.

These boundaries are further identified in Figure 1-1.

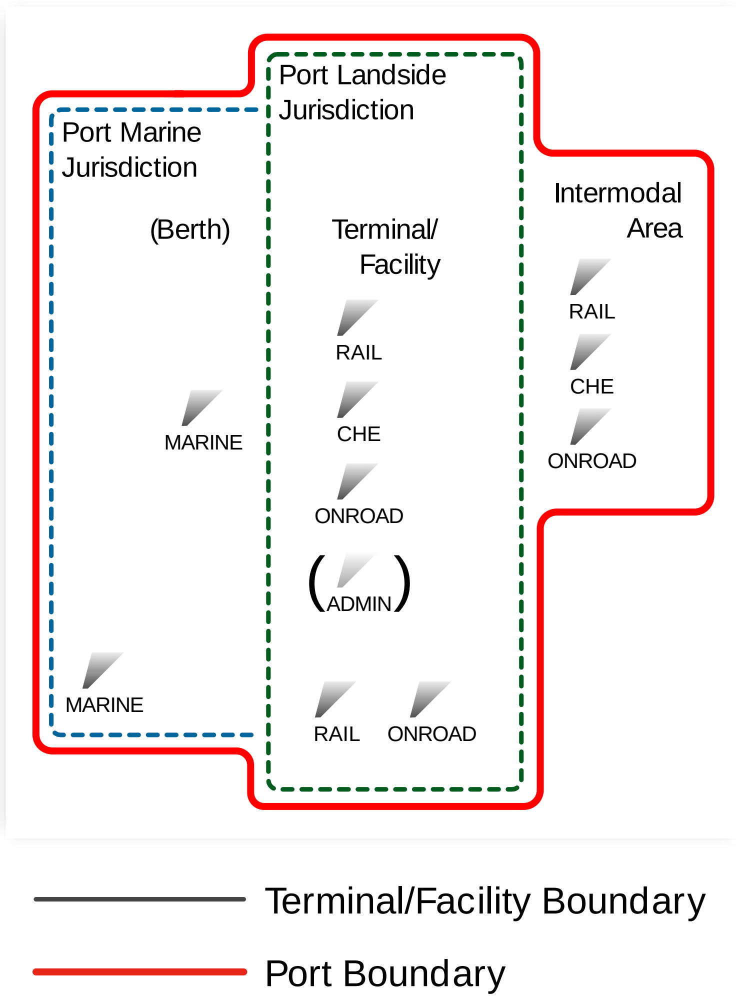


Figure 1-1: Port Protocol Boundaries

Note: In many cases, the Terminal/Facility Boundary and the Port Boundary on the landside are identical. Differences tend to exist for large ports that may own lands adjacent to the terminals or may have intermodal areas where modal shifts occur.

1.2 Conversion Rates

Many unit conversions were necessary to accept the terminal data to PEIT and to allow for consistent reporting. Most of these conversion rates are internal to PEIT and are used to allow the terminal representatives some flexibility in reporting. It is expected that this flexibility reduces the likelihood of reporting error due to conversions that would otherwise be accomplished by many different people. Conversion rates are also used to allow equivalent comparison of the different forms of energy used at port facilities. Energy summaries presented in Chapter 2 are listed by the common units used for each fuel and by energy content (joules). All conversion factors used for the inventories are provided in Appendix II.

1.3 Transport Canada Port Emissions Inventory Tool (PEIT)

PEIT was updated to Version 3.1 for this project. A model schematic is shown in Figure 1-2. The PEIT consists of an MS ACCESS database and an MS EXCEL data questionnaire. For an individual port, each terminal (or tenant) is expected to complete a data questionnaire. The database is programmed to import the port tenant data questionnaires, calculate emissions and provide activity and emission summaries in a pivot table format. Figure 1-3 provides a representation of a marine terminal with the five main source groups. Additional information on the scope and function of PEIT is provided in Appendix I.

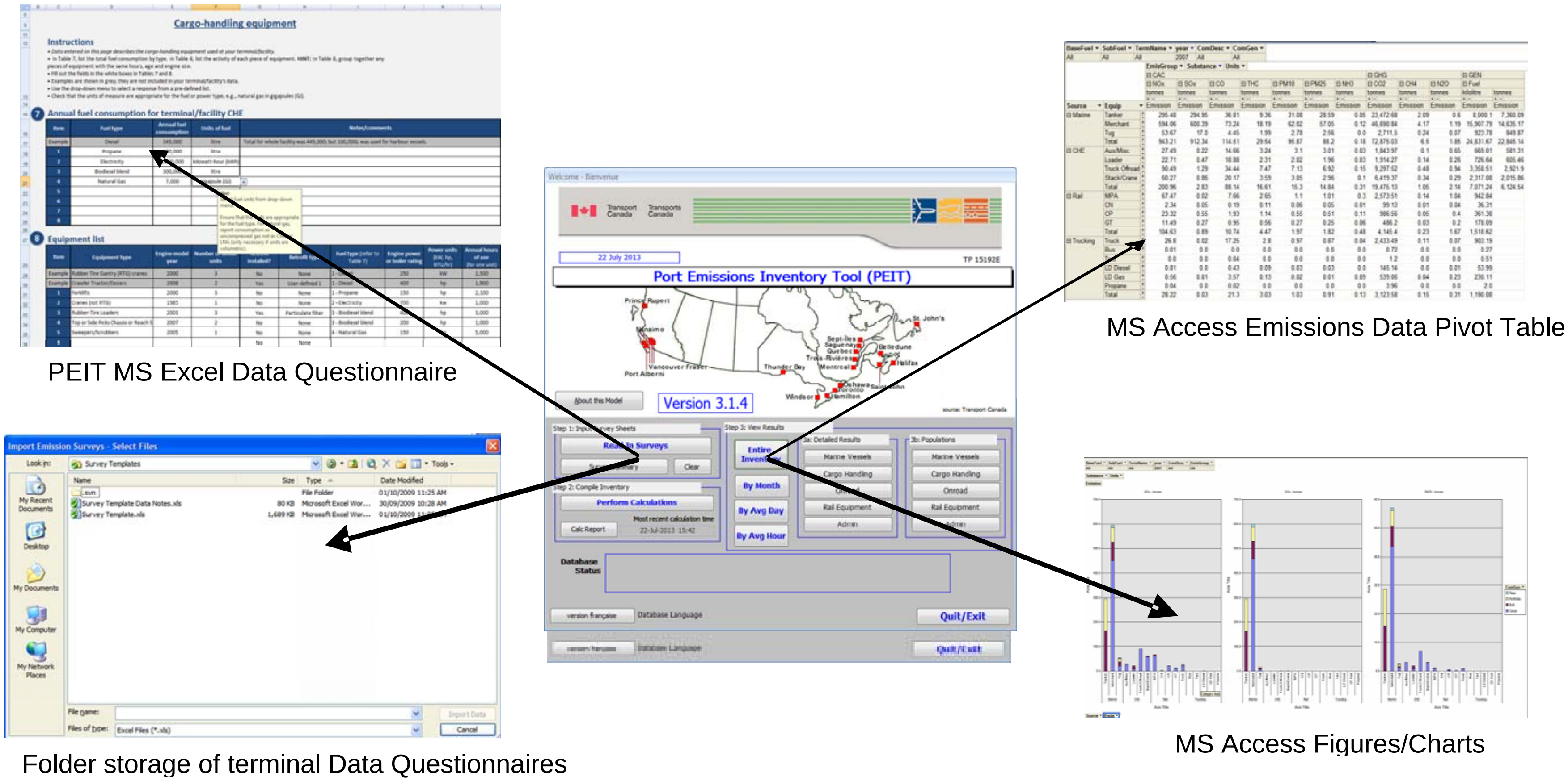


Figure 1-2: PEIT Schematic, Version 3.1

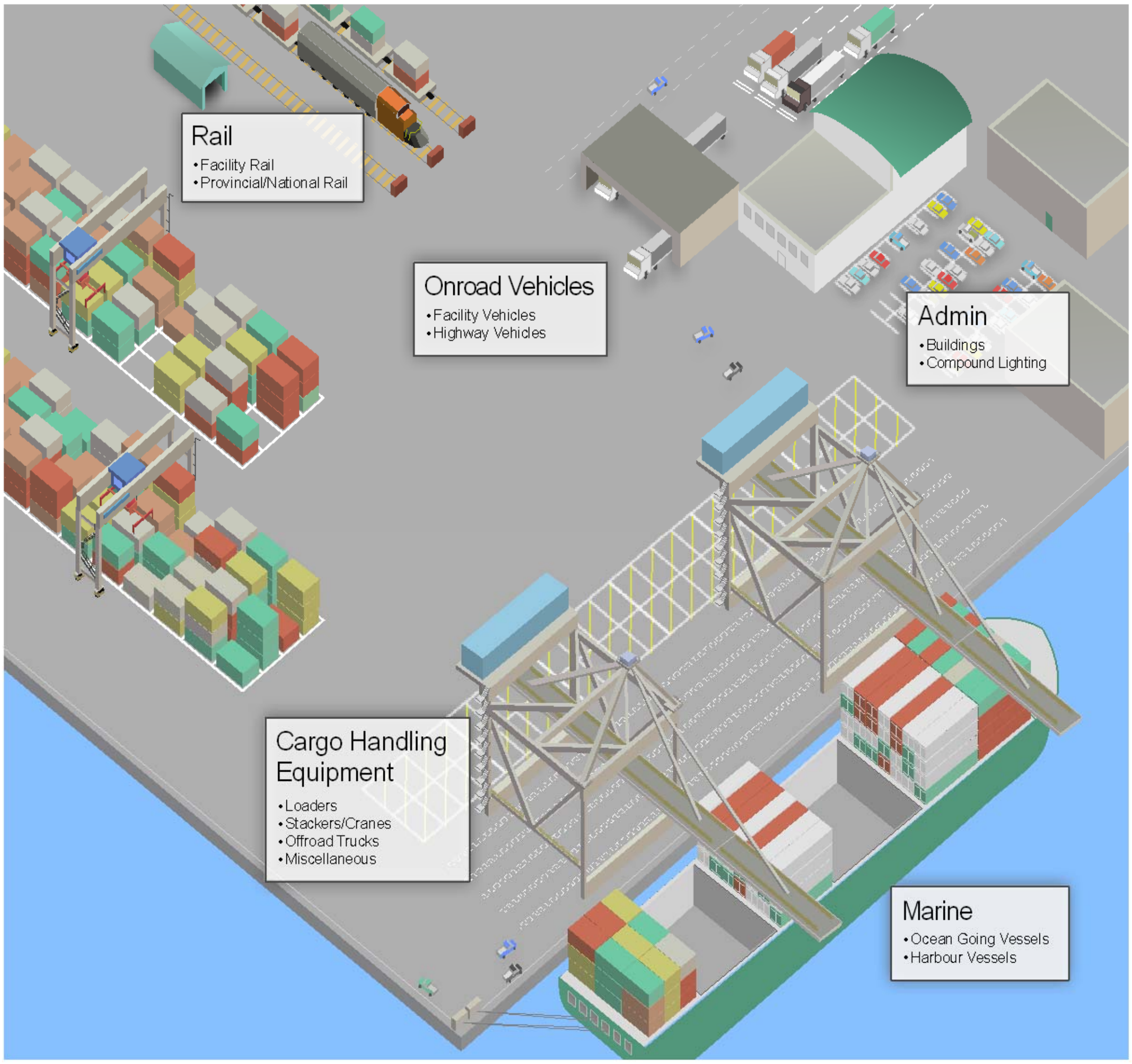


Figure 1-3: Five Source Groups Included in a Port Emissions Inventory. Graphic based on PMV's 2010 Landside Emissions Inventory (5)

1.3.1 *Limitations of PEIT and the Port Emission Inventories*

The methods used in PEIT are representative of current best practices, as identified in Appendix I. However, there are limitations to the model beyond the limitations that are commonly associated with use of emission rates and emissions models (i.e., how well a particular engine in operation relates to the emissions test data that are used to represent the engine). These limitations are associated with assumptions that are applied in PEIT due to lack of available data. These limitations are noted below:

- Use of assumed ship and locomotive speeds. While fuel consumption data is available for terminal-based equipment (including CHE, onroad vehicles and facility rail), it is not available for ships and trains that visit the terminal. Assumed speeds must be used for the ships that move through the harbour areas, in order to estimate engine loads, fuel consumption, and emissions. Similarly, assumed speeds must be used for train movements to and from terminals (for those ports that choose a Port Boundary that extends beyond terminal gates). These speeds are reasonable for average port operations, but would not reflect differences that may exist from port to port.
- Allocation of aggregated fuel/energy data records to specific source groups. In some cases, terminals have fuel or energy consumption records that involve more than one source group. An example would be electricity consumption that relates to both CHE use as well as administration (buildings). For these cases, the terminal representative was asked to allocate the data as appropriate.
- Use of assumed fuel sulphur content for cargo ships. While information is available to identify the fuels composition for those fuels purchased in Canada and North America, diesel fuel for international cargo ships is purchased from many different countries. The fuel sulphur content attributed to cargo ships and their engines/boilers stems from previous ship survey efforts that have been conducted in Canada.

Additional data uncertainty issues are addressed in Chapter 2.

1.4 Complementary Data Sources and Models

1.4.1 Environment Canada National Marine Inventory for 2010

The Environment Canada (EC) National Marine Emissions Inventory for 2010 (2) was developed from several data sources, including:

- Coast Guard INNAV ship movement data (vessel ID, position, time).
- Pacific Pilot ship data (vessel ID, position, time).
- Lloyds Sea-web ship characteristic data (ship engine type, power rating).
- Vessel emission rates and vessel profiles for average engine/boiler usage patterns.

The Coast Guard ship movement data for the EC/GL derives from a number of sources; including coastal radar and automatic identification system (AIS) receivers; as well as dead reckoning reports (manual positioning of ships in the data tracking system). The INNAV system reconciles all these data points to consistent voyage summaries with origin, destination, and many way points throughout Canada's waterways. Several of the port areas in EC/GL did not have radar or AIS receiver stations in 2010 and therefore the INNAV voyage summaries did not include spatially allocated berth locations. For the affected ports, the ship voyages were found to end at a central point within the port harbour rather than at specific terminals. The port authority ship call data (which clearly identifies the berth locations) was used to re-position the vessel berth locations in MEIT to ensure the port inventories and National Marine Inventory are consistent.

In some cases, a port or port tenant was able to provide additional data to that available from the National Marine Inventory (for example, tugboat activity data). In these cases, the additional data were added to PEIT.

The National Marine Inventory also includes forecast commodity data for eastern Canada. These commodity forecasts were used for the PEIT forecasts, as described in Chapter 5.

1.4.2 Port Metro Vancouver (PMV) Landside Emissions Inventory (LEI)

The recently completed 2010 PMV LEI model (5), which is similar in nature to PEIT, was used as a basis for completing some of the updates for PEIT Version 3.1. Permission to use the new LEI features was granted by PMV. The PMV report has an expanded discussion of port inventory forecasts that provides additional context for the forecast methodologies employed for this study.

1.5 EC/GL Ports

Fourteen EC/GL ports are included in the assessment, as identified in Figure 1-4 and Table 1-1. Of the 14 ports, Montreal is the largest, by total annual throughput as well as number of terminals.

Figure 1-4: Location of EC/GL Port Authorities

Table 1-1: Distribution of Marine Terminals at EC/GL Ports

Port	Auto	Breakbulk	Bulk Liquid	Bulk Solid	Containers	Passengers	Other	Total
Belledune	0	0	0	3	0	0	2	5
Halifax	1	1	3	3	2	1	2	13
Hamilton	0	1	4	10	0	0	1	16
Montréal	0	0	7	6	4	1	3	21
Oshawa	0	1	1	1	0	0	1	4
Québec	0	0	3	8	0	0	2	13
Saguenay	0	0	1	1	0	1	0	3
Saint John (NB)	0	2	3	3	1	1	1	11
Sept-Îles	0	3	2	8	2	0	2	17
St. John's (NL)	0	0	2	2	1	1	3	9
Thunder Bay	0	1	2	11	0	1	2	17
Toronto	0	0	0	8	0	2	0	10
Trois-Rivières	0	1	1	3	0	1	2	8
Windsor	0	0	1	8	2	0	3	14
TOTAL	**1**	**10**	**30**	**75**	**12**	**9**	**24**	**161**

The Containers commodity type is largely associated with the international trade associated with containerized goods, but (for some ports) may also include trailer handling facilities associated with (for example) dangerous goods. The “Other” category of marine terminal includes tug operators, ship yards, and rail yards. The total annual throughput for each of the ports is shown in Table 1-2 for 2010, by major commodity type.

Table 1-2: Commodity Throughput for the EC/GL Ports in 2010

Port	Auto (tonnes)	Breakbulk (tonnes)	Bulk Liquid (tonnes)	Bulk Solid (tonnes)	Containers (tonnes)	Passengers
Belledune	0	108,800	45,000	1,903,600	0	0
Halifax	264,800	141,600	6,083,300	1,914,000	425,000	261,200
Hamilton*	0	228,200	1,105,000	9,872,000	0	0
Montréal	67,800	37,000	16,537,600	6,073,400	1,331,300	71,000
Oshawa	0	128,000	24,000	93,600	0	0
Québec	2,600	22,000	18,919,700	7,959,500	2,600	0
Saguenay	0	129,200	70,000	172,500	0	19,600
Saint John (NB)	15,000	89,600	13,821,700	1,103,300	50,000	205,900
Sept-Îles	0	900,200	411,600	24,049,600	4,900	0
St. John's (NL)	30,000	10,000	485,500	103,700	80,600	12,900
Thunder Bay	0	11,000	229,300	6,545,000	0	5,000
Toronto	0	0	0	2,008,200	2,400	22,400
Trois-Rivières	0	98,800	300,000	3,019,800	0	20,000
Windsor	0	0	86,100	4,755,100	20,000	0
TOTAL	**380,200**	**1,904,500**	**58,118,800**	**69,573,600**	**1,916,800**	**618,100**

* - the total Tonnage for the Port of Hamilton for 2010 was reported by the Hamilton Port Authority was 11,472,831 and any discrepancies may be due to terminals tracking some cargo that was not transported by vessel.

The inventory boundaries ("Port Boundary" as identified in Figure 1-1) for each port are shown in Figures 1-5 to 1-18. These boundaries were chosen in consultation with each port authority (6) and largely relate to each port's waterside jurisdiction.

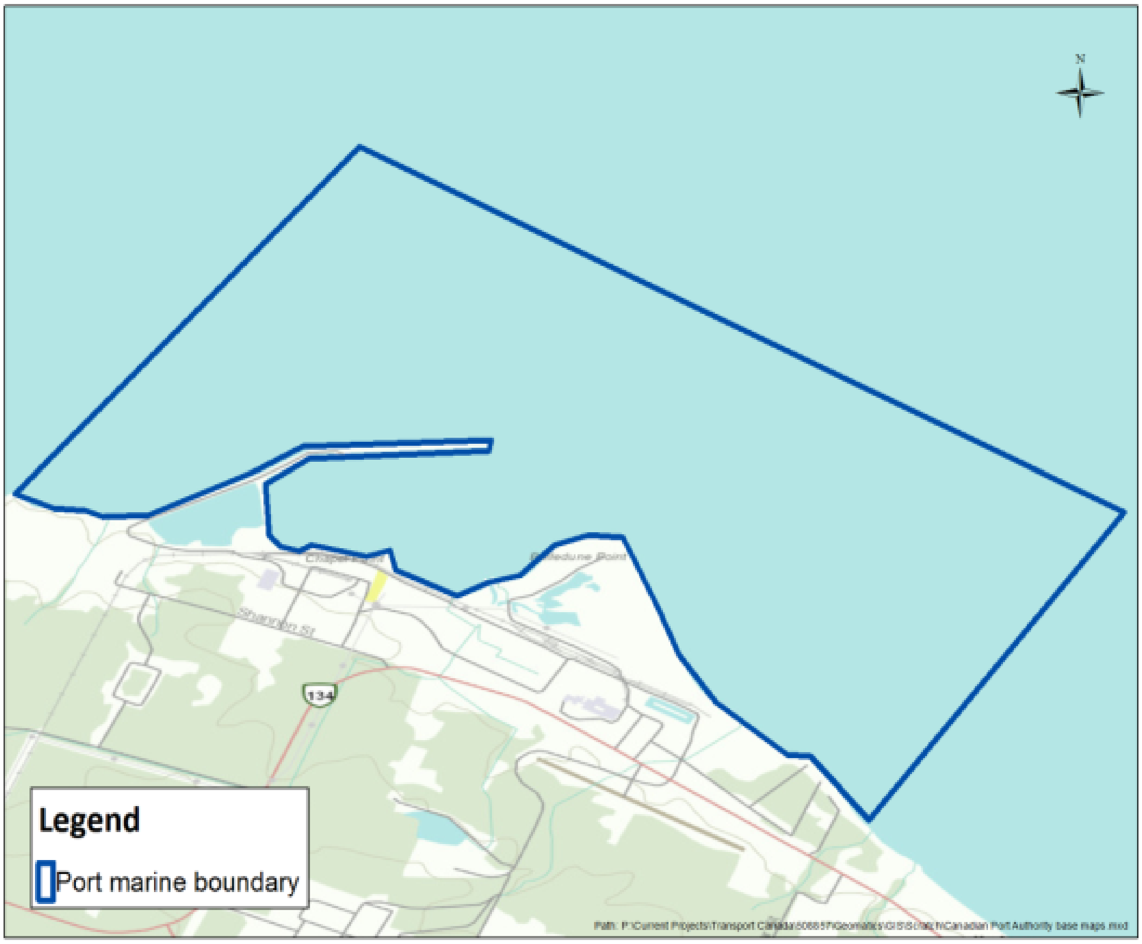


Figure 1-5: Port Marine Boundary for Port of Belledune

Figure 1-6: Port Marine Boundary for Port of Halifax

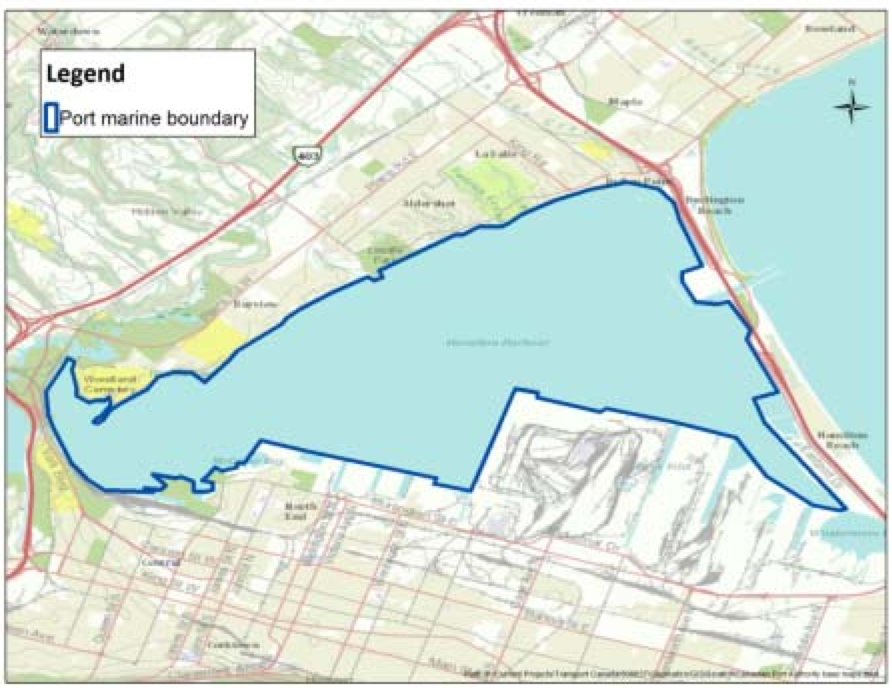


Figure 1-7: Port Marine Boundary for Port of Hamilton

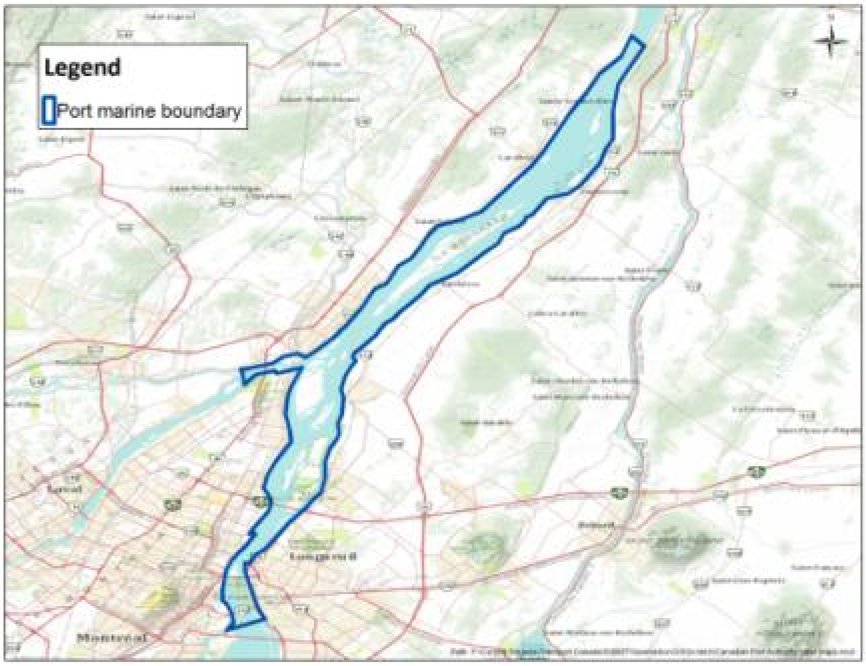


Figure 1-8: Port Marine Boundary for Port of Montreal

Figure 1-9: Port Marine Boundary for Port of Oshawa

Figure 1-10: Port Marine Boundary for Port of Quebec

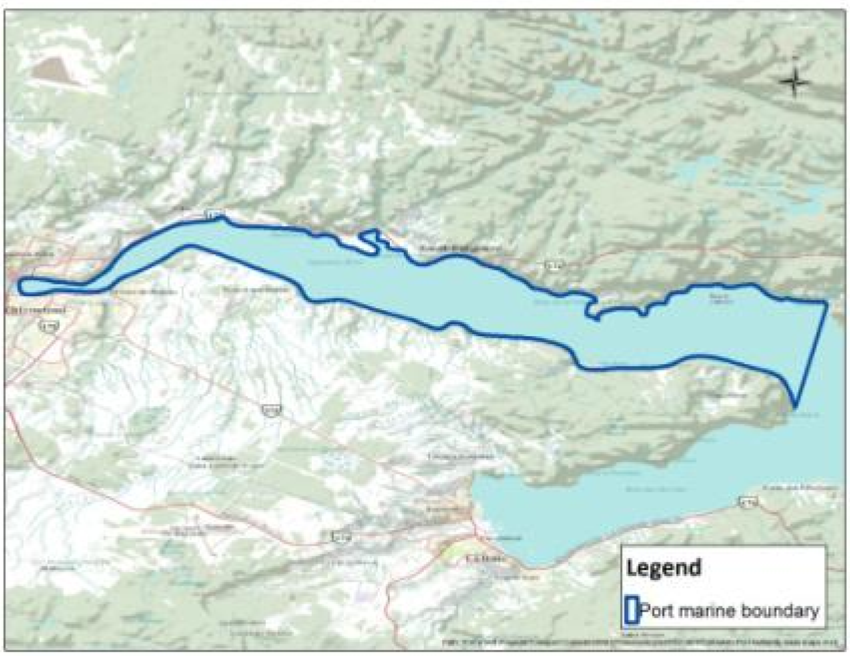


Figure 1-11: Port Marine Boundary for Port of Saguenay

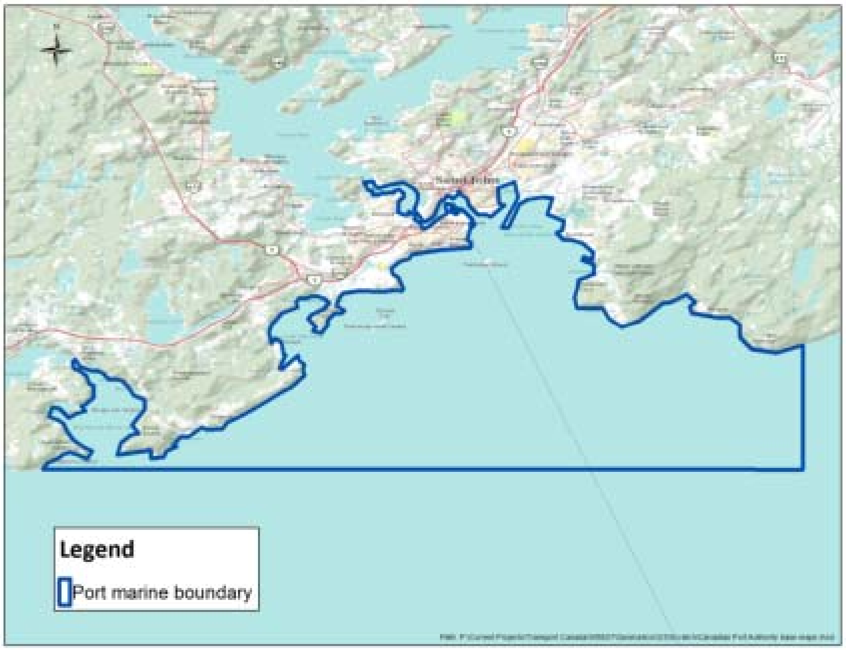


Figure 1-12: Port Marine Boundary for Port of St. John

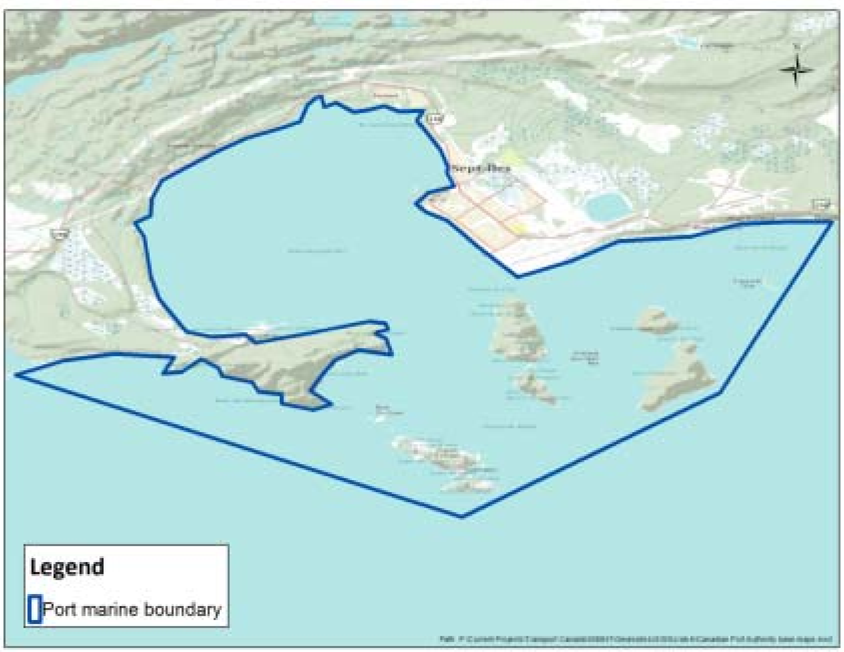


Figure 1-13: Port Marine Boundary for Port of Sept Iles

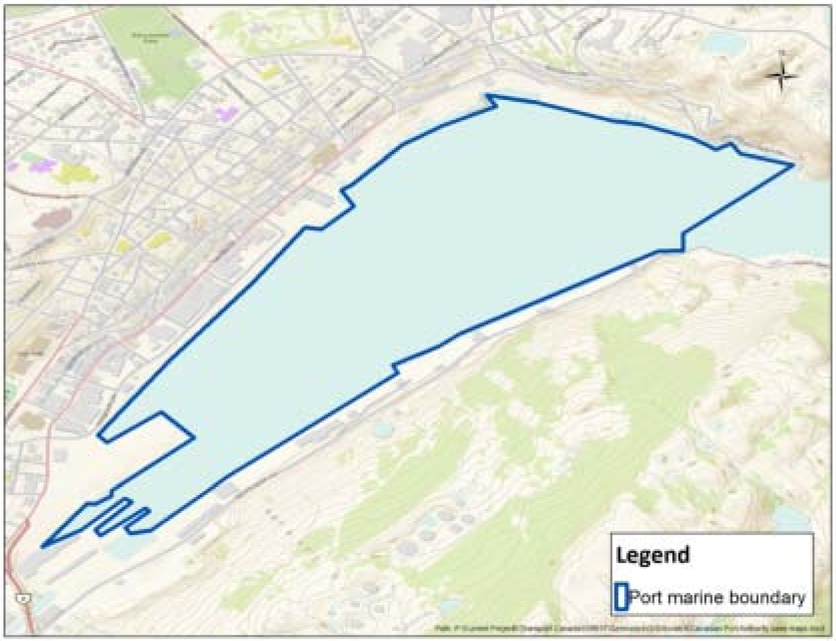


Figure 1-14: Port Marine Boundary for Port of St. John's

Figure 1-15: Port Marine Boundary for Port of Thunder Bay

Figure 1-16: Port Marine Boundary for Port of Toronto

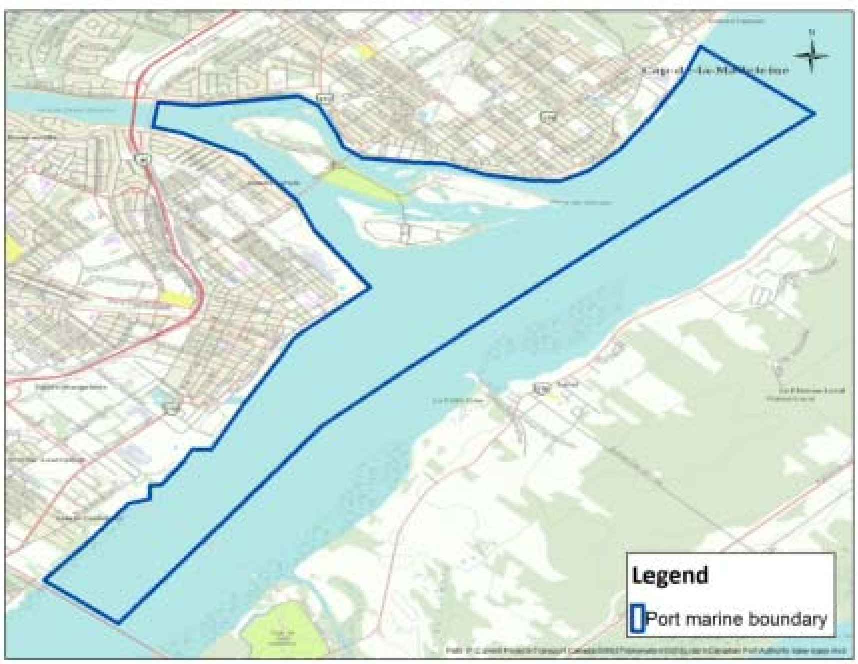


Figure 1-17: Port Marine Boundary for Port of Trois Rivières

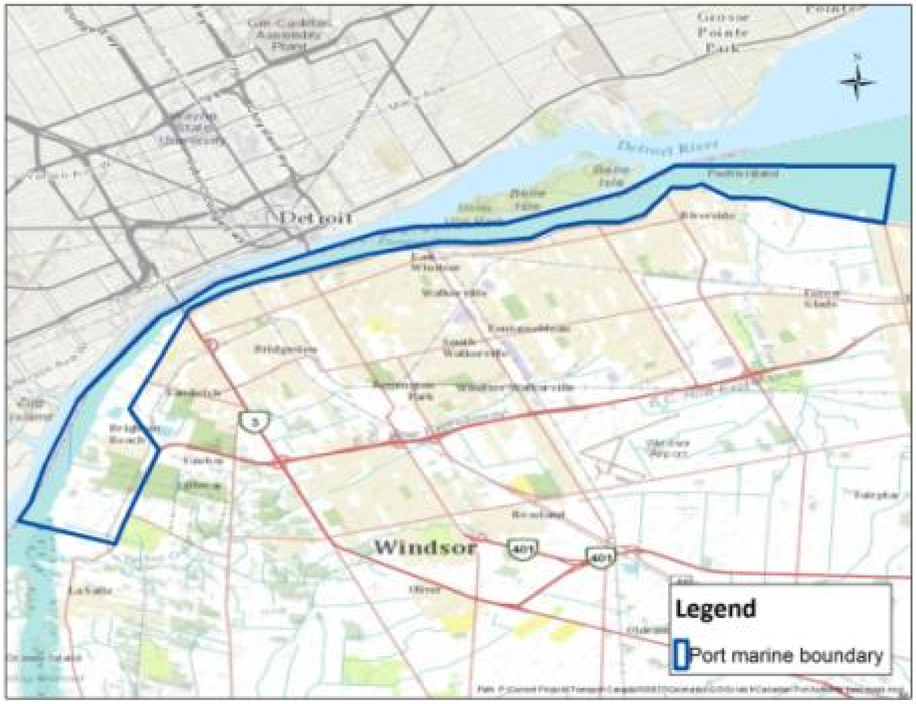


Figure 1-18: Port Marine Boundary for Port of Windsor

1.6 Report Outline and Format

This report includes the following sections:

1) Introduction
2) Data Quality and Data Gaps
3) 2010 Activity and Emissions by Source Group
4) Port Emission Summaries
5) Forecasts
6) Emission Reduction Initiatives
7) Conclusion

To facilitate the reading of table data, those tables that have data associated with the Terminal/Facility Boundary use headings in a light blue colour with black text ( ); tables dealing with the Port Boundary have table headings in a dark green colour with white text ( ).

2.0 DATA QUALITY AND ALLOCATION METHODS

2.1 Activity Data

Activity data such as hours of engine use or distance of travel are used as the basis for the emissions calculations. In all cases, the best available source of activity data is leveraged in PEIT. Where possible, this data is supported by annual fuel consumption data from records kept by the port terminals. In some cases (e.g., Admin sources), fuel and energy consumption data is expected to be very accurate due to availability of invoices or receipts from the energy providers. In other cases, estimates were made based on records that did not coincide with the calendar year or records that relate to two separate source groups that utilize the fuel. The terminal representatives were asked to make these estimates where necessary. The main activity measures for each of the source groups are identified below:

- Marine: distance of travel (harbour movements) and time at berth. No fuel consumption data is available (with the exception of tugboats and port-owned harbor craft).
- CHE: hours of engine use over the year. Total fuel(s) consumption was also collected for each terminal.
- Rail: hours of engine use over the year. Total fuel consumption data was also collected for locomotives directly operated by a terminal or port (Facility Locomotives).
- Onroad Vehicle: distance of travel over the year. Total fuel consumption data was also collected for vehicles directly operated by a terminal or port (Facility Vehicles).
- Admin: annual fuel and energy consumption over the year.

In all cases, additional source information was collected to fully utilize the available emissions data. This included identification of fuel type and quality; engine type and age; and engine or emission retrofit (if used).

2.1.1 Port Terminal Representatives and Data Requests

Although there was variation from port to port, the data collection process for an individual port began with communication between SNC-Lavalin and a port authority representative (typically a representative responsible for environmental issues) to review the scope of port operations and to determine an appropriate time and place for a meeting that ideally would include representatives from all of the port terminals. An in-person meeting was preferred although in several cases a webinar delivery was used instead. The meetings included a presentation with a brief history of port emissions assessment in North America; related efforts by Canadian government and several of Canada's larger ports; and the project goals. The focus of the presentation was the PEIT data questionnaire; why the specific fields are included; and assurance that the information requested was necessary and not superfluous. The ultimate goal of the presentations was to assure the terminal representatives that the data requests were achievable with the data available to them and were as simple as possible.

Data security was additionally addressed at these meetings. Although less of a concern than in prior years during port emissions assessment work in Canada, some of the port terminals are concerned that their specific operations data required for PEIT be made public. Assurances were given that no public reporting would identify terminal-specific activity data or emissions. For this reason, the data summaries provided in this report are limited to port, source group, and commodity type summaries only.

Table 2-1 provides identification of the source of primary data used to characterize the activity of each source group and sub-group as well as comments associated with the terminal representative responses. Large terminal operators tended to have better access to the specific data records required.

Table 2-1: Primary Data Sources for the EC/GL Port Inventories

Source Group	Sub-group	Source of Primary Data	Comments
Admin	Admin	Fuel/Energy Purchases	In several cases, a terminal provided total cost of energy and that was used by SNC-Lavalin to estimate consumption.
CHE	CHE	Fuel/Energy Purchases and Fleet Identification	Large terminals readily had fuel data available whereas small terminals often had to estimate CHE fuels from total terminal consumption. Fleet information was consistently available.
Marine	Harbour Vessels	Fuel Purchases, Fleet Identification	Operators consistently had this data available.
	Ocean Going Vessels	Port Ship Call Records	All ports have this information. It was also verified with Coast Guard data (from MEIT).
Onroad Vehicles	Facility Vehicles	Fuel Purchases, Fleet Identification	Operators consistently had this data available.
	Highway Vehicles	Gate Counts	Large operators consistently had this data available. Some medium and small operators estimated gate counts from annual commodity moved by truck.
Rail	Facility Rail	Fuel Purchases, Fleet Identification	Operators consistently had this data available.
	National/Regional Rail	Annual Train Trips	Operators usually had this data available although in some cases it was estimated from annual commodity moved by train (and average train capacity).

A limitation in the port inventories relates to Highway Vehicles and National/Regional Rail. Although the number of movements is expected to be accurate for the majority of terminals, a representative average time associated with each movement is required for PEIT. This includes an average period queuing at the terminal gate; moving through the yard (Highway Vehicles); and an aggregate time each train is within the terminal.

Having access to data records does not guarantee a proper value is entered to the PEIT questionnaire and several significant errors of this nature were determined during the data collection campaign. In most cases, these errors are not difficult to identify as they tend to be large (e.g., a factor of 10 or more) and therefore discernible through relatively simple quality checks. Small errors of this nature would not be easily found.

Ongoing communication between SNC-Lavalin and the terminal representatives was used to query any entries that appeared atypical. Many changes were made to the initial questionnaire submissions from these discussions. As a final review process for the data collection efforts, each terminal representative was sent a simple summary of his/her annual activities for final review. The template used for this process is provided in Appendix III.

2.1.2 Non-Reporting Terminals

For the EC/GL ports in total, 84% participation was achieved for the 160 terminals. As participation in the port inventory process is voluntary for the port tenants, this was considered a very good participation rate. The reasons for non-participation are varied and include concerns associated with data security. Table 2.2 identifies the number of terminals that did not report their 2010 operations data by completing a PEIT questionnaire, as well as the number of terminals that did complete a questionnaire.

Table 2-2: Summary of Reporting and Non Reporting Terminals, by Commodity Type

Commodity Type	Reporting Terminals	Non Reporting terminals	Total Terminals
Auto	0	1	1
Breakbulk	10	0	10
Bulk Liquid	20	10	30
Bulk Solid	61	14	75
Container	12	0	12
Passenger	8	1	9
Other	21	3	24
TOTAL	**132**	**29**	**161**

In terms of aggregate data collection, the measure of completion is actually much higher than 84% for two reasons: 1) the Bulk Liquid terminals tend to have relatively low landside activity; and 2) In all cases, marine data is available for the non-reporting terminals, both from the port authority records as well as the National Marine Inventory (2). This means that the most significant of the five PEIT source groups (Marine) is well characterized in all cases. As container terminals tend to have the highest landside activity intensities, 100% completion for this commodity type was important to achieve.

As part of the scope of work for the project, estimation methods are required for the non-reporting terminals so that a complete emissions footprint can be established for each port. Estimation methods were developed for the landside sources so that all of the necessary activity fields required by the PEIT questionnaire could be filled in for non-reporting terminals. As fully described in Appendix IV, both primary and secondary activity data for non-reporting terminals were estimated:

- Primary data: these fields include the important measures that govern the terminal emissions for each source group. Examples include total fuel consumption for CHE and total terminal train visits for Rail.
- Secondary data: these fields include the (many) additional measures that are used to refine the emission calculations, such as engine model, size, and age.

Defaults were generated for the primary and secondary data fields by type of commodity/terminal. Primary data defaults are based on the magnitude of the non-reporting terminal in relation to the magnitude of the reporting terminals (defined as annual throughput or annual number of Ocean-Going Vessels (OGVs) calls, depending on data availability). Secondary data defaults are statistically derived from the equipment fleets and operating criteria of the reporting terminals.

2.2 Emissions Data

Emissions data in PEIT stem from large scale emission measurement programs. In the case of CHE and Onroad Vehicles, use of the emissions data is greatly simplified by application of US EPA emission modeling software. PEIT is consistent with the Canadian Port Emission Inventory Protocol, which identifies appropriate emissions data to use in port emission inventories. The source of the PEIT emission rates is identified in Appendix I, which contains the PEIT user guide.

2.3 Allocation Methods

Activities and emissions are allocated to the terminals and source groups by the structure of the PEIT questionnaire forms. Additional allocation to the major commodity types is done to support the forecasting methods used (which rely on commodity forecasts). This allocation is achieved in a relatively simple fashion: each port terminal questionnaire is allocated to the commodity types shown in Table 2-2. In most cases, this is straightforward and the same labelling scheme consistently used by the ports is used. In cases where a terminal may deal with more than one commodity type, the dominant commodity (by mass) is used for the allocation. These cases are few and the terminals in question tend to be relatively small in scale.

There are activities and emissions on the marine side that relate to the operation of the port as a whole. Notably, this includes tugboat activity assisting vessels to berth as well as other movements such as fuel barges. These activities and emissions are allocated to the “other” category of cargo.

3.0 2010 ACTIVITY AND EMISSIONS BY SOURCE GROUP

3.1 Marine Vessels

Marine vessels are classified as either Ocean Going Vessels (OGVs) or Harbor Vessels. OGVs are ships that visit a port terminal to load and/or unload goods. In some cases, OGV activity may include ships that do not carry goods, such as Canadian Coast Guard vessels, Special Purpose government vessels, or fuel supply vessels. Harbour Vessels include: tugboats and pilot vessels that may be used to assist OGVs to berth; and port authority vessels used for operations management.

3.1.1 Marine activity

<u>OGVs</u>

Table 3-1 provides identification of the OGVs that visited the EC/GL ports in 2010, including typical ship characteristics of interest, such as age, deadweight tonnage (DWT), and main engine power rating (maximum continuous rating, or MCR). 2010 ship calls by type of vessel and port are shown in Table 3-2.

Figure 3-1: Container Ships Docked at the Port of Montreal (photo courtesy of Montreal Port Authority)

Table 3-1: 2010 EC/GL Ports OGV Characteristics

Vessel Class	Vessel Type	Number Active in 2010	Average DWT	Average Year of Build	Average Main Engine Power (kW)
Barges	Barge (Self-Propelled)	1	-	-	130
	Barge Bulk Cargo	2	124	1984	1,603
	Barge General	8	124	1985	1,603
	Barge Petroleum	6	124	1990	1,603
	Barge Towed	3	124	1988	1,603
	Barge Derrick	1	124	-	1,603
Fishing Vessels	Factory Ship	2	821	1993	2,062
	Fishery Patrol	1	591	1965	2,505
	Fishing Vessel	33	470	1986	911
	Trawler	13	945	1981	2,112
Merchant Bulk	Merchant Bulk	488	57,393	1995	8,890
Merchant Container	Merchant Container	148	44,042	1998	28,872
Merchant Cruise	Cruise	24	8,357	2000	53,090
Merchant Other	Merchant Auto	29	21,775	2002	15,100
	Merchant Coastal	1	1,314	1961	520
	Merchant General	181	12,857	2000	5,889
	Merchant Ore	3	177,506	1997	15,863
	Merchant Rail/Trailer Ferry	1	3,708	1975	3,206
	Merchant RO/RO	21	15,955	1993	10,708

Table 3-1 (Cont'd): 2010 EC/GL Ports OGV Characteristics

Vessel Class	Vessel Type	Number Active in 2010	Average DWT	Average Year of Build	Average Main Engine Power (kW)
Special Purpose	Dredge	2	1,288	1966	2,268
	Special Purpose	9	8,837	1980	2,982
	Special Purpose Cable VSL	1	4,645	1990	9,855
	Special Purpose Research VSL	8	1,537	1990	3,509
	Special Purpose Training VSl	1	213	1985	1,752
Tanker	Merchant (Tanker)	141	62,016	2003	10,499
	Merchant Chemical	151	30,567	2006	7,621
	Merchant Crude	116	142,972	2004	16,708
	Merchant Gasoline	1	17,998	2007	7,096
	Merchant Ore/Bulk/Oil	7	66,835	1990	10,581
	Tanker	2	-	-	671
	Merchant Liquified Gas	12	91,046	2006	31,618
	Merchant VLCC	1	309,636	1997	25,817
Tugs	Tug	67	1,087	1969	2,161
	Tug Harbour	7	670	1970	1,626
	Tug Ocean	4	2,566	1996	9,980
	Tug Supply	19	2,747	1990	7,876

The OGV characteristics shown in Table 3-1 originate from MEIT, which in turn sources the information from an internal dataset developed from Canadian Coast Guard data and IHS Fairplay Sea-web data (7). The Barge engine criteria relate to an assumed tugboat that would be required to push/pull the barge in each case. Although there are many fishing vessels active on the EC/GL, only one port provided data on their movements within the harbour (St. John's NL). Data for fishing vessel movements in other ports was not available.

The OGVs included in the inventory are those that are related to the port operations in some way and do not necessarily account for all OGV activity within the harbour area. Ferries, warships and Coast Guard ships are not included in the port inventories.

The data show that Cruise and Container vessels have the largest installed main engine capacity. Cruise vessels utilize a diesel-electric system and the "main engine power" noted in Table 3-1 relates to the total installed engine capacity that is used for both onboard energy requirements as well as propulsion. The port inventories do not include ferries that operate throughout B.C.

Table 3-2: Reported 2010 EC/GL Ports OGV Calls by Vessel Type

Port	Merchant Bulk	Merchant Container	Merchant Cruise	Merchant Other	Tankers	Other	Total
Belledune	59	0	0	32	12	15	118
Halifax	76	702	111	218	552	0	1,659
Hamilton	447	6	0	29	50	41	573
Montréal	300	389	16	255	892	0	1,852
Oshawa	13	0	0	1	3	27	44
Québec	437	0	0	24	406	60	927
Saguenay	22	2	9	29	10	0	72
Saint John (NB)	43	60	64	37	565	127	896
Sept-Îles	335	0	0	184	50	10	579
St. John's (NL)	22	109	11	60	40	1,904	2,146
Thunder Bay	421	0	10	36	22	0	489
Toronto	110	0	7	0	0	12	129
Trois-Rivières	64	4	0	44	20	32	164
Windsor	684	2	0	35	7	375	1,103
TOTAL	**3,033**	**1,274**	**228**	**984**	**2,629**	**2,603**	**10,751**

Table 3-3: Reported 2010 EC/GL Commercial OGV Calls by Commodity Type

Port	Auto	Breakbulk	Bulk Liquid	Bulk Solid	Container	Passenger	Other	Total
Belledune	-	-	-	118	-	-	-	118
Halifax	140	52	543	124	679	3	118	1,659
Hamilton	-	65	46	462	-	-	-	573
Montréal	-	-	849	375	481	117	30	1,852
Oshawa	-	26	5	13	-	-	-	44
Québec	-	-	445	482	-	-	-	927
Saguenay	-	-	9	54	-	-	9	72
Saint John (NB)	-	33	661	72	60	-	70	896
Sept-Îles	-	144	47	346	42	-	-	579
St. John's (NL)	-	-	62	1,431	653	-	-	2,146
Thunder Bay	-	12	22	445	-	-	10	489
Toronto	-	-	-	122	-	-	7	129
Trois-Rivières	-	22	-	142	-	-	-	164
Windsor	-	-	450	369	221	63	-	1,103
TOTAL	**140**	**354**	**3,139**	**4,555**	**2,136**	**183**	**244**	**10,751**

Table 3-2 shows that the Port of St. John's has the highest OGV vessel calls for the year. However, this is due to the many fishing vessels included in that port's inventory (fishing vessels are considered optional for a port inventory and may be added if data permits). The fishing vessels appear in the "Other" category of ships in Table 3-2. The vessel calls for each port are re-expressed by commodity type in Table 3-3. As noted in chapter 2, each port terminal is associated with one commodity type.

Total OGV activity for 2010 is presented in Table 3-4 by port as well as type of activity (harbour transit, berth, or anchor). These activity levels are associated with the port directly; only vessels that made a stop to a port terminal during the year are included. For an individual vessel, each terminal visit (port call) is made up of the harbour transit to and from the terminal (with the harbour transit extending as far as the Port Boundary as defined for each port), a period alongside and (if applicable) a period at anchor. In relatively few cases, a vessel stops at more than 1 terminal within a port during a port visit.

Table 3-4: Reported 2010 EC/GLOGV Activity by Port

Port	Harbour Transit		Berth		Anchor	
	Total Time (hrs)	Average per Vessel (hrs)	Total Time (hrs)	Average per Vessel (hrs)	Total Time (hrs)	Average per Vessel (hrs)
Belledune	62	0.5	4,865	41.2	0	0.0
Halifax	2,162	1.3	36,096	21.8	10,321	49.1
Hamilton	485	0.8	17,222	30.1	0	0.0
Montréal	3,265	1.8	79,066	42.7	817	23.3
Oshawa	9	0.2	1,694	38.5	0	0.0
Québec	2,466	2.7	36,654	39.5	1,103	46.0
Saguenay	145	2.0	2,346	32.6	87	14.5
Saint John (NB)	3,046	3.4	29,945	33.4	20,112	60.9
Sept-Îles	1,805	3.0	17,291	29.9	15,354	86.7
St. John's (NL) (with fishing)	572	0.3	149,867	69.8	0	0.0
St. John’s (no fishing)	263	0.3	50,481	51.3	0	0.0
Thunder Bay	106	0.2	21,921	44.8	0	0.0
Toronto	72	0.6	6,110	47.4	0	0.0
Trois-Rivières	306	1.7	8,207	50.0	50	10.0
Windsor	1,094	1.0	26,628	24.1	34	11.5
TOTAL (with fishing)	**15,596**	**1.4**	**437,912**	**40.7**	**47,879**	**60.6**
TOTAL (no fishing)	**15,286**	**1.6**	**338,527**	**35.3**	**47,879**	**60.6**

As previously noted, the port ship call record was considered the primary data source for marine activity. The port records are generally consistent with the Coast Guard data records for berth calls, although slight differences exist for the time alongside (at berth) in many cases. These differences tend to be on the order of minutes and are therefore insignificant to the emission estimates. However, the ports do not collect anchor information in a consistent manner from one port to another. For this reason, MEIT was used to identify all anchoring periods (for the relevant vessels only) that occurred within each port boundary. The anchoring information shown in Table 3-4 was extracted from MEIT and matched with the vessel call data before insertion to PEIT. 6 of the 14 ports have no anchoring activity within their port boundaries. 3 ports have a great deal of anchoring. Montreal is shown to have little anchoring activity; however, vessels tend to occupy vacant berths while awaiting their allocated terminal for this port (8). This may be the case at one or more of the other ports as well.

The Table 3-4 entries for St. John's NL are shown both with fishing vessels included and without. PEIT assumes that fishing vessels do not use their engines at berth, and therefore the berth periods for these vessels do not impact the emission estimates. The OGV activity estimates are re-expressed by commodity type in Table 3-5.

Table 3-5: Reported 2010 EC/GL OGV Activity by Commodity Type

Commodity Type	Harbour Transit		Berth		Anchor	
	Total Time (hrs)	Average per Vessel (hrs)	Total Time (hrs)	Average per Vessel (hrs)	Total Time (hrs)	Average per Vessel (hrs)
Auto	182	1.3	1,181	8.4	133	16.6
Breakbulk	775	2.2	17,411	49.2	352	22.0
Bulk Liquid	6,291	2.0	79,809	25.5	22,845	49.2
Bulk Solid	4,941	1.3	157,862	41.4	22,515	93.8
Container	2,351	1.4	65,320	38.0	1,132	19.9
Passenger	472	1.9	5,409	22.2	214	71.4
Other	272	1.5	11,533	63.0	687	343.6
TOTAL	**15,284**	**1.6**	**338,526**	**35.3**	**47,879**	**60.6**

Harbour Vessels

Harbour vessel movements are dominated by tugs that are used to assist vessels to/from berth as well as to push/pull barges and log booms. Tug activity was collected from the ports (their tenants) directly. For 3 ports, tug activity could not be obtained. In these cases, the tug activity from MEIT and the 2010 National Inventory (2) was extracted and used. These MEIT estimates are relatively simple in nature, constituting 3 hours of tug activity for each OGV visit to the port over the year.

Figure 3-2: Harbour Craft (tugs) at Port of Saint John, New Brunswick.

A summary of the Harbour Vessel activity at the EC/GL ports is shown in Table 3-6. Tanker activity noted in Table 3-6 relates to small craft that are used within the harbour to provide fuel to vessels.

Table 3-6: Reported 2010 EC/GL Ports Harbour Vessel Activity

Vessel Type	Number of Units	Average Year of Manufacture	Average Power Rating (hp)	Total Fuel Consumption (L)
Barge (Self-Propelled)	2	1999	175	21,800
Special Purpose	8	2000	863	260,900
Tanker	8	2000	902	180,300
Tug	50	2000	2,854	6,471,300
TOTAL	**68**	2000	2,311	**6,934,300**

3.1.2 Marine Emissions

Marine vessel emission estimates for the EC/GL ports are provided in Tables 3-7 to 3-9 (to the Terminal/Facility Boundary) and 3-10 to 3-11 (to the Port Boundary). As previously noted, the Terminal/Facility Boundary includes the terminal berths and therefore emissions associated with hotelling (berthing) are also included within this boundary. Barges, fishing vessels, and most types of tugs do not have associated berth emissions and therefore are not included in emissions summaries to the Terminal/Facility Boundary.

The largest portion of the marine emissions is associated with Merchant Bulk ships and the Solid Bulk commodity type. This is the case at both inventory boundaries. Containerships and containerized cargo are also associated with a relatively large portion of the total marine emissions.

Table 3-7: 2010 EC/GL Ports Marine Emission Estimates to the Terminal/Facility Boundary, by Vessel Type (tonnes)

Vessel Class	Vessel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Merchant Bulk	Merchant Bulk	930	828	109	29	89	82	0	74,309
Merchant Container	Merchant Container	629	598	74	20	64	59	0	50,803
Merchant Cruise	Cruise	241	171	26	9	21	19	0	17,352
Merchant Other	Merchant Auto	10	8	1	0	1	1	0	710
	Merchant Coastal	1	1	0	0	0	0	0	132
	Merchant General	192	189	24	6	20	19	0	16,342
	Merchant Ore	13	9	1	0	1	1	0	799
	Merchant Rail/Trailer Ferry	2	2	0	0	0	0	0	145
	Merchant RO/RO	85	78	10	3	8	8	0	6,741
Special Purpose	Dredge	6	0	0	0	0	0	0	312
	Special Purpose	1	0	0	0	0	0	0	58
	Special Purpose Cable VSL	1	0	0	0	0	0	0	53
	Special Purpose Research	2	0	0	0	0	0	0	112
	Special Purpose Training	0	0	0	0	0	0	0	0

Table 3-7 (Cont'd): 2010 EC/GL Ports Marine Emission Estimates to the Terminal/Facility Boundary, by Vessel Type (tonnes)

Vessel Class	Vessel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Tanker	Merchant (Tanker)	251	293	38	26	28	26	0	26,545
	Merchant Chemical	300	310	39	11	33	31	0	26,339
	Merchant Crude	100	99	13	2,328	11	10	0	8,930
	Merchant Gasoline	0	0	0	0	0	0	0	41
	Merchant Liquefied Gas	16	12	2	1	2	1	0	1,200
	Merchant Ore/Bulk/Oil	47	39	5	2	4	4	0	3,351
	Merchant VLCC	2	3	0	23	0	0	0	235
Tugs	Tug Ocean	24	2	3	1	1	1	0	1,762
	TOTAL	**2,851**	**2,643**	**345**	**2,460**	**284**	**261**	**0**	**236,272**

Table 3-8: 2010 EC/GL Ports Marine Emission Estimates to the Terminal/Facility Boundary, by Commodity type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Auto	18	15	2	1	2	2	0	1,333
Breakbulk	127	119	15	4	13	12	0	10,510
Bulk Liquid	605	647	83	2,375	67	61	0	57,171
Bulk Solid	1,008	895	119	45	97	89	0	81,388
Container	756	707	89	24	76	70	0	60,715
Passenger	256	185	27	9	22	20	0	18,651
Other	82	73	9	3	8	7	0	6,503
TOTAL	**2,851**	**2,643**	**345**	**2,460**	**284**	**261**	**0**	**236,272**

Table 3-9: 2010 EC/GL Ports Marine Emission Estimates to the Terminal/Facility Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	35	33	4	1	4	3	0	2,935
Halifax	487	447	59	267	48	44	0	40,105
Hamilton	134	122	16	4	13	12	0	10,827
Montréal	899	869	110	151	91	84	0	75,492
Oshawa	9	9	1	0	1	1	0	783
Québec	314	298	39	838	32	30	0	26,454
Saguenay	27	24	3	1	3	2	0	2,223
Saint John (NB)	291	265	36	1,170	30	27	0	24,443
Sept-Îles	157	141	19	10	16	14	0	12,624
St. John's (NL)	118	92	14	4	10	9	0	9,730
Thunder Bay	183	161	21	6	17	16	0	14,403
Toronto	44	43	6	1	4	4	0	3,801
Trois-Rivières	64	62	8	2	7	6	0	5,470
Windsor	89	77	10	3	8	8	0	6,981
TOTAL	**2,851**	**2,643**	**345**	**2,460**	**284**	**261**	**0**	**236,272**

Table 3-10: 2010 EC/GL Ports Marine Emission Estimates to the Port Boundary, by Vessel Type (tonnes)

Vessel Class	Vessel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Barges	Barge (Self-Propelled)	1	0	0	0	0	0	0	60
	Barge Bulk Cargo	0	0	0	0	0	0	0	5
	Barge Derrick	0	0	0	0	0	0	0	2
	Barge General	1	0	0	0	0	0	0	47
	Barge Petroleum	2	0	0	0	0	0	0	94
	Barge Towed	0	0	0	0	0	0	0	10
Fishing Vessels	Factory Ship	0	0	0	0	0	0	0	0
	Fishery Patrol	0	0	0	0	0	0	0	2
	Fishing Vessel	2	0	0	0	0	0	0	96
	Trawler	0	0	0	0	0	0	0	3
Merchant Bulk	Merchant Bulk	1,315	1,119	147	43	124	114	0	98,358
Merchant Container	Merchant Container	800	712	94	30	80	73	0	58,833
Merchant Cruise	Cruise	292	204	31	10	25	23	0	20,845
Merchant Other	Merchant Auto	15	11	2	1	1	1	0	914
	Merchant Coastal	1	1	0	0	0	0	0	132
	Merchant General	223	212	27	8	23	21	0	18,053
	Merchant Ore	28	18	2	1	2	2	0	1,626
	Merchant Rail/Trailer Ferry	9	7	1	0	1	1	0	558
	Merchant RO/RO	103	97	12	3	10	9	0	8,232

Table 3-10 (Cont'd): 2010 EC/GL Ports Marine Emission Estimates to the Port Boundary, by Vessel Type (tonnes)

Vessel Class	Vessel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Special Purpose	Dredge	6	0	1	0	0	0	0	329
	Special Purpose	17	0	1	1	0	0	0	859
	Special Purpose Cable VSL	1	0	0	0	0	0	0	57
	Special Purpose Research VSL	2	0	0	0	0	0	0	118
	Special Purpose Training VSl	0	0	0	0	0	0	0	1
Tankers	Merchant (Tanker)	421	454	60	32	45	41	0	40,120
	Merchant Chemical	450	460	57	16	49	45	0	37,883
	Merchant Crude	222	200	26	2,373	22	21	0	17,135
	Merchant Gasoline	1	1	0	0	0	0	0	49
	Merchant Liquefied Gas	38	26	4	2	4	3	0	2,490
	Merchant Ore/Bulk/Oil	56	47	6	3	5	5	0	3,920
	Merchant VLCC	3	4	0	24	0	0	0	319
	Tanker	8	1	1	0	0	0	0	532
Tugs	Tug	366	4	31	16	7	7	1	18,915
	Tug Harbour	0	0	0	0	0	0	0	17
	Tug Ocean	25	3	3	1	1	1	0	1,814
	Tug Supply	9	0	1	0	0	0	0	489
	TOTAL	**4,417**	**3,583**	**508**	**2,563**	**401**	**369**	**2**	**332,915**

Table 3-11: 010 EC/GL Ports Marine Emission Estimates by Commodity Type, to the Port Boundary (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Auto	30	24	3	1	3	3	0	1,990
Breakbulk	149	134	18	5	15	14	0	11,685
Bulk Liquid	1,095	1,077	141	2,434	114	105	0	92,861
Bulk Solid	1,430	1,209	161	59	134	123	0	108,003
Container	945	827	110	35	92	85	0	69,640
Passenger	326	224	35	12	27	25	0	23,382
Other	444	87	41	18	16	15	1	25,355
TOTAL	**4,417**	**3,583**	**508**	**2,563**	**401**	**369**	**2**	**332,915**

Table 3-12: 2010 EC/GL Ports Marine Emission Estimates to the Port Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	46	35	5	2	4	4	0	3,465
Halifax	797	653	93	283	74	68	0	59,393
Hamilton	174	133	19	6	15	14	0	13,076
Montréal	1,090	969	129	161	105	97	0	85,359
Oshawa	10	9	1	0	1	1	0	822
Québec	486	374	55	858	43	39	0	35,671
Saguenay	37	30	4	1	3	3	0	2,818
Saint John (NB)	732	601	87	1,211	68	63	0	56,722
Sept-Îles	433	317	45	20	37	34	0	29,431
St. John's (NL)	141	94	16	5	11	10	0	11,010
Thunder Bay	193	164	22	6	18	16	0	14,947
Toronto	47	44	6	2	5	4	0	3,964
Trois-Rivières	110	69	12	4	8	8	0	7,578
Windsor	120	92	13	4	10	9	0	8,659
TOTAL	**4,417**	**3,583**	**508**	**2,563**	**401**	**369**	**2**	**332,915**

Tables 3-13 to 3-15 provide additional information on the total marine vessel emission estimates, allocating the totals to mode of activity (Table 3-13) and source type (Tables 3-14 and 3-15). In this case, source type includes propulsion (main) engine, auxiliary engine, boiler, and "fugitive". Fugitive relates to VOC emissions from cargo (tankers only). Main engines are further allocated to two-stroke and four-stroke designs. Auxiliary engines are exclusively four-stroke.

Table 3-13: Marine Activity by Mode to the Port Boundary*

Activity Mode	NO_x	SO_x	CO	VOC	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Underway	1,068	450	99	86	65	60	1	53,033
Berth	2,851	2,643	345	2,460	284	261	0	236,272
Anchor	498	490	64	17	52	48	0	43,610
TOTAL	**4,417**	**3,583**	**508**	**2,563**	**401**	**369**	**2**	**332,915**

*Terminal/Facility Boundary emissions include the "Berth" mode only.

Table 3-14: Marine Emissions by Source Type to the Terminal/Facility Boundary

Source Type	NO_x	SO_x	CO	VOC	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Auxiliary Engine	2,505	1,541	216	83	211	194	0	143,024
Boiler	346	1,102	129	11	73	67	0	93,248
Fugitive	0	0	0	2,366	0	0	0	0
TOTAL	**2,851**	**2,643**	**345**	**2,460**	**284**	**261**	**0**	**236,272**

Table 3-15: Marine Emissions by Source Type to the Port Boundary

Source Type	NO_x	SO_x	CO	VOC	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Main 2 Stroke Engine	488	226	42	22	33	30	1	16,672
Main 4 Stroke Engine	411	74	37	18	16	15	1	22,480
Auxiliary Engine	3,087	1,912	268	102	262	241	0	177,328
Boiler	432	1,371	162	14	91	84	0	116,435
Fugitive	0	0	0	2,407	0	0	0	0
TOTAL	**4,417**	**3,583**	**508**	**2,563**	**401**	**369**	**2**	**332,915**

3.2 Cargo Handling Equipment

CHE consists of all dockside equipment used to move goods on and off ships as well as to storage or other modes of transport. This source group includes stationary equipment that may be used to support goods handling, such as generators, pumps, or heaters. CHE may be powered by conventional fuels, bio-fuels or bio-fuel blends, or electricity. CHE does not include ship-based loading or ship auxiliary equipment, which is accounted for in the marine source group (through auxiliary engine use).

Figure 3-3: Loaders at the Port of Sept Iles

3.2.1 CHE Activity

CHE equipment populations at the EC/GL ports are shown in Table 3-16, including their main characteristics of interest for the inventory (age, engine power rating, and annual hours of use).

Table 3-16: Reported 2010 EC/GL Ports CHE Populations, by Type

General Equipment Type	Specific Equipment Type	Number of Units	Average Year	Average Power Rating (hp)	Average Reported Annual Hours (per unit)
Aux/Misc	AC\Refrigeration	1,135	2005	10	371
	Aerial Lifts	15	1998	108	256
	Air Compressors	19	1994	95	1,387
	Boilers - Material Transfer	30	1996	776	914
	Conveyors	316	1998	306	1,264
	Electrical Equipment (General, Not Generators)	17	1998	358	1,065
	Gas Compressors	8	1997	17	201
	Generator Sets	47	1997	263	1,683
	Pressure Washers	9	2003	49	300
	Pumps - Water	10	2000	76	1,078
	Signal Boards/Light Plants	4	2001	51	197
	Sweepers/Scrubbers	5	1997	89	223
	Welders	18	1998	197	750
Loader	Crawler Tractor/Dozers	6	2002	341	1,128
	Excavators (normal/adapted for logs)	8	2004	139	680
	Forklifts	407	1995	138	550
	Rubber-Tire Loaders	115	2000	291	1,027
	Skid Steer Loaders (small loaders)	8	1999	77	396
	Tractors/Loaders/Backhoes	55	2003	325	1,373
Stacker/ Crane	Cranes (not RTG)	64	1990	556	1,426
	Reach Stackers	4	1995	295	1,907
	Rubber Tire Gantry (RTG) cranes	47	2001	475	2,147
	Top or Side Picks Chassis or Reach Stackers	73	1998	302	1,520
Trucks Off-road	Off-Hwy Truck (Not registered for Onroad use)	24	2007	108	1,003
	Yard trucks (Hostler, Goats, Terminal Tractors)	248	1999	190	1,379

PEIT is able to address all electrical CHE as well as those consuming fossil fuels. An electric conveyor system is shown in Figure 3-4. A single conveyor system may have several individual motors and the specifications for these motors are often difficult to obtain for the terminal representatives. Although the total electrical consumption of conveyors is characterized reasonably well for the EC/GL ports, the conveyor motors are not (e.g., number, power rating).

Figure 3-4: Conveyor System at Port of Saint John, New Brunswick.

The average annual energy consumption for each type of CHE is shown in Table 3-17, with the total annual energy consumption for the source group also provided. Table 3-18 shows the total CHE energy consumption by commodity type and fuel type; Table 3-19 shows the activities by port.

Table 3-17: Estimated 2010 EC/GL Ports CHE Energy Consumption to the Terminal/Facility Boundary, by Equipment Type*

General Equipment Type	Specific Equipment Type	Number of Units	Annual Average per unit Consumption (GJ)	Total Annual Energy Consumption (GJ)
Aux/Misc	AC/Refrigeration	1,135	13	14,900
	Aerial Lifts	15	82	1,200
	Air Compressors	19	187	3,500
	Boilers - Material Transfer	30	5,834	175,000
	Conveyors	316	452	143,000
	Electrical Equipment (General, Not Generators)	17	740	12,600
	Gas Compressors	8	16	100
	Generator Sets	47	801	37,600
	Pressure Washers	9	242	2,200
	Pumps - Water	10	1,137	11,400
	Signal Boards/Light Plants	4	14	100
	Sweepers/Scrubbers	5	160	800
	Welders	18	172	3,100
	AUX/MISC TOTAL	**1,633**	**248**	**405,600**
Loader	Crawler Tractor/Dozers	6	1,363	8,200
	Excavators (normal/adapted for logs)	8	327	2,600
	Forklifts	407	124	50,500
	Rubber-Tire Loaders	115	909	104,500
	Skid Steer Loaders (small loaders)	8	108	900
	Tractors/Loaders/Backhoes	55	937	51,500
	LOADER TOTAL	**599**	**364**	**218,200**
Stacker/ Crane	Cranes (not RTG)	64	2,347	150,200
	Reach Stackers	4	15,691	62,800
	Rubber Tire Gantry (RTG) cranes	47	893	42,000
	Top or Side Picks Chassis or Reach Stackers	73	804	58,700
	STACK/CRANE TOTAL	**188**	**1,668**	**313,600**
Truck Off-road	Off-Hwy Truck (Not registered for Onroad use)	24	788	18,900
	Yard trucks (Hostler, Goats, Terminal Tractors)	248	609	151,100

General Equipment Type	Specific Equipment Type	Number of Units	Annual Average per unit Consumption (GJ)	Total Annual Energy Consumption (GJ)
	TRUCK OFF-ROAD TOTAL	**272**	**625**	**170,000**
	TOTAL	**2,692**	**411**	**1,107,300**

* These estimates are also valid to the Port Boundary.

Table 3-18: Estimated 2010 EC/GL Ports CHE Energy Consumption to the Terminal/Facility Boundary, by Commodity Type*

Commodity Type	Diesel (L)	Gasoline (L)	Natural Gas (GJ)	Propane (L)	Electricity (GJ)	All Fuels (GJ)
Breakbulk	455,300	2,600	0	259,000	100	24,400
Bulk Liquid	555,800	0	147,100	3,000	110,300	279,000
Bulk Solid	5,052,400	36,000	0	414,300	170,700	377,600
Container	8,123,600	2,500	0	58,200	105,600	420,900
Passenger	17,900	3,200	0	3,500	300	1,200
Other	37,400	0	0	109,800	0	4,200
TOTAL	**14,242,500**	**44,400**	**147,100**	**847,800**	**387,000**	**1,107,300**

* These estimates are also valid to the Port Boundary.

Table 3-19: Estimated 2010 EC/GL Ports CHE Activity to the Terminal/Facility Boundary, by Port*

Port	Activity by Hours and Estimated Fuel Consumption							
	Aux/Misc		Loader		Stacker/Crane		Truck Offroad	
	Hours	Fuel (GJ)	Hours	Fuel (GJ)	Hours	Fuel (GJ)	Hours	Fuel (GJ)
Belledune	3,300	17,100	3,800	4,600	0	0	700	100
Halifax	9,500	24,700	11,000	9,400	24,500	68,000	4,200	42,000
Hamilton	10,000	4,500	43,300	61,800	1,900	2,000	4,500	17,600
Montréal	120,500	169,500	22,800	52,700	68,500	120,300	22,300	105,500
Oshawa	0	0	5,800	3,400	0	0	0	0
Québec	19,900	54,500	15,700	30,000	2,800	9,500	400	500
Saguenay	0	0	2,600	3,000	400	500	0	0
Saint John (NB)	2,800	15,300	2,900	3,500	1,700	4,800	200	1,700
Sept-Îles	2,700	19,900	5,600	5,600	48,200	71,700	200	100
St. John's (NL)	10,700	9,700	4,000	3,500	7,600	14,100	2,500	2,500
Thunder Bay	2,400	6,200	4,300	10,500	6,600	22,300	0	0
Toronto	7,500	1,900	6,000	6,000	6,500	400	0	0
Trois-Rivières	0	0	7,300	5,400	0	0	300	0
Windsor	8,900	82,300	10,800	19,000	0	0	0	0
TOTAL	**198,200**	**405,600**	**145,700**	**218,200**	**168,700**	**313,600**	**35,200**	**170,000**

* These estimates are also valid to the Port Boundary.

3.2.2 CHE Emissions

CHE emission estimates for 2010 are shown in Tables 3-20 to 3-22 by equipment group, commodity type and port, respectively. These estimates are valid to the Terminal/Facility Boundary and the Port Boundary since CHE exist solely on terminal grounds. CHE emissions tend to be highest for container terminals, due to the significant amount of activity associated with loading and moving containers. Not surprisingly, the port with the highest annual container throughput (Montreal) also has the highest CHE emissions.

Table 3-20: 2010 EC/GL Ports CHE Emission Estimates to the Terminal/Facility Boundary, by Equipment Group (tonnes)*

Equipment Group	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Aux / Misc	42	0	52	5	3	3	1	23,022
Loaders	143	0	121	16	12	11	0	16,669
Stacker/Crane	72	0	25	5	4	4	0	17,562
Truck Off-road	93	0	38	8	8	7	0	13,196
TOTAL	**351**	**0**	**236**	**34**	**26**	**25**	**1**	**70,450**

*These estimates are also valid to the Port Boundary.

Table 3-21: 2010 EC/GL Ports CHE Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)*

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	18	0	33	2	1	1	0	1,776
Bulk Liquid	8	0	7	0	1	1	0	11,864
Bulk Solid	130	0	101	14	11	10	0	22,503
Containers	190	0	79	16	13	13	0	33,947
Passenger	0	0	1	0	0	0	0	79
Other	4	0	13	1	0	0	0	281
TOTAL	**351**	**0**	**236**	**34**	**26**	**25**	**1**	**70,450**

*These estimates are also valid to the Port Boundary.

Table 3-22: 2010 EC/GL Ports CHE Emission Estimates to the Terminal/Facility Boundary, by Port (tonnes)*

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	3	0	3	0	0	0	0	2,749
Halifax	54	0	38	6	3	3	0	18,645
Hamilton	42	0	20	5	3	3	0	6,589
Montréal	156	0	82	14	12	11	1	24,498
Oshawa	3	0	1	0	0	0	0	264
Québec	22	0	10	2	2	2	0	3,051
Saguenay	3	0	5	0	0	0	0	254
Saint John (NB)	6	0	8	1	0	0	0	3,061
Sept-Îles	4	0	9	0	0	0	0	568
St. John's (NL)	17	0	7	1	1	1	0	1,897
Thunder Bay	11	0	6	1	1	1	0	2,015
Toronto	5	0	19	1	0	0	0	611
Trois-Rivières	5	0	12	1	0	0	0	331
Windsor	19	0	13	2	2	2	0	5,917
TOTAL	**351**	**0**	**236**	**34**	**26**	**25**	**1**	**70,450**

*These estimates are also valid to the Port Boundary.

3.3 Rail

Rail includes the national and regional rail lines that bring trains to and from the port terminals (National/Regional Rail) as well as locomotives that are operated by the terminals to position rail cars (Facility Locomotives). Facility Locomotive activity is supported by annual fuel consumption data, whereas fuel consumption data for National/Regional Locomotives is not available (and is therefore estimated).

Figure 3-5: Line haul Locomotive

3.3.1 Rail Activity

Several different locomotive models are used at the EC/GL ports. While all Facility Locomotives can be clearly identified by model type, age, and engine, the National/Regional Locomotives differ for the trains that arrive and depart to the terminals over the calendar year. For this reason, the National/Regional Locomotives were identified from the Railway Association of Canada (RAC) national fleet information (9). PEIT's characterization of National/Regional Rail is further discussed in Appendix I.

2010 Rail activity at the EC/GL ports to the Terminal/Facility Boundary is shown in Table 3-23 by locomotive type and model and in Table 3-24 by commodity type. Table 3-25 provides the total estimated rail activity to the Terminal/Facility Boundary for each port. These estimates are re-expressed to the Port Boundary in Tables 3-26 to 3-28. As previously noted, only the Ports of Hamilton, Montreal, and Toronto have Port Boundaries that differ from the Terminal/Facility Boundaries on the landside.

Table 3-23: 2010 EC/GL Ports Rail Activity to the Terminal/Facility Boundary, by Locomotive Type

Locomotive Type/Model	Annual Activity (hrs)	Annual Diesel Consumption (L)
National/Regional Line Haul	11,300	413,900
National/Regional Switch	10,400	384,300
Facility EMD SD40/GP40	3,900	143,500
Facility GE GP9/SW9	32,800	961,400
Facility MP15DC	23,000	521,800
Facility Rail Car Pusher	37,400	82,100
TOTAL	**118,800**	**2,507,000**

The Facility Rail Car Pusher is shown to have the highest annual activity, but relatively low fuel consumption. These "locomotives" are small engine vehicles that operate on the rail tracks to push cars within the terminal grounds. They tend to be efficient for terminals that deal with relatively few rail cars on a daily basis.

As noted in Table 3-23, the National/Regional Locomotives are distinguished by type of engine. Line haul engines tend to be larger and newer than the switch engines. Both types of engines are characterized in the RAC report (9). The fuel consumption values for National/Regional Locomotive activity were estimated based on the hours of activity and aggregate fuel consumption rates from RAC. For Facility Locomotives, fuel consumption was provided directly. The EC/GL ports of Oshawa, Saguenay, St. John's, and Toronto had no rail activity in 2010 and do not appear in Table 3-25.

Table 3-24: 2010 EC/GL Ports Rail Activity to the Terminal/Facility Boundary, by Commodity Type

Commodity Type	Annual Activity (hrs)	Estimated Diesel Consumption (L)
Breakbulk	2,900	98,500
Bulk Liquid	13,900	326,100
Bulk Solid	74,200	1,360,300
Container	27,800	722,100
TOTAL	**118,800**	**2,507,000**

Table 3-25: 2010 EC/GL Ports Rail Activity to the Terminal/Facility Boundary, by Port

Port	Total Facility Locomotive Activity (hrs)	Total National/Regional Activity (hrs)
Belledune	0	1,600
Halifax	1,100	2,000
Hamilton	6,500	1,500
Montréal	28,200	100
Québec	24,100	4,800
Saint John (NB)	300	600
Sept-Îles	9,500	5,400
Thunder Bay	19,400	3,700
Trois-Rivières	6,700	1,700
Windsor	1,400	300
TOTAL	**97,100**	**21,700**

Table 3-26: 2010 EC/GL Ports Rail Activity to the Port Boundary, by Locomotive Type

Locomotive Type/Model	Annual Activity (hrs)	Estimated Diesel Consumption (L)
National/Regional Line Haul	33,500	1,230,600
National/Regional Switch	10,400	384,300
Facility EMD SD40/GP40	3,900	143,500
Facility GE GP9/SW9	32,800	961,400
Facility MP15DC	23,000	521,800
Facility Rail Car Pusher	37,400	82,100
TOTAL	**141,100**	**3,323,700**

Table 3-27: 2010 EC/GL Ports Rail activity to the Port Boundary, by Commodity Type

Commodity Type	Annual Activity (hrs)	Estimated Diesel Consumption (L)
Breakbulk	3,600	126,100
Bulk Liquid	14,600	351,700
Bulk Solid	75,400	1,403,600
Container	47,400	1,442,500
TOTAL	**141,100**	**3,323,700**

Table 3-28: 2010 EC/GL Ports Rail Activity to the Port Boundary, by Port

Port	Total Facility Locomotive Activity (hrs)	Total National/Regional Activity (hrs)
Belledune	0	1,600
Halifax	1,100	2,000
Hamilton	6,500	3,000
Montréal	28,200	20,800
Québec	24,100	4,800
Saint John (NB)	300	600
Sept-Îles	9,500	5,400
Thunder Bay	19,400	3,700
Trois-Rivières	6,700	1,800
Windsor	1,400	300
TOTAL	**97,100**	**44,000**

Rail activity for the EC/GL ports is largely associated with the Bulk Solid and Container commodities, with the ports of Quebec, Montreal, and Thunder Bay having the highest level of activity for 2010.

3.3.2 Rail Emissions

Rail emission estimates are provided to the Terminal/Facility Boundary in Tables 3-29 to 3-31 by locomotive type, commodity type, and port. These summaries are re-expressed to the Port Boundary in Tables 3-32 to 3-34.

Table 3-29: 2010 EC/GL Ports Rail Emission Estimates to the Terminal/Facility Boundary, by Locomotive Group (tonnes)

Locomotive Group	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Facility	118	0	19	8	3	3	1	5,139
National/Regional	48	0	6	3	1	1	0	2,400
TOTAL	**166**	**0**	**25**	**11**	**4**	**4**	**1**	**7,539**

Table 3-30: 2010 EC/GL Ports Rail Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	5	0	1	0	0	0	0	296
Bulk Liquid	22	0	3	1	1	1	0	981
Bulk Solid	88	0	13	6	2	2	0	4,091
Containers	51	0	8	3	1	1	0	2,172
TOTAL	**166**	**0**	**25**	**11**	**4**	**4**	**1**	**7,539**

Table 3-31: 2010 EC/GL Ports Rail Emission Estimates to the Terminal/Facility Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	3	0	0	0	0	0	0	173
Halifax	5	0	1	0	0	0	0	322
Hamilton	11	0	2	1	0	0	0	508
Montréal	53	0	8	4	1	1	0	2,227
Québec	29	0	4	2	1	1	0	1,364
Saint John (NB)	2	0	0	0	0	0	0	92
Sept-Îles	34	0	4	2	1	1	0	1,430
Thunder Bay	24	0	4	2	1	1	0	1,099
Trois-Rivières	4	0	1	0	0	0	0	274
Windsor	1	0	0	0	0	0	0	50
TOTAL	**166**	**0**	**25**	**11**	**4**	**4**	**1**	**7,539**

Table 3-32: 2010 EC/GL Ports Rail Emission Estimates to the Port Boundary, by Locomotive Group (tonnes)

Locomotive Group	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Facility	118	0	19	8	3	3	1	5,139
National/Regional	89	0	12	5	2	2	1	4,856
TOTAL	**207**	**0**	**30**	**13**	**5**	**5**	**1**	**9,995**

Table 3-33: 2010 EC/GL Ports Rail Emission Estimates to the Port Boundary, by Commodity Type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	7	0	1	0	0	0	0	379
Bulk Liquid	23	0	3	2	1	1	0	1,058
Bulk Solid	90	0	14	6	2	2	0	4,221
Containers	87	0	13	5	2	2	0	4,338
TOTAL	**207**	**0**	**30**	**13**	**5**	**5**	**1**	**9,995**

Table 3-34: 2010 EC/GL Ports Rail Emission Estimates to the Port Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	3	0	0	0	0	0	0	173
Halifax	5	0	1	0	0	0	0	322
Hamilton	13	0	2	1	0	0	0	671
Montréal	92	0	13	6	2	2	0	4,509
Québec	29	0	4	2	1	1	0	1,364
Saint John (NB)	2	0	0	0	0	0	0	92
Sept-Îles	34	0	4	2	1	1	0	1,430
Thunder Bay	24	0	4	2	1	1	0	1,099
Trois-Rivières	5	0	1	0	0	0	0	285
Windsor	1	0	0	0	0	0	0	50
TOTAL	**207**	**0**	**30**	**13**	**5**	**5**	**1**	**9,995**

3.4 Onroad Vehicles

Onroad Vehicles are dominated by heavy duty trucks, but additionally include smaller vehicles that are used in support of terminal operations. Onroad Vehicle activity is separated to Highway Vehicles, for the trucks (and other vehicles) that deliver and pick up goods from the terminals; and Facility Vehicles, for the trucks and smaller vehicles that are used almost exclusively on terminal grounds.

3.4.1 Onroad Vehicle Activity

Highway Vehicles

Highway Vehicle activity at the EC/GL ports to the Terminal/Facility Boundary during 2010 is shown in Tables 3-35 and 3-36. These summaries are re-expressed to the Port Boundary in Tables 3-37 and 3-38. As previously noted, only the Ports of Hamilton, Montreal, and Toronto have Port Boundaries that differ from the Terminal/Facility Boundary on the landside. Information associated with the age distribution of the Highway Trucks is not available since they are operated by a large number of contractors that serve the ports.

Figure 3-6: Container Trucks at Halterm, Port of Halifax

Table 3-35: Reported 2010 EC/GL Ports Highway Vehicle Activity to the Terminal/Facility Boundary, by Commodity Type and Vehicle Type

Commodity Type	Vehicle Type	Total Gate Counts	Total Time on Site (hrs)	Total Idle Time (hrs)	Total Drive Time (hrs)
Breakbulk	Car	15,000	3,800	1,300	2,500
	Heavy Commercial Truck	30,000	19,100	5,700	5,200
Bulk Liquid	Heavy Commercial Truck	74,700	52,200	4,500	4,000
	Light Commercial Truck	600	100	0	0
	Medium Commercial Truck	4,000	500	400	100
	Van / Pickup - small utility	200	0	0	0
Bulk Solid	Heavy Commercial Truck	479,400	261,500	100,500	76,400
	Light Commercial Truck	700	1,300	0	200
	Medium Commercial Truck	39,200	8,400	1,800	2,000
	Van / Pickup - small utility	2,900	700	100	100
Container	Heavy Commercial Truck	606,900	278,400	201,500	48,300
	Van / Pickup - small utility	1,000	1,000	100	100
Passenger	Bus (transit or passenger)	600	100	0	0
	Car	7,000	600	100	0
	Taxi	12,000	1,200	400	800
	Van / Pickup - small utility	100	0	0	0
Other	Heavy Commercial Truck	3,200	3,100	1,600	1,500
	Van / Pickup – small utility	8,000	16,000	3,300	700
	TOTAL	**1,285,400**	**648,000**	**321,300**	**141,900**

The "Car" trips shown in Table 3-35 for Breakbulk commodity are associated with roll-on roll-off (RoRo) terminals that deal in cars. In this case, the cars are not used to transport goods, but are the goods themselves. The "Taxi" trips for Passenger terminals relates to taxis that pick up cruise passengers at the port. This activity was considered optional for a port and therefore this total does not represent all taxi activity associated with the EC/GL ports.

Table 3-36: Reported 2010 EC/GL Ports Highway Vehicle Activity to the Terminal/Facility Boundary, by Port

Port	Total Gate Counts	Total Drive Time (hrs)
Belledune	9,800	300
Halifax	141,000	12,200
Hamilton	155,700	20,200
Montréal	561,900	70,200
Oshawa	5,100	1,000
Québec	62,600	5,100
Saguenay	11,700	1,900
Saint John (NB)	43,000	6,300
Sept-Îles	14,100	1,200
St. John's (NL)	75,300	9,000
Thunder Bay	26,800	3,300
Toronto	58,400	1,900
Trois-Rivières	14,000	1,100
Windsor	105,900	8,200
TOTAL	**1,285,400**	**141,900**

Although the Highway Truck activity is largely associated with heavy duty trucks that frequent the Container and Bulk Solid terminals; cars, taxis, and buses are also associated with the movement of goods (or people) to and from the terminals. The breakdown of Onroad Vehicle activity shown in these data tables (time on site, time at idle and total drive time) represent estimates based on terminal representatives' opinion. In most cases, the gate counts are tracked accurately by the terminals and are not estimates.

Table 3-37: Reported 2010 EC/GL Ports Highway Vehicle Activity to the Port Boundary, by Commodity Type

Commodity Type	Vehicle Type	Total Gate Counts	Total Time on Site (hrs)	Total Idle Time (hrs)	Total Drive Time (hrs)
Breakbulk	Car	15,000	3,800	1,300	2,500
	Heavy Commercial Truck	30,000	19,100	6,700	6,900
Bulk Liquid	Heavy Commercial Truck	74,700	52,200	4,800	8,900
	Light Commercial Truck	600	100	0	0
	Medium Commercial Truck	4,000	500	400	100
	Van / Pickup - small utility	200	0	0	0
Bulk Solid	Heavy Commercial Truck	479,400	261,500	118,300	96,500
	Light Commercial Truck	700	1,300	0	300
	Medium Commercial Truck	39,200	8,400	2,000	4,700
	Van / Pickup - small utility	2,900	700	100	100
Container	Heavy Commercial Truck	606,900	278,400	266,700	101,900
	Van / Pickup - small utility	1,000	1,000	100	100
Passenger	Bus (transit or passenger)	600	100	0	0
	Car	7,000	600	100	0
	Taxi	12,000	1,200	400	1,000
	Van / Pickup - small utility	100	0	0	0
Other	Heavy Commercial Truck	3,200	3,100	2,300	2,800
	Van / Pickup - small utility	8,000	16,000	6,700	4,800
	TOTAL	**1,285,400**	**648,000**	**409,900**	**230,700**

Table 3-38: Reported 2010 EC/GL Ports Highway Vehicle Activity to the Port Boundary, by Port

Port	Total Gate Counts	Total Drive Time (hrs)
Belledune	9,800	300
Halifax	141,000	12,200
Hamilton	155,700	28,400
Montréal	561,900	141,100
Oshawa	5,100	1,000
Québec	62,600	5,100
Saguenay	11,700	1,900
Saint John (NB)	43,000	6,300
Sept-Îles	14,100	1,200
St. John's (NL)	75,300	9,000
Thunder Bay	26,800	3,300
Toronto	58,400	11,400
Trois-Rivières	14,000	1,200
Windsor	105,900	8,200
TOTAL	**1,285,400**	**230,700**

Facility Vehicles

Facility Vehicle activity at the EC/GL ports to the Terminal/Facility Boundary during 2010 is shown in Tables 3-39 and 3-40 by commodity type and port, respectively. These estimates are also consistent with the Port Boundary, since the vehicles do not leave the terminal grounds.

Table 3-39: Reported 2010 EC/GL Ports Facility Vehicle Fuel Consumption to the Terminal/Facility Boundary, by Commodity Type*

Commodity Type	Diesel		Gasoline	
	Vehicle Counts	Consumption (L)	Vehicle Counts	Consumption (L)
Breakbulk	5	312,000	25	58,000
Bulk Liquid	3	24,800	54	229,700
Bulk Solid	26	182,100	90	232,900
Containers	34	399,900	81	449,500
Passenger	12	19,300	27	25,800
Other	31	30,700	77	189,500
TOTAL	**111**	**968,700**	**354**	**1,185,600**

*These estimates are also valid to the Port Boundary.

Table 3-40: Reported 2010 EC/GL Ports Facility Vehicle Energy Consumption to the Terminal/Facility Boundary, by Port*

Port	Vehicle counts	Fuel consumption (litres)	Energy consumption (GJ)
Belledune	2	10,400	400
Halifax	88	381,400	13,100
Hamilton	28	60,900	2,100
Montréal	159	723,000	26,100
Oshawa	1	300	0
Québec	25	93,100	3,300
Saguenay	4	9,300	300
Saint John (NB)	34	53,300	1,900
Sept-Îles	41	375,800	14,300
St. John's (NL)	13	275,400	10,400
Thunder Bay	24	66,400	2,300
Toronto	29	73,900	2,800
Trois-Rivières	4	6,100	200
Windsor	13	24,800	900
TOTAL	**465**	**2,154,300**	**78,100**

*These estimates are also valid to the Port Boundary.

3.4.2 Onroad Vehicle Emissions

Onroad Vehicle emission estimates for the EC/GL Ports during 2010 are provided in Tables 3-41 and 3-42 for Highway Vehicles and Facility Vehicles, respectively. These summaries are allocated to commodity type, showing that the greatest portion of Onroad Vehicle emissions relates to the container terminals. The total Onroad Vehicle emissions estimates are provided in Table 3-43 by type of vehicle. The estimated total Onroad Vehicle emissions are re-expressed by fuel type and port in Tables 3-44 to 3-47.

Table 3-41: 2010 EC/GL Ports Onroad Highway Vehicle Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	2	0	1	0	0	0	0	149
Bulk Liquid	1	0	0	0	0	0	0	145
Bulk Solid	29	0	10	3	2	2	0	2,836
Containers	34	0	11	4	2	2	0	3,170
Passenger	1	0	0	0	0	0	0	76
Other	0	0	0	0	0	0	0	7
TOTAL	**66**	**0**	**22**	**8**	**5**	**4**	**0**	**6,383**

Table 3-42: 2010 EC/GL Ports Onroad Facility Vehicle Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)*

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	8	0	3	1	1	1	0	975
Bulk Liquid	2	0	10	1	0	0	0	609
Bulk Solid	6	0	6	1	0	0	0	1,031
Containers	11	0	18	2	1	1	0	2,147
Passenger	0	0	0	0	0	0	0	43
Other	0	0	0	0	0	0	0	10
TOTAL	**27**	**0**	**38**	**3**	**2**	**2**	**0**	**4,815**

*These estimates are also valid to the Port Boundary

Table 3-43: 2010 EC/GL Ports Total Onroad Vehicle Emission Estimates to the Terminal/Facility Boundary, by Vehicle Type (tonnes)

Vehicle Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Bus	5	0	3	0	0	0	0	492
Car	0	0	1	0	0	0	0	77
Light Comm. Truck	74	0	29	8	5	5	0	7,312
Medium Comm. Truck	1	0	2	0	0	0	0	306
Heavy Comm. Truck	6	0	2	1	0	0	0	508
Taxi	0	0	0	0	0	0	0	6
Van / Pickup	7	0	23	2	0	0	0	2,497
TOTAL	**93**	**0**	**60**	**11**	**7**	**6**	**0**	**11,198**

Table 3-44: 2010 EC/GL Ports Total Onroad Vehicle Emissions Estimates to the Terminal/Facility Boundary, by Fuel Type (tonnes)

Fuel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Diesel	89	0	30	10	6	5	0	8,854
Gasoline	4	0	30	2	0	0	0	2,344
TOTAL	**93**	**0**	**60**	**11**	**7**	**6**	**0**	**11,198**

Table 3-45: 2010 EC/GL Ports Total Onroad Vehicle Emissions Estimates to the Port Boundary, by Fuel Type (tonnes)

Fuel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Diesel	131	0	43	13	10	8	0	13,364
Gasoline	6	0	40	2	0	0	0	2,902
TOTAL	**136**	**0**	**83**	**15**	**10**	**8**	**0**	**16,265**

Table 3-46: 2010 EC/GL Ports Total Onroad Vehicle Emissions Estimates to the Terminal/Facility Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	1	0	0	0	0	0	0	63
Halifax	10	0	16	2	1	1	0	1,607
Hamilton	8	0	3	1	1	0	0	832
Montréal	43	0	25	5	3	3	0	4,698
Oshawa	0	0	0	0	0	0	0	35
Québec	3	0	2	0	0	0	0	503
Saguenay	1	0	0	0	0	0	0	121
Saint John (NB)	0	0	1	0	0	0	0	132
Sept-Îles	8	0	3	1	1	1	0	1,045
St. John's (NL)	9	0	4	1	1	1	0	1,009
Thunder Bay	1	0	2	0	0	0	0	257
Toronto	3	0	1	0	0	0	0	341
Trois-Rivières	0	0	0	0	0	0	0	52
Windsor	5	0	2	1	0	0	0	504
TOTAL	**93**	**0**	**60**	**11**	**7**	**6**	**0**	**11,198**

Table 3-47: 2010 EC/GL Ports Total Onroad Vehicle Emissions Estimates to the Port Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	1	0	0	0	0	0	0	63
Halifax	11	0	16	2	1	1	0	1,683
Hamilton	12	0	5	1	1	1	0	1,338
Montréal	79	0	45	8	6	5	0	8,893
Oshawa	0	0	0	0	0	0	0	35
Québec	3	0	2	0	0	0	0	505
Saguenay	1	0	0	0	0	0	0	128
Saint John (NB)	1	0	1	0	0	0	0	152
Sept-Îles	8	0	3	1	1	1	0	1,046
St. John's (NL)	9	0	4	1	1	1	0	1,009
Thunder Bay	1	0	2	0	0	0	0	260
Toronto	5	0	2	1	0	0	0	560
Trois-Rivières	1	0	0	0	0	0	0	77
Windsor	5	0	2	1	0	0	0	515
TOTAL	**136**	**0**	**83**	**15**	**10**	**8**	**0**	**16,265**

3.5 Admin

Admin includes energy consumption and emissions associated with administration of the port terminals and port authorities. The majority of activity for this group is associated with buildings, including administrative buildings, and outbuildings like storage structures. For some terminals, a significant amount of energy is also consumed for exterior lighting. Admin does not include energy and emissions that may be associated with processing of goods. Admin energy consumption is displayed in Tables 3-48 and 3-49. Admin emissions are displayed in Tables 3-50 to 3-52.

3.5.1 Admin Activity

Table 3-48: Reported 2010 EC/GL Ports Admin Energy Consumption to the Terminal/Facility Boundary, by Commodity Type*

Commodity Type	Diesel/Heating Oil (L)	Electricity (MWh)	Natural Gas (GJ)	Propane (L)
Breakbulk	0	2,400	800	4,300
Bulk Liquid	75,000	14,100	119,800	0
Bulk - Solid	25,100	166,100	416,200	291,700
Containers	101,700	9,500	6,400	0
Passenger	84,800	6,000	21,200	0
Other	316,600	2,000	3,300	0
TOTAL	**603,300**	**200,200**	**567,700**	**296,000**

*These estimates are also valid to the Port Boundary.

Table 3-49: Reported 2010 EC/GL Ports Admin Energy Consumption to the Terminal/Facility Boundary, by Port*

Port	Diesel/Heating Oil (L)	Electricity (MWh)	Natural Gas (GJ)	Propane (L)
Belledune	100	1,500	2,300	0
Halifax	264,600	8,400	26,400	0
Hamilton	200	40,200	358,800	4,300
Montréal	153,300	19,200	135,000	0
Oshawa	0	600	700	0
Québec	7,500	16,600	2,800	13,000
Saguenay	0	800	0	0
Saint John (NB)	3,400	4,700	2,700	0
Sept-Îles	62,200	78,300	0	0
St. John's (NL)	86,500	4,600	200	0
Thunder Bay	14,300	8,500	3,600	278,700
Toronto	700	2,400	6,100	0
Trois-Rivières	8,800	3,900	5,700	0
Windsor	1,300	10,400	23,300	0
TOTAL	**603,300**	**200,200**	**567,700**	**296,000**

*These estimates are also valid to the Port Boundary.

3.5.2 Admin Emissions

Table 3-50: 2010 EC/GL Ports Admin Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)*

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Breakbulk	0	0	0	0	0	0	0	811
Bulk Liquid	5	0	4	0	0	0	0	9,154
Bulk Solid	19	0	104	2	1	1	1	30,560
Containers	2	0	1	0	0	0	0	3,684
Passengers	1	0	0	0	0	0	0	2,067
Other	1	0	1	0	0	0	0	2,532
TOTAL	**28**	**0**	**110**	**2**	**2**	**2**	**2**	**48,808**

*These estimates are also valid to the Port Boundary.

Table 3-51: 2010 EC/GL Ports Admin Emission Estimates to the Terminal/Facility Boundary, by Fuel Type (tonnes)*

Fuel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Diesel/Heating Oil	3	0	1	0	0	0	0	1,814
Electricity	0	0	0	0	0	0	0	18,180
Gasoline	0	0	88	2	0	0	0	26
Natural Gas	24	0	21	0	2	2	2	28,332
Propane	0	0	0	0	0	0	0	457
TOTAL	**28**	**0**	**110**	**2**	**2**	**2**	**2**	**48,808**

*These estimates are also valid to the Port Boundary.

Table 3-52: 2010 EC/GL Ports Admin Emission Estimates to the Terminal/Facility Boundary, by Port (tonnes)*

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	0	0	0	0	0	0	0	857
Halifax	2	0	1	0	0	0	0	8,582
Hamilton	15	0	13	0	1	1	1	23,221
Montréal	6	0	5	0	0	0	0	7,229
Oshawa	0	0	0	0	0	0	0	110
Québec	1	0	89	2	0	0	0	249
Saguenay	0	0	0	0	0	0	0	2
Saint John (NB)	0	0	0	0	0	0	0	2,541
Sept-Îles	0	0	0	0	0	0	0	385
St. John's (NL)	1	0	1	0	0	0	0	353
Thunder Bay	1	0	0	0	0	0	0	1,790
Toronto	0	0	0	0	0	0	0	619
Trois-Rivières	0	0	0	0	0	0	0	320
Windsor	1	0	1	0	0	0	0	2,551
TOTAL	**28**	**0**	**110**	**2**	**2**	**2**	**2**	**48,808**

*These estimates are also valid to the Port Boundary.

4.0 PORT EMISSIONS SUMMARIES FOR 2010

Port emission summaries are provided in this chapter, to the Terminal/Facility Boundary and the Port Boundary. As previously noted, the Terminal/Facility Boundary and the Port Boundary coincide for 11 of the 14 ports on the landside (Ports of Montreal, Hamilton, and Toronto being exceptions), whereas significant differences exist between the two boundaries on the waterside for all ports, due to extensive harbour areas for each. These harbour areas are unique to each port.

Emission estimates are almost entirely combustion related, due to engine and boiler use. Exceptions exist for electricity consumption and fugitive VOC emissions from ships carrying fossil fuels. The emissions associated with electricity consumption in the following tables are limited to CO_2e and constitute a low-to-moderate portion of the total CO_2e emissions for a particular port, depending on the nature of local electricity generation (hydro, nuclear or fossil-fuel derived). The fugitive VOC emissions tend to dominate the port totals of this air contaminant since engine related VOC emission rates (largely diesel engines) are relatively low. The fugitive VOC emission estimates are identified separately for the port emission summaries by fuel type, showing their relative contribution. As previously noted, these fugitive emissions are not the total fugitive VOC emissions that would be expected for a port (especially a port that has fuel distribution terminals) as they do not include the fugitive emissions associated with the transfer and storage of fuels on terminal grounds.

4.1 Emissions to the Terminal/Facility Boundary

Port emissions are expressed to the Terminal/Facility Boundary in Tables 4-1 to 4-3 by source group, commodity type, and fuel type, respectively. Total emissions are dominated by the Marine source group for every air contaminant (exception NH_3). When viewed by commodity type, the highest emissions are associated with the Bulk Solid and Container groups, but not for all air contaminants (VOC emissions are highest with the Bulk Liquid commodity type). Emissions related to heavy fuel oil used by the OGVs dominate the totals when distinguishing the emissions to the specific fuels used at the ports.

Total port emissions are highest for Montreal, followed by Halifax and Quebec; Canada's busiest ports in the EC/GL region.

Table 4-1: 2010 EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Source Group (tonnes)

Source Group	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Admin	26	0	109	2	2	2	2	45,263
Cargo-handling equipment	351	0	236	34	26	25	1	70,450
Marine	2,851	2,643	345	2,460	284	261	0	236,272
Onroad Vehicle	93	0	60	11	7	6	0	11,198
Rail	166	0	25	11	4	4	1	7,539
TOTAL	**3,487**	**2,644**	**774**	**2,519**	**323**	**298**	**4**	**370,722**

Table 4-2: 2010 EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Commodity Type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Autos	18	15	2	1	2	2	0	1,333
Breakbulk	160	119	53	8	15	14	0	14,518
Bulk Liquid	643	647	108	2,377	69	63	1	79,924
Bulk Solid	1,279	896	353	71	114	105	2	142,075
Containers	1,043	708	206	50	94	87	1	105,834
Passenger	257	185	29	9	22	20	0	18,933
Other	87	73	23	4	8	7	0	8,105
TOTAL	**3,487**	**2,644**	**774**	**2,519**	**323**	**298**	**4**	**370,722**

Table 4-3: 2010 EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Fuel Type (tonnes)

Fuel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Diesel	591	1	194	50	36	34	2	60,139
Electricity	0	0	0	0	0	0	0	34,987
Gasoline	5	0	145	5	0	0	0	2,473
Natural gas	26	0	26	0	2	2	2	35,094
Propane	14	0	65	4	0	0	0	1,756
Heavy fuel oil	1,932	1,776	231	63	191	176	0	159,397
Marine distillate oil	919	867	114	31	93	85	0	76,875
Fugitive cargo losses (all fuels)	0	0	0	2,366	0	0	0	0
TOTAL	**3,487**	**2,644**	**774**	**2,519**	**323**	**298**	**4**	**370,722**

Table 4-4: 2010 EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Port (tonnes)

Port	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	42	33	8	2	4	4	0	6,622
Halifax	557	447	114	275	53	49	0	67,891
Hamilton	209	122	53	11	18	17	1	41,871
Montréal	1,157	869	229	174	108	100	1	113,183
Oshawa	13	9	3	1	1	1	0	1,186
Québec	370	298	144	844	35	32	0	31,588
Saguenay	32	24	8	2	3	3	0	2,600
Saint John (NB)	299	265	46	1,171	30	28	0	29,758
Sept-Îles	203	141	36	13	17	16	0	16,051
St. John's (NL)	145	92	26	6	12	11	0	12,989
Thunder Bay	220	161	34	9	19	18	0	19,514
Toronto	52	43	26	3	5	5	0	5,372
Trois-Rivières	74	62	21	4	7	7	0	6,429
Windsor	115	77	26	5	10	10	0	15,669
TOTAL	**3,487**	**2,644**	**774**	**2,519**	**323**	**298**	**4**	**370,722**

4.2 Emissions to the Port Boundary

The emission summaries for the ports are re-expressed here, including the additional water-side and land-side emissions within each port's Port Boundary. The EC/GL port emissions are displayed in Tables 4-5 to 4-8 by source group, commodity type, fuel type, and port, respectively. At the Port Boundary, similar trends can be noted to those for the Terminal/Facility Boundary.

Table 4-5: 2010 EC/GL Ports Emission Estimates to the Port Boundary, by Source Group (tonnes)

Source Group	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Admin	28	0	110	2	2	2	2	48,808
Cargo-handling equipment	351	0	236	34	26	25	1	70,450
Marine	4,417	3,583	508	2,563	401	369	2	332,915
Onroad Vehicle	136	0	83	15	10	8	0	16,265
Rail	207	0	30	13	5	5	1	9,995
TOTAL	**5,139**	**3,584**	**968**	**2,628**	**445**	**410**	**6**	**478,433**

Table 4-6: 2010 EC/GL Ports Emission Estimates to the Port Boundary, by Commodity Type (tonnes)

Commodity Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Autos	30	24	3	1	3	3	0	1,990
Breakbulk	184	134	56	9	17	16	0	15,852
Bulk Liquid	1,135	1,077	165	2,436	116	107	1	115,762
Bulk Solid	1,712	1,210	399	86	151	140	2	170,133
Containers	1,299	828	241	64	114	105	1	120,140
Passenger	328	224	37	12	27	25	0	25,650
Other	452	88	66	20	16	15	1	28,907
TOTAL	**5,139**	**3,584**	**968**	**2,628**	**445**	**410**	**6**	**478,433**

Table 4-7: 2010 EC/GL Ports Emission Estimates to the Port Boundary, by Fuel Type (tonnes)

Fuel Type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Diesel	675	1	213	55	41	38	2	67,938
Electricity	0	0	0	0	0	0	0	36,333
Gasoline	6	0	155	5	0	0	0	3,031
Natural gas	27	0	27	0	2	2	2	36,460
Propane	14	0	65	4	0	0	0	1,756
Heavy fuel oil	2,877	2,498	331	101	278	255	1	216,332
Marine distillate oil	1,396	1,085	164	49	121	111	1	108,562
Marine gas oil	144	0	13	6	3	3	0	8,020
Fugitive cargo losses (all fuels)	0	0	0	2,407	0	0	0	0
TOTAL	**5,139**	**3,584**	**968**	**2,628**	**445**	**410**	**6**	**478,433**

Table 4-8: 2010 EC/GL Ports Emission Estimates to the Port Boundary, by Port (tonnes)

Port authority	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
Belledune	52	35	9	2	4	4	0	7,307
Halifax	868	653	149	290	78	72	1	88,625
Hamilton	257	133	59	13	21	19	1	44,894
Montréal	1,423	970	275	189	126	116	2	130,488
Oshawa	13	9	3	1	1	1	0	1,231
Québec	542	374	160	864	46	42	1	40,839
Saguenay	42	30	9	2	4	3	0	3,203
Saint John (NB)	741	601	97	1,212	69	63	0	62,568
Sept-Îles	479	317	63	23	39	35	0	32,860
St. John's (NL)	169	94	28	7	12	11	0	14,270
Thunder Bay	230	164	35	9	19	18	0	20,111
Toronto	57	44	27	3	5	5	0	5,754
Trois-Rivières	120	69	25	5	9	8	0	8,592
Windsor	146	92	29	6	12	12	0	17,692
TOTAL	**5,139**	**3,584**	**968**	**2,628**	**445**	**410**	**6**	**478,433**

The marine gas oil fuel type identified in Table 4-7 relates to tugboat activity in the port harbours. This category is used to distinguish the marine diesel used by “non-large vessels” (tugs) to that used by “large vessels”. The domestic sulphur in diesel fuel regulations require a lower diesel sulphur content for the smaller craft (10). In some cases, larger vessels would be expected to use the lower sulphur diesel, simply due to fuel availability by region (it is often not economically viable to offer two different grades of marine diesel for purchase); although this cannot be assumed in the inventory estimates due to lack of data. This fuel distinction is consistent with MEIT and the National Marine Inventory (2).

5.0 FORECASTS

5.1 Future Activity Levels

Forecast inventories were achieved by use of PEIT, accounting for changes expected to the activity levels (e.g., hours of engine use or truck/rail gate counts) by assuming a linear relationship with cargo throughput. This means that the inventory forecast accuracy heavily depends on the accuracy of the commodity forecasts.

The forecast data used in the 2010 National Marine Inventory were used for all of the EC/GL ports (2). Although the port authorities were asked for commodity forecasts, only Montreal was able to provide data (and only for 2015). Since the Montreal data are already accounted for in the 2010 National Marine Inventory forecasts, the same growth rates were applied to all ports. Table 5-1 provides the forecast commodity rates by forecast year.

Table 5-1: EC/GL Ports Commodity Forecasts (Growth Rates), by Year*

Port	Commodity	2015	2020	2025
All	Auto	1.18	1.18	1.18
All	Breakbulk	1.06	1.14	1.21
All	Bulk Liquid	1.04	1.07	1.11
All	Bulk Solid	1.34	1.34	1.34
All	Container	1.27	1.50	1.75
All	Passenger	1.37	1.37	1.37
All	Other	1.05	1.10	1.16

*These rates are relative to the 2010 throughput levels.

The growth rates are relative to 2010, therefore (for example) 118% of the 2010 Auto shipments to Montreal are expected by 2015. The same levels are predicted for 2020 and 2025. Since there were no Auto shipments to that port in 2010, this rate has no effect on the Port Montreal forecast (only Halifax has an auto terminal). Similarly, the growth rate for containers for Belledune in 2015 is 127%, which also has no effect since Belledune had no containers in 2010.

These commodity growth rates were determined in early 2012 and therefore are not fully reflective of the current economic conditions in eastern Canada. Bulk Solid growth in particular, may not be realized by 2015 due to the recent decline in demand for iron ore worldwide.

5.2 Future Emission Rates

The future inventories also account for the known fuel and emission regulations in effect in North America, as well as the expected emission rates associated with newer equipment. Engine emission standards set by organizations such as the US EPA are characterized in the MOVES and NONROAD emissions models leveraged in PEIT. However, these standards tend to focus on the key criteria air contaminants of concern: NO_x, SO_x, CO, VOCs, and PM. Emission rates of other contaminants, such as CO_2, will also likely decrease in future years due to improvements in engine/equipment design. The future fuel consumption and GHG emission rates may therefore be over-estimated.

MOVES now includes the effects of recently promulgated fuel efficiency standards for cars and light duty trucks (e.g., the CAFÉ standards). Recently finalized fuel economy and GHG standards for heavy duty vehicles have not yet been implemented in the current release of MOVES leveraged in PEIT (MOVES2010b). These standards apply to model years 2014–2017. The newest version of the model, MOVES 2013, is expected to include these standards when it is released at the end of 2013. The effect of these standards was simulated in PEIT by applying scaling factors to the GHG and fuel economy rates generated by MOVES2010b for all future years 2014 to 2025 as indicated in Table 5-2. These scaling factors have been determined by the US EPA in their Regulatory Impact Analysis for the sector (11). More stringent fuel economy standards are expected after 2018, but these have not yet been finalized. As such, the “2017+” scaling factor is assumed to represent all years between 2017 and 2025. This means that the 2020 and 2025 Onroad Vehicle fuel and GHG emissions estimates are likely over-estimated by some degree.

Table 5-2: Fuel Economy and CO_2 Scaling Factors for Heavy Duty Vehicles

Vehicle Description	Model Year	CO_2 / Fuel scaling factor
Light commercial truck	2014-2016	0.95
Light commercial truck	2017+	0.91
Medium commercial truck	2014-2016	0.95
Medium commercial truck	2017+	0.91
Heavy commercial truck	2014-2016	0.97
Heavy commercial truck	2017+	0.94

Although the emission rates of the CACs may also be affected (lowered) by the recent fuel/CO_2 standards, this was not assumed in PEIT.

Fuel consumption regulations for ships can also be modeled based on recent International Maritime Organization (IMO) standards, as identified in the paragraphs below. For these reasons, the future Onroad Vehicle and Marine estimates account for future fuel consumption and GHG emission rates to the degree possible.

Future locomotive emission rates for National/Regional Rail were estimated from US EPA data (12). As shown in Table 5-3, the expected reduction in emission rates for the four common air contaminants can be applied to newer locomotives introduced to the active fleet by year. Since RAC baseline emission rates for the Canadian locomotives are used directly in PEIT, only the reduction ratios are applied to the new locomotives in future years. For example, a line haul locomotive introduced to the fleet in 2015 would be expected to have a VOC emission rate equal to just 8% (0.04/0.48) of the 2010 rate. This approach may over-estimate the actual reduction in emission rates, since the baseline for PEIT is 2010 and not 1998. To account for this, a relatively low rollover assumption was applied, as noted in Chapter 5.3. Future locomotive SO_x emission rates are fully accounted for by projecting the sulphur content of diesel in future years according to the Environment Canada Sulphur in Diesel Fuel Regulation (10).

Future fuel consumption and emission rates for ships were determined from regulations promulgated by the IMO in Marpol Annex VI (Prevention of Air Pollution from Ships) (13). Canada now has an Emission Control Area (ECA) for both the West and East Coasts of North America (since August 2012) and therefore tighter fuel and emission controls will be in effect for the EC/GL region compared to other areas around the world. The marine emission criteria applied for the forecast inventories are identified in Tables 5-4 and 5-5.

Table 5-3: US EPA Locomotive Emissions Data, by Emissions Tier

	Implementation Dates	Implementation Dates	Emissions (g/hp-hr)			
			NOx	CO	VOCs	PM
Line Haul	**Baseline "In-Use" Locomotives (1998)**	**Pre-1998**	**13**	**1.28**	**0.48**	**0.32**
	Tier 0	1998	8.60	1.28	0.48	0.32
	Tier 1	2002	6.70	1.28	0.47	0.32
	Tier 2	2005	5.50	1.28	0.26	0.18
	Tier 3	2012	4.95	1.28	0.13	0.09
	Tier 4	2015, 2017 (NO_x)	1.00	1.28	0.04	0.03
Switch	**Baseline "In-Use" Locomotives (1998)**	**Pre-1998**	**17.40**	**1.83**	**1.01**	**0.44**
	Tier 0	1998	14.00	1.83	1.01	0.44
	Tier 1	2002	11.00	1.83	1.01	0.43
	Tier 2	2005	8.10	1.83	0.51	0.19
	Tier 3	2012	5.00	1.83	0.26	0.09
	Tier 4	2015	1.00	1.83	0.08	0.02

Table 5-4: IMO NO_x, SO_x and Fuel Regulations

Standard	Engine RPM "n"	NOx Emission Limit (g/kWh)	Fuel Standard (max. sulphur content)	Year	Relevance
Tier 1	n < 130	17.0	n/a	2000	Applies to all vessels constructed during or after this year
	n = 130-2000	$45*n^{-0.2}$			
	n > 2000	9.8			
SO_x /FUEL	n/a	n/a	1.00%	2010	Only applies to ECA areas
Tier 2	n < 130	14.4	n/a	2011	Applies to all vessels constructed during or after this year
	n = 130-2000	$44*n^{-0.23}$			
	n > 2000	7.7			
SO_x /FUEL	n/a	n/a	0.10%	2015	Only applies to ECA areas
Tier 3	n < 130	3.4	n/a	2021	Applies to all vessels constructed during or after this year. Only applies to vessels operating in ECA areas
	n = 130-2000	$9*n^{-0.2}$			
	n > 2000	1.96			
SO_x /FUEL	n/a	n/a	0.50%	2020	Applies to all areas, pending a 2018 fuel availability review.

The IMO Tier 3 NO_x standard is to be applied to new ships built in 2021 or following. This is a recent change to the regulation's implementation date, which was originally set at 2016 (14).

As of March 2012, MARPOL Annex VI has regulations on energy efficiency for ships through the Energy Efficiency Design Index (EEDI) for new ships built after 2013 and Ship Energy Efficiency Management Plan (SEEMP) requirements for all ships. EEDI/SEEMP criteria are applied as percentage reductions to the average efficiency of ships built between 1999 and 2009. Efficiency in this case relates to the amount of energy (fuel) required to move cargo from origin to destination. These reductions are expressed in Table 5-5.

Uptake of the IMO regulation for EEDI is expected to be 100% for the new vessels built after 2015. The EEDI/SEEMP criteria relate to an entire voyage and therefore applying the reductions to ship movements in the port areas (within the Port Boundaries) is not fully applicable.

Table 5-5: IMO EEDI/SEEMP Criteria (Reductions to Baseline Fuel Consumption)

Ship Type	Size	Phase 0 (Jan 2013)	Phase 1 (Jan 2015)	Phase 2 (Jan 2020)	Phase 3 (Jan 2025)
Bulk Carrier	≥20,000 DWT	0	10	20	30
	10,000–20,000 DWT	N/A*	0–10**	0–20**	0–30**
Gas Carrier	≥10,000 DWT	0	10	20	30
	2,000–10,000 DWT	N/A*	0–10**	0–20**	0–30**
Tanker	≥20,000 DWT	0	10	20	30
	4,000–20,000 DWT	N/A*	0–10**	0–20**	0–30**
Container Ship	≥15,000 DWT	0	10	20	30
	10,000–15,000 DWT	N/A*	0–10**	0–20**	0–30**
General Cargo Ships	≥15,000 DWT	0	10	15	30
	3,000–15,000 DWT	N/A*	0–10**	0–15**	0–30**
Refrigerated Cargo Carriers	≥5,000 DWT	0	10	15	30
	3,000–5,000 DWT	N/A*	0–10**	0–15**	0–30**
Combination Carriers	≥20,000 DWT	0	10	20	30
	4,000–20,000 DWT	N/A*	0–10**	0–20**	0–30**

* No required EEDI criteria applies.

** Reduction factor to be linearly interpolated between the two values dependent upon vessel size; the lower value of the reduction factor is to be applied to the smaller ship size.

As identified in Appendix I, PEIT ship engine fuel consumption rates are estimated with the factors shown in Table 5-6, which originate from a 2009 IMO study on ship GHG emissions (15). No improvement to ship fuel oil consumption on an energy basis is assumed following 2007. Further marine emission improvement may instead be gained by improved efficiency on a tonne-km basis, as the EEDI regulation targets. Although the EEDI criteria are not used in PEIT, ship rollover assumptions (as discussed in the following section) will simulate an improvement to the ship propulsion engine fuel consumption as the older ships are replaced by newer ones in line with the rates in Table 5-6. No improvement is simulated for the ship auxiliary engines.

Table 5-6: Marine Specific Fuel Oil Consumption (SFOC) in g/kWh by Engine Classification (kW) and Age (from IMO 2009)

Engine	Age of Build	SFOC (>15,000 kW)	SFOC (5,000-15,000 kW)	SFOC (<5,000 kW)
Main 2-stroke	1970-1983	205	205	205
	1984-2000	185	185	185
	2001-2007	175	175	175
	2008+	175	175	175
Main 4-stroke	1970-1983	215	225	225
	1984-2000	195	205	205
	2001-2007	185	195	195
	2008+	185	195	195
Auxiliary 4-stroke	1970-1983	220	220	220
	1984-2000	220	220	220
	2001-2007	220	220	220
	2008+	220	220	220

Environment Canada regulates the sulphur content of marine diesel through its Sulphur in Diesel Fuel Regulation (10). The forecasts are also consistent with this regulation, which effectively limits the marine diesel used by "Non-large Vessels" to 15 ppm (0.0015%) sulphur by 2014. This impacts the domestic tugs and harbor craft only.

PEIT does not account for changes to the electricity emissions intensity value (g CO_2e per kWh consumed) that may occur in future years, due to lack of information. Although the GHG emissions associated with the production of electricity in each province change from year to year, this is largely unpredictable at present.

5.3 Future Equipment Populations

Emission rate forecasts require assumptions associated with fleet turnover for all source groups. For example, application of the IMO NO_x criteria for ships in 2015 requires an estimate of how many ships built in or after 2011 will serve the EC/GL ports in 2015. Consistent with the 2010 National Marine Inventory (2) (for marine sources), the relative age distributions of Onroad Vehicles, CHE and Marine were held constant in future years. This means that if 10% of container terminal cranes were built in 2010 for the 2010 inventory, 10% of cranes would be simulated as built in 2015 for the 2015 inventory. This general approach to port and marine emission inventory forecasts was evaluated in the 2010 PMV LEI for Onroad Vehicles and CHE by using the port's 2005 and 2010 operations data (5).

Admin sources largely consist of boilers for building heating. PEIT assumes all Admin boilers are 15 years old for any given inventory year, due to lack of available information. This constitutes a very simple rollover assumption that only impacts NO_x emission rates (newer boiler technologies focus on NO_x emissions since boiler emissions of other CACs are not considered high).

A unique rollover scheme was applied to rail due to lack of detailed locomotive data for the existing National/Regional Rail locomotives that currently serve the EC/GL ports (5). 2% of the National/Regional locomotive fleet was assumed to be replaced each year, starting in 2012. Given the relatively small distribution of Facility Locomotives used on terminal grounds, no rollover was assumed for this source group. However, the emission reduction initiatives (ERIs) described in Chapter 6, include replacement of older switch locomotives with newer gen set units at one port. For this case, replacement of older Facility Locomotive models with newer ones is included in the forecasts.

5.4 Emission Forecasts

5.4.1 No Growth Scenario

A "no-growth" forecast is useful to consider since it outlines the expected change of emissions (or lack thereof) with a static level of port activity. In some cases, dramatic improvement is expected due to the upcoming domestic and international fuel/emission regulations. Assessing the "no growth" scenario is also very useful for quality assurance purposes, since the visible trends can be related to the expected changes to emission rates and equipment fleets noted in Chapters 5.2 and 5.3.

Table 5-7 provides the no-growth inventory forecasts by year for a subset of the air contaminants, broken down to the five source groups.

The main reasons for the significant, relative decline in emissions are identified below:

<u>Admin:</u>

- Decrease in NO_x is due to the inventory assumption that all boilers are 15 years old each inventory year (boiler age is not collected in the PEIT questionnaire). By 2015, this assumption simulates replacement of uncontrolled boilers with boilers having low NO_x

burners and flue gas recirculation (14). In reality, the 2010 boiler NO_x emissions may be over-estimated since some of the boilers would be newer than 15 years old.

CHE:

- The drop in NO_x, CO, VOCs, and PM are due to assumed equipment/fleet turnover and lower emission rates as the higher tier equipment are introduced.

Marine:

- The drop in SO_x and PM is due to an ECA for both the West and East Coasts of North America that will be effective in 2015. The ECA will reduce the allowable sulphur content of marine fuels used.
- A small decrease in NO_x, CO, VOC, and CO_2e is due to fleet turnover and lower fuel/emission rates for the newer vessels. The CO_2e decrease is small since the improvements to fuel consumption rates are expected for the propulsion engines only.

Onroad Vehicle:

- Fleet turnover is expected to cause a decrease in all air contaminant emission rates, including a minor decrease in CO_2e from improvements expected in fuel consumption for the newer vehicles.

Rail:

- The large drop in emissions by 2015 is largely associated with the new gen set locomotives introduced at one of the ports in late 2010 and 2011. Additionally, a small to moderate decrease in NO_x, VOCs, and PM is expected due to the introduction of new locomotives to the national/regional fleet.

For the smaller ports, these trends may not be realistic. In particular, equipment/fleet turnover of CHE may not progress as quickly as simulated. If this is the case, the decrease in emission rates for CHE by 2015 may not in fact be realized until a later year.

Table 5-7: "No Growth" Forecasts to the Port Boundary for 2015, 2020 and 2025

Inventory Year	Source Group	NO_x	SO_x	CO	VOCs	$PM_{2.5}$	CO_2e
2010	Admin	28	0	110	2	2	48,808
	CHE	351	0	236	34	25	70,450
	Marine	4,417	3,583	508	2,563	369	332,915
	Onroad Vehicle	136	0	83	15	8	16,265
	Rail	207	0	30	13	5	9,995
	TOTAL	**5,139**	**3,584**	**968**	**2,628**	**410**	**478,433**
2015	Admin	14	0	102	2	2	48,805
	CHE	237	0	155	24	17	70,334
	Marine	4,077	184	508	2,563	95	332,066
	Onroad Vehicle	81	0	54	10	5	16,184
	Rail	202	0	30	13	5	9,981
	TOTAL	**4,611**	**185**	**849**	**2,612**	**124**	**477,370**
2020	Admin	13	0	59	1	2	48,805
	CHE	136	0	97	17	9	70,298
	Marine	3,831	184	508	2,563	95	331,844
	Onroad Vehicle	47	0	38	6	3	15,901
	Rail	194	0	30	12	5	9,981
	TOTAL	**4,220**	**185**	**732**	**2,600**	**114**	**476,830**
2025	Admin	12	0	58	1	2	48,805
	CHE	88	0	70	14	6	70,284
	Marine	3,226	184	508	2,563	95	331,779
	Onroad Vehicle	28	0	30	4	2	15,583
	Rail	185	0	30	12	5	9,981
	TOTAL	**3,540**	**185**	**697**	**2,594**	**109**	**476,432**

The no-growth forecasts show that a reduction in emissions of all air contaminants is expected in future years should the ports experience zero growth in cargo throughput. The decrease in GHG emissions, as determined by the CO_2e estimates, is expected to be minor without further initiatives to increase efficiency to those currently promulgated by government agencies.

5.4.2 Forecasts for 2015, 2020 and 2025

Emission forecasts are provided in Tables 5-8 and 5-9 for the EC/GL ports to the Terminal/Facility Boundary and Port Boundary, respectively. These forecasts are allocated to each source group in Tables 5-10 and 5-11.

Table 5-8: Forecast EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Year (tonnes)

Inventory Year	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
2010	3,487	2,644	774	2,519	323	298	4	370,722
2015	3,814	170	791	2,633	120	111	5	447,025
2020	3,667	180	696	2,699	114	105	5	473,560
2025	3,291	191	688	2,796	114	104	5	502,683

Table 5-9: Forecast EC/GL Ports Emission Estimates to the Port Boundary, by Year (tonnes)

Inventory Year	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3	CO_2e
2010	5,139	3,584	968	2,628	445	410	6	478,433
2015	5,542	224	1,003	2,752	162	149	7	570,241
2020	5,342	236	913	2,822	157	144	7	601,543
2025	4,754	249	912	2,924	159	145	7	636,382

The EC/GL port emissions are expected to increase, stay relatively constant or decrease, depending on the air contaminant. For several of the air contaminants, significant declines in emissions are expected, even with the commodity growth expected over the next 15 years.

Table 5-10: Forecast EC/GL Ports Emission Estimates to the Terminal/Facility Boundary, by Source Group and Year (tonnes)

Inventory Year	Source Group	NO_x	SO_x	CO	VOCs	$PM_{2.5}$	CO_2e
2010	Admin	26	0	109	2	2	45,263
	CHE	351	0	236	34	25	70,450
	Marine	2,851	2,643	345	2,460	261	236,272
	Onroad Vehicle	93	0	60	11	6	11,198
	Rail	166	0	25	11	4	7,539
	TOTAL	**3,487**	**2,644**	**774**	**2,519**	**298**	**370,722**
2015	Admin	13	0	100	2	2	45,261
	CHE	302	0	193	31	21	88,837
	Marine	3,278	169	425	2,581	79	290,721
	Onroad Vehicle	70	0	49	9	4	14,074
	Rail	152	0	24	10	4	8,133
	TOTAL	**3,814**	**170**	**791**	**2,633**	**111**	**447,025**
2020	Admin	12	0	58	1	2	45,261
	CHE	189	0	128	24	12	97,115
	Marine	3,272	179	450	2,658	84	307,566
	Onroad Vehicle	44	0	37	6	3	15,170
	Rail	150	0	24	10	4	8,448
	TOTAL	**3,667**	**180**	**696**	**2,699**	**105**	**473,560**
2025	Admin	11	0	57	1	2	45,261
	CHE	133	1	97	21	8	106,198
	Marine	2,970	190	477	2,760	89	326,158
	Onroad Vehicle	29	0	32	4	2	16,273
	Rail	148	0	25	10	4	8,793
	TOTAL	**3,291**	**191**	**688**	**2,796**	**104**	**502,683**

Table 5-11: Forecast EC/GL Ports Emission Estimates to the Port Boundary, by Source Group and Year (tonnes)

Inventory Year	Source Group	NO_x	SO_x	CO	VOCs	$PM_{2.5}$	CO_2e
2010	Admin	28	0	110	2	2	48,808
	CHE	351	0	236	34	25	70,450
	Marine	4,417	3,583	508	2,563	369	332,915
	Onroad Vehicle	136	0	83	15	8	16,265
	Rail	207	0	30	13	5	9,995
	TOTAL	**5,139**	**3,584**	**968**	**2,628**	**410**	**478,433**
2015	Admin	14	0	102	2	2	48,817
	CHE	302	0	193	31	21	88,837
	Marine	4,923	223	611	2,694	115	400,975
	Onroad Vehicle	103	0	66	13	6	20,391
	Rail	201	0	31	13	5	11,222
	TOTAL	**5,542**	**224**	**1,003**	**2,752**	**149**	**570,241**
2020	Admin	13	0	59	1	2	48,817
	CHE	189	0	128	24	12	97,115
	Marine	4,872	235	644	2,776	120	421,435
	Onroad Vehicle	66	0	51	8	4	22,134
	Rail	201	0	33	13	5	12,043
	TOTAL	**5,342**	**236**	**913**	**2,822**	**144**	**601,543**
2025	Admin	12	0	58	1	2	48,817
	CHE	133	1	97	21	8	106,198
	Marine	4,364	248	680	2,883	127	444,503
	Onroad Vehicle	44	0	43	6	3	23,927
	Rail	201	0	35	13	5	12,937
	TOTAL	**4,754**	**249**	**912**	**2,924**	**145**	**636,382**

6.0 EMISSION REDUCTION INITIATIVES

Emission Reduction Initiatives (ERIs) were included to the project scope of work to illustrate the effectiveness of current and future actions by the EC/GL ports and port terminals. Current ERIs have been implemented and can be characterized with use of operational data. Future ERIs require an estimation of the expected improvement in fuel consumption, emission rates or, in one case, distance of travel. For these reasons, the future ERIs have greater uncertainty. Practically, estimating the effects of an ERI with PEIT requires identification of equipment use before and after implementation. PEIT was used to create 3 inventories to evaluate the impact of the ERIs as follows:

- Business As Usual (BAU) Inventory: the 2010 PEIT inventory without inclusion of any current ERIs.
- Baseline Inventory: the 2010 PEIT inventory with the current ERIs included.
- ERI Inventory: the 2010 PEIT inventory with all ERIs (current and future) accounted for.

Each of the 3 inventories was forecast to 2025 in order to determine the effect of the ERIs by inventory year. The Baseline Inventory is considered "correct" for 2010, whereas the ERI Inventory is considered correct for all future years (the forecasts shown in Chapter 5 relate to the ERI inventory).

An ERI was loosely defined to be an emission reduction action that would not have occurred through normal port or terminal management. For example, replacement of an older piece of equipment at its typical end of life would not be considered an ERI. In addition, any initiative thought to be small in magnitude or not readily supported by specific information was also not included.

Table 6-1 provides identification of the current (completed) and future ERIs, including year of initiative and effect. The "energy efficient lighting" ERI is a significant upgrade performed on the compound lighting infrastructure at one terminal. The oxidation catalyst ERI is an aftermarket product installed on cargo-handling equipment. At one terminal, biodiesel averaging 18% renewable fuel content was used instead of regular diesel.

The one "future" ERI has already been established, but was not in effect during 2010. In this case, the gen set switch locomotives are 3-engine 2000hp models with Tier III compliant engines. The emission factors and fuel consumption for that specific model were unavailable so the emission factors employed were from a similar 3-engine 2000hp Tier III model, from a different manufacturer.

The nature of each ERI is also identified, by noting which inventory measures are affected. In most cases, fuel consumption is affected, which affects (lowers) all air contaminants. In other cases, only a subset of the energies/contaminants is affected.

Table 6-2 provides an estimate of the benefit of each completed ERI, including reduction in emissions and fuel consumption. Table 6-3 provides a similar estimate for the future ERI, which is expected to be fully realized by 2015.

Table 6-1: Current (1–4) and Future (5) Emission Reduction Initiatives at the EC/GL Ports

ERI Number	Status	Reduction Initiative	Effect on EI Estimates	Inventory Years Affected	Year Initiative Started
1	Completed	Energy-efficient lighting	Lower fuel use and CO_2 emissions	2010–2025	2010
2		Oxidation catalyst	Lower CAC emissions	2010–2025	2010
3		New Highway Truck marshalling area	Lower fuel use and all emissions	2010–2025	2010
4		Use of high bio content diesel	Lower GHG emissions	2010–2025	2010
5	Future	Use of gen set switch locomotive engines	Lower fuel use and all emissions	2015–2025	2015

Table 6-2: Estimated Fuel (litres) and Emissions (kg) Reductions for the Completed ERIs in 2010 to the Port Boundary

Initiative	Fuel (L)	CACs						CO_2e
		NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	
1	-	0	0	0	0	0	0	-766,891
2	-	17	0	134	37	20	19	0
3	-24,100	-713	-1	-218	-91	-48	-42	-64,738
4	0	0	0	0	0	0	0	-64,324
TOTAL	**-24,100**	**-696**	**-1**	**-83**	**-53**	**-29**	**-23**	**-831,628**

Initiatives: 1 – Energy-efficient lighting
2 – Oxidation catalyst
3 – New Onroad highway truck marshalling area
4 – Use of high bio content diesel

Table 6-3: Estimated Fuel (litres) and Emissions (kg) Reductions for the Planned ERIs in 2015 to the Port Boundary

Initiative	Fuel (L)	CACs						CO_2e
		NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	
5	-342,716	-42,315	-7	-5,979	-2,720	-1,023	-993	-912,653

Initiatives: 5 – Use of gen set switch locomotive engines

7.0 CONCLUSIONS

7.1 Port Emissions in Context

While Canadian port authorities have responsibility for environmental management, they do not have authority over emissions released by the rail and marine operators that frequent their ports. Additionally, they have limited authority over practices employed by their tenants (the terminal operators) (17). Regulatory actions that restrict emissions are implemented at the national level. As such, actions taken by port authorities with respect to emissions tend to be complementary to government actions and collaborative or incentive-based in nature. While some of the emission improvements at Canadian ports over the last several years are a direct result of government regulations, some also relate to voluntary initiatives that engage the port partners.

The relative magnitude of port emissions can be evaluated in different ways. The movement of goods by the marine mode has long been identified as the most efficient when compared to alternatives including aviation, rail and trucking. For example, the National Resources Defense Council (NRDC) identified the GHG efficiency for containerized goods on each transport mode as follows (18):

- Ship – 11 gCO_2e/ton-mile
- Rail – 40 gCO_2e/ton-mile
- Truck – 119 gCO_2e/ton-mile
- Air – 1,193 gCO_2e/ton-mile

While these measures would change to some degree based on commodity and trade route chosen, the outcome of modal comparisons consistently shows a considerable efficiency advantage for shipping that extends to other air contaminants as well as CO_2.

Assuming a loaded container has a mass of approximately 10 tons, the movement of one container from Europe to Canada (distance assumed to be 3,500 mi) would release approximately 385 kg of CO_2e. Handling and processing that container through one of Canada's east coast ports would release approximately 48 kg of CO_2e (this assessment is shown in Chapter 7.3). Moving the container to an eventual destination in North America by rail (distance assumed to be 600 mi) would release approximately 240 kg of CO_2e. In this representative scenario, the port-related emissions constitute approximately 7% of the total emissions associated with the full movement of the one container.

Port-related emissions can also be compared to emissions from other sources within a defined urban center. As an example for the Port of Hamilton, the total 2010 port-related emissions (to the Port Boundary) are compared to 2005 emissions from Hamilton City operations as well as 2006 emissions from the broader community in Table 7-1. The community emissions do not include industrial facilities within the city (19).

Table 7-1: Port of Hamilton Emissions Relative to the City of Hamilton (tonnes)

Fuel Type	SO_x	NO_x	$PM_{2.5}$	CO_2e
Port	133	257	19	44,894
City Operations	979	17,717	178	135,038
Community	74,818	14,164	3,189	12,758,652

The port's emissions constitute from 1% (NO_x) to 33% (CO_2e) of the 2005 municipal emissions and from 0.2% (SO_x) to 2% (NO_x) of the 2005 community emissions. For larger communities such as Montreal, the port-related emissions likely constitute a smaller relative portion.

7.2 Inventory Uncertainty

Inventory uncertainty cannot be fully quantified. While estimates of the uncertainty associated with emission rates is possible (although complex), the uncertainty of the activity data reports from the port terminal representatives is very difficult to evaluate. The accuracy of the data generation methods used for the non reporting terminals is also difficult to estimate.

Potential reporting errors were minimized through both data review from an experienced practitioner as well as PEIT-developed checks for consistency between predicted fuel consumption (based on reported hours of equipment use) and reported fuel consumption. The latter tests were conducted for the CHE source group only, since this source group has readily available annual fuel data in almost all cases (for the reporting terminals). Additional logic checks were performed during development of the emission intensity values developed for the main commodity types handled by the ports. These intensities are discussed in Chapter 7.2.

Table 7-2 provides a summary of the inventory fuel data, allocating the amounts to 3 categories – data records, activity-based estimates and surrogate means (e.g., methods identified in Chapter 2.1.2 and elaborated in Appendix IV).

Table 7-2: Inventory Fuel Data Summary

Fuel Type	Inventory Total (GJ)	Fuel Data Record (GJ)	Activity Based Estimate (GJ)	Surrogate (GJ)
Diesel/Heating oil	893,500	651,200	205,200	37,100
Electricity	1,107,500	976,900	0	130,700
Gasoline	44,000	36,700	1,500	5,800
Natural gas	714,800	634,700	0	80,100
Propane	29,200	22,100	0	7,100
Heavy fuel oil	2,873,600	0	2,873,600	0
Marine diesel oil	1,527,400	167,300	1,360,100	0
Marine gasoline oil	104,600	99,100	0	5,500

Table 7-2 shows that a relatively small amount of the total fuels consumed stems from surrogate estimates. Consumption of marine fuels almost entirely relates to activity-based estimates and therefore the uncertainty with these estimates for a particular port should be considered higher than for the other fuels used by the land-based sources (an exception being marine gas oil, which is largely used by tugs).

An estimate of the aggregate uncertainty in fuels consumed by the EC/GL ports was made using the following base uncertainty estimates:

- Fuel data records – 10%
- Activity based estimates – 30%
- Surrogate estimates – 60%

These relative uncertainties are simple rough estimates for discussion purposes and are based on the judgment of the authors. The uncertainties were applied to the total terminal fuel estimates and were propagated through the inventory using a method described in the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (7). Equation (1) shown below outlines the uncertainty calculation method. It assumes a normal distribution of the relevant variables with no systematic bias in the estimation methods.

Equation (1): for quantifying uncertainty where uncertain values are to be added

$$U_{Total} = \sqrt{(AxU_A)^2 + (BxU_B)^2 + ... + (NxU_N)^2} \quad (1)$$

Where: U_{Total} is the percentage uncertainty for a sub-total or total of a number of estimates

(A, B.....N), each of which having an estimated uncertainty (U_A, U_B....U_N)

Applying the uncertainty scheme to the total inventory fuel consumption yields the measures shown in Table 7-3. These values provide a reasonable estimate of the total inventory fuels uncertainty, assuming no inherent bias in the general data collection and data derivation methods employed in the inventory, as well as no significant errors in the final consumption reports from the terminals. These assumptions should be considered before use of the uncertainty estimates for any other purposes.

Table 7-3: Estimated Inventory Uncertainty in Fuel Consumption (values in GJ)

	Diesel	Electricity	Gasoline	Natural Gas	Propane	Heavy Fuel Oil	Marine Distillate Oil	Marine Gas Oil
Inventory Total	893,500	1,107,500	44,000	714,800	29,200	2,873,600	1,527,400	104,600
Aggregate Uncertainty (%)	2.6%	3.5%	4.5%	5.2%	14.9%	4.7%	4.3%	6.1%
Aggregate Uncertainty (±, GJ)	23,000	38,800	2,000	37,000	4,300	135,800	65,200	6,400

7.3 Emission Intensities

Emission intensities can be developed for a type of process or activity as a metric for wider emissions accounting (e.g., data for life cycle inventories) or simply as a measure of environmental performance. Performance metrics for transportation are gaining interest for a number of different reasons including adherence to government efficiency standards, with the IMO's Energy Efficiency Design Index (EEDI) or the Energy Efficiency Operational Indicator (EEOI) as good examples of this.

A defined activity or activity cycle must be identified to develop port-related emission intensity, especially if its purpose is to compare performance by location or by year. PEIT can support the development of port-related emission intensities for goods handling if the following criteria are met:

- A well defined, consistent boundary is applied (e.g., Terminal/Facility Boundary); and
- Both activity and throughput over a specified period such as a year are consistent.

In practical terms, port-wide data cannot be used to develop these intensities due to lack of commodity resolution in the base data. For example, the "type" of each terminal in a port was designated as one of the major commodity groups (breakbulk, container, etc). However, in some cases a terminal may deal in more than 1 major commodity. To serve as example, the Port of Belledune handles breakbulk goods, but does not have a terminal that is exclusive to breakbulk handling. Instead, the breakbulk goods are handled at a terminal that largely deals in bulk solid goods. For this reason, the emissions for the terminal are associated with bulk solid goods. This is a limitation of PEIT and port emission inventories in general – it is very difficult to accurately attribute activities and emissions to more than one commodity type at any one terminal, since disaggregated activity data are generally not available.

Terminal-level data must therefore be used to develop the emission intensities, only including those terminals that deal exclusively in one type of commodity. To serve as example, Tables 7-4 and 7-5 provide the emissions intensities for the five largest bulk solid and container terminals in EC/GL, including the key air contaminants of interest.

Table 7-4: Terminal Emission Intensities for Bulk Solid Handling at EC/GL Ports (g/tonne)

Measure	NO_x	SO_x	$PM_{2.5}$	CO_2e
Minimum	2.5	2.4	0.2	220
Maximum	36.4	23.8	2.5	2,532
Weighted Average	17.2	12.2	1.3	1,597

Table 7-5: Terminal Emission Intensities for Container Handling at EC/GL Ports (kg/TEU)

Measure	NO_x	SO_x	$PM_{2.5}$	CO_2e
Minimum	0.42	0.23	0.03	38
Maximum	0.63	0.44	0.05	75
Weighted Average	0.48	0.32	0.04	48

The intensities shown in the tables above include all emission sources (including Admin) and all energies consumed, including electricity. Figures 7-1 and 7-2 provide further breakdown of the intensity values identifying the contribution by the individual source groups. These figures show that Marine tends to be the highest contributor to the intensities, as is generally expected.

Table 7-4 shows considerable variability in the emission intensities for bulk solid handling, while Table 7-5 shows less variation for container handling. This is due to fundamental differences in moving and processing bulk solids for the specific bulk solid types handled. For example, handling salt is quite different in nature than handling iron ore. For this reason, bulk solid intensity values are not very useful unless a specific type of bulk solid is identified.

Container intensity values are comparable, acknowledging that some influence would be due to the weight of the containers (the average mass for the containers in 2010 ranged from a low of approximately 4 tonnes/TEU to a high of 11 tonnes/TEU for the EC/GL terminals) and the number of refrigerated reefers a terminal may handle.

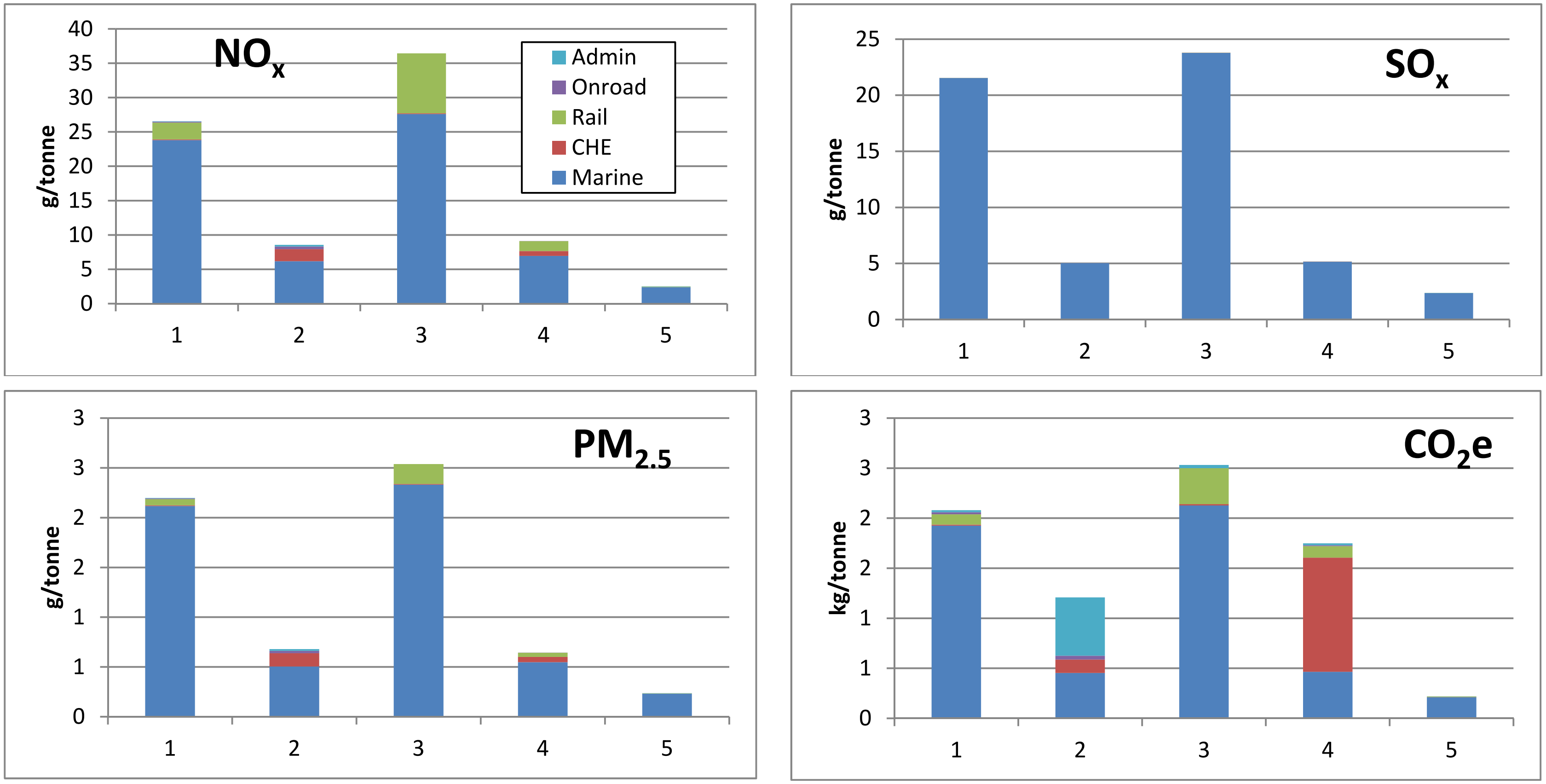


Figure 7-1: Terminal Emission Intensities for Bulk Solid Handling by Source Group

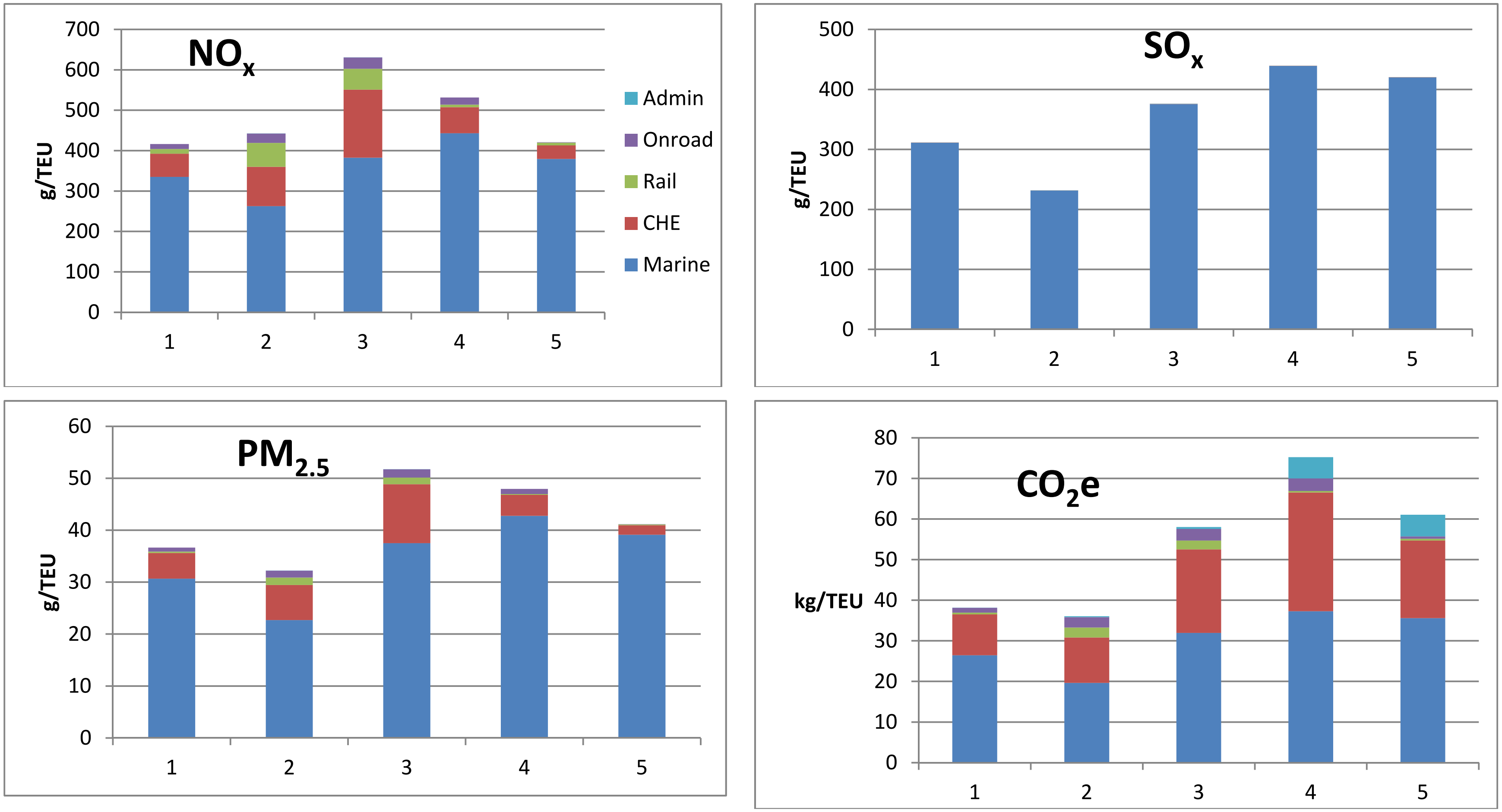


Figure 7-2: Terminal Emission Intensities for Container Handling by Source Group

Figure 7-2 provides some indication of why the container intensities are lower at some terminals than others. The following observations are made, without identifying any specifics of the individual terminals:

- Terminals with higher throughput tend to achieve lower intensity values for all emissions.
- CHE constitutes a significant portion of the total emissions; however the contribution of CHE for the CACs (compared to Marine) tends to be lower than for CO_2e due to use of cleaner fuels on the landside and, in some cases, use of electrified equipment.
- Contributions from Admin tend to be insignificant with the exception of CO_2e in some cases.

Given the current interest in container handling, energy intensity values were also developed for the top 5 EC/GL terminals to further explore the variabilities identified in Figure 7-2. The container terminal energy intensities are displayed in Figure 7-3. These intensity patterns are similar to those of the CO_2e intensities with some difference due to the carbon intensity of electricity from one region to the next.

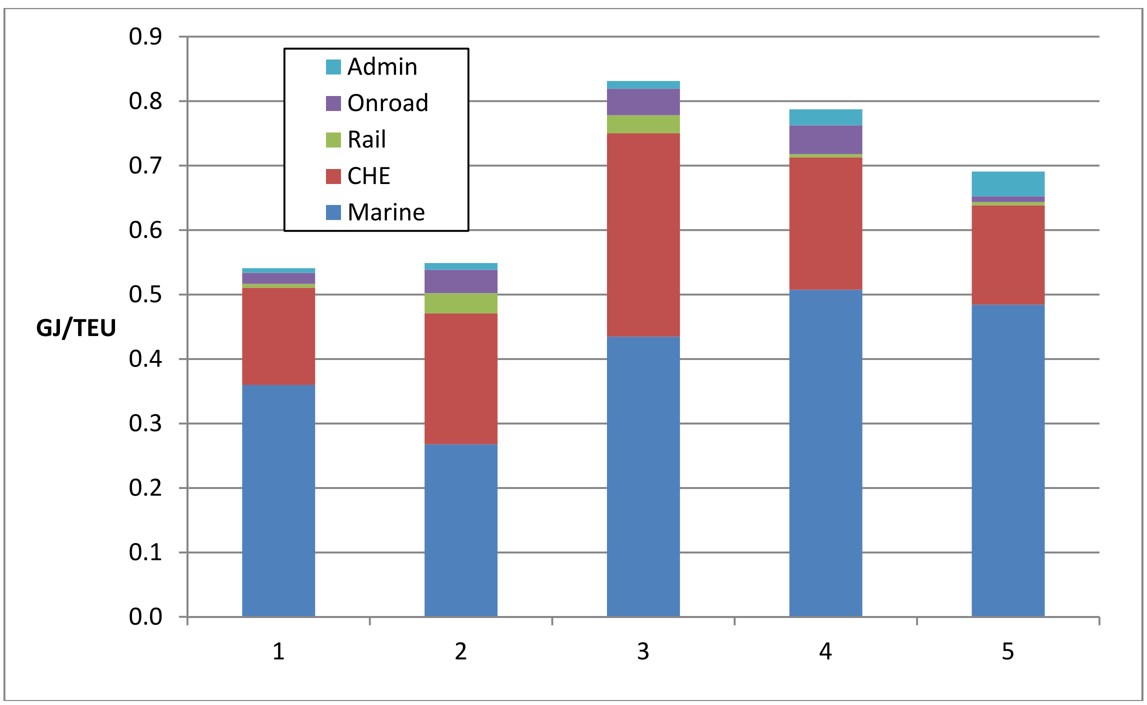


Figure 7-3: Terminal Energy Intensities for Container Handling, by Source Group

A similar exercise was conducted for breakbulk goods. However, in this case only two terminals that exclusively handle a significant quantity of breakbulk goods are available for analysis. With this in mind, the weighted average intensity values for breakbulk goods on the EC/GL in 2010 are as follows:

- 182 g/tonne NO_x
- 149 g/tonne SO_x
- 17 g/tonne $PM_{2.5}$
- 15 kg/tonne CO_2e

A listing of commodity-based emission intensities for the EC/GL ports in 2010 is provided in Appendix V. These values are identified by specific commodity type and are representative of the EC/GL ports as a whole (e.g., they are weighted by the relative amounts that pass through the individual terminals that deal in the specific commodities).

7.4 Trends in Emissions

Figures 7-4 to 7-7 show the expected trend in emissions for the EC/GL ports as a whole, for NO_x, SO_x, $PM_{2.5}$ and CO_2e respectively. These trends relate to the Port Boundary. The same trends are shown in Figures 7-8 to 7-11 for the Terminal/Facility Boundary. While the total energy consumption and GHG emissions are expected to increase for the ports, SO_x and PM are expected to significantly decrease. NO_x emissions are forecast to rise by 2015 and then remain flat into the future. Although the port landside sources of NO_x will decline in aggregate emissions, the marine sources are expected to increase due to higher shipping levels. Given the significant international attention being applied to the marine sector, further improvements to efficiency and emission rates (to those simulated here) may be gained by 2025.

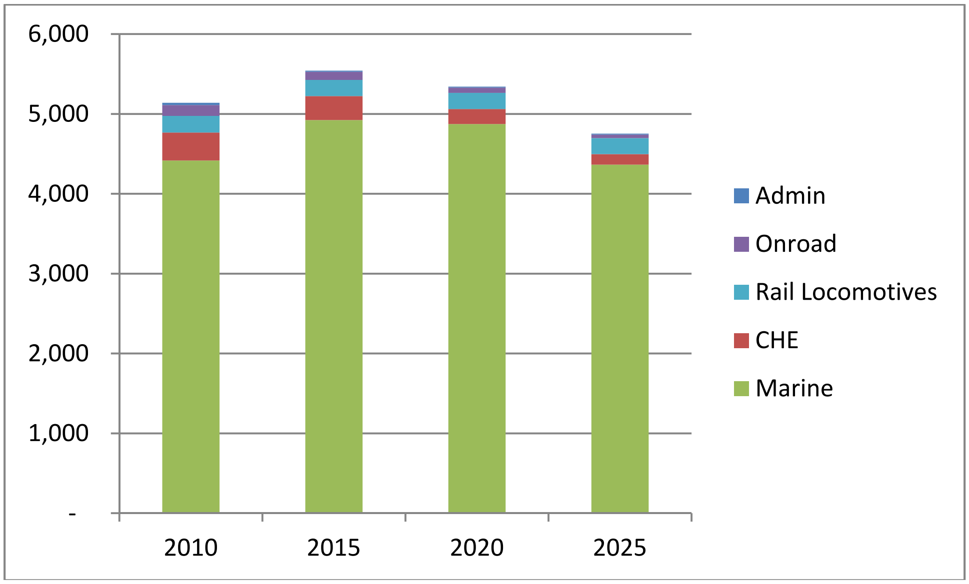


Figure 7-4: EC/GL Ports NO_x Emission Estimates to the Port Boundary (tonnes)

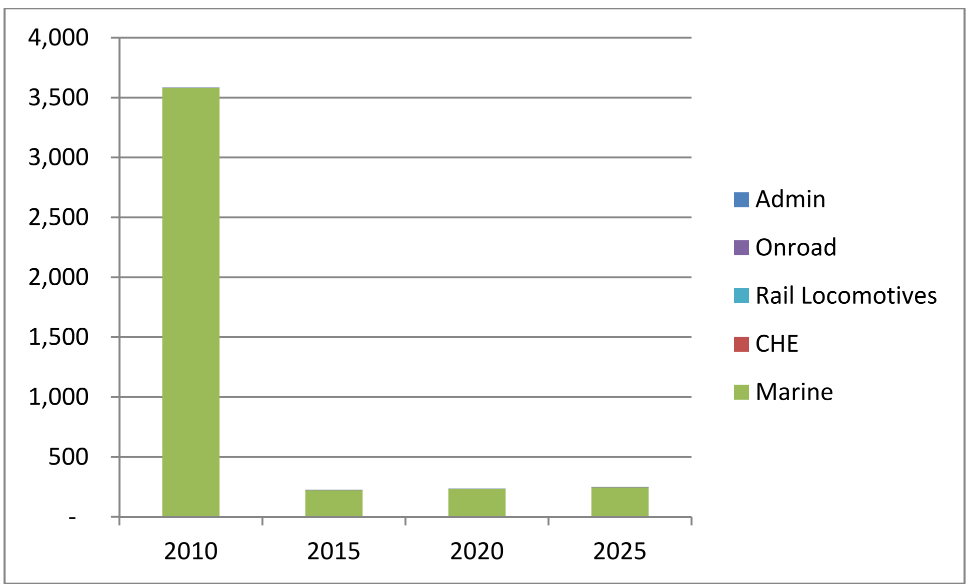


Figure 7-5: EC/GL Ports SO_x Emission Estimates to the Port Boundary (tonnes)

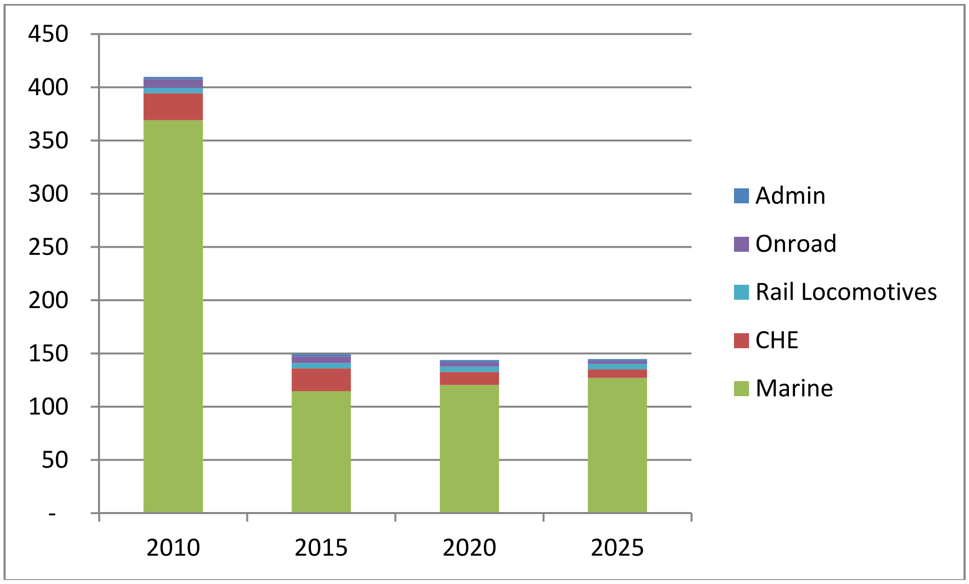


Figure 7-6: EC/GL Ports $PM_{2.5}$ Emission Estimates to the Port Boundary (tonnes)

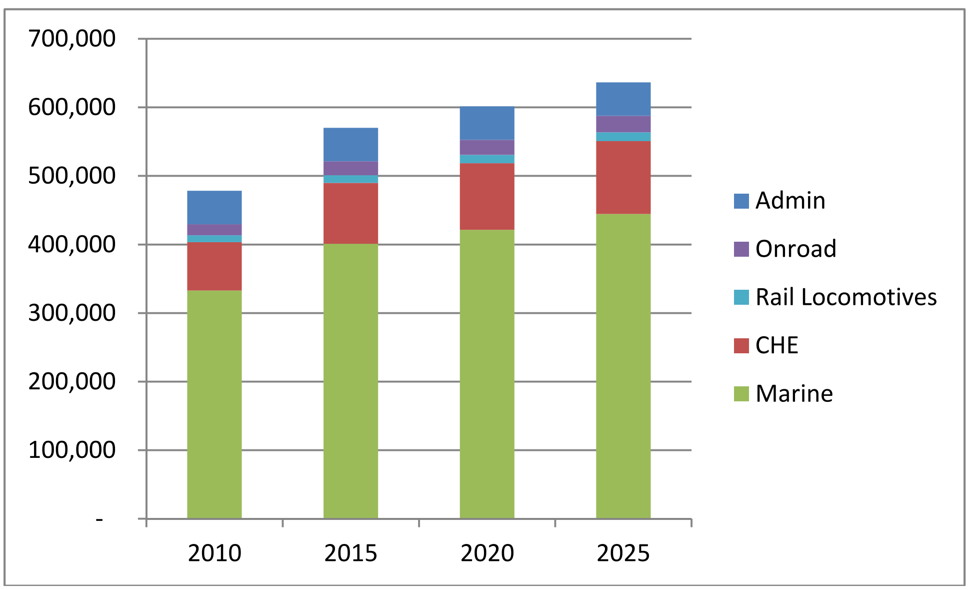


Figure 7-7: EC/GL Ports CO_2e Emission Estimates to the Port Boundary (tonnes)

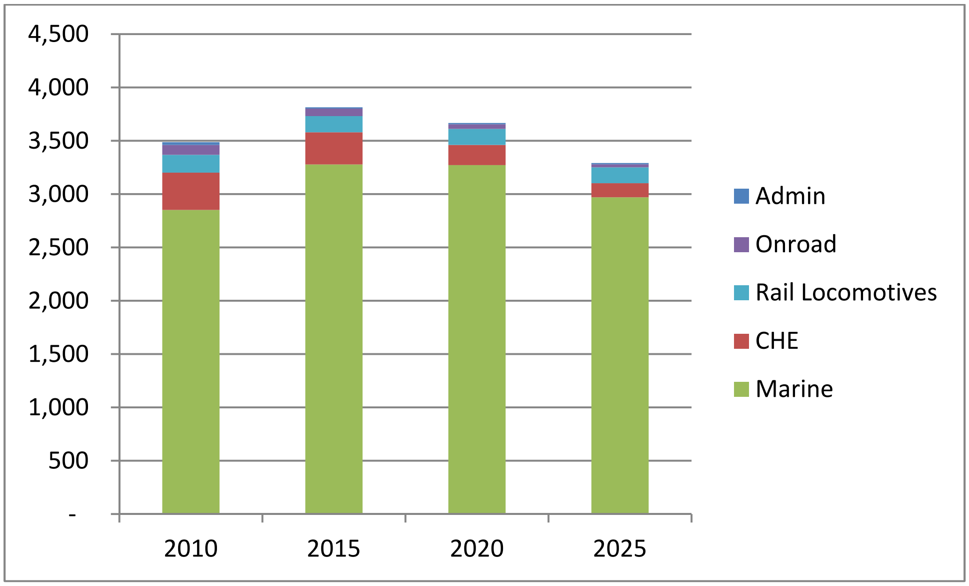


Figure 7-8: EC/GL Ports NO_x Emission Estimates to the Terminal/Facility Boundary (tonnes)

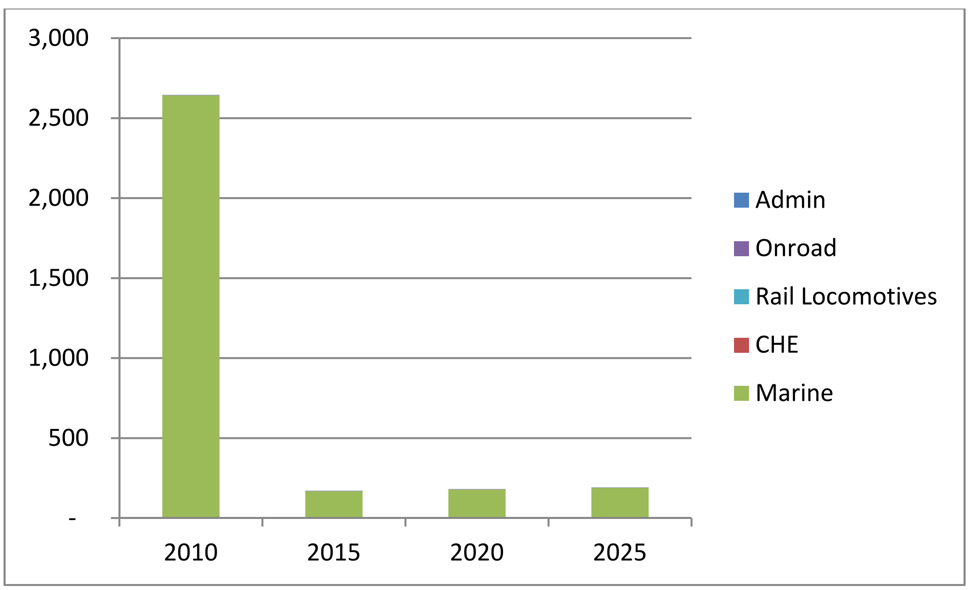


Figure 7-9: EC/GL Ports SO_x Emission Estimates to the Terminal/Facility Boundary (tonnes)

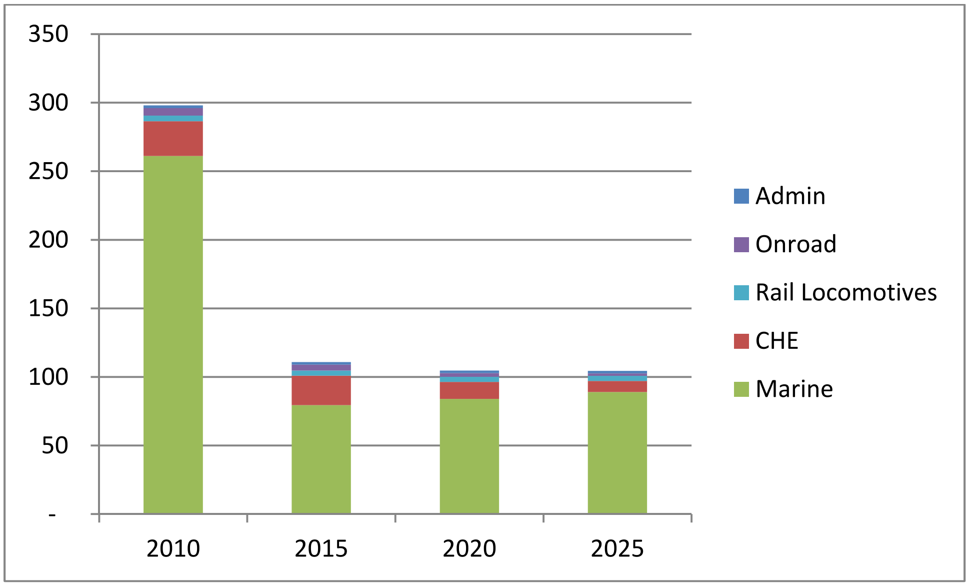


Figure 7-10: EC/GL Ports $PM_{2.5}$ Emission Estimates to the Terminal/Facility Boundary (tonnes)

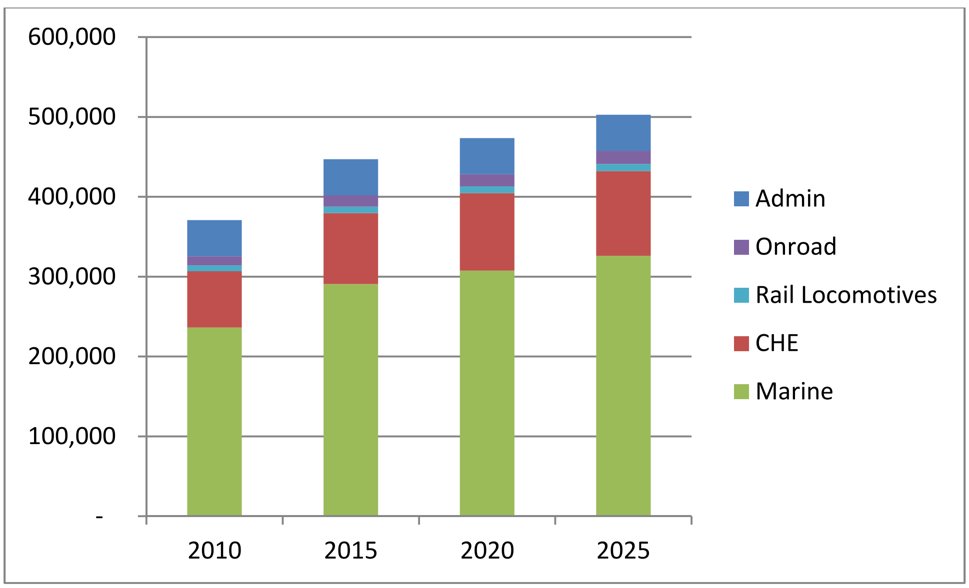


Figure 7-11: EC/GL Ports CO_2e Emission Estimates to the Terminal/Facility Boundary (tonnes)

7.5 Project Summary and Recommendations

A 2010 activity and emissions inventory was completed for the EC/GL ports of Belledune, Halifax, Hamilton, Montreal, Oshawa, Quebec, Saguenay, Saint John, Sept-Îles, St. John's, Thunder Bay, Toronto, Trois-Rivières and Windsor. The inventory is based on the four primary source groups Marine Vessels, CHE, Rail, and Onroad Vehicles and also accounts for administration (Admin) sources at the port authorities and the tenant terminals. In addition to a 2010 inventory, forecasts were prepared for 2015, 2020 and 2025, accounting for expected commodity growth and equipment turnover at the ports as well as documented fuel and emission regulations for the sector.

The inventories were made possible by use of the Port Emissions Inventory Tool (PEIT) Version 3.1. This tool has been supported by the Canadian government since 2008 and was updated during the project to meet the scope of work and to be consistent with the best available emissions data for the source groups. The model estimates provide a comprehensive accounting of the equipment, activities, fuels consumed, and emissions released for each of the ports during 2010, as well as an accounting of the current and planned ERIs that have been developed at the port and port terminals. The complete ports energy/emissions baseline for 2010 is a significant and first-time achievement for Canada that leverages a history of technical development work since approximately 2005 as well as government and industry collaboration that has improved over the years to the degree that a very high participation rate was achieved for the many port tenants in Eastern Canada and the Great Lakes. The terminal representatives that provided the essential activity information for 2010, did so voluntarily. It is hoped that the software developed for this work (PEIT) will be of continued use to the ports and terminals to update their inventories in a simple and transparent way.

With the exception of PM and SO_x, emissions for the EC/GL ports are expected to increase in future years due to expected growth in trade. The rate of increase in emissions has been significantly lowered for the CACs due to actions taken by Canadian government, ports/terminals, and the international shipping community. It has reversed for PM and SO_x. This shows that there have been successful efforts to minimize the environmental footprint of the Canadian ports. It is expected that these efforts will continue and may achieve reductions beyond the forecasts identified in this study, which relate to the identifiable programs and regulations at this time (that generally tend not to extend beyond five years into the future).

Commodity-based emission intensities were developed from the EC/GL ports inventory by identifying terminal emissions for a particular commodity and applying a tonnage- or TEU-based weighting. The values determined for containerized goods, which are inclusive of all sources (including Admin) and energies are as follows:

- 48 kg/TEU CO_2e
- 0.48 kg/TEU NO_x
- 0.32 kg/TEU SO_x
- 0.04 kg/TEU $PM_{2.5}$

Similar indicators were determined for breakbulk handling and a number of specific bulk solid goods (e.g., iron ore, grains, etc). It is suggested that the emission intensities may have greatest application to an individual terminal or an individual port as a key performance indicator that can be used to communicate and track environmental performance over time. Such metrics may also be useful to other groups to evaluate the energy and emissions consequence of moving goods by the different modes of transport. The port-based emission intensities can be used with transportation-specific intensities (e.g., emissions per tonne-km) that are becoming available for the shipping, rail, and trucking sectors. In this regard, the intensity values identified in Appendix IV constitute a valuable data source for groups interested in transportation emissions assessment or life cycle analyses.

Access to high quality data continues to improve. As such, there may be opportunities to improve upon PEIT and the representativeness of the port/terminal inventories. A number of recommendations are made for the future:

- PEIT currently addresses fugitive emissions of VOCs from the storage of fuel cargo on board ships and dockside loading/unloading. This module is consistent with MEIT V4.0 and makes assumptions about the type and volume of fuel based on vessel type. However, port ship call records include identification of the type and volume of fuel transferred at terminal, meaning that significant improvements of this module may be possible by utilizing additional data fields from the port ship call record (the cargo fields are not currently used).
- Fugitive GHG emissions associated with refrigerated cargo (reefers) are not included to PEIT currently. Estimates of these emissions would be possible by using additional data fields from the ship call records, similar to the recommendation above.

- Historically, administrative sources have not been included to port inventories and therefore the methods employed to PEIT are relatively simple at present. Additional information could be collected for the Admin sources such as boilers to better characterize the emissions and energy consumption for this source group.
- National/Regional Rail remains the most difficult source to characterize for the ports. Improvements in the rail module of PEIT may be possible, depending on activity data availability. This would require methods investigation and the cooperation of the national rail lines.

8.0 WORKS CITED

1. **Transport Canada.** Transport Canada Acts and Regulations. *Transport Canada.* [Online] [Cited: 03 31, 2013.] http://www.tc.gc.ca/eng/acts-regulations/acts-1998c10.htm.

2. **SNC-Lavalin Environment.** *2010 National Marine Inventory.* Ottawa : Environment Canada, 2012.

3. **Intergovernmental Panel on Climate Change.** Publications and Data Reports. [Online] 1995. [Cited: 03 31, 2013.] http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#.UXgxbEq6NXY.

4. **SNC-Lavalin Environment.** *Transport Canada Port Emissions Inventory Protocol.* Ottawa, ON : Transport Canada, 2012.

5. **SNC-Lavalin Inc., Environment Division.** *Port Metro Vancouver 2010 Landside Emission Inventory.* [Online] www.portmetrovancouver.com/en/environment/initiatives/Air.aspx. Burnaby, BC : s.n., 2012.

6. **Transport Canada.** Letters Patent and Supplementary Letters Patent - Transport Canada. [Online] March 2013. http://www.tc.gc.ca/eng/programs/ports-letterspatent-1119.htm.

7. **IHS Fairplay.** Maritime Intelligence and Publications: IHS Fairplay. *IHS.* [Online] [Cited: 03 31, 2013.] http://www.ihs.com/products/maritime-information/ships/sea-web.aspx.

8. **SENES Consultants and SNC Lavalin Environment.** *Emissions Inventory of Landside and Marine Sources at the Port of Montreal.* Montreal, QC : Transport Canada, 2009.

9. **Railway Association of Canada.** *Locomotive Emissions Monitoring Program .* s.l. : Available from: http://www.railcan.ca/assets/images/publications/LEM/LEM2010eng_rev8.pdf, 2010.

10. **Environment Canada.** Sulphur in Diesel Fuel Regulations. [Online] 03 26, 2013. [Cited: 03 26, 2013.] http://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=7A8F92ED-1.

11. **US EPA.** *Final Rulemaking to Establish Greenhouse Gas Emissions Standards and fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles. Regulatory Impact Analysis, August 2011.* s.l. : US EPA, 2011. 420R11901.

12. **US EPA Assessments and Standards Division.** *Regulatory Impact Analysis: Control of Emission of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Litres per Cylinder.* s.l. : US EPA, 2008. EPA420-R-08-001a.

13. **International Maritime Organization.** Prevention of Air Pollution from Ships. *International Maritime Organization.* [Online] 03 26, 2013. [Cited: 03 26, 2013.] http://www.imo.org/OurWork/Environment/pollutionprevention/airpollution/pages/air-pollution.aspx.

14. **International Maritime Organization.** IMO Marine Environment Protection Committee 65th session pushes forward with energy-efficiency implementation. *International Maritime Organization.* [Online] 05 21, 2013. [Cited: 05 26, 2013.] http://www.imo.org/MediaCentre/PressBriefings/Pages/18-MEPC65ENDS.aspx.

15. **International Maritime Agency.** *Second IMO GHG Study 2009.* 2009.

16. **US EPA.** *AP-42 Compilation of Emission Factors.* [Online] [Cited: 03 31, 2013.] http://www.epa.gov/ttnchie1/ap42/ch01/index.html.

17. **Transport Canada.** *Canada Marine Act – Review.* Ottawa, ON : Transport Canada Marine Policy Branch, 2003. TP14107B.

18. **Natural Resources Defense Council.** Clean by Design: Transportation. *NRDC The Earth's Best Defense.* [Online] 5 2, 2012. [Cited: 10 28, 2013.] http://www.nrdc.org/international/cleanbydesign/transportation.asp.

19. **Stantec.** *FINAL REPORT - City of Hamilton: Air Pollutant and GHG Inventory Project.* Hamilton, ON : City of Hamilton, 2009. PED09287.

20. **Intergovernmental Panel on Climate Change.** Task Force on National Greenhouse Gas Inventories. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.* [Online] June 15, 2001. [Cited: May 17, 2013.] http://www.ipcc-nggip.iges.or.jp/public/gp/english/.

21. **The British Columbia Coast Pilots Ltd.** British Columbia Coast Pilots. [Online] [Cited: 03 26, 2013.] http://www.bccoastpilots.com/.

22. **WRI/WBCSD.** Greenhouse Gas Protocol. *All Tools.* [Online] September 2003. [Cited: May 17, 2013.] http://www.ghgprotocol.org/calculation-tools/all-tools .

23. **IPCC.** *Second Assessment Report.* 1996.

APPENDIX A

PEIT V 3.1 User Guide

Transport Canada Transports Canada

TP 15192E

TRANSPORT CANADA
PORT EMISSIONS INVENTORY TOOL (PEIT) USER GUIDE
VERSION 3.1

Prepared For:

Transport Canada

April 23, 2013

Prepared By:

SNC-Lavalin Inc., Environment & Water

8648 Commerce Court
Burnaby BC, Canada, V5A 4N6

Canada

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

IN-TEXT TABLES

TABLE OF CONTENTS (Cont'd)

IN-TEXT FIGURES

Table 1: Index of Acronyms

CACs	common air contaminants
CH_4	methane
CNG	Compressed Natural Gas
CO	carbon monoxide
CO_2	carbon dioxide
DPM	diesel particulate matter
CO_2e	carbon dioxide equivalent
EF	emission factor
EI	Emissions Inventory
EPA	US Environmental Protection Agency
GHG	greenhouse gases
GWP	Global Warming Potential
HC	hydrocarbons
HFO	Heavy Fuel Oil, also called residual oil
hp	horsepower
IMO	International Maritime Organization
INNAV	Information System on Marine Navigation (Canadian Coast Guard)
IPCC	Intergovernmental Panel on Climate Change
kW	kilowatt
MDO	marine diesel oil, also called marine distillate
N_2O	dinitrogen monoxide, also referred to as nitrous oxide
NO_x	oxides of nitrogen
PM	suspended particulate matter
PM_{10}, $PM_{2.5}$	suspended particulate matter of diameter 10 (2.5) microns or less
ppm	parts per million (used to identify sulphur level in diesel fuel)
Protocol	Transport Canada Port Emissions Inventory Protocol
RAC	Railway Association of Canada
SO_2	sulfur dioxide
SO_x	oxides of sulfur
TEU	twenty foot equivalent unit
tonne	Metric tonne = 1,000 kg

1. INTRODUCTION

This User Guide is designed to provide instructions on the use of the Transport Canada Ports Emissions Inventory Tool (PEIT) developed by SNC-Lavalin Inc., Environment Division (SLE). The Model was developed for Transport Canada during 2009 and updated in 2012 and 2013. The initial version of the User Guide included instruction on its application, whereas the recent update includes information on emission rates and use of defaults. The changes made in 2013 were in support of an emissions assessment for all 18 of Canada's official ports, for the 2010 calendar year, for the eastern ports[1] and the western ports[2]. The theoretical basis for PEIT is the Transport Canada Port Emissions Inventory Protocol (Protocol), which defines the sources, activities, boundaries and calculation methods that should be used for a port emissions inventory[3]. While the User Guide now provides information on the emission sources and calculations (Chapter 4), it primarily focuses on activity data sources, how to enter the data into the PEIT questionnaire and default fields that should be used if port data are not available. The Protocol can be consulted for further information on emissions data.

PEIT requires information on five distinct source groups:

- Marine Vessels – commercial Marine Vessels (CMVs) and harbour craft (tugs, ferries)
- Cargo Handling Equipment (CHE)
- Rail – port based locomotives and those from a national or regional rail line
- Onroad Vehicles – highway trucks (and other vehicles) and facility-operated vehicles
- Admin – administrative sources, including buildings and compound lighting

The five emission source groups constitute almost all of the total emissions that could be attributed to a port. Emissions include all common air contaminants (CACs), Greenhouse Gases (GHGs) and select air toxics. CACs include all 'criteria air contaminants' which is the preferred term in the US. In most cases, the majority of emissions are generated by port tenants and not the port directly. For this reason, a port requires the co-operation of its tenants to collect the necessary data required for PEIT.

A port emission inventory (EI) traditionally has focused on engine emissions from mobile sources. However, PEIT now accounts for direct emissions from stationary sources (e.g., space heating, boilers, and generators) and indirect emissions from purchased electricity. Fugitive hydrocarbon emissions from

[1] SLE, 2013. East Coast/Great Lakes Ports 2010 Emissions Inventory Study (DRAFT). Prepared for Transport Canada, contract no. T8125-110138/002/XSB. June 6, 2013

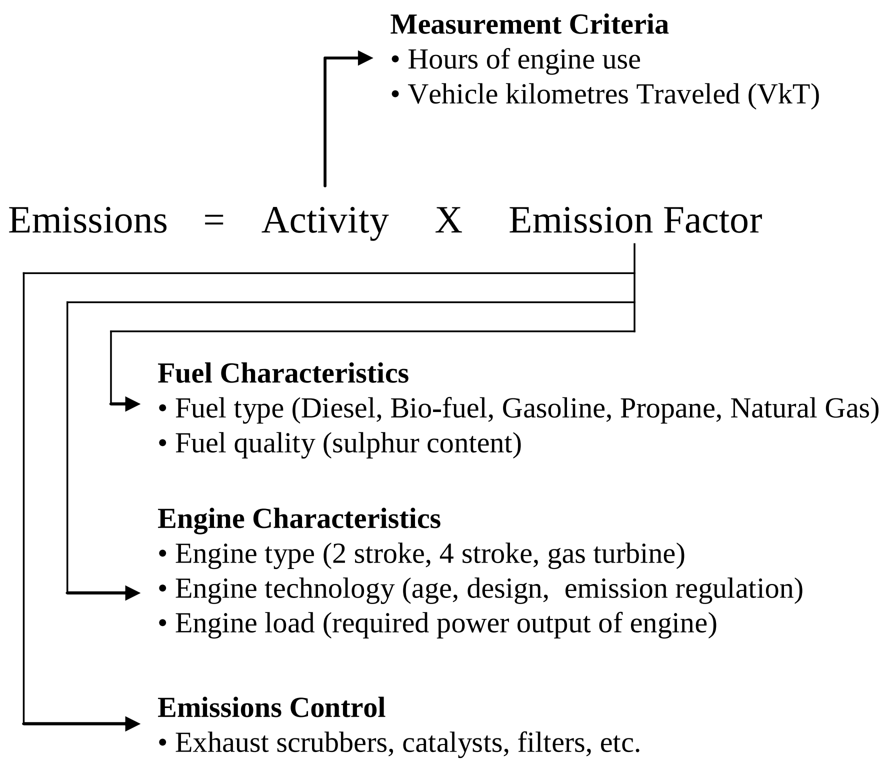
[2] SLE, 2013. West Coast Ports 2010 Emissions Inventory Study (DRAFT). Prepared for Transport Canada, contract no. T8125-101004/001/XSB. July 24, 2013

[3] SLE, 2012. Transport Canada Port Emissions Inventory Protocol. Prepared for Transport Canada.

ship fuels transport and loading/unloading are also now included. These sources may be considered optional for a port EI.

Emissions are calculated in PEIT from the generalized equation shown in Figure 1. The Model requires 'Activity' data and contains all 'Emission Factors' necessary to support the EI calculations. Depending on source, PEIT also requires identification of fuel and engine characteristics and emissions control technology (if an engine retrofit was completed).

Figure 1 – General Form of Emission Calculation (from Protocol)



PEIT also requires commodity data – amount of goods loaded or unloaded – to spatially allocate emissions and to support EI forecasts. Temporal information is additionally required to establish emission summaries by hour of day and day of week. The temporal information is optional and is used by the model to allow determination of relative emission levels by hour of day and day of week. In many cases, temporal information is simply work shift schedules; this establishes the times of day and days of week when emissions would be minimal (or zero).

A graphical representation of PEIT is provided in Figure 2. The PEIT questionnaire form (lower left of Figure 2) has specific MS Excel data tables for each of the five source groups identified. Although PEIT is representative of current best practices for port EI development, the EI quality will ultimately depend on the quality of activity data that are entered to the questionnaire tables. For example, errors or omissions in ship berthing records will result in inaccurate emission estimates from the model. A port representative should complete a number of logical checks to ensure that the activity data summaries (such as number of ship movements or number of rail movements) are accurate for the port as a whole.

The model user interface is built upon an MS Access database, which provides the supporting structure for the three main functions of PEIT. These functions are:

1) Import questionnaire activity information for a port or individual marine terminal/facility, perform quality checks on required data fields and expected value ranges.

2) Perform emission calculations based upon the activity data entered on the questionnaire sheets.

3) Report and aggregate the emissions to the following resolution:

    a) Inventory Boundary, Source Group, Equipment Type, Activity Type, Commodity Group, Fuel Type and Air Contaminant.

    b) Annual Total Emissions.

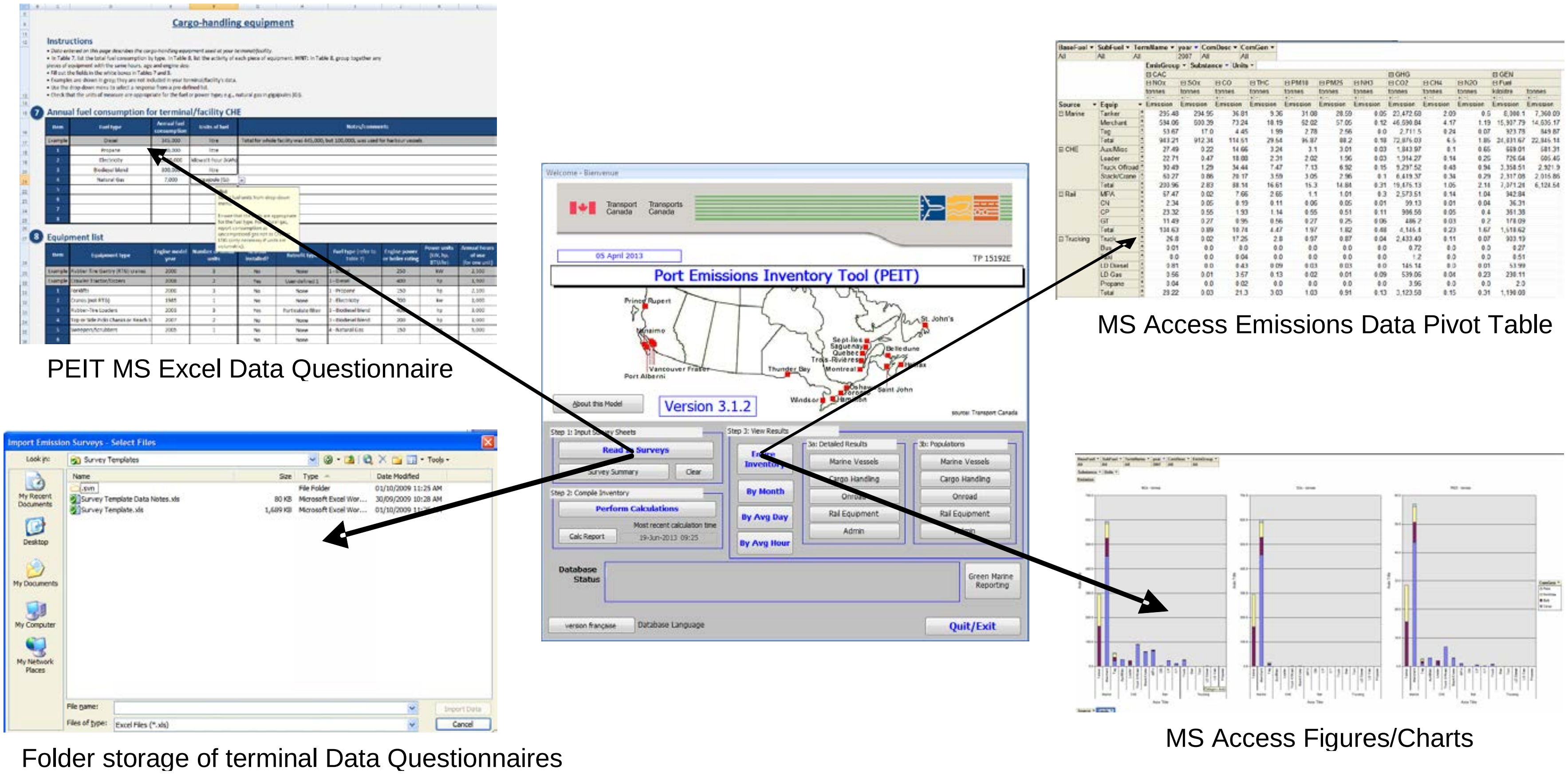
PEIT is fully operational within Access 2007 and 2010 (both runtime and full versions). The runtime version of Access 2007 can be downloaded from Microsoft's website. Another requirement to use PEIT is Microsoft Excel version 2003 or newer.

In most cases, a port will require each of its tenants to complete one PEIT questionnaire. Once all tenant questionnaires are imported to the database (potentially with additional information for the port itself) and quality checks have been successful, the port EI will be generated. The questionnaire data tables are described in detail in Chapter 3.

A brief description of the PEIT error checking process is provided in Chapter 5. Once a port authority receives a completed questionnaire from one of its tenants, the database should immediately be used to complete its internal data quality control. This process marks problematic fields (and missing entries) that must be addressed before any emission calculations. The tenant's marked up questionnaire (if errors are present) can then be sent back to the tenant for timely feedback.

In most if not all cases, an EI report should be prepared by the port or the port's contractor to accompany the PEIT emission summaries, to describe some of the important inventory decisions and assumptions that were made. References to such an EI report are made in Chapter 3, when describing the required data fields.

Figure 2 – Schematic of Port Emission Inventory Model



1.1. Inventory Year and Forecasts

The current version of PEIT supports port EI generation for the 2010, 2011, 2012 and 2013[4] calendar years. To begin the port EI process, a port representative must first decide which inventory year will be used, and communicate this to its tenants before any data collection activities commence. The activity data collected, including identification of equipment fleets, must relate to the inventory year chosen.

A port may decide to complete an EI forecast. Although PEIT can be used to facilitate generation of EI forecasts, generation of EI forecasts was not a primary design consideration. This is because there is no commonly accepted method for achieving detailed port EI forecasts and the potential methods for completing a port (or terminal) forecast require assumptions that can dramatically influence the future estimates. However, there are some common features that were used to generate the Port Metro Vancouver and Port of Montreal EI forecasts[5]. A summary of port EI forecast issues is provided here:

- A simplistic forecast can be generated by linearly scaling the EI estimates (allocated by commodity type) by expected changes to throughput values (tonnage of goods for bulk goods and TEUs for containers) to reflect the expected future port activity. All emission estimates in the Model are linked to commodity levels and therefore a quick, simple forecast can be achieved this way. This type of forecast does not include the effects of fleet replacement and lower engine emission rates for some of the air contaminants. As such, the EI forecast should be labelled appropriately, if used.
- A more detailed, and representative forecast can be achieved by linearly scaling the EI activity estimates (such as hours of engine use or kms of travel) by expected changes to commodity throughput values and re-establishing the equipment populations by age, based on expected fleet turnover for ships, locomotives, trucks and CHE. This can be completed by 1) projecting the current age distribution of engines into the future, keeping the same relative ages, or 2) entering specific engine details based on a careful consideration of what equipment is expected to be purchased and when (e.g., if a new terminal is expected to come on line in a future year).

---

4 An Emission Control Area (ECA) was established for the east and west coasts of North America in late 2013, which limits the sulphur content of marine fuels allowed in North American waters. PEIT assumes the (higher) average fuel sulphur contents from earlier analysis work for all years 2010 – 2013. Therefore PEIT over-estimate of the marine SO_X and PM emissions may result for the last few months of the 2013 year.

5 The Port Montreal report is available at http://www.tc.gc.ca/eng/quebec/environment-menu-1361.htm and the Port Metro Vancouver report is available at http://www.portmetrovancouver.com/environment/initiatives/air.aspx. These reports should be consulted for further information.

Detailed forecasts that account for expected changes to equipment fleets (including ships) were completed for Port Metro Vancouver and the Port of Montreal. In each case, a unique approach was used to establish the expected equipment fleets in the future. These steps require a considerable level of attention and experience and should likely be left to a qualified expert to complete.

1.2. Green Marine Reporting Requirements

Green Marine is a voluntary environmental program developed by the marine industry. Green Marine currently addresses six environmental issues, including air contaminant emissions and GHG emissions. PEIT facilitates completion of the Green Marine requirements for recognition of effective air quality and GHG management at the port or terminal level. In order to achieve level 3 on the air emissions performance indicator, a port must complete an inventory of air emissions and GHG emissions[6]. An individual marine terminal can also achieve the same level with use of PEIT. The inclusion of electricity consumption for the Green Marine Admin group is optional[7].

[6] See the Green Marine website at http://www.green-marine.org

[7] Based on information provided by D. Bolduc of the St. Lawrence Economic Development Council (SODES).

2. EI SCOPE

2.1. Air Contaminants

PEIT develops summaries of common air contaminants (CACs) and greenhouse gases (GHGs), including:

- CACs – NO_x, VOC, CO, SO_x, PM_{10}, $PM_{2.5}$
- GHGs – CO_2, CH_4, N_2O

Equivalent carbon dioxide (CO_2e) emissions are estimated in the Model, based on the Intergovernmental Panel on Climate Change (IPCC) global warming potential (GWP) values as reported in the Second Assessment Report[8], as follows:

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

The Model can additionally address air toxics. At this time, the following air toxics are supported: 2,2,4-trimethylpentane, acenaphthene, acenaphthylene, acetaldehyde, acrolein, ammonia, anthracene, arsenic (and related compounds), benz(*a*)anthracene, benzene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g*,*h*,*i*)perylene, benzo(*k*)fluoranthene, chromium (Cr^{3+} and Cr^{6+}), chrysene,, ethyl Benzene, fluoranthene, fluorene, formaldehyde, hexane, indeno(1,2,3,*c*,*d*)pyrene, lead, manganese, mercury (divalent gaseous, elemental gaseous, particulate), naphthalene, nickel, phenanthrene, pyrene, styrene, toluene, and the xylenes.

Additional allocation of PM to elemental carbon, organic carbon and sulphates is supported.

2.2. EI Boundaries

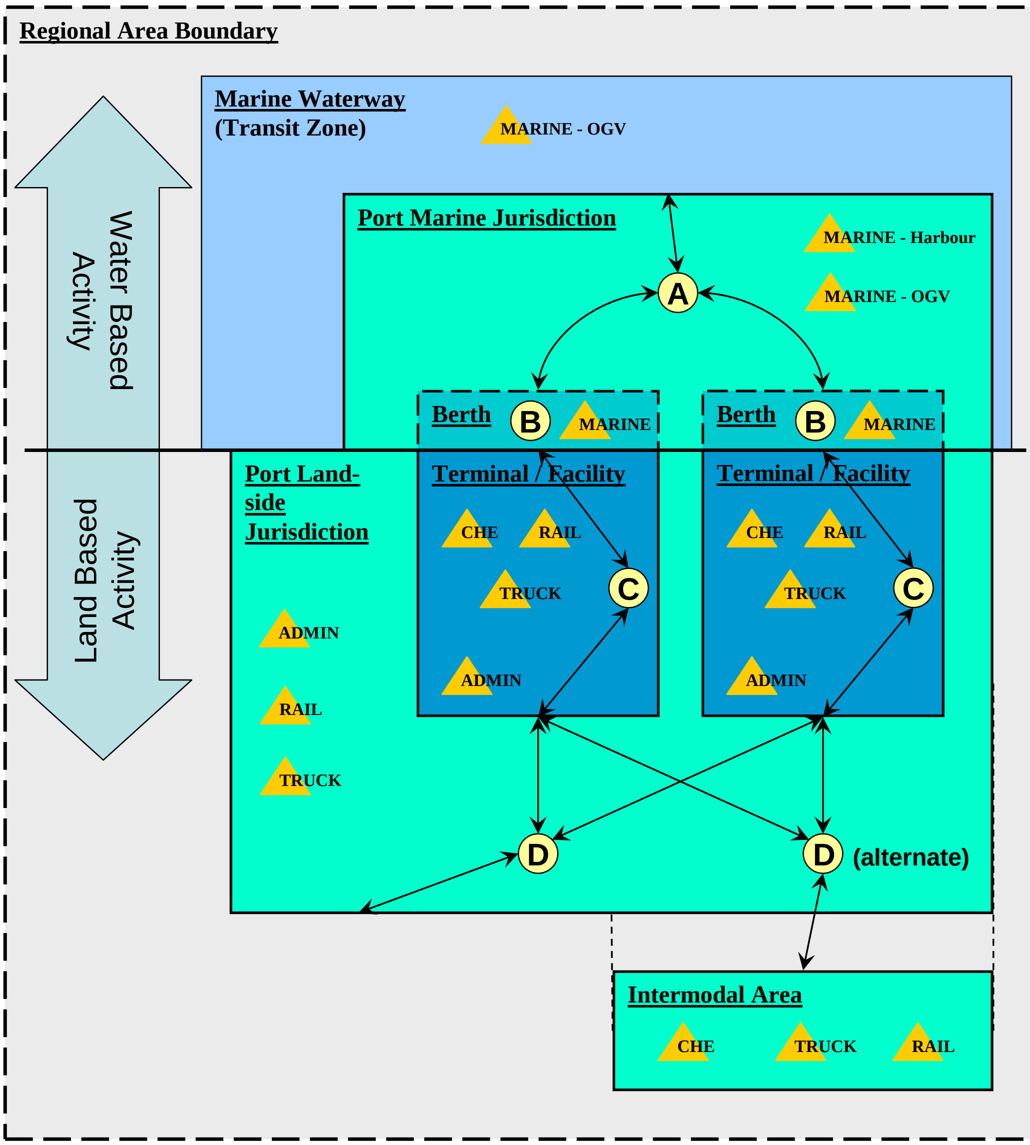
Figure 3 provides a representation of the port emission sources and where they are situated in relation to defined EI boundaries. PEIT refers to two boundaries:

a) Terminal/Facility Boundary – a port terminal or facility property that is directly managed by a port or port tenant. This boundary is usually defined by clear features, including the facility gate. Any marine berths that are part of the terminal/facility are included.

8 GWP values are based on a 100 year time horizon. See the IPCC second assessment report at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

b) Port Boundary – all land side and water side areas managed by the port where port related marine, CHE, rail or truck activity may occur. This boundary includes the port marine jurisdiction and all port landside property, some of which may be privately held.

Figure 3 – Port EI Boundary Schematic



Four Activity Zones are used in PEIT to define modes of activity for the data questionnaire form. As shown in Figure 3, the expected activity in these zones can be identified as follows:

- A: Marine transit, anchor and manoeuvring within the port marine jurisdiction.
- B: Marine berthing while at a terminal/facility.
- C: CHE, Rail and Truck activity on the terminal/facility grounds.
- D: Rail and Truck activity that occurs off of terminal/facility grounds, but within the port land-side jurisdiction. A port may utilize an off-site intermodal facility (e.g., container handling facility) and in that case Activity Zone D would include Rail and Truck activity from the terminal/facility boundary to the furthest extent of the Intermodal Area, even if the affected area includes public or private property.

It is expected that port tenants (e.g., terminal operators) can identify their terminal/facility boundaries without difficulty. In most cases, the port boundaries on the water side and the land side for a particular port will need to be identified by the port authority and communicated to the port's tenants before the PEIT questionnaire can be completed.

2.3. Port Tenants Included in the EI

Historically, port EIs have included activities that are directly related to the marine transport of goods. This general framework can be used to determine which port tenants should be included in a port EI assessment to be consistent with assessments that have been done in North America during the last several years. In some cases, a port may have tenants that do not engage in commercial marine activities in any way and these tenants may be excluded from the EI process. The following criteria are suggested to establish port tenant participation in the EI process:

- Does the facility handle traditional port commodities (e.g., bulk goods, containers, general cargo and passengers)?
- Does the facility provide service to the port or its tenants?

If the answer to either of the questions presented above is 'yes', then the facility should likely be included in the port EI.

3. DATA QUESTIONNAIRE FORMS

PEIT imports port and terminal data by way of MS Excel questionnaire worksheets. Each of the PEIT Questionnaire worksheets is structured with the colour coding shown in Figure 4. Fields highlighted in grey are example values. Yellow is used to identify missing or problematic fields that must be addressed before PEIT will complete emissions calculations. This colour will only appear after the questionnaire form has been input to the database (see Chapter 4). Following this step, the user can find the problematic cells, read the associated comments and make adjustments accordingly.

In two cases (for Onroad Vehicles and Rail) values in grey are also used for defaults if data are not available. This is further identified in the Onroad Vehicle and Rail descriptions that follow.

Figure 4 – Colour Coding Scheme in Questionnaire Forms

LEGEND:	(grey)	**Example or Default Value**
	(yellow)	**Missing/Check Entry (see cell comment)**

3.1. Basic Terminal Information ('Introduction' Worksheet)

The first Questionnaire worksheet, 'Introduction', contains basic information about the inventory. Most of the required fields can be filled in by the port authority before the questionnaires are sent to the tenants. An important field that must be entered identically for each tenant is the 'Inventory Year'.

It is important to note that one field is hidden in the table. The field 'Terminal Unique KEY' on row 19 is hidden from the tenant since it is used by the port (or contractor) for identification of the tenant information in the PEIT outputs. Any label can be used for this field and a port may use its own classification scheme so that tenant activity and emissions in the output pivot tables cannot easily be traced to the operator (e.g., if the model were to be shared with outside groups). Each Terminal key must be unique and not match any other questionnaire being entered otherwise the older data will be automatically replaced. This feature is included in the model for the purposes of tenant confidentiality, which may or may not be important in the port EI analysis.

The Terminal Unique KEY field can be filled in before or after the tenant completes the questionnaire. To expose this field, the user must first unlock the worksheet ('Unprotect Sheet' function in Excel) and unhide row 19. Once this field is entered, the row should be hidden and the worksheet protected again. The Excel password for all worksheets is 'sncPort'.

All other fields are self-explanatory.

3.2. Terminal/Facility Operations Data

Questionnaire Table 1 (Figure 5) is used to enter terminal/facility operations data in the 'Terminal' worksheet for the inventory year. The fields for annual commodity throughput and units of measure are required, but only for those commodities handled at the terminal/facility.

Figure 5 – Questionnaire Table 1

Item	Commodity type	Annual throughput	Units of measure	Notes / comments
Example	Bulk Solid - Fish	120,000	tonne	30,000t mackerel, 90,000t salmon
1				
2				
3				
4				
5				
6				

3.3. Administrative Activities

Terminal/Facility (or port) administrative energy consumption is entered in the 'Admin' worksheet, to **Questionnaire Table 2** (Figure 6)**.** Consumption data are entered for any fuel source, allocated to 'Boiler', General admin electricity' and 'Generator' (for the infrequent cases where a terminal may generate electricity before it is consumed).

Figure 6 – Questionnaire Table 2

Item	Fuel type	Energy / equipment type	Total annual consumption	Units of fuel	Description of energy usage
Example	Electricity	Electric grid	125,000	kilowatt-hour (kWh)	80% building usage, 20% compound lighting
Example	Natural Gas	Boiler	40,000	gigajoule (GJ)	Total of 2,000,000 GJ. Only 2% used for admin, rest for process.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

3.4. Marine

3.4.1. Maritime 1 (Harbour Vessels)

Harbour Vessels are distinguished from Ocean Going Vessels (OGVs) as vessels that are operated by a local company (which could be the port). In most cases, this source group will include tugboats that are used to assist OGVs in manoeuvring activities but may also include ferry services, pilots and even commercial tour operators. Total annual fuel consumption must be available for each vessel group that is entered. If a vessel group has a portion of its operations that extend outside of the Port Boundary (in most cases, the Port Marine Jurisdiction) an estimate must be made for the fuel consumed within the Port Boundary. If such an estimate is necessary, any assumptions should be expressed clearly in the EI report.

Questionnaire Table 3 (Figure 7) is used to enter annual fuel consumption data for Harbour Vessel groups. The required fields include identification of fuel type (drop list), annual fuel consumption and units for the fuel consumption (drop list). Sulphur level for all fuels is handled automatically in PEIT (see Appendix A). Each vessel group to be included in the *Maritime 1* category will have one (or more) annual fuel consumption entry.

Questionnaire Table 4 (Figure 7) is used to enter vessel annual activity information for each vessel. The 'Fuel type' field in **Questionnaire Table 4** is used to identify the particular fuel (which must be identified in Table 3) is used for the vessel. Each field in **Questionnaire Table 4** is described in Table 2 below.

Table 2: Field Definitions for Model Table 4

Vessel Name	Identify harbour vessel
Vessel Type	Identify vessel from drop list
Relative intensity of use	Amount of time the vessel is used relative to the other vessels in the group (low, high etc)
Installed rated engine power - Main engine	Vessel main engine power rating (total power if more than 1 propulsion engine)
Installed rated engine power - Aux engine	Vessel auxiliary engine power rating (total power if more than 1 auxiliary engine)
Installed rated engine power - Power units	Units used for the power rating values (kW, hp)
Engine type and age - Main engine	Vessel main engine type and main engine age (choose from drop list)
Engine type and age – Auxiliary engine	Vessel auxiliary engine type and auxiliary engine age (choose from drop list)
Fuel type	Identification of fuel type, from those described in Table 3 (choose from drop list)

Figure 7 – Questionnaire Tables 3 and 4

Fuel consumption of marine harbour vessels by group

Item	Fuel type	Annual fuel consumption	Units of fuel
Example	Marine diesel oil (MDO)	100,000	litre
1			
2			
3			
4			
5			
6			

(The example entry shown in grey is only for demonstration; it will not be included in your facility's data.)

Notes / comments:

Individual activity information of each marine harbour vessel

Item	Vessel name	Vessel type	Relative intensity of use	Installed rated engine power			Engine type and age		Fuel type (refer to Table 3)
				Main engine	Auxiliary engine	Power units	Main engine	Auxiliary engine	
Example	Coastal Jumper	Barge	1 - Low	1,000		kW	4-stroke, pre 2000	No aux engine	1 - Marine diesel oil (MDO)
Example	Titanic 2	Tug boat / Boom boat	4 - Medium/high	200	30	hp	2-stroke, post 2000	2-stroke, post 2000	1 - Marine diesel oil (MDO)
1									
2									
3									
4									
5									
6									

3.4.2. Maritime 2 (Ocean Going Vessel) Activity

Questionnaire Tables 5 and 6 (Figure 8) are used to capture the necessary data to estimate OGV emissions in Activity Zones A and B.

Questionnaire Table 5 (Figure 8) has three required fields to set port-wide parameters. The first two fields provide distance (nautical miles) and speed (knots) values for each vessel that arrives to berth. This sets the time required for each vessel to traverse the harbour area. It is suggested that these values be determined by the port authority and potentially be pre-entered for a tenant questionnaire. The third field represents total electrical consumption over the year for shoreside power provision ('cold ironing' for ships). At this time, most terminals will not have shoreside power available and this field would remain blank.

Figure 8 – Questionnaire Tables 5 and 6

Port marine characteristics

Distance from terminal to port marine jurisdiction boundary		nautical miles
Average vessel speed while in port marine jurisdiction		knots
Total electric power consumption for shore power (ships at berth)		megawatt-hours (MWh)

Vessel calls to port

Port Call	Vessel information				Vessel Activity				Commodity data			Notes/comments
	IMO Ship Number (Lloyd's ID)	Vessel name (OPTIONAL)	Vessel type (OPTIONAL)	Deadweight tonnage (OPTIONAL)	Arrival date (yyyy-mm-dd)	Time at berth (hours)	Total time at anchor (OPTIONAL, hours)	Shore power used?	Commodity type (OPTIONAL)	Amount transferred (OPTIONAL)	Units of measure (OPTIONAL)	
Example	7052363				2008-03-01	15.5	0.0	Yes	Autos	9,456	units	Loading 9,456 autos.
Example		Southern Intrepid	Merchant-Container	100,000	2008-04-31	47.3	85.5	No	Grain, special crop	15,262	tonne	Unloading grain
1								No				
2								No				
3								No				
4								No				
5								No				
6								No				
7								No				
8								No				

Questionnaire Table 6 (Figure 8) has a number of required and optional fields. For the great majority of vessels that visit a port, the vessel can be identified by its IMO Number. PEIT has a lookup table to select vessel characteristics (e.g., engine power rating) from the IMO number. If the IMO number for a particular vessel cannot be identified, the Vessel name, Vessel type and deadweight tonnage (DWT) fields must be entered. These fields are described in Table 3.

Table 3: Field Definitions for Questionnaire Table 6

IMO Number	Vessel identification, available from port records
Vessel name	Optional – must be entered if the IMO number is not available
Vessel type	Optional – must be entered if the IMO number is not available. Choose the vessel INNAV type, (available from port records drop list)
DWT	Optional – must be entered if the IMO number is not available. Vessel DWT is available from port records
Arrival date	Vessel arrival date to port
Time at berth	Total time spent at berth (hours)
Total time at anchor	Total time spent by the vessel anchoring within the Port Boundary (optional and does not have to be used). Leave blank if no anchoring occurs
Shore power used?	If shore power was used for the vessel, choose 'yes'. This links with the total electric power consumption value in Table 5
Commodity type	Optional – may be entered, data permitting
Amount transferred	Optional, may be entered, data permitting
Units of measure	Optional, but required if commodity data is entered.

Based on previous port assessments, service/drydock calls do not have associated emissions; therefore these calls should be removed from the ship call record before entry to **Questionnaire Table 6**. In past Canadian port assessments, Service/drydock periods have mistakenly been associated with ongoing vessel emissions. Given that a vessel drydock stay may continue for several weeks or more, it is very important that these activities are identified properly in the data.

3.5. Cargo Handling (CHE)

Questionnaire Tables 7 and 8 in the 'CHE' worksheet are used for entering activity data for cargo handling equipment (CHE).

Annual fuel consumption for each of the fuels used by CHE on the terminal/facility is entered in **Questionnaire Table 7** (Figure 9). These fields are required and therefore if direct fuel purchase data are not available, estimates must be completed (and these should be described in the EI report).

Questionnaire Table 8 (Figure 9) is used to identify each piece of CHE used at the terminal/facility. Each unique piece of equipment must be identified separately; if several pieces of the same CHE exist (same equipment type, model year, fuel type, etc) then the 'Number of similar units' field can be used to indicate more than one identical CHE. Otherwise, this field will always be equal to one. Field definitions for **Questionnaire Table 8** are provided in Table 4.

Table 4: Field Definitions for Questionnaire Table 8

Equipment Type	Equipment identification, from drop list
Engine model year	Engine year, may or may not be the same as chassis year
Number of similar units	Number of identical units. All other fields in row must apply to each unit, including Annual Hours of Use (for one unit).
Retrofit installed?	yes or no
Retrofit type	Identify from drop list (if retrofits apply). This field will not be used in most cases
Fuel type	Type of fuel consumed in equipment, chosen from the entries to Table 7
Engine power or boiler rating	Engine power rating (no units) or boiler power rating (no units)
Power units	Units used for Engine Power or Boiler Rating entry, choose from drop list
Annual hours of use (one unit)	Number of hours CHE was used for the year (if more than 1 identical unit, this per-unit value must apply to all. Do not sum total hours for all pieces

In some cases, 'Annual hours of use' may be difficult to accurately determine. However, this value must be entered to Table 8. When the questionnaire is entered to the Model, a comparison of total estimated CHE fuel consumption (based on reported hours in **Questionnaire Table 8**) to total annual fuel consumption (from **Questionnaire Table 7**) is made. This is a first level quality check that may indicate the Annual Hours of Use fields should be reconsidered by the terminal/facility operator. Subsequent PEIT runs can be used to complete the quality check again (as described in greater detail in Chapter 4).

Figure 9 – Questionnaire Tables 7 and 8

Annual fuel consumption for terminal/facility CHE

Item	Fuel type	Annual fuel consumption	Units of fuel	Notes/comments
Example	Diesel	345,000	litre	Total for whole facility was 445,000; but 100,000L was used for harbour vessels.
1				
2				
3				
4				
5				
6				
7				
8				

(The example entry shown in grey is only for dem

Equipment list

Item	Equipment type	Engine model year	Number of similar units	Retrofit installed?	Retrofit type	Fuel type (refer to Table 7)	Engine power or boiler rating	Power units (kW, hp, BTU/hr)	Annual hours of use (for one unit)	Notes/comments
Example	Rubber Tire Gantry (RTG) cranes	2000	3	No	None	1 - Diesel	250	kW	2,500	
Example	Crawler Tractor/Dozers	2008	2	Yes	User-defined 1	1 - Diesel	400	hp	1,900	Retrofit is a Douglas 99203 DOC.
1				No	None					
2				No	None					
3				No	None					
4				No	None					
5				No	None					

3.6. Onroad Vehicle

Questionnaire Tables 9, 10 and 11 (Figure 10) are used to enter Onroad Vehicle activity information. The source group Onroad Vehicle is dominated by heavy duty (diesel) truck activity, but may also include smaller trucks, buses and even cars. A new entry is required for each unique route of travel through the port land-side jurisdiction (even if the same vehicle group is used).

Questionnaire Table 9 (Figure 10) is used to enter required information for 'Highway Vehicles' that are not owned or managed by the terminal/facility. These are vehicles that are involved in the transfer of goods or people to and from the terminal/facility. Since the vehicles are operated by a different contractor, no fuel consumption information is expected. Identification of vehicles, number of annual trips and vehicle activity per trip (distance, time) are entered to this table. Field definitions for **Questionnaire Table 9** are provided in Table 5 below.

Table 5: Field Definitions for Questionnaire Table 9

Vehicle Type	Type of vehicle that serves the terminal/facility. Choose from drop list
Annual Gate Count	Number of round-trip visits to the terminal/facility
Average time spent on terminal/facility grounds	Amount of time (min) on average that each vehicle spends on terminal/facility grounds during each trip for loading or unloading
Average time driving on terminal/facility grounds	Amount of time (min) on average that each vehicle spends driving on terminal/facility grounds
Average time idling on terminal/facility grounds	Amount of time (min) on average that each vehicle spends idling on terminal/facility grounds (e.g., at an entrance gate or loading/unloading)
Vehicle age profile	Optional entry, only can be used if information is entered to Questionnaire Table 12. Otherwise, enter "Average / not known"
Distance from terminal to port entry/intermodal point	Optional, only used if the Port Boundary extends beyond the Terminal/Facility Boundary
Distance from terminal to port exit/intermodal point	Optional, only used if the Port Boundary extends beyond the Terminal/Facility Boundary
Average time idling on port grounds	Optional, only used if the Port Boundary extends beyond the Terminal/Facility Boundary
Average speed driven on port grounds	Optional, only used if the Port Boundary extends beyond the Terminal/Facility Boundary

Figure 10 – Questionnaire Tables 9, 10 and 11

Highway vehicles (not operated by terminal/facility)

Item	Vehicle type	Annual gate counts	Zone C			Vehicle age profile (OPTIONAL, refer to Table 12)	Zone D (OPTIONAL)				Notes / comments
			Average time spent on terminal/facility grounds (min)	Average time driving on terminal/facility grounds (min)	Average time idling on terminal/facility grounds (min)		Distance from terminal to port entry/intermodal point (km)	Distance from terminal to port exit/intermodal point (km)	Average time idling on port grounds (min)	Average speed driven on port grounds (km/h)	
Example	Heavy Commercial Truck	2,500	15	2	3	Average / not known	10	15	10	35	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Terminal/facility vehicle fuel consumption

Item	Fuel type	Annual fuel consumption	Units of fuel
Example	Gasoline	10,000	litre
1			
2			
3			
4			
5			
6			
7			
8			

(The example entry shown in grey is only for demonstration; it will not be included in your facility's data.)

Notes / comments

List of terminal / facility vehicles

Item	Vehicle type	Fleet age	Number of similar vehicles	Relative intensity of use	Fuel type (refer to Table 10)
Example	Van / Pickup - small utility	2005 - 2009	5	3 - Medium (average)	1 - Gasoline
1					
2					
3					
4					
5					
6					
7					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

(The example entry shown in grey is only for demonstration; it will not be included in your facility's data.)

Gate Count data for **Questionnaire Table 9** should be based on terminal/facility records. If such records do not exist, the EI report should clearly document any assumptions made (e.g., one truck trip for each 50 tonnes of commodity moved, etc.).

In many cases, a terminal/facility operator should choose 'Average / not known' for the 'Vehicle age profile' choices from the drop menu. Especially for container terminals, trucking companies serving the terminal likely comprise a large fleet that can be difficult to characterize without a detailed investigation. The default distribution is defined (in grey entries) in **Questionnaire Table 12** and represents the model default for heavy duty tractor trailer trucks in the US EPA MOVES model; percent of total activity attributable to each model year (which includes truck population by year as well as relative intensity of use). Age '0' is equal to the inventory year. This default distribution is shown in **Questionnaire Table 12** as an example; if a different 'Vehicle type' is chosen PEIT will automatically identify the appropriate MOVES age distribution once the 'Average / not known' entry is chosen in the 'Vehicle age profile' column.

If fleet data are available, a 25-year age distribution (percent of total trips attributable to each model age) must be entered in **Questionnaire Table 12** before it can be chosen for the 'Vehicle age profile' field in **Questionnaire Table 9. Questionnaire Tables 10 and 11** (Figure 10) are used to enter activity information on terminal/facility owned or leased vehicles. **Questionnaire Table 10** is used for annual fuel consumption, which must be entered, even if an estimate is necessary. **Questionnaire Table 11** is used to identify the vehicle type, general age range and number of vehicles for each vehicle group. The 'Relative intensity of use' and 'Fuel type' fields are used to allocate the amount of fuel that is consumed by each group (if there is more than 1 group that uses a particular fuel type noted in **Questionnaire Table 10**).

3.7. Rail

Rail activity information is entered to **Questionnaire Table 13** for train movements by the national and regional rail lines and **Questionnaire Table 14** for port or terminal owned or leased locomotives (Figure 11). **Questionnaire Table 15** (Figure 11) is used for optional information, only if specific data exist for locomotive models used at the port. In most cases, a terminal/facility will not have specific data unless it owns or leases one or more locomotive. Custom locomotive duty cycles are developed from assessment of locomotive event recorder data.

Field definitions for **Questionnaire Table 13** are provided in Table 6.

Table 6: Field Definitions for Questionnaire Table 13

Rail line service provider	Choose from drop list for type of operator
Duty cycle	Choose from drop list. In some cases 'Average / not known' will be chosen, unless information is available (and entered in Table 15)
Annual train visits to terminal	Number of trains arriving to the terminal/facility in the year
Average number of locomotives per Train	Number of locomotives for each train on average. A non-integer number (e.g., 1.5) can be used if necessary
Average time spent on terminal grounds	Amount of time (in hours) each train spends on terminal/facility grounds each visit on average. A non-integer number (e.g., '0.7') can be used
Average time spent on port grounds each visit	Optional - amount of time each train spends on port grounds each visit on average. A non-integer number (e.g., '0.7') can be used

The 'Average movement details per visit' fields in **Questionnaire Table 13** include the average amount of time each train or locomotive spends on terminal/facility grounds and, potentially, on port grounds. A terminal/facility operator may have to consult with the port authority to determine the average amount of time each train spends on port grounds before and after arriving to the terminal/facility gate. Should trains service more than 1 terminal/facility during visits, attention will be required to ensure double counting does not occur for the 'Average time spent on port grounds' column. This is an important data quality check the port authority should make. In general, the port authority should always carefully check this field for its tenant questionnaire submissions.

Field definitions for **Questionnaire Table 14** are provided in Table 7.

Table 7: Field Definitions for Questionnaire Table 14

Ownership	Choose from drop list for type of ownership
Model	Locomotive model used by the operator. Choose from drop list. A general type can be chosen in the locomotive is leased from a provider (e.g., 'CN/CP Switch' is an average for switch locomotives in Canada)
Duty cycle	Choose from drop list. In some cases 'Average / not known' will be chosen, unless information is available (and entered in Table 15). The average switch duty cycle is shown in grey in the Questionnaire Table 15
Engine year	Choose from drop list. This field is used to identify age of locomotive if possible
Fuel Type	Choose from drop list
Annual fuel consumption	Data or an estimate is required
Units of fuel	Choose from drop list

Figure 11 – Questionnaire Tables 13, 14 and 15

National/regional rail on terminal/facility grounds

Item	Rail line service provider	Duty Cycle	Annual train visits to terminal/facility	Average movement details per visit			Notes/comments
				Average number of locomotives per train	Average time spent on terminal/facility grounds (hours)	Average time spent on port grounds	
Example	Regional line	Average / not known	100	1	0.25	0.5	Ontario Southern Rail
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

(The examp

Facility locomotives

Item	Locomotive details				Fuel details			Notes/comments
	Ownership	Model	Duty cycle	Engine year	Fuel Type	Annual fuel consumption	Units of fuel	
Example	Terminal owned or leased	MP15DC	Average / not known	2002 and older	Diesel	11,000	litre	Leased from Falcon Rail.
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Custom locomotive duty cycle (OPTIONAL)

Notch	Duty cycle (percent time in notch)			
	National average for switch locomotives	User-defined A	User-defined B	User-defined C
Idle	84.90%			
N1	5.40%			
N2	4.20%			
N3	2.20%			
N4	1.40%			
N5	0.60%			
N6	0.30%			
N7	0.20%			
N8	0.60%			
Dynamic braking	0.20%			
Total check	100%	0%	0%	0%

Notes / comments

4. EMISSION CALCULATIONS

This chapter is included to the User's Guide to identify the methods used in PEIT to achieve the emission estimates. This information is not required to effectively use PEIT, although it should be considered if a port has a previous emissions assessment and wishes to understand how the methods used in the past assessment may differ from those used in PEIT. The model utilizes current best-practices and the most recent emissions data available. The reader may wish to consult additional literature that is referenced, such as formal emissions models that have been supported by the US EPA.

For combustion sources, calculations are identified for each of the formal emission source groups and sub-groups identified in the Protocol. These are:

- Marine
    - Harbour Vessels
    - Ocean Going Vessels (OGVs)
- CHE
- Onroad Vehicle
    - Highway Vehicles
    - Facility Vehicles
- Rail
    - National/Regional Rail
    - Facility Rail
- Admin

Use of the sub-groups for Marine, Onroad Vehicle and Rail are to distinguish the emission sources that are supported by annual fuel consumption data (operated by the port or a tenant) and those that are not.

PEIT automatically completes emission calculations based on the activity data entered on the questionnaires. The general form of the emission equations is provided here for each source group, with additional criteria of importance. In each case, the reader will be able to identify how the activity metrics entered into the questionnaire forms are used in the calculations.

4.1. GHG Emissions

All emissions associated with GHG (CO_2, CH_4 and N_2O) are reported using emission factors from the Environment Canada National Inventory Report (NIR) 2010. In particular, Tables A8-1, A8-2, A8-3 and A8-11 of the NIR were employed for any combustion source with available fuel consumption data.

Table 8 summarizes the GHG emission factors for diesel and gasoline, where the CH_4 and N_2O rates vary by equipment type and age. The renewable content of diesel and gasoline varies across the country and is summarized in PEIT table GEN_Link_Biofuel_RegionFactors.

Table 8: GHG Emission Factors for Diesel and Gasoline from NIR (g/L)

Fuel type	Source Group	Equipment Type	CO_2 (0% renewable)	CO_2 (100% renewable)	CH_4	N_2O
Diesel	Admin	All	2,663	2,449	0.150	1.100
	CHE	All	2,663	2,449	0.150	1.100
	Onroad	Passenger car, <2004	2,663	2,449	0.100	0.160
		Passenger car, 2004-2006	2,663	2,449	0.068	0.210
		Passenger car, >2006	2,663	2,449	0.051	0.220
		Passenger truck, <2004	2,663	2,449	0.068	0.160
		Passenger truck, 2004-2006	2,663	2,449	0.068	0.160
		Passenger truck, >2006	2,663	2,449	0.068	0.160
		Commercial trucks and buses, <2004	2,663	2,449	0.150	0.075
		Commercial trucks and buses, 2004-2006	2,663	2,449	0.140	0.082
		Commercial trucks and buses, >2006	2,663	2,449	0.120	0.082
	Rail	All	2,663	2,449	0.150	1.100
Gasoline	Admin	All	2,289	1,494	2.700	0.050
	CHE	All	2,289	1,494	2.700	0.050
	Onroad	Passenger car, <1996	2,289	1,494	0.320	0.660
		Passenger car, >1996	2,289	1,494	0.120	0.160
		Passenger truck <1996	2,289	1,494	0.210	0.660
		Passenger truck, >1996	2,289	1,494	0.130	0.250
		Commercial trucks and buses	2,289	1,494	0.490	0.084

The renewable CO_2 emission rates are used to determine a blended, effective rate for any fuels with bio content (e.g., biodiesel or ethanol). Table 9 summarizes the GHG emission factors for the other fuels used in PEIT. The emission rates for natural gas vary by province and that is captured in the table.

Table 9: GHG Emission Factors for Marine Fuels, Natural Gas and Propane from NIR (g/L)

Fuel type	Source Group	Region	CO_2	CH_4	N_2O
Heavy fuel oil	Marine	All	3,124	0.280	0.079
Marine distillate oil	Marine	All	2,725	0.260	0.073
Natural gas*	Admin	Alberta	1.92	0.000037	0.000035
		British Columbia	1.92	0.000037	0.000035
		Manitoba	1.88	0.000037	0.000035
		Northwest Territories	2.45	0.000037	0.000035
		Ontario	1.88	0.000037	0.000035
		Quebec	1.88	0.000037	0.000035
		Saskatchewan	1.82	0.000037	0.000035
		Rest of Canada	1.96	0.000037	0.000035
	CHE	All	1.89	0.009000	0.000060
	Marine	All	1.89	0.009000	0.000060
	Onroad	All	1.89	0.009000	0.000060
Propane	Admin	All	1,510	0.024	0.108
	CHE	All	1,510	0.640	0.028
	Onroad	All	1,510	0.640	0.028

* Natural gas rates are for standard temperature and pressure.

The emissions intensity values for electricity are established by province, based upon annual utility generation over a year. Tables A13-2 to A13-13 from the NIR[9] were employed for each of the provinces and territories. These values can be viewed in the PEIT data table GEN_Link_Egrid.

4.2. Marine Vessel Emissions

Marine Vessel emission estimates in PEIT leverage Canada's Marine Emissions Inventory Tool (MEIT), Version 4.0. MEIT is a database emissions model that uses ship movement data (e.g., Coast Guard data) and previous ship survey data (for engine and fuel criteria) to develop emission estimates for ship engines and boilers within a defined geographical region. MEIT has been used to develop several

[9] http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1

Canadian marine vessel emission inventories since 2005[10],[11]. The emission equations and data tables provided here were sourced from the Environment Canada 2010 National Marine Emissions Inventory[12].

Emission Calculation:

Engines: $E = P \times LF \times T \times EF_{energy}$ (1)

Boilers: $E = F \times T \times EF_{fuel}$ (2)

Where E = Emissions

F = Fuel consumption in tonnes/hour

P = Power Rating of Engine (Maximum Continuous Rating)

LF = Load Factor (fraction of rated power for an engine)

T = Time in mode

EF_{energy} = Emission Factors in g/kWh

EF_{fuel} = Emission Factors in kg/tonne

The total emissions for a marine vessel are the sum of emissions from engines (mains and auxilliaries) and boilers in each activity mode. Emission factors for engines (EF_{energy}) relate to engine type (2-stroke, 4-stroke) engine build year and fuel consumed on a vessel by vessel basis. These characteristics are automatically identified from internal data tables once the required ship information is entered onto the questionnaires. Boiler emission factors (EF_{fuel}) are more generic, but relate to the expected fuels consumed. The current set of PEIT engine and boiler fuel consumption and CAC emission factors is identified in Tables 10, 11 and 12. GHG emissions are calculated from the estimated fuel consumption and NIR rates, as previously identified.

Both SO_x and PM emissions are known to vary with fuel sulphur content. As such, MEIT has accounted for SO_x and PM emissions in a dynamic manner since V2.2. These equations are also used in PEIT. Each equation assumes a linear relationship with fuel sulphur content as follows:

SO_x:

Engines: EF (g/kWh) = 4.2(S) (3)

Boilers: EF (kg/tonne) = 20.0(S) (4)

PM:

[10] Levelton Consultants, Maritime Innovation and J. Corbett, 2006. Marine Emission Inventory Study: Eastern Canada and Great Lakes. Prepared for Transport Canada.

[11] Weir Marine Engineering, 2008. 2007 Marine Emissions Inventory and Forecast Study. Prepared for Transport Canada.

[12] SLE, 2012. 2010 National Marine Emissions Inventory for Canada. Final Report. Prepared for Environment Canada, November 5, 2012.

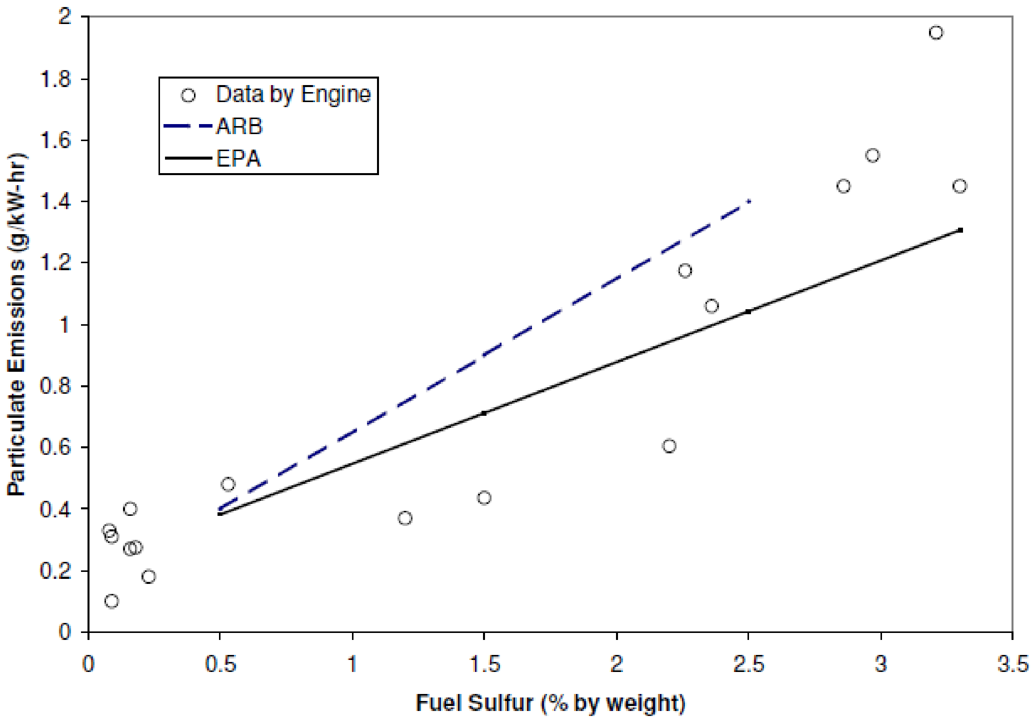
Engines: (g/kWh) = 0.4653(S) + 0.25 (5)

Boilers: (kg/tonne) = 1.17(S) + 0.41 (6)

where S = sulphur content of fuel in %.

Ratios of 0.96 and 0.92 are applied for PM_{10} to total PM and $PM_{2.5}$ to $PM_{10,}$ respectively. While the SO_x expressions are based on an assumption of total oxidation of the fuel sulphur to SO_2 in the atmosphere, the PM expressions are based on previous PM emissions tests at different sulphur levels. The boiler PM equation originates from the EPA[13] and the engine PM equation is a result of the California Air Resources Board (CARB) analysis of past emissions data as shown in Figure 12.

Figure 12 – Engine PM Emission Rates (g/kWh) by Fuel Sulphur Content*



* The CARB analysis ('ARB' in the figure above) is a re-analysis of the data, rejecting several data points that were included in the prior EPA regression analysis[14].

[13] EPA AP-42 Compilation of Emission Factors, Chapter 1. See http://www.epa.gov/ttnchie1/ap42/

[14] T. Sax and A. Alexis, California Air Resources Board, 2007. A Critical Review of Ocean-going Vessel Particular Matter Emission Factors. Available from arb.ca.gov

Table 10: Marine Engine Specific Fuel Oil Consumption (SFOC) in g/kWh by Engine Classification (kW) and Age (from IMO 2009)

Engine	Age of Build	SFOC (>15,500 kW)	SFOC (5,000 – 15,000 kW)	SFOC (<5,000 kW)
Main 2-stroke	1970-1983	205	205	205
	1984-2000	185	185	185
	2001-2007	175	175	175
	2008+	175	175	175
Main 4-stroke	1970-1983	215	225	225
	1984-2000	195	205	205
	2001-2007	185	195	195
	2008+	185	195	195
Auxiliary 4-stroke	1970-1983	220	220	220
	1984-2000	220	220	220
	2001-2007	220	220	220
	2008+	220	220	220

The fuel consumption rates shown in **Table** 10 were developed by the IMO in their most recent GHG emissions study[15]. Table 13 provides the current 'Low Load' scale factors that are used to adjust the base emission rates in Tables 11 and 12 for slow speed movements when the engine emissions on a g/kWh basis are expected to be higher.

Table 11: Current Activity Based Emission Factors (g/kWh) by Engine Classification*

Engine	Cat.	Fuel	NO_x (dom/int)	CO	HC	NH_3
Main 2-stroke	C3	HFO	17/18.1	1.4	0.6	0.021
		MDO	17	1.1	0.6	0.020
Main 4-stroke		HFO	13.2/14.0	1.1	0.5	0.023
		MDO	13.2	1.1	0.5	0.022
Auxiliary 4-stroke	C2	HFO	13.9/14.7	1.1	0.4	0.001
		MDO	13.9	1.1	0.4	0.001

*Note: HFO – heavy fuel oil, MDO – marine distillate oil
NO_x values are shown for domestic (dom) and international (int) fuel by purchase location. Domestic HFO fuel is lower in sulphur content on average.

Table 12: Current MEIT Boiler Emission Factors (kg/tonne fuel)

Fuel	NO_x	CO	HC	NH_3
HFO,MDO	12.3	4.6	0.38	0.006

[15] IMO, 2009. Second IMO GHG Study. Available at http://www.imo.org

Table 13: Current MEIT Low Load (main engine load 0.1) Scale Factors for All Emission Factors (unitless)

Fuel	NO_x	CO	HC	PM	NH_3
1.22	1.22	2.00	2.83	1.38	1.22

The engine NO_x emission rates are subject to the International Maritime Organization (IMO) regulations, which limits emissions based on the build year of vessel. The IMO emission limits, shown in Appendix A, are applied to each ship as indicated by the vessel build year.

For the OGVs, emissions result from the main engines (MEs), auxilliary engines (AEs) and boilers during transit and berthing. Several necessary assumptions are applied to achieve the emissions estimates. These assumptions are consistent with MEIT V4.0 as follows:

- All harbour movements occur under an ME load factor of 0.1 (meaning the 'Low Load' scale rates apply).
- An ME load factor of 0.0 is used for berthing (MEs are 'off').
- AEs and boilers are considered 'on' at all times.
- While ME power rating is identified for each vessel directly, AE power rating and load factor, and boiler fuel consumption is identified from MEIT lookup tables generated from previous vessel survey programs conducted in Canada.
- Fuel sulphur content is estimated for each vessel and engine/boiler based on previous vessel survey programs conducted in Canada.

Canada's 2010 National Marine Emissions Inventory can be consulted for these lookup tables. It's important to note that the fuel sulphur content data tables will not be applicable in late 2013 and beyond, due to an Emissions Control Area (ECA) for the west and east coasts of North America.

For Harbour Vessels, the engine emission estimates directly relate to the fuel consumption data entered. For example, for a ship that consumed a reported 1,000 litres of diesel in a year, the activity estimate required in equation (1) (time in mode) is completed in PEIT, based on a fuel consumption rate for the particular engine model and size (the appropriate SFOC values in Table 8). This approach allows use of the best available data (fuel consumption), while additionally accounting for CAC emission rates that strongly depend on the type and age of engine. Harbour Vessels are assumed to have no boilers and zero emissions while at berth.

4.2.1. Fugitive Cargo Emissions (OGVs)

Estimates of fugitive VOC emissions were adopted in PEIT from a new module included to MEIT V4.0. VOC emissions escape from the tanks of fuel carrying ships during transit and also during loading and unloading activities. As transit is relatively brief for the port inventories (through the harbour areas only), the loading/unloading activities are most significant.

The fugitive emission calculations require an estimate of the type and amount of fuel carried in the ships that visit Canadian ports. The current form of the module does not use cargo tonnage directly (since this information is not included in the Coast Guard movement records utilized by MEIT), and estimates for the cargo are achieved by assuming most of a vessel DWT is comprised of fuel cargo, for the appropriate ship classes. The equations used to estimate the fugitive emissions are defined below.

Transit:

$$E\ (mg) = DWT/D * LF * T * TF * EF_{transit} \quad (5)$$

Load/Unload:

$$E\ (mg) = DWT/D * LF * EF_{load} \quad (6)$$

Where:

E = emissions

DWT = deadweight tonnage

D = density of fuel (see Appendix A: Default Values)

LF = load factor (assumed to be 0.9 currently)

T = Time in mode

TF = transit factor (assumed to be 0.5 currently)

$EF_{transit}$ = transit emission rate

EF_{load} = loading/unloading emission rate

The emission rates for fugitive VOC emissions were taken from the US EPA, as defined in Table 14[16].

Table 14: Fugitive VOC Emission Rates

Vessel Class	Transit Emission Rate (mg/week/litre)	Load/Unload Emission Rate (mg/litre)
Crude Oil Tanker	150	73
Distillate Oil Tanker	0.54	0.55

[16] These rates are published in the US EPA AP-42 Compilation of emission factors, Chapter 5.2

Gasoline Tanker	320	215
LNG Tanker	0.0	0.0

Currently, MEIT assumes LNG vapours are captured and used as fuel for the vessel engines. As noted above, the load factor (LF) is less than 1.0 since DWT accounts for the mass of engine fuel as well as crew and supplies on board, in addition to cargo. The transit factor (TF) assumes that the cargo is carried one way only (e.g., the return leg of a voyage is done under ballast).

The fugitive emissions module should be considered preliminary and improvements to the module are recommended in the future. The module is currently considered appropriate for long term average emission estimates for a fleet of vessels (e.g., an annual emissions inventory) but not for application to a single vessel or a short-term period with multiple vessels.

4.3. CHE Emissions

Emission Calculation:

$$E = P \times LF \times T \times EF_{duty\text{-}cycle} \qquad (7)$$

Where E = Emissions

P = Power rating of engine

LF = Load Factor (fraction of rated power)

T = Time (elapsed) of engine use

$EF_{duty\text{-}cycle}$ = Emission Factors in g/hp-hr, based on a defined usage cycle

The equation shown above is used on an engine model by engine model basis, to account for important differences in engine emission characteristics by engine type, engine age and fuel quality. These emission rates were developed for the PEIT from the US EPA NONROAD 2008 emissions model. The emission rates for each specific piece of equipment by size (kW) and age were developed assuming the average annual hours of operation from the U.S. fleet statistics data in the model. This allows for estimation of engine deterioration.

Engine retrofits and alternative fuels are represented in the PEIT. In addition, a linear load factor correction is used, based on the reported total facility fuel consumption for CHE. Incorporation of these elements can be represented with an extended version of the equation presented above:

Modified Emission Calculation for retrofits and alternative fuels:

$$E = P \times LF \times T \times EF_{duty\text{-}cycle} \times FA \times RF \times LM \qquad (8)$$

Where FA = Fuel Adjustment (ratio)

RF = Retrofit Adjustment (ratio)

LM = Load Modification (actual fuel consumed / predicted fuel consumed)

Retrofit Adjustment ratios are typically sourced from the US EPA 'Verified Technologies List'[17]. Fuel Adjustment ratios are needed in some cases (e.g., hybrid equipment) and these may be sourced from a reputable publication. Assistance with this issue may be required from a consultant. As previously indicated, retrofit labels will be identified by individual terminals; the port authority will enter the individual retrofit characteristics from the Verified Technologies List (or other source) into the Model retrofit data table. The Model data tables should be consulted as the primary source for identification of all retrofit or fuel adjustments used in the emission calculations (for all source groups).

4.4. Rail Emissions

Emission Calculation:

$$E = EF_{duty\text{-}cycle} \times T \qquad (9)$$

Where E = Emissions

$EF_{duty\text{-}cycle}$ = Emission Factors in g/hr, based on a defined usage cycle

T = Time (elapsed) of engine use

The total emissions for a locomotive are the sum of emissions in each activity mode.

The duty cycle emission factors are determined dynamically in PEIT from base emissions data specific to locomotive type and age, and engine throttle notch. Determination of duty cycle depends on data entered to the questionnaires, which allows development of a duty cycle average engine power level (kW or hp) and a duty cycle average activity based emission factor (g/kWh or g/hp-hr). The combination of these values provides emission factors in g/hr. The default duty cycle is shown on the questionnaire Rail worksheet, Table 15. This duty cycle, which is the national average duty cycle for switch locomotives, is automatically selected if the user selects 'Average/not known' for duty cycle. PEIT is populated with a large dataset of rail emission rates generated from emissions tests completed by the US EPA[18] for older model locomotives and additional studies for the newer (gen set) locomotives[19].

As it is difficult to characterize the specific national or regional rail locomotives that serve a particular port, the National/Regional Locomotives were represented from national fleet information. For national

[17] http://epa.gov/cleandiesel/verification/verif-list.htm

[18] 1998, US EPA Office of Mobile Sources. Locomotive Emission Standards Regulatory Support Document (Appendix B)

[19] PEIT identifies references for the emissions data in its 'Rail_Link_Emisfactors' table

or regional locomotives, emissions data were sourced from the Railway Association of Canada (RAC) on a per-litre basis (g/litre)[20]. The fuel-based rates, combined with duty cycle averaged fuel consumption rates (litres/hour), allow determination of emission factors in g/hr. However, it should be recognized that these rates may not be entirely representative of a particular region in Canada, if locomotive models and/or fuel qualities significantly differ from the national averages.

The RAC fuel-based emission rates for line haul and switch locomotives and the fuel consumption rates for a GE AC4400 and an EMD SD40 locomotive (the most common line haul and switch locomotives in the national fleet, respectively) are shown in Tables 15 and 16.

Table 15: Fuel-based Emission Rates (g/L) for Line Haul and Switch Activity

Source	Rail Emission Factor					
	NO_x	SO_x*	CO	VOCs	PM	NH_3
Line haul	44.0	0.187	4.7	1.7	1.5	0.3
Switch	77.9	0.187	4.7	1.7	2.3	0.3

* Assumes sulphur level of 110 ppm.

Table 16: Notch-specific Fuel Consumption Rates (L/hr) for Line Haul and Switch Locomotives

Notch	Idle	N1	N2	N3	N4	N5	N6	N7	N8	DB
Line	13.5	42.0	98.0	204.6	298.6	414.7	527.2	646.6	796.4	22.3
Switch	20.7	33.2	86.6	142.6	209.4	288.2	383.6	515.3	610.2	59.1

To make estimates of the smaller size fractions of PM, all of the PM mass is considered to be PM_{10} and 97% of the PM mass is considered to be $PM_{2.5}$.

For port or terminal operated locomotives ('Facility Locomotives'), fuel consumption records exist. The annual fuel consumption records are used in PEIT to automatically adjust the activity metric ('T') so that the emission estimates are consistent with the fuel consumption data. In all cases, the user is expected to identify the specific locomotive model used on the terminal grounds.

4.5. Onroad Vehicle Emissions

Highway Truck emission estimates are determined in PEIT separately for transit activities and idle or 'creep' activities. Distance estimates are used for transit emission calculations and time estimates are used for idle/creep calculations.

[20] See the 2010 Locomotive Emissions Monitoring Program (LEM), http://www.railcan.ca/publications/emissions

Emission Calculation:

Transit: $E = D \times EF_{distance}$ (10)

Idle/creep: $E = T \times EF_{time}$ (11)

Where E = Emissions

T = Time

D = Distance travelled

$EF_{distance}$ = Emission Factors in g/km

EF_{time} = Emission Factors in g/hr

All vehicle emission factors were sourced from the US EPA MOVES 2010b model[21]. The vehicle emission rates were generated from the model assuming the national U.S. vehicle populations and annual accumulated mileage values by age and vehicle class, due to lack of similar Canadian data.

Engine retrofits and alternative fuels are represented in PEIT. Incorporation of these elements are addressed with a modified version of the equations presented above:

Modified Emission Calculation:

Transit: $E = D \times EF_{distance} \times FA \times RF$ (12)

Idle/creep: $E = T \times EF_{time} \times FA \times RF$ (13)

Where FA = Fuel Adjustment (ratio)

RF = Retrofit Adjustment (ratio)

These ratios are determined from the particular supplier of the emissions device, and entered to PEIT directly.

For port or terminal operated vehicles ('Facility Vehicles'), fuel consumption records exist. For these vehicles, only equation (12) is used, with the activity metric ('D') automatically adjusted so that the emission estimates are consistent with the fuel consumption data. Due to lack of information, transit and idle emission cannot be distinguished for Facility Vehicles and an average duty cycle is assumed.

4.6. Admin

Admin sources amount to electricity use for buildings as well as compound lighting and boilers for space heating. Most boilers use natural gas, although PEIT accepts propane and heating oil (diesel) as well. The emission rates for boilers are shown in Table 17. These rates originate from the US EPA AP-42

[21] http://www.epa.gov/otaq/models/moves/index.htm

Compilation of Emission Factors[22]. As noted in Chapter 4.1, the GHG rates from AP-42 were not used, in favour of the Environment Canada NIR values.

Table 17: Boiler Emission Factors (g/hp-hr)

Fuel type	NO_x	SO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	NH_3
Diesel / Heating Oil	0.168	0.002	0.042	0.005	0.017	0.016	0.009
Natural Gas	0.113	0.002	0.095	0.000	0.009	0.009	0.008
Propane	0.159	0.000	0.092	0.012	0.009	0.009	0.014

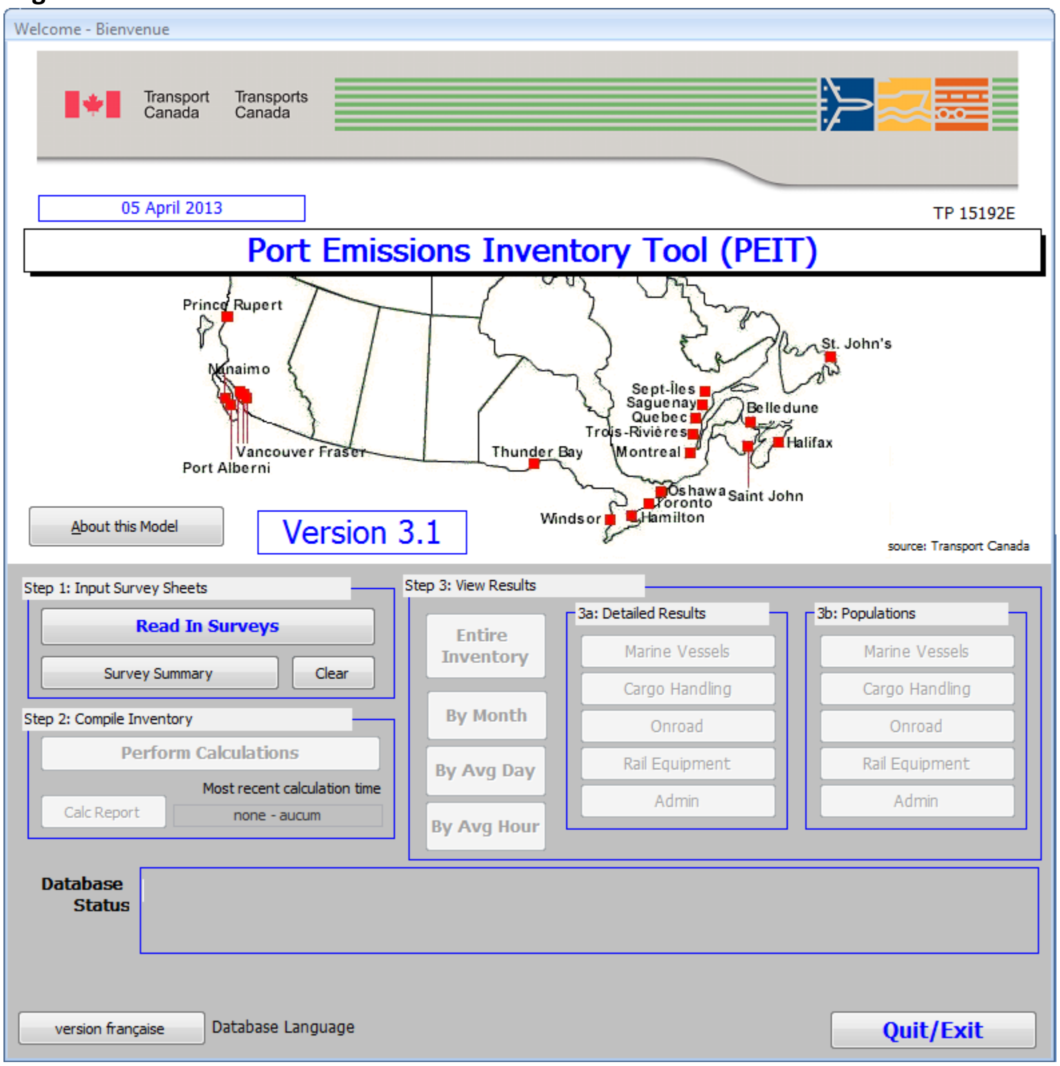
The type and age of Admin boilers is not currently a field in the PEIT questionnaire. It was expected that this information would be difficult to acquire for many of the port tenants (although this has not been investigated). As such, an assumption applied in PEIT for boilers is that all units are 15 years old. In effect, this simulates uncontrolled boilers, since units with low NO_x burners and flue gas recirculation did not become widely available until 2000. For this reason, the NO_x emissions associated with natural gas boilers may be overestimated in PEIT.

[22] See http://www.epa.gov/ttnchie1/ap42/, Chapter 1

5. PEIT FUNCTIONALITY AND QUALITY CONTROL

A graphic of the PEIT welcome screen is provided in Figure 13. The 'Step 1' selections constitute the data import and additionally facilitate internal activity data checks. The 'Survey Summary' should always be consulted to ensure that there are no errors or missing fields in the tenant questionnaires. PEIT will not complete its emission calculations with outstanding errors present in the questionnaire forms.

Figure 13 – PEIT Welcome Screen



5.1. Quality Control

In Step 1, importing the survey sheets, the user indicates which questionnaire(s) are to be imported into the database tool. This simply involves identifying the folder in which the questionnaires are located. One questionnaire or a group of questionnaires can be selected. The database will conduct a quality check on each MS Excel questionnaire sheet, assessing each field and its expected value range. The database reports missing data or irregularities directly on each questionnaire form with yellow highlighting. The Excel 'notes' mechanism is also used to provide a text description of the problem. This process is shown in Figure 14.

Figure 14 – **Sample Survey Sheet for CHE (problematic data flagged in yellow)**

Annual fuel consumption for terminal/facility CHE

Item	Fuel type	Annual fuel consumption	Units of fuel	Notes/comments
Example	Diesel	345,000	litre	Total for whole facility was 445,000; but 100,000L was used for harbour vessels.
1	Diesel	200,000		
2				
3				
4				
5				
6				
7				
8				

(The example entry shown in grey is only for dem

Equipment list

Item	Equipment type	Engine model year	Number of similar units	Retrofit installed?	Retrofit type	Fuel type (refer to Table 7)	Engine power or boiler rating	Power units (kW, hp, BTU/hr)	Annual hours of use (for one unit)	Notes/comments
Example	Rubber Tire Gantry (RTG) cranes	2000	3	No	None	1 - Diesel	250	kW	2,500	
Example	Crawler Tractor/Dozers	2008	2	Yes	User-defined 1	1 - Diesel	400	hp	1,900	Retrofit is a Douglas 99203 DOC.
1	Cranes (not RTG)		2	No	None	1 - Diesel	800		2,400	
2				No	None					
3				No	None					
4				No	None					
5				No	None					
6				No	None					

Hint
Select the power unit for the engine size of the equipment from the drop-down menu.

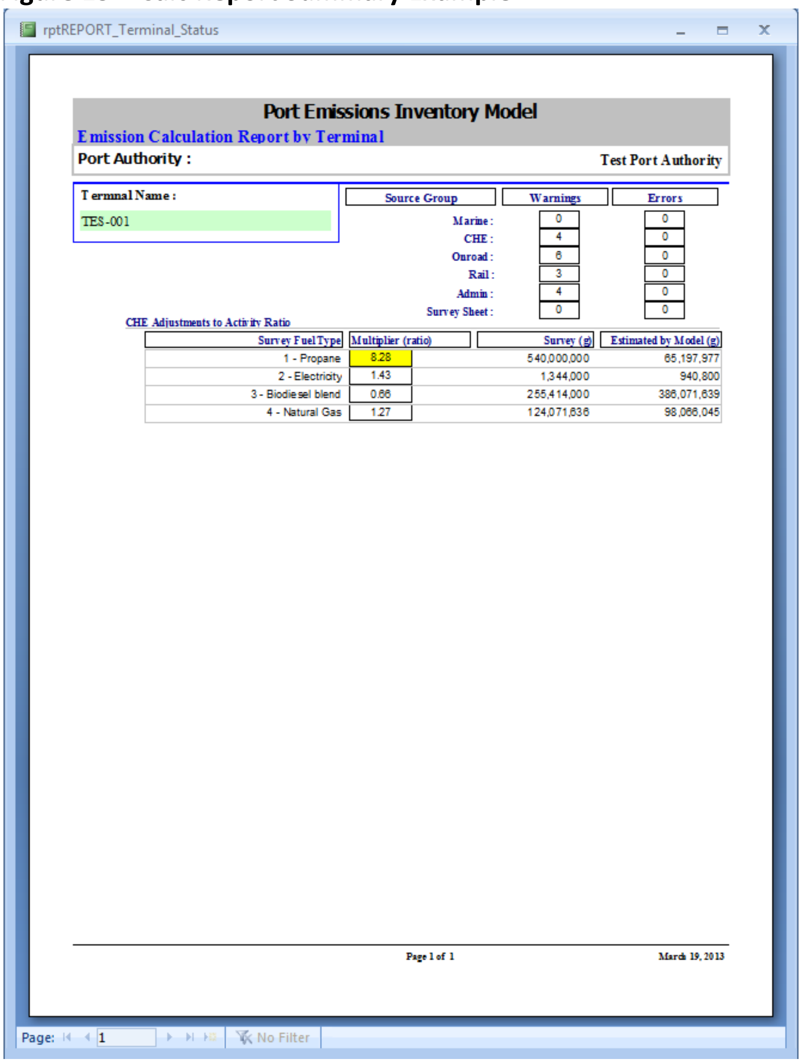
Once the flagged questionnaire cells are properly adjusted, the user can re-import the questionnaire to complete the data check process again. The final questionnaire must be error free (on all of its sheets) before any calculations will be performed in 'Step 2' of PEIT.

As indicated in Figure 13, the database also prepares a 'Survey Summary'. This summary can be viewed as a standard Access report with a line by line statement of errors or warnings.

Once 'Perform Calculations' is selected, PEIT will calculate the emissions for the data entered and complete additional checks on the information. The 'Calc Report' opens automatically upon completion of the emission calculations and a summary includes a comparison of modelled versus reported CHE fuel consumption for each questionnaire (as noted in Section 3.5). If the difference between modelled and actual fuel consumption is less than 0.5 or greater than 2.0 (shown in the 'Multiplier (ratio)' field), **Questionnaire Table 8** should be carefully re-assessed, in particular the 'Annual hours of use (for one unit)' column. PEIT will proceed with its calculations if the criteria noted above are not addressed.

Therefore this comparison constitutes a warning that should be considered by the port and its tenant. In some cases a port will proceed with the PEIT calculations without addressing such a warning (e.g., if the emissions are judged relatively insignificant or better activity data simply cannot be acquired). Example CalcReport output is shown in Figure 15.

Figure 15 – Calc Report Summary Example



The 'Step 2' function (Perform Calculations) does not require any direct interaction from the user. Depending on the amount of data processed (in particular marine OGV activity) the time required to complete the calculations may span several minutes or more. The database reports the 'most recent calculation time', which indicates that the Model now contains completed emission calculations.

5.2. Reporting

The 'Step 3' function (View Results) provides the user the ability to examine emission totals by different source and fuel categories through Excel pivot tables. These features can be dynamically filtered and adjusted. In most cases, the user should focus on the 'Entire Inventory' pivot table since it is easiest to interpret. The 'Monthly', 'Daily' and 'Hourly' features simply provide an allocation of the annual emissions over shorter time periods based on the work schedules entered for each terminal (daily and hourly only). The 'Monthly' allocation is based on the distribution of ship calls to the port over the year. Table 18 provides a description of the field selection lists in the 'Entire Inventory' pivot table.

Table 18: Reporting Field Selection Key Descriptions

Selection Key	Definition	Notes (links to Questionnaire worksheet data)
Inventory Year	Year of inventory	Should only be 1 choice if all tenants select the same year
portAuthority	Name of port authority	Defined in 'Introduction' worksheet
Activity	General activity types	Defined in all activity worksheets
Terminal UKey	Allows for selection of terminals to be included	Based on terminal identification scheme chosen by the port and set in the worksheet 'Introduction'
CommodityClass	General commodity classes can be selected	Links with available general commodity classes in the 'Terminal' worksheet
Commodity	Specific commodity classes can be selected	Links with available specific commodity classes in the 'Terminal' worksheet
Boundary	EI boundary choice	Terminal/Facility Boundary or Port Boundary. Port Boundary includes all emissions in the Terminal/Facility Boundary
EquipmentGroup	Specific equipment groups can be selected	Associated with the 'Source Group' key which contains the parent groups
Tech	Technology type of engine (e.g., Tier 1, Tier 2, etc.)	Defined in all activity worksheets
Retrofit	Engine and emission retrofits	Emissions associated with specific retrofits can be selected

Table 18 (Cont'd): Reporting Field Selection Key Descriptions

Selection Key	Definition	Notes (links to Questionnaire worksheet data)
Substance	Specific air contaminants can be selected	CACs, GHGs and air toxics are included. Associated with the 'SubstanceGroup' key which contains the parent groups
SubstanceGroup	Air contaminant groups can be selected	Associated with the 'Substance' key which allows further selection
Units	Shows all units used in the EI data	Relates to the Questionnaire choices by the tenants
SourceGroup	General source groups can be selected	Associated with the 'EquipmentType' key which allows further selection
EquipmentType	Specific equipment pieces can be selected	Associated with the 'SourceGroup' key which contains the parent groups
Fuel	Emissions associated with specific fuels can be selected	Associated with the 'SourceGroup' and other keys

5.3. Test Questionnaire

A test questionnaire is included with the model. This test questionnaire can be loaded into the model and the emission results compared against a fixed standard, to ensure that the model calculates as expected. The test questionnaires are labelled "TC Port EI Questionnaire – EN – test.xls" and "TC Port EI Questionnaire – FR – test.xls". The English and French versions contain the same activity data. The emission results from these test questionnaires are stored in a file labelled "TC Port EI Test Questionnaire – Emission results.xls". The emissions results from the file must match the results generated by the model. If the results do not match then a previous user has modified one of the tables in the model.

Appendix A: Supplemental Data Tables

Tables 19 – 24 list supplemental data utilized in the PEIT model. Table 19 lists volumetric and energy densities, global warming potentials, electricity carbon intensities by region, and sulphur content of fuels. Tables 20 – 22 list the age distributions of onroad vehicles for 2010 – 2012, and Table 23 lists renewable fuel (biodiesel and ethanol) content by region. Table 24 lists the IMO NO_X and SO_X fuel regulations. These data are accessed by the model in its calculations, through the equations described in the main body of this report.

Table 19: Parameter Values by Type and Region of Canada

Parameter	Field	Value	Units	Source
Physical Density	Lumber	600	kg/m^3	EPA AP-42, Appendix A (Miscellaneous Data & Conversion Factors)
	Diesel	851	g/L	
	Gasoline	741		
	Heavy fuel oil	944		
	Marine diesel oil	845		
	Propane	540		
Energy density	Diesel	39	MJ/L	
	Gasoline	34		
	Heavy fuel oil	42		
	Marine diesel oil	42		
	Propane	26		
Global warming potentials	CO_2	1	CO_2e	IPCC Second Assessment Report
	CH_4	21		
	N_2O	310		

Parameter	Field	Value	Units	Source
Electricity carbon intensities	Alberta	863	g CO_2e/kWh	EC 2011 National Inventory Report (for 2010 inventory year; also used for 2011 – 2013 years)
	Manitoba	3		
	New Brunswick	503		
	Newfoundland and Labrador	18		
	Nova Scotia	760		
	Nunavut	380		
	Ontario	133		
	Prince Edward Island	3		
	Quebec	3		
	Saskatchewan	801		
	Yukon	47		
Sulphur content of fuel	Diesel – non-rail	15	ppm	EC Sulphur in Diesel Regulations
	Diesel – facility rail	15		EC Sulphur in Diesel Regulations
	Diesel – National/Regional rail	129		RAC Locomotive Emission Model 2010
	Gasoline	30		EC Sulphur in Gasoline Regulations
	Natural Gas	3		Fortis BC
	Propane	75		Fortis BC
	HFO - domestic	1.5	Percent (%)	MEIT 4.0 / 2010 EC National Marine Inventory
	HFO – international	2.6		

Parameter	Field	Value	Units	Source
	MDO – Domestic	0.05		
	MDO – International	1		
	MGO - Domestic	0.0015		

Table 20: Onroad Vehicle Age Distributions (% of fleet) for Inventory Year 2010*

Vehicle age	Gas		Diesel				
	Car	Pickup/ Van	Light Comm.	Medium Comm.	Heavy Comm.	Bus	Pickup/ Van
0	0.062	0.056	0.052	0.065	0.054	0.061	0.056
1	0.052	0.039	0.036	0.062	0.053	0.058	0.039
2	0.058	0.049	0.045	0.068	0.059	0.064	0.049
3	0.065	0.072	0.055	0.071	0.061	0.066	0.063
4	0.066	0.073	0.051	0.073	0.076	0.066	0.060
5	0.064	0.076	0.070	0.071	0.072	0.066	0.067
6	0.061	0.074	0.112	0.057	0.057	0.052	0.100
7	0.060	0.069	0.076	0.044	0.043	0.041	0.071
8	0.062	0.064	0.084	0.038	0.040	0.035	0.076
9	0.063	0.061	0.087	0.043	0.043	0.040	0.078
10	0.063	0.055	0.058	0.046	0.052	0.043	0.061
11	0.057	0.047	0.068	0.045	0.055	0.040	0.066
12	0.049	0.041	0.014	0.035	0.042	0.039	0.015
13	0.043	0.035	0.040	0.026	0.033	0.034	0.040
14	0.036	0.031	0.024	0.027	0.032	0.032	0.026
15	0.030	0.026	0.026	0.031	0.036	0.030	0.025
16	0.025	0.023	0.020	0.029	0.030	0.026	0.021
17	0.019	0.019	0.014	0.021	0.022	0.022	0.015
18	0.014	0.014	0.009	0.016	0.016	0.018	0.011
19	0.011	0.011	0.007	0.015	0.015	0.020	0.008
20	0.009	0.011	0.008	0.017	0.017	0.027	0.008
21	0.008	0.010	0.008	0.021	0.019	0.023	0.007
22	0.006	0.009	0.006	0.017	0.016	0.019	0.005
23	0.005	0.008	0.004	0.014	0.013	0.018	0.004
24+	0.012	0.026	0.027	0.049	0.043	0.061	0.028

* Based on "EPA, MOVES2010 Highway Vehicle – Population and Activity Data, November 2010, EPA-420-R-10-026"

Table 21: Onroad Vehicle Age Distributions (% of fleet) for Inventory Year 2011*

Vehicle age	Gas		Diesel				
	Car	Pickup/ Van	Light Comm.	Medium Comm.	Heavy Comm.	Bus	Pickup/ Van
0	0.071	0.061	0.056	0.068	0.057	0.064	0.061
1	0.062	0.055	0.051	0.063	0.053	0.059	0.055
2	0.052	0.039	0.036	0.060	0.052	0.057	0.039
3	0.058	0.048	0.044	0.066	0.058	0.063	0.048
4	0.064	0.070	0.054	0.068	0.060	0.064	0.062
5	0.065	0.070	0.049	0.069	0.073	0.064	0.058
6	0.063	0.073	0.067	0.068	0.069	0.063	0.064
7	0.060	0.071	0.107	0.053	0.054	0.049	0.095
8	0.059	0.065	0.073	0.042	0.041	0.039	0.067
9	0.060	0.060	0.079	0.036	0.038	0.033	0.071
10	0.060	0.057	0.082	0.040	0.041	0.038	0.073
11	0.060	0.051	0.055	0.043	0.049	0.040	0.057
12	0.052	0.044	0.063	0.041	0.051	0.038	0.061
13	0.042	0.038	0.013	0.032	0.039	0.036	0.014
14	0.035	0.032	0.037	0.024	0.031	0.031	0.036
15	0.030	0.028	0.021	0.025	0.029	0.030	0.023
16	0.024	0.023	0.023	0.028	0.033	0.027	0.022
17	0.020	0.021	0.018	0.026	0.027	0.024	0.019
18	0.015	0.016	0.012	0.019	0.020	0.020	0.014
19	0.011	0.013	0.008	0.014	0.014	0.017	0.009
20	0.008	0.010	0.006	0.013	0.014	0.018	0.007
21	0.007	0.010	0.007	0.016	0.015	0.024	0.007
22	0.006	0.009	0.007	0.018	0.017	0.020	0.006
23	0.005	0.008	0.005	0.015	0.014	0.017	0.005
24+	0.012	0.028	0.026	0.052	0.048	0.066	0.026

* Based on "EPA, MOVES2010 Highway Vehicle – Population and Activity Data, November 2010, EPA-420-R-10-026"

Table 22: Onroad Vehicle Age Distributions (% of fleet) for Inventory Year 2012

Vehicle age	Gas		Diesel				
	Car	Pickup/ Van	Light Comm.	Medium Comm.	Heavy Comm.	Bus	Pickup/ Van
0	0.077	0.062	0.057	0.070	0.060	0.067	0.061
1	0.070	0.060	0.055	0.066	0.056	0.063	0.059
2	0.062	0.054	0.050	0.061	0.052	0.058	0.054
3	0.051	0.038	0.035	0.058	0.051	0.056	0.038
4	0.057	0.047	0.043	0.064	0.056	0.061	0.047
5	0.063	0.068	0.052	0.065	0.057	0.061	0.060
6	0.063	0.068	0.048	0.066	0.071	0.061	0.056
7	0.061	0.070	0.065	0.064	0.066	0.059	0.061
8	0.058	0.067	0.102	0.050	0.052	0.046	0.090
9	0.056	0.062	0.069	0.039	0.039	0.037	0.063
10	0.057	0.057	0.074	0.033	0.036	0.031	0.067
11	0.057	0.053	0.077	0.037	0.038	0.035	0.068
12	0.055	0.048	0.051	0.039	0.046	0.037	0.053
13	0.045	0.040	0.058	0.038	0.048	0.035	0.056
14	0.035	0.034	0.011	0.030	0.037	0.034	0.013
15	0.029	0.028	0.033	0.022	0.028	0.029	0.032
16	0.024	0.025	0.019	0.023	0.027	0.027	0.021
17	0.019	0.021	0.021	0.025	0.030	0.025	0.020
18	0.015	0.018	0.016	0.024	0.025	0.022	0.017
19	0.011	0.015	0.011	0.017	0.018	0.018	0.012
20	0.008	0.011	0.007	0.012	0.013	0.015	0.008
21	0.006	0.009	0.005	0.012	0.012	0.016	0.006
22	0.005	0.009	0.006	0.014	0.014	0.022	0.006
23	0.004	0.008	0.006	0.016	0.015	0.018	0.005
24+	0.012	0.030	0.027	0.056	0.053	0.070	0.027

* Based on "EPA, MOVES2010 Highway Vehicle – Population and Activity Data, November 2010, EPA-420-R-10-026"

Table 23: Renewable Fuel Content by Region of Canada*

Fuel Type	Year	Region (fraction)					
		AB	BC	MB	ON	SK	Rest of Canada
Diesel	2010	0	0.03	0.02	0	0	0
	2011	0.02	0.04	0.02	0	0	0
	2012	0.02	0.05	0.02	0.02	0.015	0
	2013	0.02	0.05	0.02	0.02	0.015	0
Gasoline	2010	0	0.05	0.085	0.05	0.075	0
	2011	0.05	0.05	0.085	0.05	0.075	0.05
	2012	0.05	0.1	0.085	0.05	0.075	0.05
	2013	0.05	0.1	0.085	0.05	0.075	0.05

* http://www.greenfuels.org/en/public-policy/federal-programs.aspx

Table 24: IMO NO_X and SO_X/Fuel Regulations*

Standard	Engine RPM 'n'	NOx Emission Limit (g/kWh)	Fuel Standard (max. sulphur content)	Year	Relevance
Tier 1	n < 130	17.0	n/a	2000	Applies to all vessels constructed during or after this year.
	n = 130-2000	$45*n^{-0.2}$			
	n > 2000	9.8			
SO_x /FUEL	n/a	n/a	1.00%	2010	Only applies to ECA areas.
Tier 2	n < 130	14.4	n/a	2011	Applies to all vessels constructed during or after this year.
	n = 130-2000	$44*n^{-0.23}$			
	n > 2000	7.7			
SO_x /FUEL	n/a	n/a	0.10%	2015	Only applies to ECA areas.
Tier 3	n < 130	3.4	n/a	2021	Applies to all vessels constructed during or after this year. Only applies to vessels operating in ECA areas.
	n = 130-2000	$9*n^{-0.2}$			
	n > 2000	1.96			
SO_x /FUEL	n/a	n/a	0.50%	2020	Applies to all areas, pending a 2018 fuel availability review.

* http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=694C8126-1

APPENDIX B

Definitions and Conversion Factors Table

Table A-1: Definitions and Conversion Factors used in EC/GL Ports Emissions Inventory project

Type	Name	Value	Units	Source
Density	Lumber	600	kg/m^3	EPA AP-42, Appendix A (Miscellaneous Data & Conversion Factors)
	Diesel	851	g/L	
	Gasoline	741		
	Heavy fuel oil	944		
	Marine diesel oil	845		
	Propane	540		
Energy density	Diesel	39	MJ/L	
	Gasoline	34		
	Heavy fuel oil	42		
	Marine diesel oil	42		
	Propane	26		
Global warming potentials	CO_2	1	CO_2e	IPCC Second Assessment Report
	CH_4	21		
	N_2O	310		
Electricity carbon intensities	New Brunswick	503	g CO_2e/kWh	EC 2011 National Inventory Report (for 2010 inventory year)
	Newfoundland and Labrador	18		
	Nova Scotia	760		
	Ontario	133		
	Quebec	3		
Sulphur content	Diesel – non-rail	15	ppm	EC Sulphur in Diesel Regulations
	Diesel – facility rail	15		EC Sulphur in Diesel Regulations
	Diesel – National/Regional rail	129		RAC Locomotive Emission Model 2010
	Gasoline	30		EC Sulphur in Gasoline Regulations
	Natural Gas	3		Fortis BC
	Propane	75		Fortis BC
	HFO - domestic	1.5	Percent (%)	MEIT 4.0 / 2010 EC National Marine Inventory
	HFO – international	2.6		
	MDO – Domestic	0.05		
	MDO – International	1		
	MGO - Domestic	0.0015		

APPENDIX C

Example Quality Control Letter

SNC•LAVALIN Environment

Partnering to provide sustainable solutions

February 6, 2013

[redacted]

Dear [redacted]

SNC-Lavalin Inc, Environment Division (SLE) has been contracted by Transport Canada (TC) to develop a port emission inventories for Canada's ports, for the 2010 calendar year. Between July and December 2012, SLE collected information from you and other terminal representatives. We have compiled the activity information you provided to us and are sending you this brief summary as part of the quality control process used to manage the inventory effort.

The summary provided in the following tables include fuel consumption information by source categories, as well as commodity throughput and terminal gate counts. We would request that you review the summary and let us know if you find any errors or omissions.

Table 1: Reported 2010 fuel usage for administration (admin), cargo-handling equipment, trucks operated by the terminal (facility trucking), rail operated by the terminal (facility rail) and marine vessels operated by the terminal (Marine).

Source Category	Fuel Type	Reported Consumption	
Admin	Electricity	124,352	Kilowatt-hour (kWh)
Cargo Handling	Diesel	80,000	Litre
Cargo Handling	Propane	1,074	Litre

Table 2: Reported commodity throughput for 2010

Commodity Type	Quantity	
Breakbulk - Metals	[redacted]	Tonne

Table 3: Reported terminal gate counts for 2010

Vehicle Type / Locomotive	Annual Count
Highway Trucks - Heavy Duty	3,906

We thank you again for your previous effort in completing the activity questionnaire. Please contact SLE (john.lindner@snclavalin.com, W: 604-515-5160 ext. 104, C: 778-875-1645) if you believe an adjustment to the information you reported is warranted. Adjustments will only be accepted until Friday, February 22, 2013, since the project is nearing completion.

Yours truly,

John Lindner
Project Scientist
SNC-Lavalin Environment

APPENDIX D

Non-Reporting Terminals

Completed questionnaires were provided by most, but not all terminals during the data collection process for the inventory. This appendix describes how activity values were estimated for these terminals. As shown in Table D-1, 27 terminals did not provide any information for the inventory. Additionally, 41 of the 132 completed questionnaires were missing at least one required data field.

Table D-1: Summary of Reporting and Non-reporting Terminals for 2010 EC/GL Ports Inventory, by Commodity Type

Commodity Type	Reporting Terminals	Non-reporting Terminals	Total Terminals
Auto	0	1	1
Breakbulk	10	0	10
Bulk Liquid	20	10	30
Bulk Solid	61	14	75
Container	12	0	12
Passenger	8	1	9
Other	21	3	24
TOTAL	**132**	**29**	**161**

The landside activity associated with the one Auto terminal was not estimated due to lack of available supporting/surrogate data that could be used. For all of the other commodity/terminal types, data entries for similar activities were used to gap-fill as needed.

Data gaps were filled for two types of missing data:

- Primary activity measures; and
- Secondary activity measures.

Primary activity measures scale depending on the magnitude of a terminal. The magnitude of a terminal was based on cargo throughput or ship call records, depending on the commodity type of the terminal and whether throughput records were available from the port authority. Primary activity measures included the following values:

- Admin:
  - Annual fuel consumption (electricity, heating oil, natural gas).
- Marine:
  - Harbour vessel annual fuel consumption (MGO).
- Cargo-handling equipment:
  - Vehicle counts; and
  - Annual fuel consumption (diesel, electricity, gasoline, propane, natural gas).
- Onroad Vehicle:
  - Facility vehicle counts; and
  - Highway vehicle annual gate counts (pickup trucks, commercial vehicles).
- Rail:
  - National rail annual train trips; and
  - Facility rail annual fuel consumption (diesel).

In contrast to the primary activity measures, secondary activity measures are independent of the magnitude of the terminal operation. Examples of secondary activity measures include engine size/age of cargo-handling equipment or the average time spent on site by each train that visits the terminal.

Activity data was used to generate an EC/GL default data set of primary and secondary activity measures for each of six commodity classes (exception Auto):

- Breakbulk;
- Bulk Liquid;
- Bulk Solid;
- Containers;
- Passengers; and
- Other (tug support and port operations).

There were no minimum criteria to include an activity value in the default data set. All available activity data from the 132 questionnaires were included.

Table D-2 lists the primary activity measure defaults by commodity type.

Table D-2: Calculated Primary Activity Measure Defaults for all Commodity Classes using 2010 EC/GL Questionnaires.

Primary Activity Measure	Commodity Classes (units of throughput)				
	Breakbulk (per 1,000 t)	Bulk Liquid (per 1,000 t)	Bulk Solid (per 1,000 t)	Containers (per 1,000 t)	Passengers (per 1,000 persons)
Admin Annual Fuel Consumption					
Electricity (MWh)	1.2	0.3	2.2	0.2	3.2
Heating oil (L)	0.0	19.4	0.3	3.0	508.3
Natural gas (GJ)	0.4	2.2	5.8	0.2	5.3
Marine Harbour Vessel Annual Fuel Consumption					
MDO (L)	2,405.3	36.2	7.8	0.0	0.0
CHE Vehicles					
Equipment count	0.111	0.006	0.008	0.048	0.018
CHE Annual Fuel Consumption					
Diesel (L)	234.6	5.5	71.7	241.0	28.7
Electricity (GJ)	0.1	2.4	2.6	3.4	0.5
Gasoline (L)	1.3	0.0	0.6	0.1	5.2
Propane (L)	133.5	0.1	6.4	1.8	5.7
Natural gas (GJ)	0.0	5.3	0.0	0.0	0.0
Onroad Highway Truck Annual Gate Counts					
Pickup trucks	7.7	0.3	0.0	0.0	19.5
Medium commercial	0.0	0.1	0.6	0.0	0.0
Heavy commercial	15.5	0.0	6.7	18.3	0.0
Onroad Facility Vehicles					
Vehicle count	0.015	0.001	0.002	0.003	0.055
Onroad Facility Truck Annual Fuel Consumption					
Diesel (L)	160.8	1.3	2.8	11.7	31.3
Gasoline (L)	29.9	2.1	3.0	13.6	41.3
National Rail Annual Train Trips					
CN/CP (counts)	0.15	0.05	0.09	0.02	0.00
Facility Rail Annual Fuel Consumption					
Diesel (L)	50.8	11.6	13.1	4.9	0.0

Table D-3 summarizes the secondary activity measure defaults generated by the 134 returned questionnaires, by commodity class.

Table D-3: Calculated Secondary Activity Measures for all Commodity Classes using 2010 EC/GL Questionnaires.

Secondary Activity Measure	Breakbulk	Bulk Liquid	Bulk Solid	Containers	Passengers	Other
Marine Harbour vessels						
Most frequent vessel type*	-	-	Tug	Tug	Tug	Tug
Average engine size (hp)	-	-	165	746	247	2431
Most frequent engine type/age	-	-	4-stroke, pre-2000	4-stroke, pre-2000	4-stroke, pre-2000	4-stroke, pre-2000
CHE						
Average engine model year	1995	1995	2000	2003	2001	2001
Average engine power (hp)	129	248	382	76	77	49
Average annual hours	545	1014	1347	690	508	213
Most frequent equipment type*	Forklift	Forklift	Pump-Transfer	Yard Truck	Welder	Forklift
Onroad Vehicle – Highway						
Average drive time on terminal (min)	10	9	3	5	4	15
Average idle time on terminal (min)	9	12	7	20	2	36
Average distance port to entrance (km)	1	1	1	2	1	-
Average distance port to exit (km)	1	1	1	2	1	-
Average time idling on port grounds (km)	3	5	12	10	1	-
Most frequent speed on port grounds* (km/h)	24	23	25	25	27	0

Table D-3 (Cont'd): Calculated Secondary Activity Measures for all Commodity Classes using 2010 EC/GL Questionnaires.

Secondary Activity Measure	Breakbulk	Bulk Liquid	Bulk Solid	Containers	Passengers	Other
Onroad Vehicle – Facility						
Age of vehicle	2005-2009	2005-2009	2005-2009	2005-2009	2000-2004	2005-2009
Most frequent vehicle*	Van/Pickup	Van/Pickup	Van/Pickup	Van/Pickup	Van/Pickup	Van/Pickup
Rail – National/Regional						
Average number of locomotives per train	2	2	2	2	-	-
Average time spent on terminal per visit (hrs)	0.5	1.5	0.8	0.4	-	-
Average time spent on port grounds per visit (hrs)	0.2	0.1	0.1	0.1	-	-

* Based on vehicle counts.

The calculated default activity measures in the above tables were used to populate data gaps in questionnaires. In addition to the data in these tables, secondary activity data were also available from activity questionnaires completed for previous emission inventories (Hamilton (2008), Halifax (2009), Montreal (2008) and Sept-Iles (2008)). Each of these previous inventories used the PEIT model. These additional data were used for a non reporting terminal only when the old activity questionnaire was available for that same terminal. The previous inventory data were provided to SNC-Lavalin by Transport Canada or the respective port authorities. For confidentiality reasons, the values used cannot be listed in this appendix.

Figure D-1 shows the decision flowchart that was followed to populate questionnaires where data gaps existed.

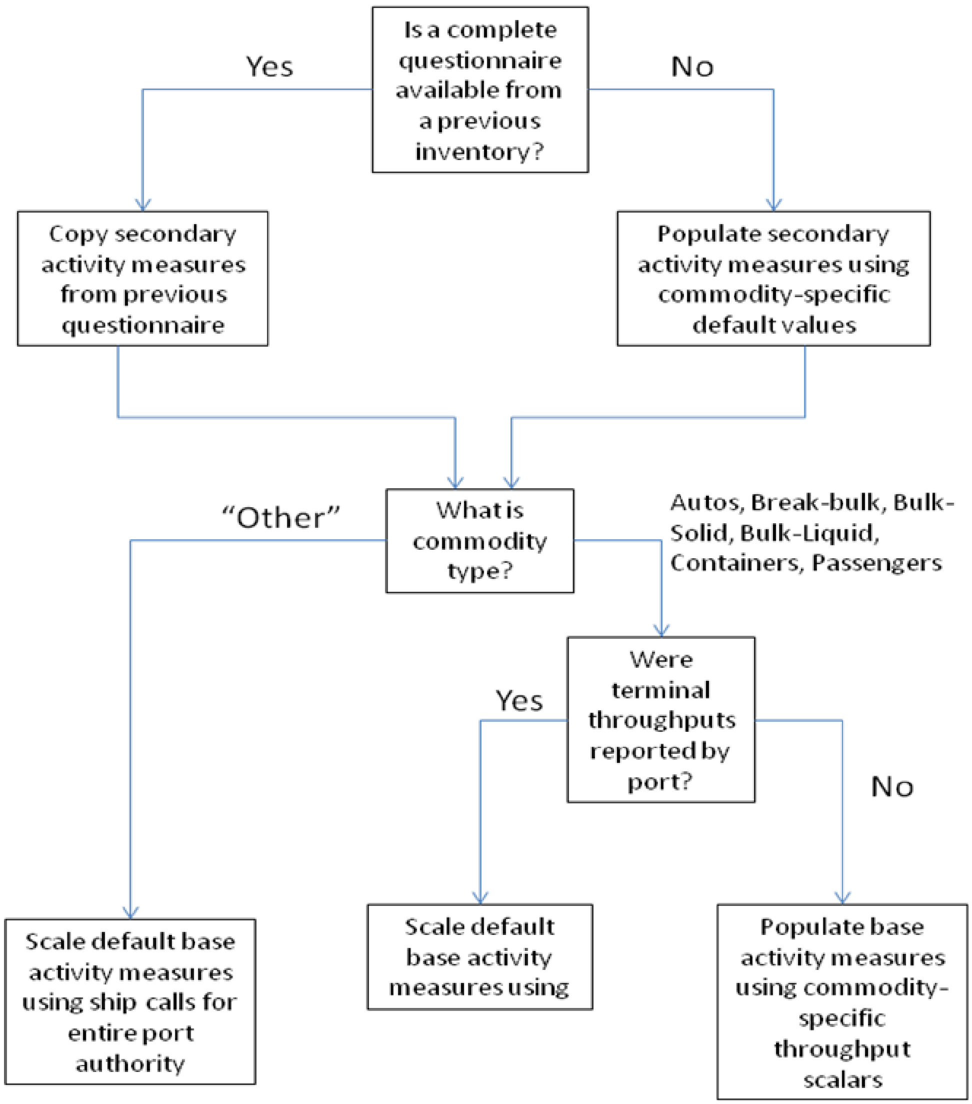


Figure D-1: Decision flowchart followed to populate data gaps in questionnaires.

As shown in the figure, default secondary activity data was entered directly into the questionnaire from Tables D-1 and D-2 or a previous questionnaire, depending on the commodity class.

Primary activity measures were calculated as follows:

$$A = D\ x\ S, \qquad (1)$$

Where *A* is the calculated primary activity measure, *D* is the default normalized primary activity measure (from Tables 1-1 to 1-3), and *S* is the size surrogate of the facility (in 1,000s of units of throughput or 10s of ship calls). As noted previously, throughput is considered a more accurate representation of a terminal's activity magnitude, but ship calls were used where throughput was not available.

An example of estimating missing cargo-handling equipment for a terminal is shown in Figure D-2. Terminal "Example A" is a Bulk Liquid facility with an annual throughput of 1,000,000 t, which corresponds to *S* in Equation 1. Given the throughput and values from Table D-1, the 2010 diesel fuel consumption was calculated as 12,500 litres and the equipment count as 3 (as shown in orange). The secondary activity measures shown in blue are from Table D-2.

7 Annual fuel consumption for terminal/facility CHE

Item	Fuel type	Annual fuel consumption	Units of fuel	Notes/comments
Example	Diesel	345,000	litre	Total for whole facility was 445,000; but 100,000L was used for harbour vessels.
1	Diesel	12,500	litre	
2				
3				
4				
5				
6				
7				
8				

8 Equipment list

Item	Equipment type	Engine model year	Number of similar units	Retrofit installed?	Retrofit type	Fuel type (refer to Table 7)	Engine power or boiler rating	Power units (kW, hp, BTU/hr)	Annual hours of use (for one unit)
Example	Rubber Tire Gantry (RTG) cranes	2000	3	No	None	1 - Diesel	250	kW	2,500
Example	Crawler Tractor/Dozers	2008	2	Yes	User-defined 1	1 - Diesel	400	hp	1,900
1	Pumps - Transfer	2000	3	No	None	1 - Diesel	382	hp	1,347
2				No	None				

Figure D-2: Example of estimated cargo-handling equipment sheet in activity questionnaire for terminal "Example A". Primary activity measures are shown in orange and secondary activity measures are shown in blue.

APPENDIX E

EC/GL Ports Commodity-based Emission Intensities

This appendix provides a record of the emission intensities for the major pollutants by source group for each of the commodity types collected as part of the EC/GL ports inventory project. Tables E-1 lists the emission intensities for NO_x, SO_x, $PM_{2.5}$ and CO_2e, grouped by the five source groups. The emission intensities were generated for each specific commodity type under the following conditions:

- Specific commodity types with more than one questionnaire (to protect confidentiality);
- Questionnaires where the source group activity was not estimated; and
- Terminals that handled only one specific commodity type.

Table E-1: Emission intensities from 2010 EC/GL Questionnaires, by Commodity Class and Source Group

Commodity Type	Cargo Unit	Source Group	NO_x (g per cargo unit)	SO_x (g per cargo unit)	$PM_{2.5}$ (g per cargo unit)	CO_2e (kg per cargo unit)
Breakbulk	tonnes	Admin	0.00	0.00	0.00	0.32
		CHE	21.01	0.02	1.84	1.54
		Marine	159.05	148.57	14.67	13.15
		Onroad	1.28	0.00	0.08	0.16
		Rail	0.64	0.00	0.02	0.04
		TOTAL	**181.98**	**148.60**	**16.60**	**15.20**
Bulk Liquid - Chemicals	tonnes	Admin	0.00	0.00	0.00	0.01
		CHE	2.21	0.00	0.10	0.24
		Marine	13.05	14.84	1.40	1.27
		Onroad	0.11	0.00	0.01	0.14
		Rail	0.00	0.00	0.00	0.00
		TOTAL	**15.38**	**14.85**	**1.51**	**1.66**

Table E-1 (Cont'd): Emission intensities from 2010 EC/GL Questionnaires, by Commodity Class and Source Group

Commodity Type	Cargo Unit	Source Group	NO_x (g per cargo unit)	SO_x (g per cargo unit)	$PM_{2.5}$ (g per cargo unit)	CO_2e (kg per cargo unit)
Bulk Liquid - Petroleum products	tonnes	Admin	0.03	0.00	0.00	0.09
		CHE	0.12	0.00	0.01	0.21
		Marine	10.39	11.12	1.06	0.98
		Onroad	0.02	0.00	0.00	0.00
		Rail	0.01	0.00	0.00	0.00
		TOTAL	**10.57**	**11.12**	**1.07**	**1.29**
Bulk Solid - Construction materials	tonnes	Admin	0.23	0.00	0.00	0.06
		CHE	5.54	0.00	0.40	0.47
		Marine	18.35	17.58	1.70	1.58
		Onroad	1.00	0.00	0.06	0.09
		Rail	0.00	0.00	0.00	0.00
		TOTAL	**25.11**	**17.59**	**2.16**	**2.20**
Bulk Solid - Fertilizer	tonnes	Admin	0.00	0.00	0.00	0.00
		CHE	3.85	0.00	0.23	0.56
		Marine	35.35	34.19	3.36	3.03
		Onroad	0.59	0.00	0.04	0.07
		Rail	0.19	0.00	0.00	0.01
		TOTAL	**39.98**	**34.19**	**3.63**	**3.68**
Bulk Solid - Grain, special crops and feed	tonnes	Admin	0.02	0.00	0.00	0.02
		CHE	0.12	0.00	0.01	0.01
		Marine	24.66	22.21	2.18	1.98
		Onroad	0.39	0.00	0.02	0.04
		Rail	2.24	0.00	0.06	0.10
		TOTAL	**27.44**	**22.21**	**2.27**	**2.16**

Table E-1 (Cont'd): Emission intensities from 2010 EC/GL Questionnaires, by Commodity Class and Source Group

Commodity Type	Cargo Unit	Source Group	NO_x (g per cargo unit)	SO_x (g per cargo unit)	$PM_{2.5}$ (g per cargo unit)	CO_2e (kg per cargo unit)
Bulk Solid – Iron, steel and ore/mineral products*	tonnes	Admin	0.00	0.00	0.00	0.01
		CHE	0.10	0.00	0.01	0.02
		Marine	4.09	3.36	0.35	0.30
		Onroad	0.07	0.00	0.00	0.01
		Rail	0.00	0.00	0.00	0.00
		TOTAL	**4.27**	**3.36**	**0.36**	**0.34**
Bulk Solid - Salt	tonnes	Admin	0.00	0.00	0.00	0.00
		CHE	1.53	0.00	0.11	0.14
		Marine	5.56	4.56	0.46	0.41
		Onroad	0.46	0.00	0.03	0.05
		Rail	0.00	0.00	0.00	0.00
		TOTAL	**7.55**	**4.56**	**0.60**	**0.60**
Containers	TEU	Admin	0.18	0.00	0.01	1.16
		CHE	92.43	0.10	6.67	15.43
		Marine	357.25	336.87	33.14	28.75
		Onroad	19.87	0.03	1.16	2.28
		Rail	32.92	0.02	0.81	1.40
		TOTAL	**502.64**	**337.01**	**41.78**	**49.01**
Passengers (Cruise/Ferry)	persons	Admin	0.25	0.00	0.02	0.32
		CHE	0.91	0.00	0.06	0.15
		Marine	479.98	347.49	38.29	34.99
		Onroad	0.04	0.00	0.00	0.03
		Rail	0.00	0.00	0.00	0.00
		TOTAL	**470.72**	**335.74**	**37.40**	**34.53**

* "Iron, steel and other ore/mineral products" includes terminals handling two specific types of bulk solid as defined in PEIT: "Iron and steel products" and "Other ore and mineral products".

APPENDIX F

Speciated Inventory Estimates

This appendix summarizes the emissions of toxics and suspended particulate matter from the 2010 East Coast/Great Lakes emissions inventory. Table F-1 lists the toxic emissions by substance type to the different boundaries. Tables F-2 and F-3 summarize the toxic and suspended particulate matter emissions by source group. Under Table F-3, diesel particulate matter is assumed to include all marine fuels (HFO, MDO, MGO) in addition to diesel varieties used on the landside.

Table F-1: 2010 EC/GL Toxic Emissions by Substance Type (kg)

Substance Type	Substance	Emissions to Terminal/Facility Boundary	Emissions to Port Boundary
Hazardous Air Pollutants	2,2,4-Trimethylpentane	179.6	213.6
	Acetaldehyde	6,324.6	8,106.3
	Acrolein	384.1	534.4
	Benzene	2,255.0	2,692.2
	Ethyl Benzene	346.9	444.0
	Formaldehyde	15,320.1	18,799.3
	Hexane	471.3	707.1
	Styrene	170.7	260.8
	Toluene	1,250.7	1,467.1
	Xylene	1,066.0	1,317.2

Table F-1 (Cont'd): 2010 EC/GL Toxic Emissions by Substance Type (kg)

Substance Type	Substance	Emissions to Terminal/Facility Boundary	Emissions to Port Boundary
Polycyclic aromatic hydrocarbons	Acenaphthene	6.1	7.0
	Acenaphthylene	10.5	13.5
	Anthracene	5.5	7.2
	Benz(a)anthracene	5.3	6.8
	Benzo(a)pyrene	1.2	1.6
	Benzo(b)fluoranthene	2.4	3.0
	Benzo(g,h,i)perylene	1.3	1.7
	Benzo(k)fluoranthene	1.3	1.6
	Chrysene	1.1	1.4
	Fluoranthene	4.1	5.0
	Fluorene	10.3	12.3
	Indeno(1,2,3,c,d)pyrene	2.2	2.9
	Naphthalene	243.2	302.5
	Phenanthrene	18.6	21.4
	Pyrene	6.3	7.9
Metals	Arsenic & compounds	11.8	18.2
	Chromium (Cr3+)	13.2	21.9
	Chromium (Cr6+)	6.8	11.3
	Lead	40.4	50.7
	Manganese	4.7	8.0
	Mercury (divalent gaseous)	0.0	0.0
	Mercury (elemental gaseous)	0.0	0.1
	Mercury (particulate)	0.0	0.0
	Nickel	371.1	603.44

Table F-2: 2010 EC/GL Toxic Emissions to the Port Boundary by Source Group (kg)

Source Group	HAP	PAH	Metals
Admin	596.7	1.6	0.2
CHE	10,394.4	28.3	9.9
Marine	19,812.8	276.2	698.7
Onroad Vehicle	2,216.6	52.4	2.7
Rail	1,521.7	37.3	2.2
TOTAL	**34,542.1**	**395.9**	**713.7**

Table F-2: 2010 EC/GL Suspended Particulate Matter Emissions to the Port Boundary by Source Group (kg)

Source Group	Diesel Particulate Matter	Elemental Carbon	Organic Carbon	Sulphates
Admin	200	714	541	159
CHE	24,730	635	10,404	182
Marine	369,068	82,580	146,395	141,599
Onroad Vehicle	8,135	182	3,422	45
Rail	5,037	83	3,429	1,413
TOTAL	**407,169**	**84,192**	**164,192**	**143,399**