The Port of New York and New Jersey Port Commerce Department 2010 Multi-Facility Emissions Inventory

Cargo Handling Equipment, Heavy-Duty Diesel Vehicles, Railroad Locomotives, and Commercial Marine Vessels

THE PORT AUTHORITY OF NY & NJ

December 2012

Prepared by:
STARCREST CONSULTING GROUP, LLC

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

PORT COMMERCE DEPARTMENT

2010 MULTI-FACILITY EMISSIONS INVENTORY OF CARGO HANDLING EQUIPMENT, HEAVY-DUTY DIESEL VEHICLES, RAILROAD LOCOMOTIVES, AND COMMERCIAL MARINE VESSELS

DECEMBER 2012

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Operating Mode	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Transit	2,193	194	156	111	222	1,467
Dwelling	866	101	81	27	71	1,232
Total	**3,059**	**295**	**236**	**138**	**293**	**2,699**

LIST OF ACRONYMS

AIS	automatic identification system
CHE	cargo handling equipment
CH_4	methane
CMV	commercial marine vessel
CO	carbon monoxide
CO_2	carbon dioxide
EPA	United States Environmental Protection Agency
EPAMT	Elizabeth Port Authority Marine Terminal
GHGs	greenhouse gases
g/hp-hr	grams per horsepower hour
g/mi	grams per mile
g/hr	grams per hour
g/MMGTM	grams of emissions per million gross ton-miles
GTM	gross ton-miles
GVWR	gross vehicle weight rating
HDDV	heavy duty diesel vehicle
hp	horsepower
hp-hr	horsepower hour
kW	kilowatt
LPG	liquefied petroleum gas
NO_x	oxides of nitrogen
N_2O	nitrous oxide
NYCT	New York Container Terminal
NYNJHS	New York/New Jersey Harbor System
NYNJLINA	New York/New Jersey Long Island Non-Attainment Area
OGV	ocean-going vessel
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PNCT	Port Newark Container Terminal
ppm	parts per million
RAT	Regional Air Team
SCC	source classification code
SO_2	sulfur dioxide
TEUs	twenty-foot equivalent units
tpy	tons per year
VOCs	volatile organic compounds
VMT	vehicle miles traveled

EXECUTIVE SUMMARY

The purpose of this inventory is to estimate air emissions generated in 2010 by land-based mobile sources and commercial marine vessels associated with marine terminal activity linked to facilities maintained by the Port Authority of New York and New Jersey (Port Authority) and leased to private terminal operators. This report is an update of the 2008 Multi-Facility Emissions Inventory, which covers land-based mobile sources and commercial marine vessels (CMV) associated with the Port Authority facilities leased to private operators.

ES.1 Key Findings

Although the primary purpose of this emissions inventory is to provide an update to the emission estimates presented in the 2008 inventory report, there were also some immediate findings:

- Port Authority maritime emissions of oxides of nitrogen (NO_x) related to the Port Authority marine terminals are 2% lower than the 2008 estimates and 12% lower than the 2006 estimates, and constitute two percent (2%) of the overall NYNJLINA NO_x emissions.
- Port Authority maritime emissions of particulate matter less than 10 microns (PM_{10}) related to the Port Authority marine terminals are 2% lower than the 2008 estimates and 19% lower than the 2006 estimates, and constitute four tenths of a percent (0.4%) of the overall NYNJLINA PM_{10} emissions.
- Port Authority maritime emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) related to the Port Authority marine terminals are 2% lower than the 2008 estimates and 18% lower than the 2006 estimates, and constitute one percent (1%) of the overall NYNJLINA $PM_{2.5}$ emissions.
- Port Authority maritime emissions of volatile organic compounds (VOCs) related to the Port Authority marine terminals are 5% higher than the 2008 estimates but are 13% lower than the 2006 estimates, and constitute less than a tenth of a percent (0.09%) of the overall NYNJLINA VOC emissions.
- Port Authority maritime emissions of carbon monoxide (CO) related to the Port Authority marine terminals are 5% lower than the 2008 estimates and 14% lower than the 2006 estimates, and constitute less than a tenth of a percent (0.07%) of the overall NYNJLINA CO emissions.
- Port Authority maritime emissions of sulfur dioxide (SO_2) related to the Port Authority marine terminals are 9% lower than the 2008 estimates and 25% lower than the 2006 estimates, and constitute less than four percent (3.6%) of the overall NYNJLINA SO_2 emissions.
- Emissions of greenhouse gases (GHG) related to the Port Authority marine terminals are 1% higher than the 2008 estimates but 7% lower than the 2006 estimates, and constitute 6-tenths of a percent (0.6%) of the overall NYNJLINA GHG emissions.

ES.2 Major Changes in 2010

There are two major changes to this 2010 emissions inventory compared with the 2008 and previous inventories that warrant discussion because they had an effect on the estimates of 2010 emissions and need to be kept in mind when comparing 2010 emissions to previous years' emissions, such as 2008 and 2006 emissions.

The 2010 emission estimates presented in this emissions inventory include emissions from the Global Container Terminal, which was acquired by the Port Authority mid-way through 2010. Activity and emissions from this terminal during the second half of 2010 have been included in the emission estimates presented in this 2010 Multi-Facility Emissions Inventory report. Despite adding Global Container Terminal for the first time in this 2010 report, the 2010 emission estimates overall were lower than 2008 and 2006 emissions.

In addition to the Global Container Terminal being included for the second half of 2010, a more accurate methodology was used for the first time in 2010 to determine the activity of ocean-going vessels (OGVs), which resulted in higher OGV emission estimates for most pollutants as compared to estimates made for previous years. The improved methodology uses Automatic Identification System (AIS) data to track the position, course, and speed for port arrivals, shifts and departures. The use of actual speeds and distances versus the interview-based assumptions used in previous inventories resulted in higher main engine emission estimates for the 2010 OGV emissions compared with estimates of previous years' emissions.

The Port Authority anticipates using the more accurate AIS methodology for future PANYNJ emission inventory reports, so future comparisons to 2010 emissions will be a more apples to apples comparison than the current comparisons of 2010 emissions with earlier emission estimates. It should be noted that the higher estimates of OGV emissions do not necessarily reflect actual higher emissions in 2010 than in previous years; rather, the improved vessel movement data provides a more complete picture of vessel operations that was not available using the older methods. In fact, with a lower number of vessel calls and the Port Authority's implementation of their low sulfur fuel program, OGV emissions would be expected to be lower in 2010 than in earlier years, and future inventories developed in future years will determine whether decreases continue to occur. The Port Authority will continue to stay abreast of the most current methodologies and make improvements to the methods used to estimate emissions from all emission source categories.

ES.3 Scope

This inventory includes emissions generated in 2010 that are linked to six Port Authority-associated marine terminals. In 2010, the Port Authority acquired the land on which the Global Marine Terminal is located, and the terminal's emissions after acquisition, during the second half of the year, are included in this inventory for the first time. Because the Global Marine Terminal was not associated with the Port Authority before this time, the terminal's emissions were not included in the previous two port-wide emissions inventories.

The following terminals are located in New Jersey:

- Port Newark,
- The Elizabeth Port Authority Marine Terminal
- Port Jersey Port Authority Marine Terminal (in Bayonne and Jersey City – includes Global Marine Terminal and auto marine operations)

The remaining two marine terminals are in New York:

- The Howland Hook Marine Terminal (on Staten Island)
- The Brooklyn Port Authority Marine Terminal.

This inventory does not include emissions from activities linked to the various marine terminals that are entirely privately owned and operated and numerous solid and liquid bulk facilities, including the many oil and fuel depots located along the Arthur Kill and Kill Van Kull waterways – as they are not under the aegis of the Port Authority in any way. These facilities, along with the Port Authority marine terminals included in this emissions inventory, make up the Port of New York and New Jersey (the Port).

This inventory also does not include emissions linked to the Port Authority's non-maritime facilities, such as airports, bridges and tunnels.

The study area for this inventory includes seventeen counties across the states of New Jersey and New York coincident with the New York/Northern New Jersey/Long Island Non-Attainment Area (NYNJLINA). The NYNJLINA was recognized by the multi-agency Regional Air Team (RAT), of which the Port Authority is a member, as an appropriate boundary to conduct a series of marine-industry related emission inventories that initially looked at the year 2000 commercial marine vessel fleet. The boundary was chosen to coincide with the U.S. Environmental Protection Agency's (EPA) determination that this area has levels of ozone that "persistently exceed the national ambient air quality standards."[1] In 2005 EPA likewise determined that much of this area does not meet the national air quality standards for $PM_{2.5}$.

ES.4 Previous Inventories

This report builds on previous Port Authority maritime-related emission inventories covering earlier-year fleets: commercial marine vessels, consisting of ocean-going vessels and harbor craft such as tow boats and assist tugs (2000, 2006, and 2008), on-dock railroad locomotives (2002, 2006, and 2008), heavy-duty diesel vehicles, also known as on-road trucks (2005, 2006, and 2008), and cargo handling equipment (2002, 2004, 2006, and 2008). This inventory is the third study to look at all of the emission source categories within a given year.

[1] *http://epa.gov/oar/oaqps/greenbk/index.html.*

ES.5 Emissions Surveyed

This inventory report presents estimates of the quantity of emissions from mobile sources tied to the Port Authority leased marine terminals. Most of these emissions are in a category commonly referred to as "criteria pollutants" because the EPA has established health-based or environmentally-based criteria or guidelines for setting ambient limits for them and for the pollutant ozone, which is not emitted directly but develops in the atmosphere, in part as a result of emissions of other pollutants (identified below). In this report, the term "criteria pollutants" refers to the following emissions:

- Oxides of nitrogen (NO_X), an ozone precursor,
- Carbon monoxide (CO),
- Particulate matter less than 10 microns in diameter (PM_{10}),
- Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$),
- Volatile organic compounds (VOCs), an ozone precursor, and
- Sulfur dioxide (SO_2).

The remaining emissions are referred to as greenhouse gas (GHG) emissions because of their contribution to global climate change caused by the global warming phenomenon. The greenhouse gas emissions included in this inventory are:

- Carbon dioxide (CO_2),
- Nitrous oxide (N_2O), and
- Methane (CH_4).

Throughout the report, the GHG pollutants are combined into "CO_2 equivalents," a means of expressing the various GHGs in consistent terms relative to the atmospheric activity of CO_2. CO_2 equivalents are calculated by summing the mass emissions of each pollutant multiplied by its CO_2 equivalency factor, as listed below.

- CO_2 - 1
- N_2O - 310
- CH_4 – 21

The only exception to not providing CO_2 equivalent emissions in tables and charts is comparisons with NYNJLINA CO_2 emissions because the NYNJLINA emissions only include CO_2 emissions, not CO_2 equivalent emissions.

ES.6 Overall Port Activity

The Port of New York and New Jersey is the largest seaport on the east coast, the third largest in the U.S., and among the ten largest in the world. It provides almost immediate access to one of the country's wealthiest regions and rail and truck access to half the nation. The region was first settled because of the Hudson River Valley's advantages as a harbor, and port commerce was integral in the growth of the New York metropolitan region into the economic and cultural center it is today.

One measure of Port activity is the throughput of containerized cargo, commonly expressed in terms of twenty-foot equivalent units (TEUs). In 2010, 5.29 million TEUs passed through the Port (including both Port Authority and non-Port Authority facilities), similar to the nearly 5.21 million TEUs moved in 2008. In terms of total metric tons of cargo, throughput decreased 8% from 88.9 million to 81.4 million metric tons, and the value of all cargo moved through the Port reached $175 billion.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

The emission estimates developed as described in this report are summarized below. Table ES.1 presents the criteria pollutant and CO_2 emissions by source category, the total PANYNJ emissions, and the total emissions in the NYNJLINA[2] in tons per year, and the percentage that the PANYNJ emissions makeup of the total NYNJLINA emissions. For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

Table ES.1: Criteria Pollutant and CO_2 Emission Summary by Source Category, tpy

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Cargo Handling Equipment	1,109	67	65	94	380	1.1	122,814
Heavy-Duty Diesel Vehicles	2,104	46	42	96	477	2.1	228,960
Railroad Locomotives	261	9	9	20	46	3.8	17,207
Ocean-Going Vessels	3,059	295	236	138	293	2,699	155,696
Harbor Craft	360	20	19	14	40	7.6	19,537
Total PANYNJ Emissions	**6,894**	**436**	**371**	**362**	**1,235**	**2,714**	**544,215**
NYNJLINA Emissions	**339,423**	**102,719**	**32,978**	**419,604**	**1,888,145**	**75,196**	**112,835,680**
PANYNJ Percentage	**2.0%**	**0.4%**	**1.1%**	**0.09%**	**0.07%**	**3.6%**	**0.5%**

[2] See: 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table ES.2 illustrates the percentage contribution of each source category to the total PANYNJ emissions of each pollutant.

Table ES.2: Criteria Pollutant Emission Summary by Source Category, %

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	16%	15%	17%	26%	31%	0%
Heavy-Duty Diesel Vehicles	31%	10%	11%	27%	39%	0%
Railroad Locomotives	4%	2%	2%	5%	4%	0%
Ocean-Going Vessels	44%	68%	64%	38%	24%	99%
Harbor Craft	5%	5%	5%	4%	3%	0%
Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Tables ES.3 and ES.4 present the emissions and percentages of greenhouse gases.

Table ES.3: Greenhouse Gas Emission Summary by Source Category, tpy

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	122,814	3	7	123,847
Heavy-Duty Diesel Vehicles	228,960	1	1	229,000
Railroad Locomotives	17,207	0	1	17,364
Ocean-Going Vessels	155,696	9	3	158,562
Harbor Craft	19,537	5	13	20,385
Totals	**544,215**	**18**	**24**	**549,158**

Table ES.4: Greenhouse Gas Emission Summary by Source Category, %

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	23%	16%	27%	23%
Heavy-Duty Diesel Vehicles	42%	4%	3%	42%
Railroad Locomotives	3%	2%	6%	3%
Ocean-Going Vessels	29%	49%	12%	29%
Harbor Craft	4%	29%	53%	4%
Totals	**100%**	**100%**	**100%**	**100%**

The following figures illustrate the distribution of emissions by source category in terms of tons per year and percent of total, in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure ES.1: Distribution of NO_x Emissions by Source Category, tpy & percent

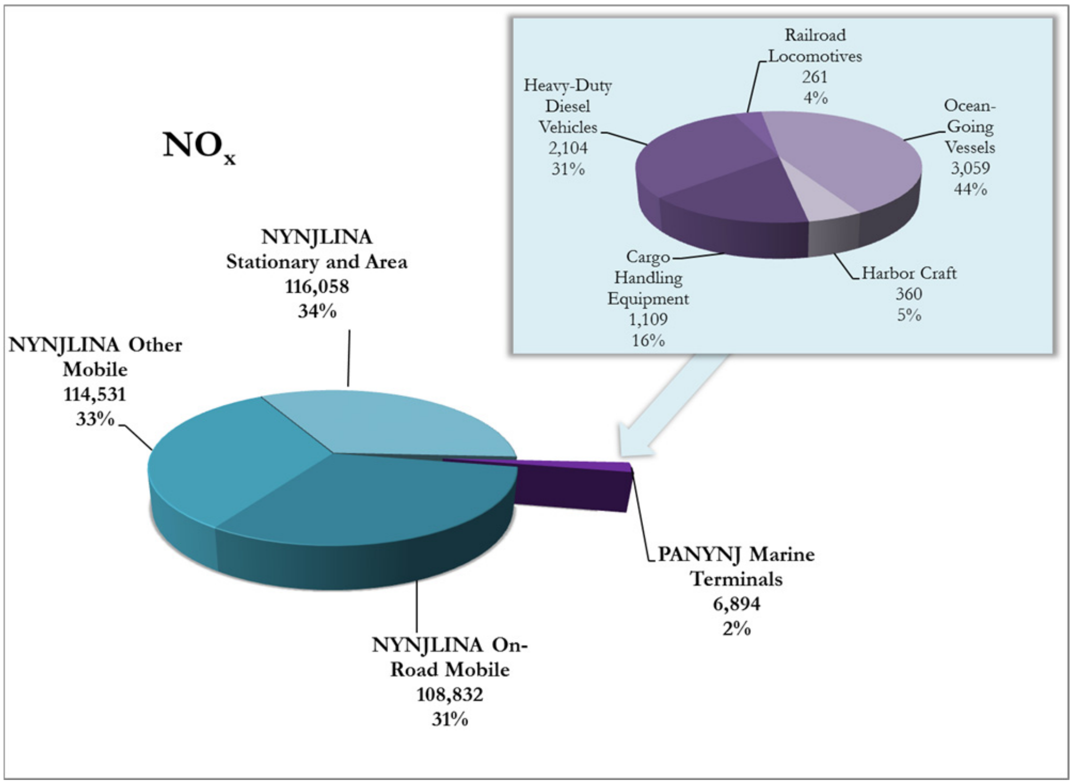


Figure ES.2: Distribution of PM_{10} Emissions by Source Category, tpy & percent

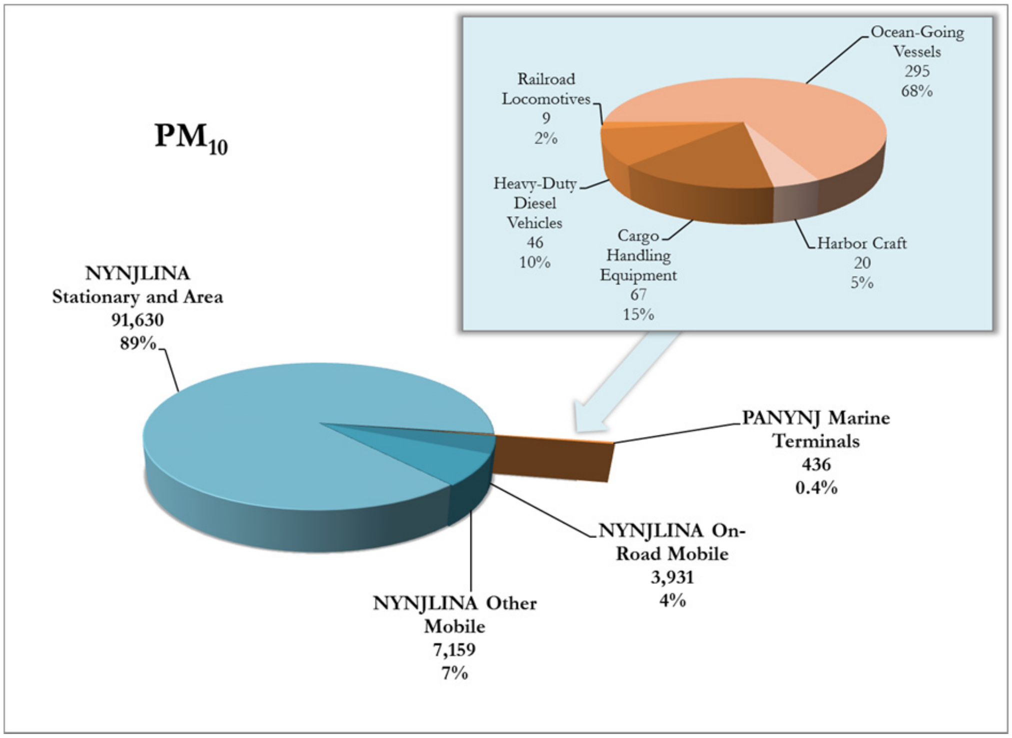


Figure ES.3: Distribution of $PM_{2.5}$ Emissions by Source Category, tpy & percent

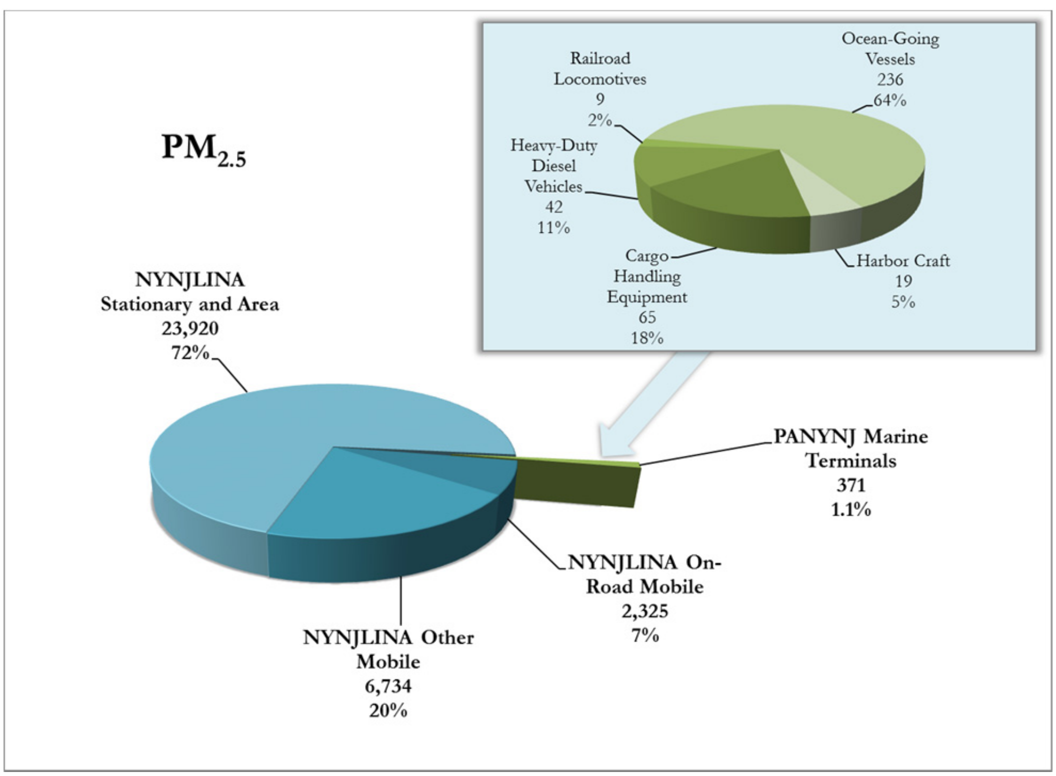


Figure ES.4: Distribution of VOC Emissions by Source Category, tpy & percent

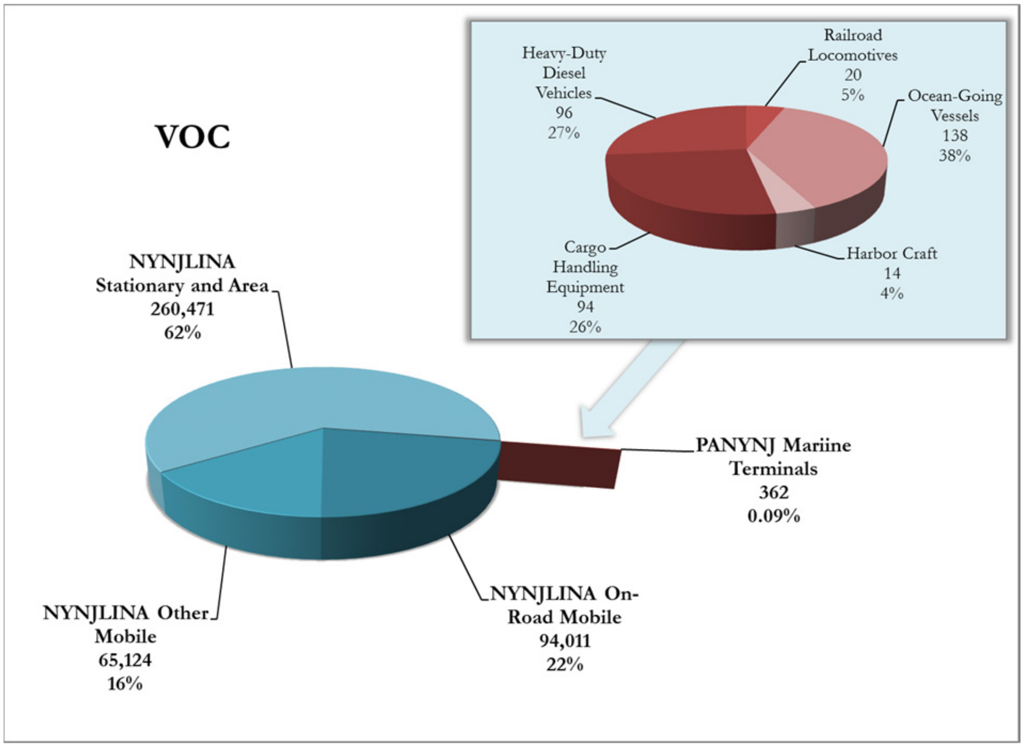


Figure ES.5: Distribution of CO Emissions by Source Category, tpy & percent

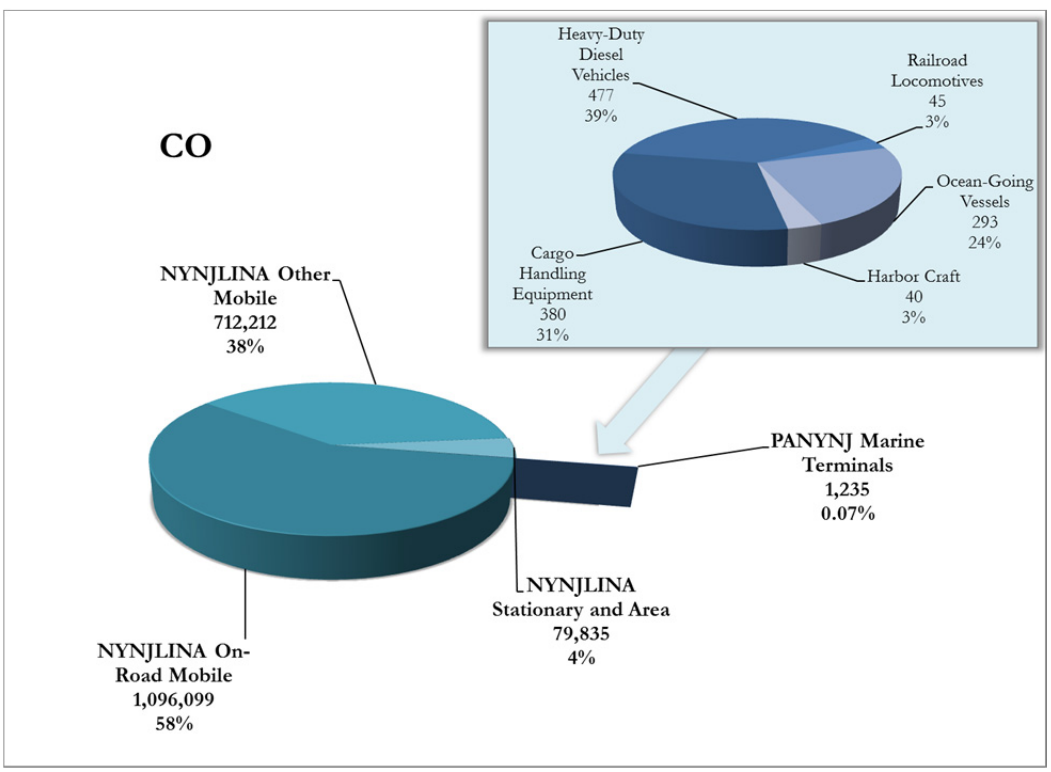


Figure ES.6: Distribution of SO_2 Emissions by Source Category, tpy & percent

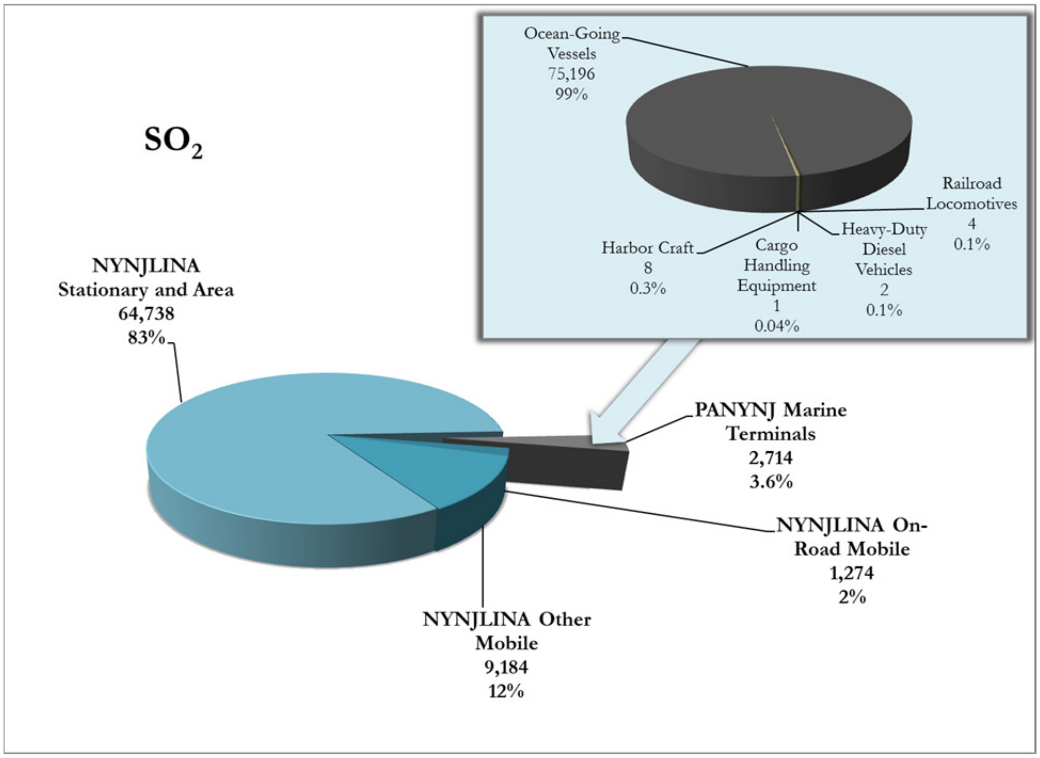
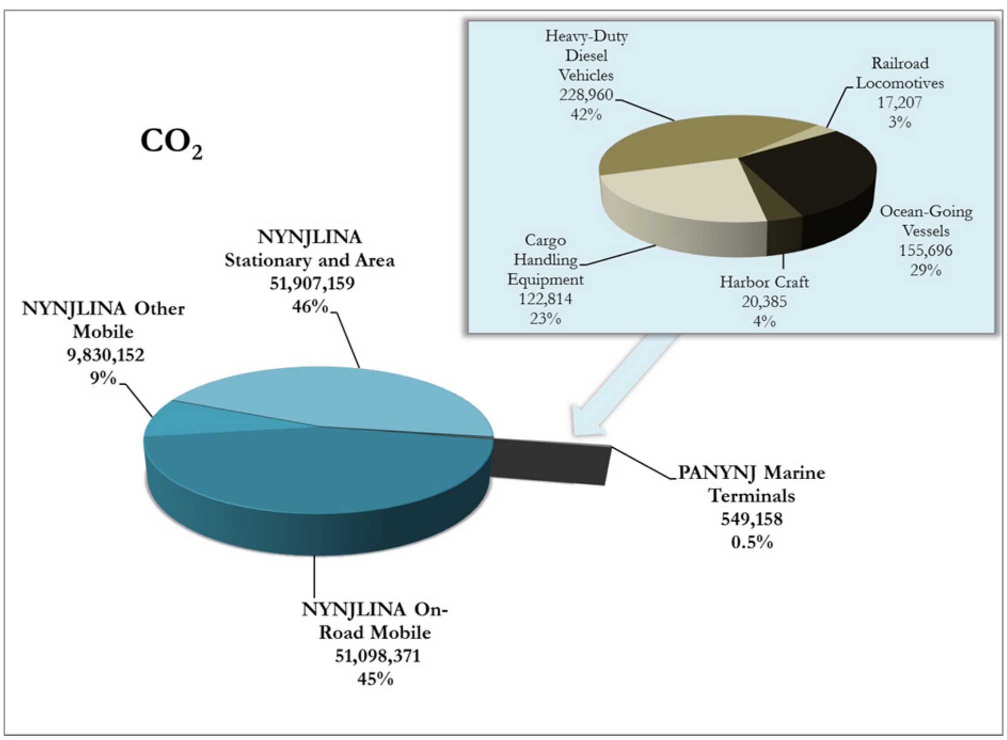


Figure ES.7: Distribution of CO_2 Emissions by Source Category, tpy & percent



SECTION 1: INTRODUCTION

Goods from all over the world enter and leave the United States through the largest port complex on the East Coast of North America, the Port of New York and New Jersey (the Port). With immediate access to extensive interstate highway and railroad networks, marine cargo moves efficiently in and out through the Port's marine terminals, helping to supply the New York/New Jersey metropolitan area, which is one of the busiest freight handling and consumer centers in the country. The Port of New York and New Jersey includes many marine terminals, six of which are under the aegis of the Port Authority of New York and New Jersey (the Port Authority): Port Newark, Elizabeth Port Authority Marine Terminal, Global Marine Terminal, and the Port Authority Auto Marine Terminal in New Jersey; and the Howland Hook Marine Terminal and the Brooklyn Port Authority Marine Terminal in New York (see Figure 1.1). The Port Authority acquired the land on which the Global Marine Terminal is located in mid-2010, so emissions from this terminal during the second half of 2010 have been included in this inventory.

This inventory does not include emissions from activities linked to the various marine terminals that are entirely privately owned and operated – such as numerous solid and liquid bulk facilities, including the many oil and fuel depots located along the Arthur Kill and Kill Van Kull waterways – as they are not under the aegis of the Port Authority in any way. These facilities, along with the Port Authority facilities included in this emissions inventory, make up the Port of New York and New Jersey (the Port).

This inventory also does not include emissions linked to the Port Authority's non-maritime facilities, such as airports, bridges and tunnels.

This report furthers ongoing efforts by the Port Authority's Port Commerce Department to assess and evaluate air emissions associated with the Port Authority's marine terminals, including emissions from cargo handling equipment (CHE), heavy duty diesel vehicles (HDDV, i.e., trucks), locomotives, and commercial marine vessels (CMV, includes ocean going vessels and harbor craft) that visit these facilities. The current inventory covers the activities discussed above associated with the Port Authority's six marine terminals that take place in the counties within an area known as the New York/Northern New Jersey/Long Island Non-Attainment Area (NYNJLINA). The NYNJLINA was recognized by the multi-agency Regional Air Team (RAT), of which the Port Authority is a member, as an appropriate boundary to conduct a series of marine-industry related emission inventories that started with the year 2000 commercial marine vessel fleet. The NYNJLINA originally encompassed seventeen counties across the states of New Jersey and New York that constitute the bulk of counties in the designated New York/Northern New Jersey/Long Island/Connecticut ozone non-attainment area and also includes most of the counties designated by the U.S. Environmental Protection Agency (EPA) in 2005 as non-attainment for particulate matter 2.5 microns or less in diameter ($PM_{2.5}$). One of the NYNJLINA counties, Ocean County, New Jersey, has not been included with the NYNJLINA counties listed in various tables in this report because there are no identified Port Authority marine terminal related activities or emissions within the county.

The Port Authority has previously developed port industry emissions inventories for CHE, HDDVs (i.e., freight trucks), railroad locomotives, and commercial marine vessels (CMV), including those associated with the marine terminals maintained by the Port Authority and leased to private operators. The most recent of these inventories was the *2008 Multi-Facility Emissions Inventory* released in October 2010. The purpose of this 2010 emissions inventory is to update the emission estimates presented in the 2008 emissions inventory, and it is focused on the six Port Authority marine terminals. This current study has evaluated the CHE, HDDV, railroad locomotive, and commercial marine vessel source categories for the year 2010, which allows for a comparison with the earlier emission estimates for those source categories. The goals of this emissions inventory include:

- Estimate the contribution to overall emissions in the NYNJLINA attributable to CHE, HDDV, locomotive, and commercial marine vessel activity associated with the six Port Authority marine terminals;
- Illustrate, to the extent feasible, the effects of voluntary measures initiated by the Port Authority and their tenants to reduce emissions; and
- Continue to help support a case to obtain funding through grants and other programs for enhancing air quality within the NYNJLINA through targeted port-industry related emission reduction initiatives.

1.1 Approach

Methods used to collect data and to estimate and report emissions from the emission source categories are typical of the approach taken by Starcrest, in concert with the EPA and other regulators, for port emission inventories. The report compares emissions related to terminal operations, including visiting vessels, cargo handling equipment, trucks and locomotives within the NYNJLINA with total area emissions and emissions by county. It does not include the use of dispersion models to predict ambient concentrations of pollutants or the assessment of health impacts.

The approach to developing this activity-based or "bottom-up" emissions inventory was based in large part on interviews and conversations with the tenants who own, operate, maintain, and/or lease equipment. The activity and operational data collected was used to estimate emissions for each of the source categories in a manner consistent with the latest estimating methods. The information that was collected and analyzed, and is presented in this report, improves the understanding of the nature and magnitude of emission sources associated with the five Port Authority marine terminals, and will help facilitate an evaluation of the change in emission levels since the previous inventory year.

1.1.1 Pollutants

This inventory estimates and reports the quantity of emissions from mobile emission sources associated with maritime facilities maintained by the Port Authority and leased to terminal operators. The estimates are based on activities that occurred during calendar year 2010. Most of the emissions are in a category commonly referred to as "criteria pollutants" because the EPA has established health-based or environmentally-based criteria or guidelines that set ambient limits for these emissions or for the pollutant ozone, which is not emitted directly but develops in the atmosphere, in part as a result of emissions of other materials (identified below). In this report, the term "criteria pollutants" refers to the following emissions:

- Oxides of nitrogen (NO_X), an ozone precursor,
- Carbon monoxide (CO),
- Particulate matter less than 10 microns in diameter (PM_{10}),
- Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$),
- Volatile organic compounds (VOCs), an ozone precursor, and
- Sulfur dioxide (SO_2).

The remaining emissions are referred to as greenhouse gas (GHG) emissions because of their contribution to global climate change caused by the global warming phenomenon. The greenhouse gas emissions included in this inventory are:

- Carbon dioxide (CO_2),
- Nitrous oxide (N_2O), and
- Methane (CH_4).

These GHGs have also been combined into "CO_2 equivalents," a means of expressing the various GHGs in consistent terms relative to the atmospheric activity of CO_2. CO_2 equivalents are calculated by summing the mass emissions of each pollutant multiplied by its CO_2 equivalency factor, as listed below.

- CO_2 - 1
- N_2O - 310
- CH_4 – 21

1.1.2 Facilities

The Port Authority maintains six of the Port of New York and New Jersey's marine terminals, four in New Jersey and two in New York (Figure 1). All six are leased to private terminal operators. There are also numerous marine terminals situated within the Port of New York and New Jersey that are privately owned and operated, which are not associated with the Port Authority, and are therefore excluded from this emissions inventory.

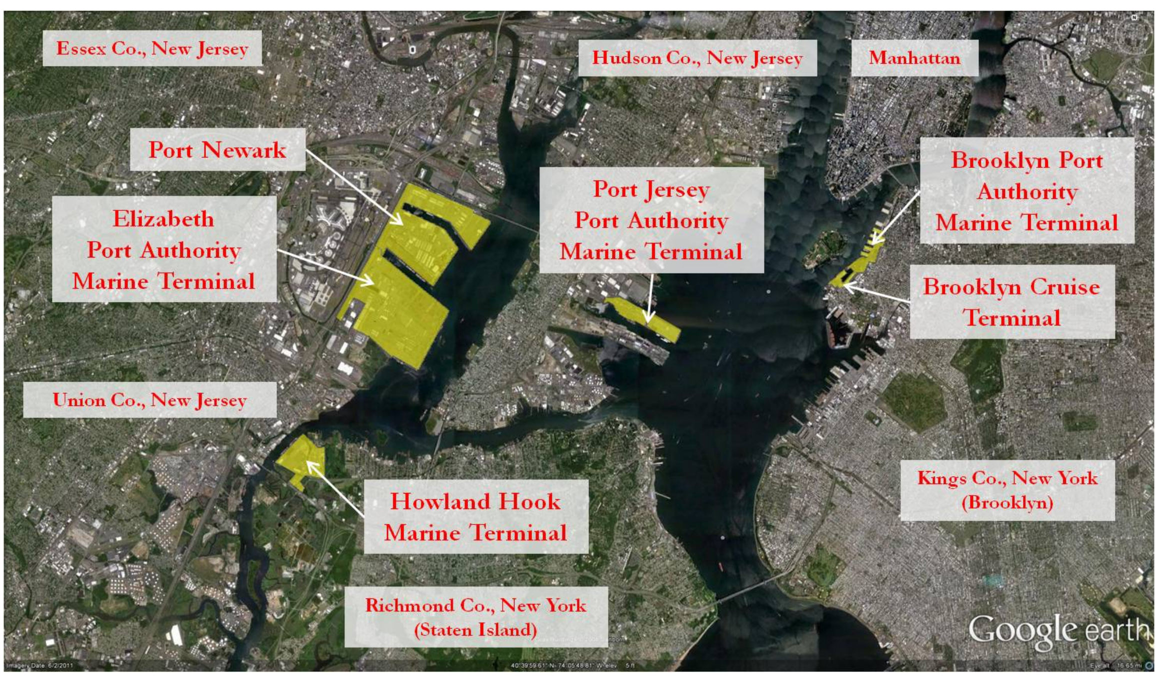
The Port Authority's New Jersey marine terminals are:

- Port Newark (which includes container, auto marine, and on-terminal warehousing operations),
- The Elizabeth Port Authority Marine Terminal (which includes container, auto marine, and on-terminal warehousing operations),
- Port Jersey Port Authority Marine Terminal (in Bayonne and Jersey City which includes auto marine operations and the Global Marine Terminal, which was acquired by the Port Authority in July 2010 and was not included in the 2006 or 2008 port-wide emissions inventories).

The Port Authority's New York marine facilities are:

- The Howland Hook Marine Terminal (at Staten Island which includes container operations),
- The Brooklyn Port Authority Marine Terminal (which includes container operations and the adjacent cruise terminal).

Figure 1.1: Location of the Port Authority of New York & New Jersey Marine Terminals



1.1.3 Major Changes in 2010

There are two major changes to this 2010 emissions inventory compared with the 2008 and previous inventories that warrant discussion because they had an effect on the estimates of 2010 emissions and need to be kept in mind when comparing 2010 emissions to previous years' emissions, such as 2008 and 2006 emissions.

The 2010 emission estimates presented in this emissions inventory include emissions from the Global Container Terminal, which was acquired by the Port Authority mid-way through 2010. Activity and emissions from this terminal during the second half of 2010 have been included in the emission estimates presented in this 2010 Multi-Facility Emissions Inventory report. Despite adding Global Container Terminal for the first time in this 2010 report, the 2010 emission estimates overall were lower than 2008 and 2006 emissions.

In addition to the Global Container Terminal being included for the second half of 2010, a more accurate methodology was used for the first time in 2010 to determine the activity of ocean-going vessels (OGVs), which resulted in higher OGV emission estimates for most pollutants as compared to estimates made for previous years. The improved methodology uses Automatic Identification System (AIS) data to track the position, course, and speed for port arrivals, shifts and departures. The use of actual speeds and distances versus the interview-based assumptions used in previous inventories resulted in higher main engine emission estimates for the 2010 OGV emissions compared with estimates of previous years' emissions.

The Port Authority anticipates using the more accurate AIS methodology for future PANYNJ emission inventory reports, so future comparisons to 2010 emissions will be a more apples to apples comparison than the current comparisons of 2010 emissions with earlier emission estimates. It should be noted that the higher estimates of OGV emissions do not necessarily reflect actual higher emissions in 2010 than in previous years; rather, the improved vessel movement data provides a more complete picture of vessel operations that was not available using the older methods. In fact, with a lower number of vessel calls and the Port Authority's implementation of their low sulfur fuel program, OGV emissions would be expected to be lower in 2010 than in earlier years, and future inventories developed in future years will determine whether decreases continue to occur. The Port Authority will continue to stay abreast of the most current methodologies and make improvements to the methods used to estimate emissions from all emission source categories.

1.2 Report Organization by Section

The sections that follow are organized by source category and detail specific emissions inventory methods and results for cargo handling equipment (Section 2), heavy-duty diesel vehicles (Section 3), locomotives (Section 4), and commercial marine vessels (Section 5).

1.3 Summary of Results

The emission estimates developed as described in this report are summarized in this subsection. Table 1.1 presents the criteria pollutant and CO_2 emissions by source category, the total PANYNJ emissions (the emissions included in this report), the total emissions in the NYNJLINA[3] in tons per year, and the percentage that the PANYNJ emissions makeup of the total NYNJLINA emissions. For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal or facility type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

Table 1.1: Criteria Pollutant Emission Summary by Source Category, tpy

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Cargo Handling Equipment	1,109	67	65	94	380	1.1	122,814
Heavy-Duty Diesel Vehicles	2,104	46	42	96	477	2.1	228,960
Railroad Locomotives	261	9	9	20	46	3.8	17,207
Ocean-Going Vessels	3,059	295	236	138	293	2,699	155,696
Harbor Craft	360	20	19	14	40	7.6	19,537
Total PANYNJ Emissions	**6,894**	**436**	**371**	**362**	**1,235**	**2,714**	**544,215**
NYNJLINA Emissions	**339,423**	**102,719**	**32,978**	**419,604**	**1,888,145**	**75,196**	**112,835,680**
PANYNJ Percentage	**2.0%**	**0.4%**	**1.1%**	**0.09%**	**0.07%**	**3.6%**	**0.5%**

[3] See: 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table 1.2 illustrates the percentage contribution of each source category to the total PANYNJ emissions of each pollutant, while Tables 1.3 and 1.4 similarly present the emissions and percentages of greenhouse gases.

Table 1.2: Criteria Pollutant Emission Summary by Source Category, percent

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	16%	15%	17%	26%	31%	0%
Heavy-Duty Diesel Vehicles	31%	10%	11%	27%	39%	0%
Railroad Locomotives	4%	2%	2%	5%	4%	0%
Ocean-Going Vessels	44%	68%	64%	38%	24%	99%
Harbor Craft	5%	4%	5%	4%	3%	0%
Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 1.3: Greenhouse Gas Emission Summary by Source Category, tpy

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	122,814	3	7	123,847
Heavy-Duty Diesel Vehicles	228,960	1	1	229,000
Railroad Locomotives	17,207	0	1	17,364
Ocean-Going Vessels	155,696	9	3	158,562
Harbor Craft	19,537	5	13	20,385
Totals	**544,215**	**18**	**24**	**549,158**

Table 1.4: Greenhouse Gas Emission Summary by Source Category, percent

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	23%	16%	27%	23%
Heavy-Duty Diesel Vehicles	42%	4%	3%	42%
Railroad Locomotives	3%	2%	6%	3%
Ocean-Going Vessels	29%	49%	12%	29%
Harbor Craft	4%	29%	53%	4%
Totals	**100%**	**100%**	**100%**	**100%**

Figures 1.2 through 1.8 illustrate the contribution of emissions from Port Authority marine terminal emission source categories to overall emissions in the NYNJLINA. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure 1.2: Distribution of NO_x Emissions by Source Category, tpy & percent

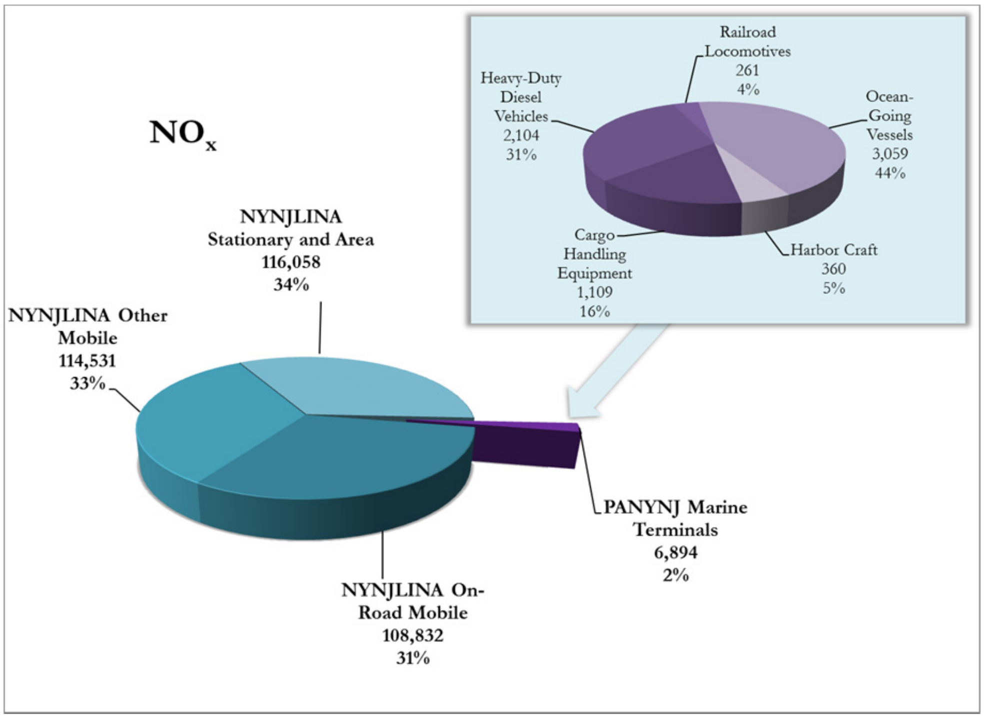


Figure 1.3: Distribution of PM_{10} Emissions by Source Category, tpy & percent

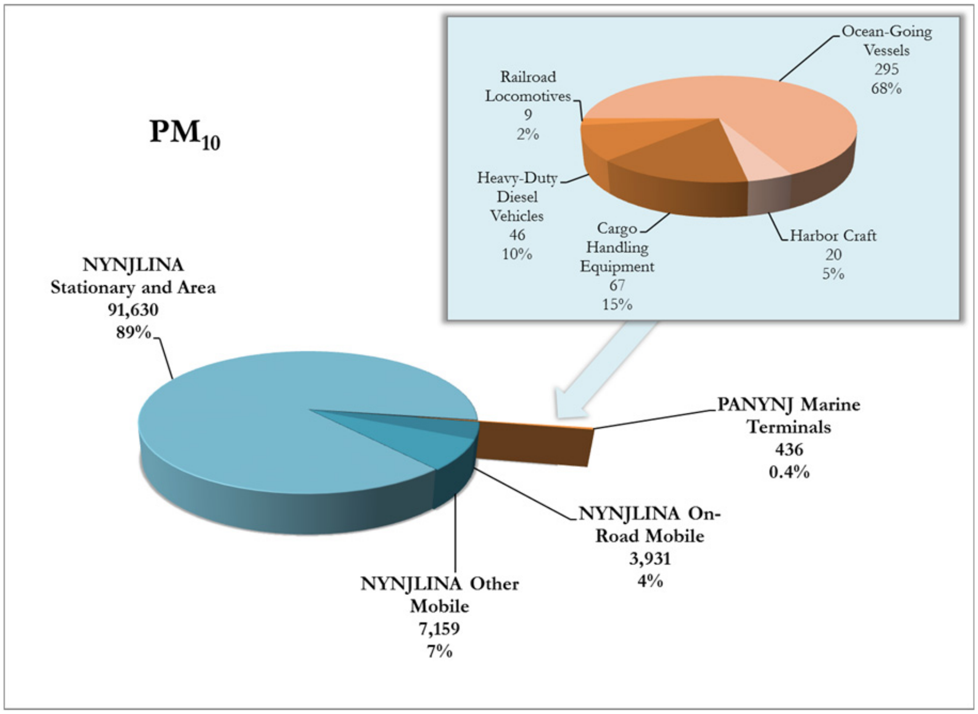


Figure 1.4: Distribution of $PM_{2.5}$ Emissions by Source Category, tpy & percent

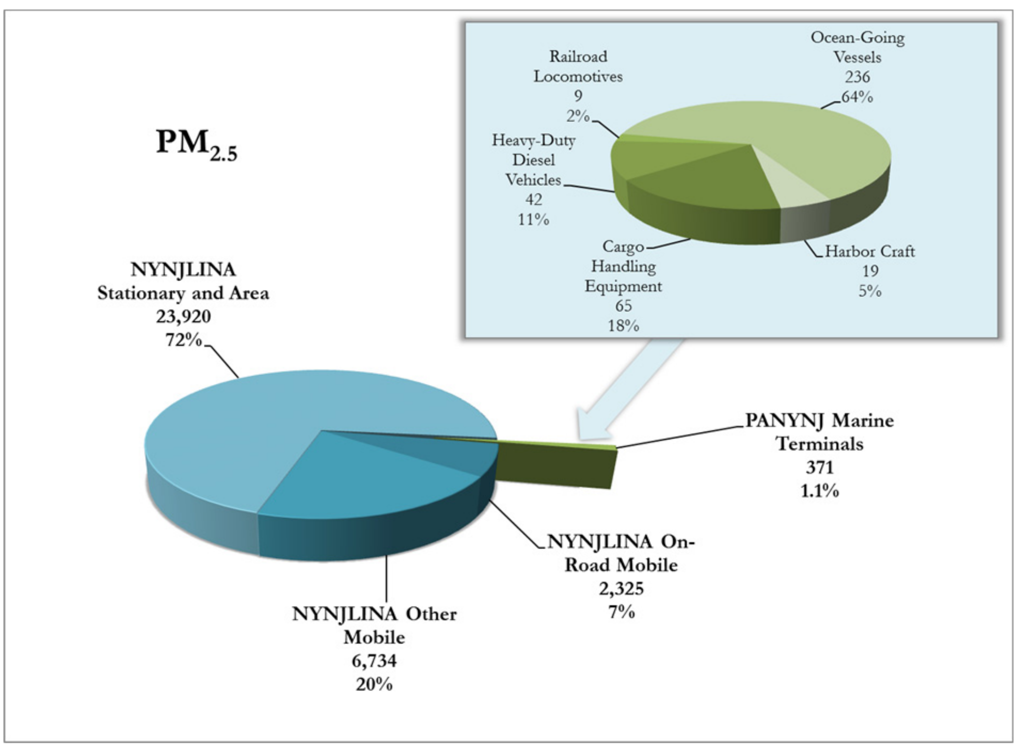


Figure 1.5: Distribution of VOC Emissions by Source Category, tpy & percent

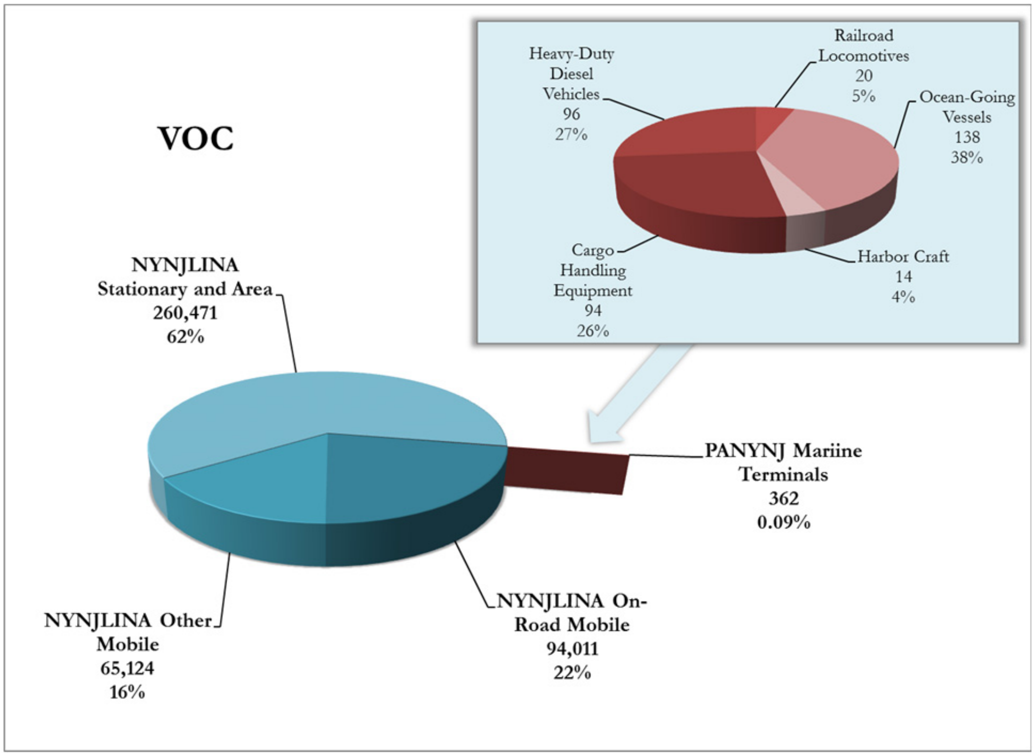


Figure 1.6: Distribution of CO Emissions by Source Category, tpy & percent

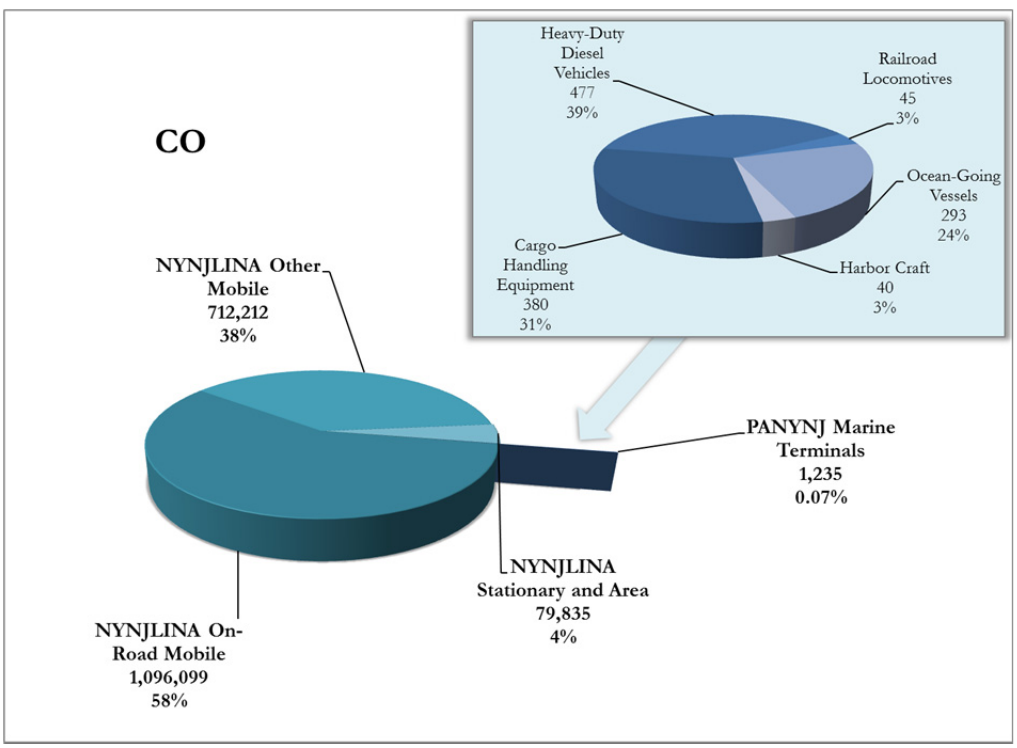


Figure 1.7: Distribution of SO_2 Emissions by Source Category, tpy & percent

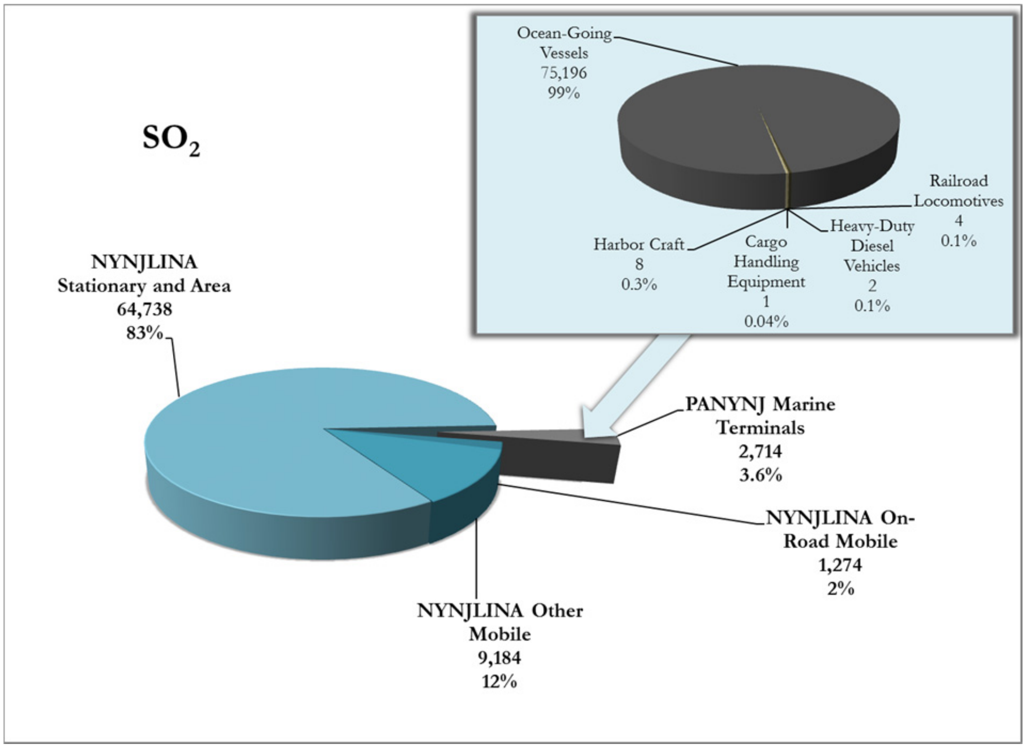
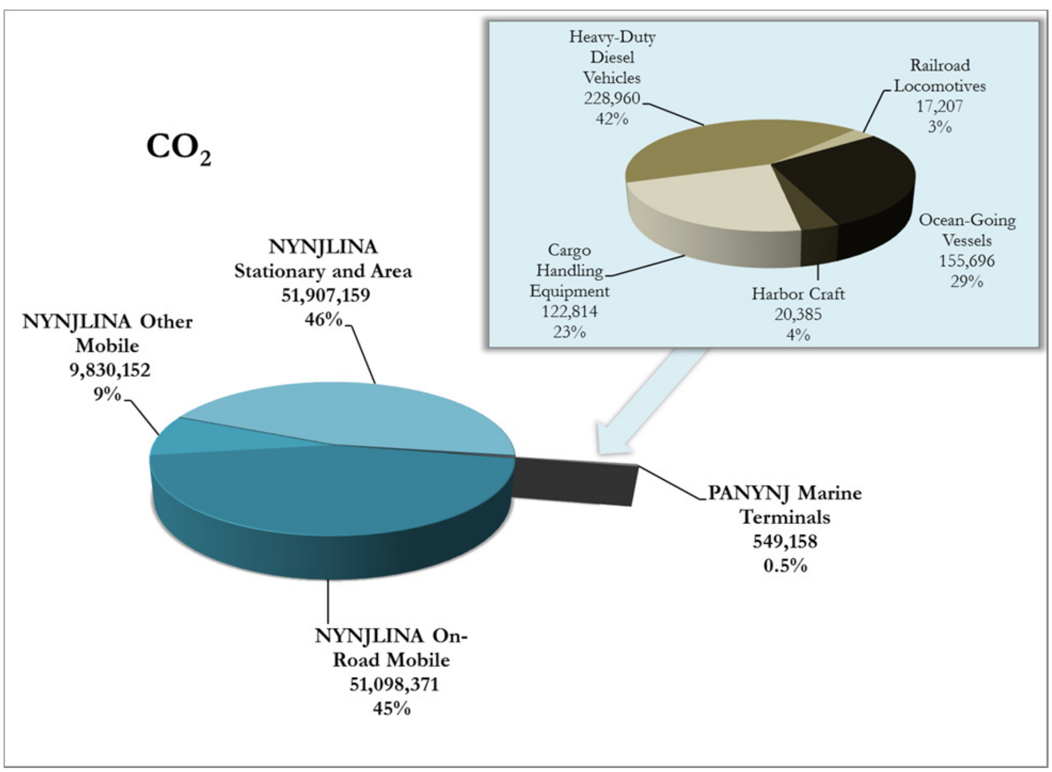


Figure 1.8: Distribution of CO_2 Emissions by Source Category, tpy & percent



1.4: Overall Comparison of Emissions Related to the Port Authority Marine Terminals

This section presents the estimates detailed in the foregoing sections in the context of county-wide and non-attainment area-wide emissions. The emissions from each source category and from all categories combined are compared with all emissions in the NYNJLINA and emissions released in each county are compared with county-wide emissions. Specifically, this subsection compares overall Port Authority marine terminal related emissions with county-level emission totals as reported in the most recent National Emissions Inventory database.[4]

Table 1.5 summarizes by county the estimated emissions from the Port Authority marine terminal related activities covered by this report, and Table 1.6 lists total emissions of each criteria pollutant by county and state, as reported in the most recent National Emissions Inventory database.

For comparison to the NYNJLINA CO_2 emissions, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. Thus CO_2 emissions and not CO_2 equivalent emissions are included in the tables that compare to NYNJLINA emissions.

[4] 2008 National Emission Inventory Database, US EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table 1.5: Port Authority Criteria Pollutant and CO_2 Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	137	3	3	7	27	1	16,169
Essex	NJ	1,343	81	69	69	273	565	125,970
Hudson	NJ	865	56	46	42	127	370	62,701
Middlesex	NJ	357	8	7	17	72	1	46,757
Monmouth	NJ	349	29	23	17	38	211	15,888
Union	NJ	1,713	109	96	105	394	574	140,987
New Jersey subtotal		**4,764**	**286**	**245**	**257**	**932**	**1,721**	**408,473**
Bronx	NY	35	1	1	2	7	0	4,780
Kings (Brooklyn)	NY	600	45	37	31	81	305	50,796
Nassau	NY	52	1	1	2	11	0	31,179
New York	NY	249	22	18	11	25	174	2,436
Orange	NY	34	1	1	2	7	0	17,094
Queens	NY	34	1	1	2	7	0	41,433
Richmond (Staten Island)	NY	1,002	76	64	50	144	512	134,285
Rockland	NY	58	2	2	3	10	1	3,890
Suffolk	NY	34	1	1	2	6	0	21,605
Westchester	NY	32	1	1	1	6	0	3,974
New York subtotal		**2,130**	**151**	**125**	**104**	**303**	**993**	**311,471**
PANYNJ Total		**6,894**	**436**	**371**	**362**	**1,235**	**2,714**	**719,944**

Table 1.6: Summary of NYNJLINA Criteria Pollutant and CO_2 Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	19,221	3,785	1,159	22,310	157,843	903	8,860,866
Essex	NJ	22,236	2,818	1,202	15,376	89,041	1,974	4,880,257
Hudson	NJ	32,088	4,781	3,577	11,073	48,521	5,415	8,343,407
Middlesex	NJ	20,821	6,117	1,784	21,598	129,636	993	8,353,902
Monmouth	NJ	13,899	4,133	1,116	16,478	108,040	787	3,652,374
Union	NJ	19,833	3,276	1,578	14,043	75,762	1,870	12,812,034
New Jersey subtotal		**128,097**	**24,911**	**10,416**	**100,878**	**608,842**	**11,941**	**46,902,841**
Bronx	NY	11,643	5,001	1,480	26,550	75,120	1,868	2,902,652
Kings (Brooklyn)	NY	26,732	9,931	2,966	47,212	112,068	3,980	4,983,207
Nassau	NY	24,574	6,991	2,006	37,235	183,911	3,770	8,179,900
New York	NY	30,058	8,373	3,430	45,066	158,713	7,114	5,882,564
Orange	NY	12,424	11,812	2,351	13,320	69,889	16,368	5,571,244
Queens	NY	31,662	9,814	3,108	47,241	144,316	4,302	13,210,327
Richmond (Staten Island)	NY	9,273	2,446	801	10,254	35,204	912	2,193,801
Rockland	NY	6,529	1,890	552	8,375	43,672	2,243	2,319,347
Suffolk	NY	39,738	12,124	3,757	55,567	307,921	18,387	15,640,748
Westchester	NY	18,692	9,427	2,111	27,906	148,488	4,310	5,049,050
New York subtotal		**211,324**	**77,809**	**22,563**	**318,727**	**1,279,304**	**63,255**	**65,932,841**
NYNJLINA Total		**339,421**	**102,720**	**32,978**	**419,606**	**1,888,145**	**75,197**	**112,835,682**

The subsequent tables and charts (Tables 1.7 through 1.13 and Figures 1.9 through 1.15, respectively) provide additional pollutant specific detail to this county level data for criteria pollutants and CO_2, placing emissions tied to Port Authority owned marine terminals into a local and regional perspective. These figures compare overall emissions related to Port Authority marine terminals on a county level with overall county-wide emissions. Each table (one for each criteria pollutant, and CO_2)) shows the county-wide emissions, Port Authority marine terminal-related emissions, and the percentage that the Port Authority emissions makeup of the county total. A column chart illustrates each such table. As noted previously, not all subtotals and totals exactly equal the sums of individual values in the tables because of rounding of the individual values.

Table 1.7: Comparison of NO_x Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	137	0.7%
Essex	NJ	22,236	1,343	6.0%
Hudson	NJ	32,088	865	2.7%
Middlesex	NJ	20,821	357	1.7%
Monmouth	NJ	13,899	349	2.5%
Union	NJ	19,833	1,713	8.6%
New Jersey subtotal		**128,097**	**4,764**	**3.7%**
Bronx	NY	11,643	35	0.3%
Kings (Brooklyn)	NY	26,732	600	2.2%
Nassau	NY	24,574	52	0.2%
New York	NY	30,058	249	0.8%
Orange	NY	12,424	34	0.3%
Queens	NY	31,662	34	0.1%
Richmond (Staten Island)	NY	9,273	1,002	10.8%
Rockland	NY	6,529	58	0.9%
Suffolk	NY	39,738	34	0.1%
Westchester	NY	18,692	32	0.2%
New York subtotal		**211,324**	**2,130**	**1.0%**
NYNJLINA and PANYNJ Totals		**339,421**	**6,894**	**2.0%**

Figure 1.9: Comparison of NO_x Emissions by County, tpy

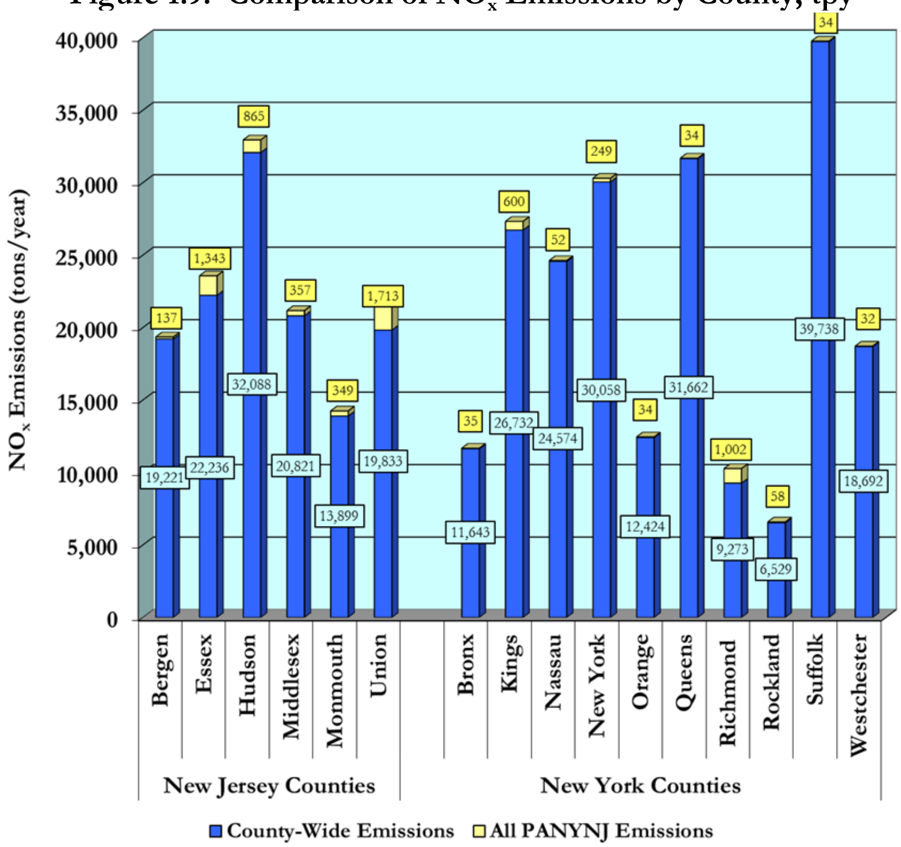


Table 1.8: Comparison of PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	3	0.1%
Essex	NJ	2,818	81	2.9%
Hudson	NJ	4,781	56	1.2%
Middlesex	NJ	6,117	8	0.1%
Monmouth	NJ	4,133	29	0.7%
Union	NJ	3,276	109	3.3%
New Jersey subtotal		**24,911**	**286**	**1.1%**
Bronx	NY	5,001	1	0.0%
Kings (Brooklyn)	NY	9,931	45	0.5%
Nassau	NY	6,991	1	0.0%
New York	NY	8,373	22	0.3%
Orange	NY	11,812	1	0.0%
Queens	NY	9,814	1	0.0%
Richmond (Staten Island)	NY	2,446	76	3.1%
Rockland	NY	1,890	2	0.1%
Suffolk	NY	12,124	1	0.0%
Westchester	NY	9,427	1	0.0%
New York subtotal		**77,809**	**151**	**0.2%**
NYNJLINA and PANYNJ Totals		**102,720**	**436**	**0.4%**

Figure 1.10: Comparison of PM_{10} Emissions by County, tpy

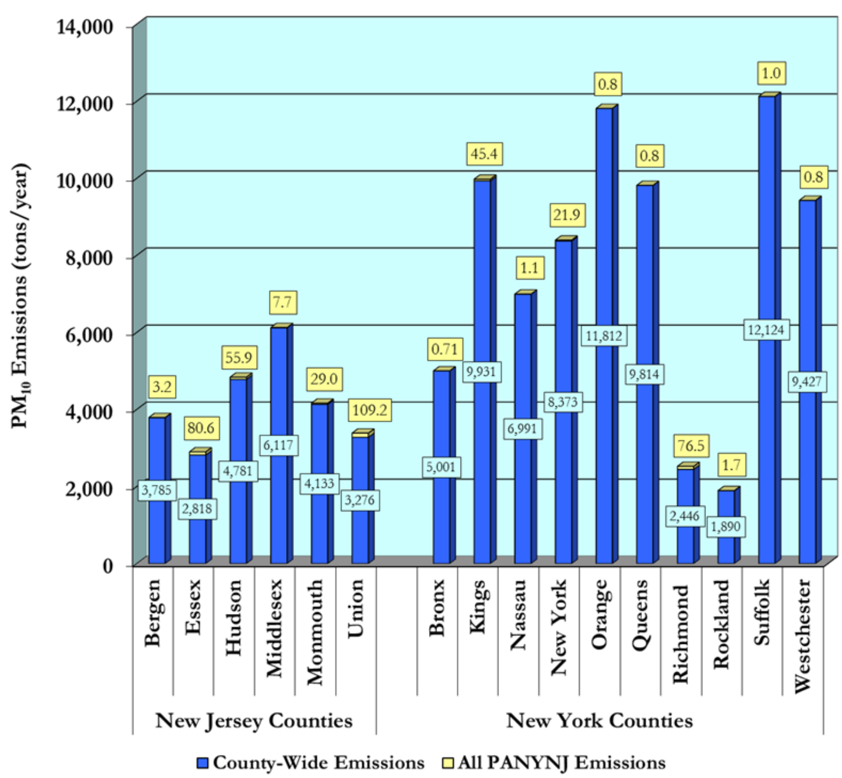


Table 1.9: Comparison of $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	3	0.3%
Essex	NJ	1,202	69	5.7%
Hudson	NJ	3,577	46	1.3%
Middlesex	NJ	1,784	7	0.4%
Monmouth	NJ	1,116	23	2.1%
Union	NJ	1,578	96	6.1%
New Jersey subtotal		**10,416**	**245**	**2.4%**
Bronx	NY	1,480	1	0.0%
Kings (Brooklyn)	NY	2,966	37	1.3%
Nassau	NY	2,006	1	0.1%
New York	NY	3,430	18	0.5%
Orange	NY	2,351	1	0.0%
Queens	NY	3,108	1	0.0%
Richmond (Staten Island)	NY	801	64	8.0%
Rockland	NY	552	2	0.3%
Suffolk	NY	3,757	1	0.0%
Westchester	NY	2,111	1	0.0%
New York subtotal		**22,563**	**125**	**0.6%**
NYNJLINA and PANYNJ Totals		**32,978**	**371**	**1.1%**

Figure 1.11: Comparison of $PM_{2.5}$ Emissions by County, tpy

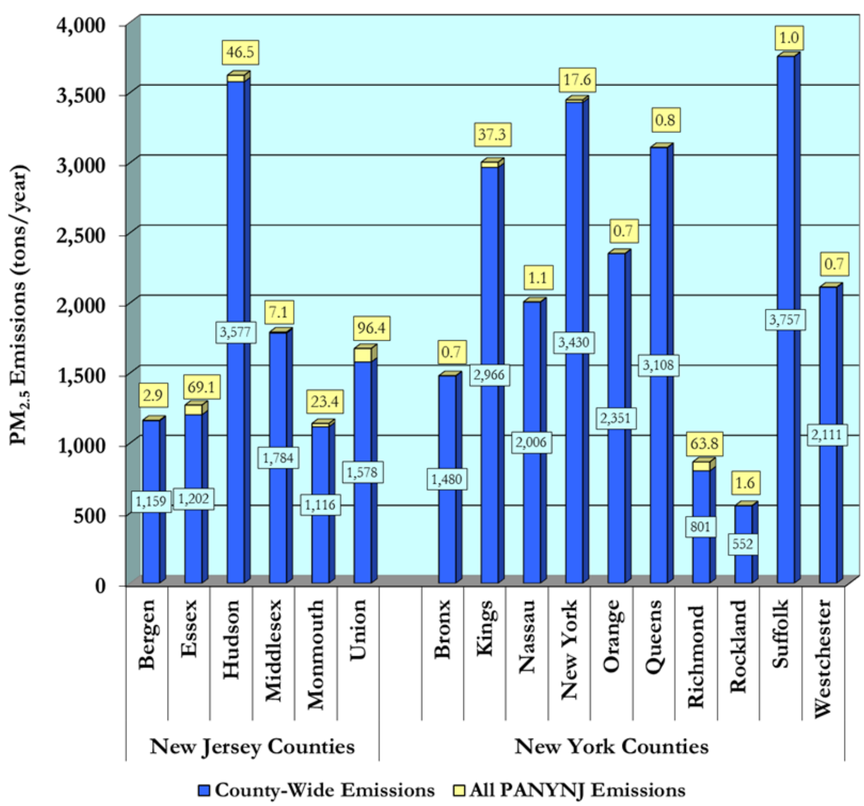


Table 1.10: Comparison of VOC Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	7	0.0%
Essex	NJ	15,376	69	0.4%
Hudson	NJ	11,073	42	0.4%
Middlesex	NJ	21,598	17	0.1%
Monmouth	NJ	16,478	17	0.1%
Union	NJ	14,043	105	0.7%
New Jersey subtotal		**100,878**	**257**	**0.3%**
Bronx	NY	26,550	2	0.0%
Kings (Brooklyn)	NY	47,212	31	0.1%
Nassau	NY	37,235	2	0.0%
New York	NY	45,066	11	0.0%
Orange	NY	13,320	2	0.0%
Queens	NY	47,241	2	0.0%
Richmond (Staten Island)	NY	10,254	50	0.5%
Rockland	NY	8,375	3	0.0%
Suffolk	NY	55,567	2	0.0%
Westchester	NY	27,906	1	0.0%
New York subtotal		**318,727**	**104**	**0.0%**
NYNJLINA and PANYNJ Totals		**419,606**	**362**	**0.1%**

Figure 1.12: Comparison of VOC Emissions by County, tpy

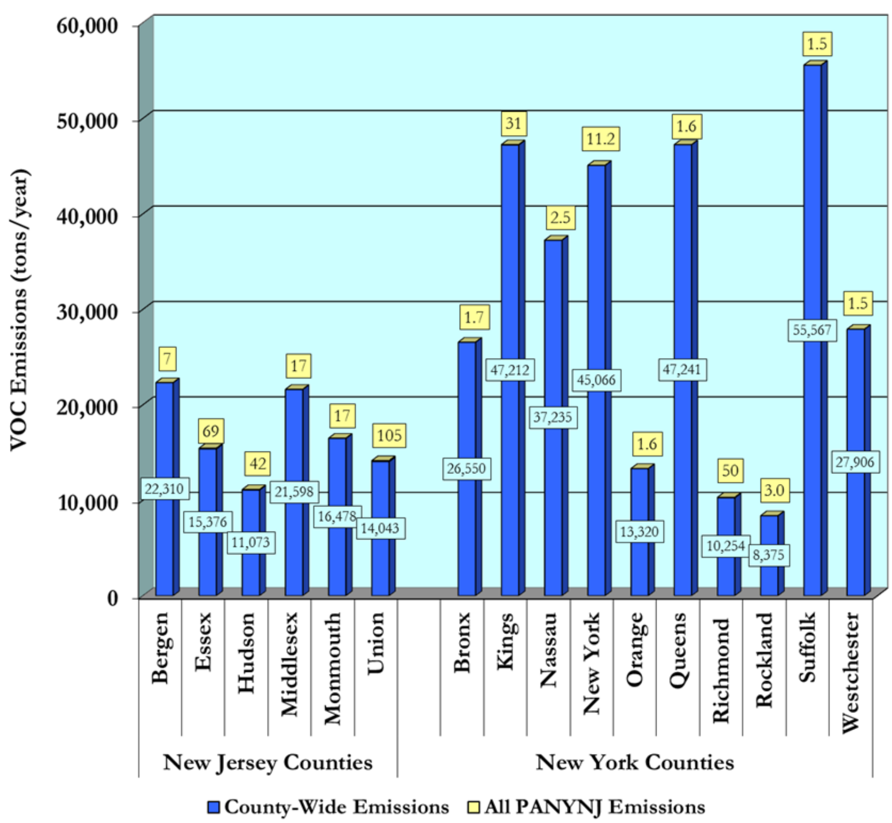


Table 1.11: Comparison of CO Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	27	0.0%
Essex	NJ	89,041	273	0.3%
Hudson	NJ	48,521	127	0.3%
Middlesex	NJ	129,636	72	0.1%
Monmouth	NJ	108,040	38	0.0%
Union	NJ	75,762	394	0.5%
New Jersey subtotal		**608,842**	**932**	**0.2%**
Bronx	NY	75,120	7	0.0%
Kings (Brooklyn)	NY	112,068	81	0.1%
Nassau	NY	183,911	11	0.0%
New York	NY	158,713	25	0.0%
Orange	NY	69,889	7	0.0%
Queens	NY	144,316	7	0.0%
Richmond (Staten Island)	NY	35,204	144	0.4%
Rockland	NY	43,672	10	0.0%
Suffolk	NY	307,921	6	0.0%
Westchester	NY	148,488	6	0.0%
New York subtotal		**1,279,304**	**303**	**0.0%**
NYNJLINA and PANYNJ Totals		**1,888,145**	**1,235**	**0.1%**

Figure 1.13: Comparison of CO Emissions by County, tpy

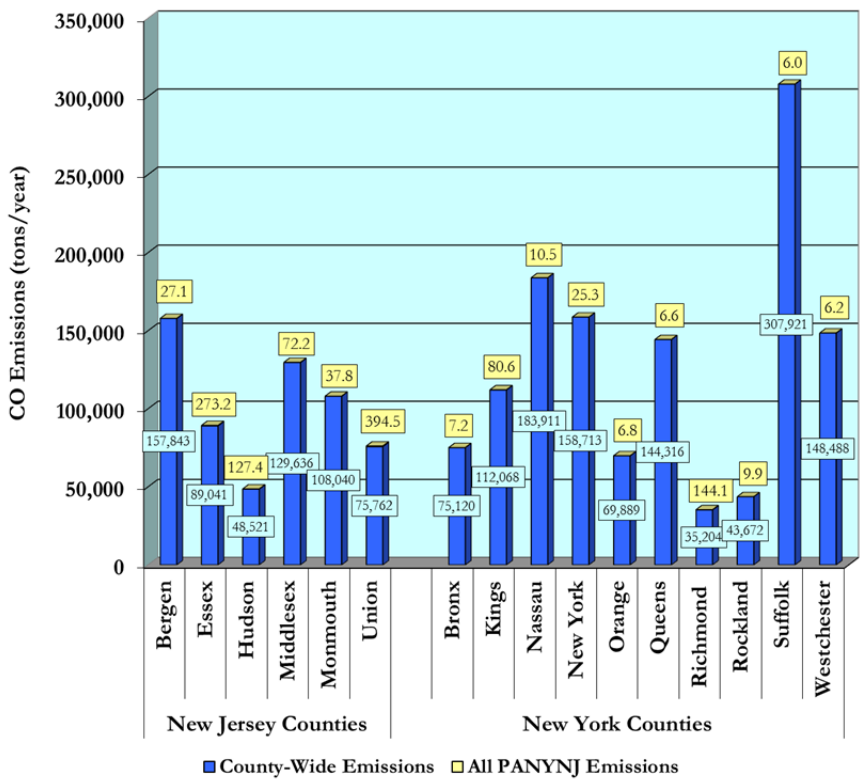


Table 1.12: Comparison of SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	903	1	0.1%
Essex	NJ	1,974	565	28.6%
Hudson	NJ	5,415	370	6.8%
Middlesex	NJ	993	1	0.1%
Monmouth	NJ	787	211	26.8%
Union	NJ	1,870	574	30.7%
New Jersey subtotal		**11,941**	**1,721**	**14.4%**
Bronx	NY	1,868	0	0.0%
Kings (Brooklyn)	NY	3,980	305	7.7%
Nassau	NY	3,770	0	0.0%
New York	NY	7,114	174	2.4%
Orange	NY	16,368	0	0.0%
Queens	NY	4,302	0	0.0%
Richmond (Staten Island)	NY	912	512	56.1%
Rockland	NY	2,243	1	0.0%
Suffolk	NY	18,387	0	0.0%
Westchester	NY	4,310	0	0.0%
New York subtotal		**63,255**	**993**	**1.6%**
NYNJLINA and PANYNJ Totals		**75,197**	**2,714**	**3.6%**

Figure 1.14: Comparison of SO_2 Emissions by County, tpy

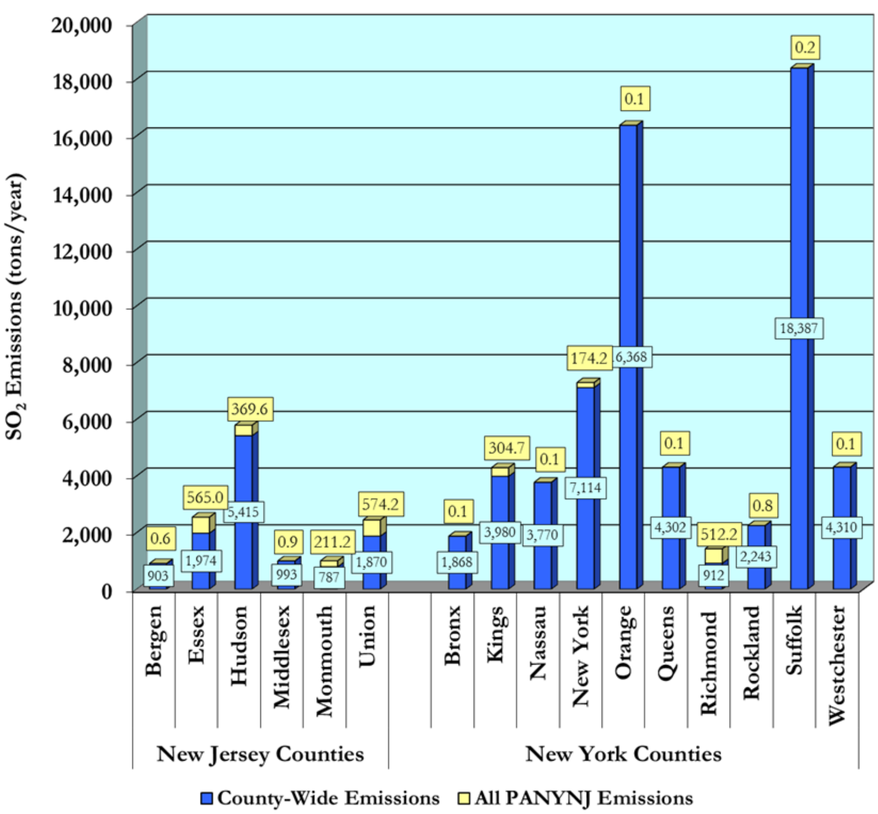
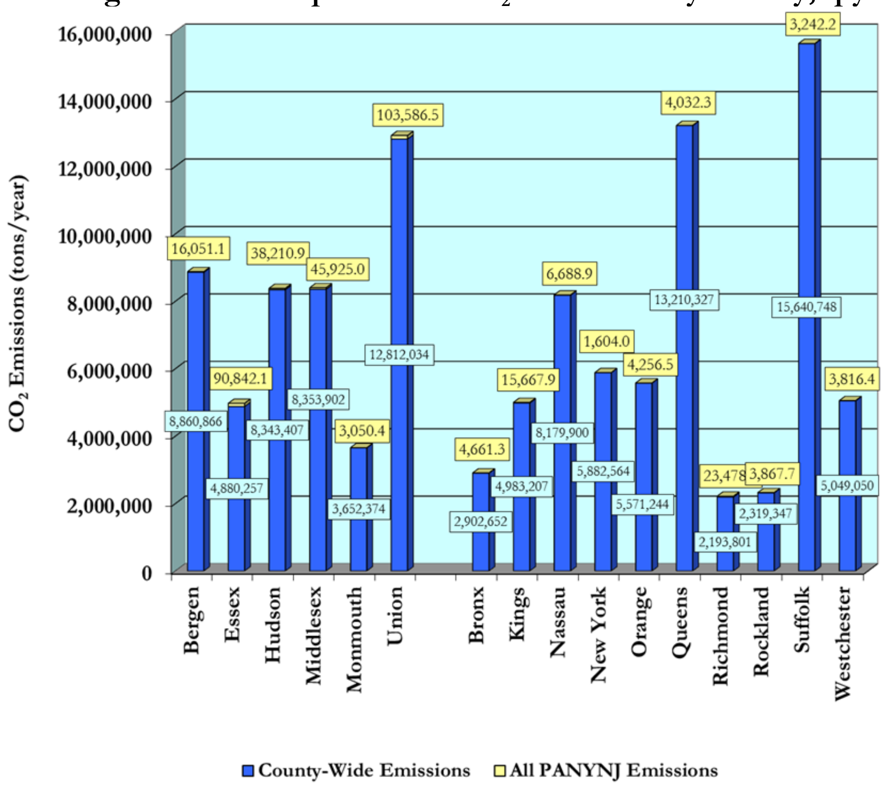


Table 1.13: Comparison of CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	16,169	0.2%
Essex	NJ	4,880,257	125,970	2.6%
Hudson	NJ	8,343,407	62,701	0.8%
Middlesex	NJ	8,353,902	46,757	0.6%
Monmouth	NJ	3,652,374	15,888	0.4%
Union	NJ	12,812,034	140,987	1.1%
New Jersey subtotal		**46,902,841**	**408,473**	**0.9%**
Bronx	NY	2,902,652	4,780	0.2%
Kings (Brooklyn)	NY	4,983,207	50,796	1.0%
Nassau	NY	8,179,900	31,179	0.4%
New York	NY	5,882,564	2,436	0.0%
Orange	NY	5,571,244	17,094	0.3%
Queens	NY	13,210,327	41,433	0.3%
Richmond (Staten Island)	NY	2,193,801	134,285	6.1%
Rockland	NY	2,319,347	3,890	0.2%
Suffolk	NY	15,640,748	21,605	0.1%
Westchester	NY	5,049,050	3,974	0.1%
New York subtotal		**65,932,841**	**311,471**	**0.5%**
NYNJLINA and PANYNJ Totals		**112,835,682**	**719,944**	**0.6%**

Figure 1.15: Comparison of CO_2 Emissions by County, tpy



SECTION 2: CARGO HANDLING EQUIPMENT

This section presents estimated emissions from the off-road equipment used on Port Authority marine container terminals to handle marine cargo and to support terminal operations. This equipment is known collectively as cargo handling equipment (CHE). The following subsections present estimated CHE emissions in the context of state-wide and NYNJLINA emissions, describe the methodologies used to collect information and estimate emissions, and present a description of the equipment types.

The following six Port Authority marine terminals have been included in the emission estimates:

- Red Hook Container Terminal operated by American Stevedoring, Inc (ASI) along with ASI's secondary barge depot at Port Newark;
- New York Container Terminal (NYCT), at Howland Hook Marine Terminal on Staten Island;
- APM Terminal, at the Elizabeth Port Authority Marine Terminal;
- Maher Terminal, at the Elizabeth Port Authority Marine Terminal;
- Port Newark Container Terminal (PNCT), at Port Newark; and
- Global Marine Terminal.

Within this section, the following four subsections focus on:

- 2.1 - Emission Estimates
- 2.2 - Emission Comparisons
- 2.3 - Methodology
- 2.4 - Description of CHE

ES2.1 Executive Summary

Table ES2-1 presents the estimated CHE criteria pollutant and CO_2 emissions in the context of overall emissions in the states of New York and New Jersey, and in the NYNJLINA, including emissions in tons per year and the percentage that PANYNJ CHE emissions make up of overall NYNJLINA emissions, based on EPA's 2008 National Emissions Inventory, the latest available figures. For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

Table ES2.1: Comparison of PANYNJ CHE Emissions with State and NYNJLINA Emissions, tpy

Geographical Extent / Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
New York and New Jersey	681,640	402,204	104,007	852,825	4,219,848	238,527	223,372,325
NYNJLINA	339,421	102,720	32,978	419,606	1,888,145	75,197	112,835,682
Cargo Handling Equipment	1,109	67	65	94	380	1	122,814
Percent of NYNJLINA Emissions	0.33%	0.06%	0.20%	0.02%	0.02%	0.001%	0.11%

The following figures illustrate the distribution of PANYNJ CHE emissions by type of equipment in terms of tons per year and percent of total CHE emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure ES2.1: Distribution and Comparison of NO_x from CHE, tpy and percent

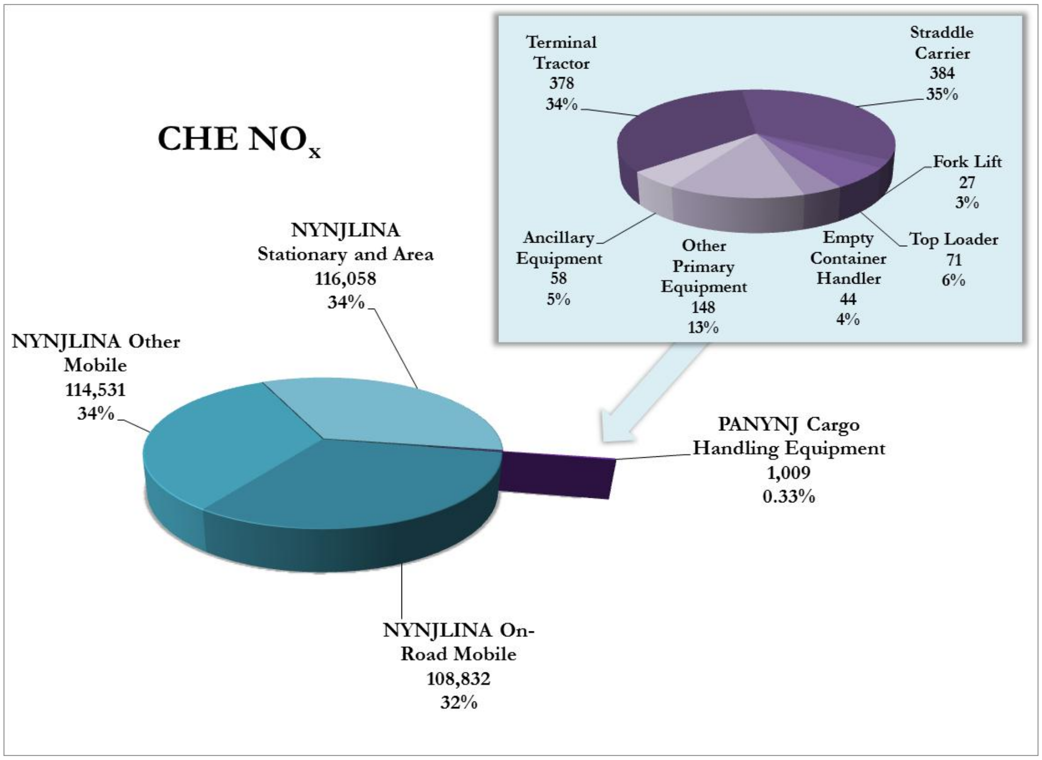


Figure ES2.2: Distribution and Comparison of PM_{10} from CHE, tpy and percent

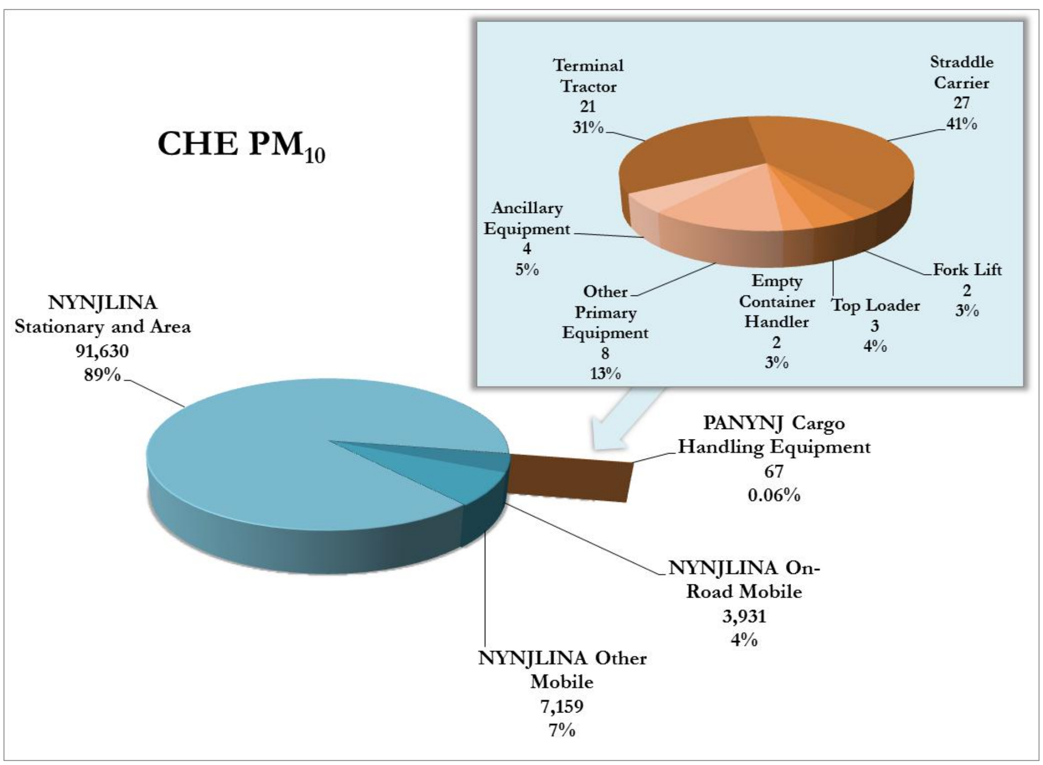


Figure ES2.3: Distribution and Comparison of $PM_{2.5}$ from CHE, tpy and percent

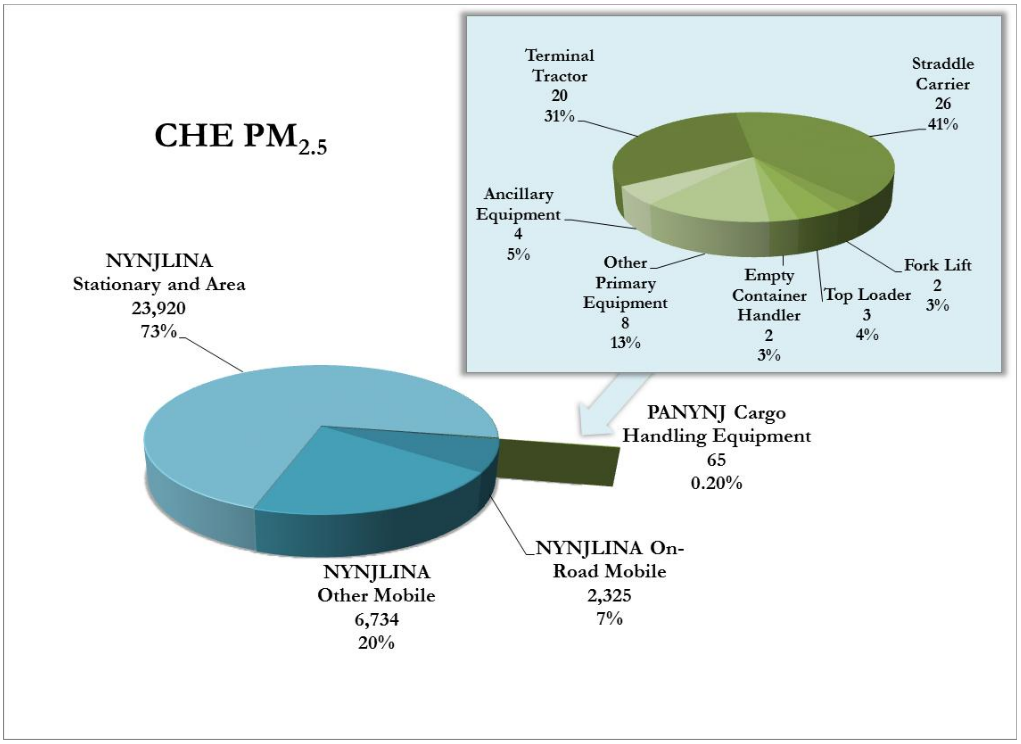


Figure ES2.4: Distribution and Comparison of VOC from CHE, tpy and percent

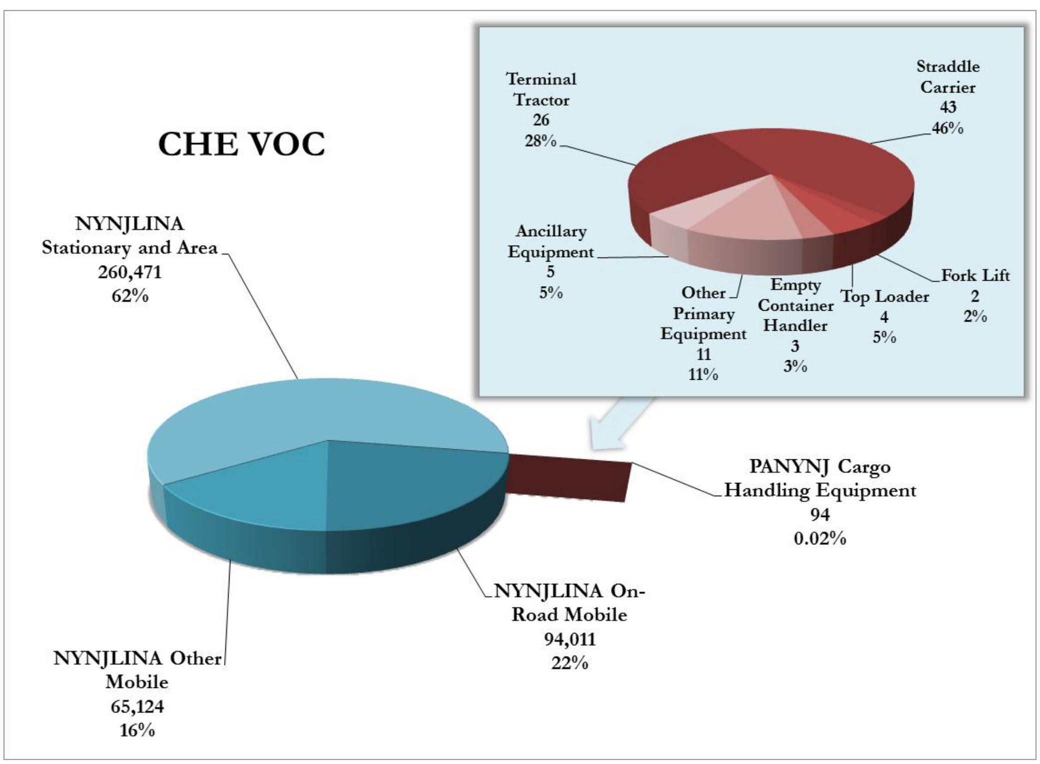


Figure ES2.5: Distribution and Comparison of CO from CHE, tpy and percent

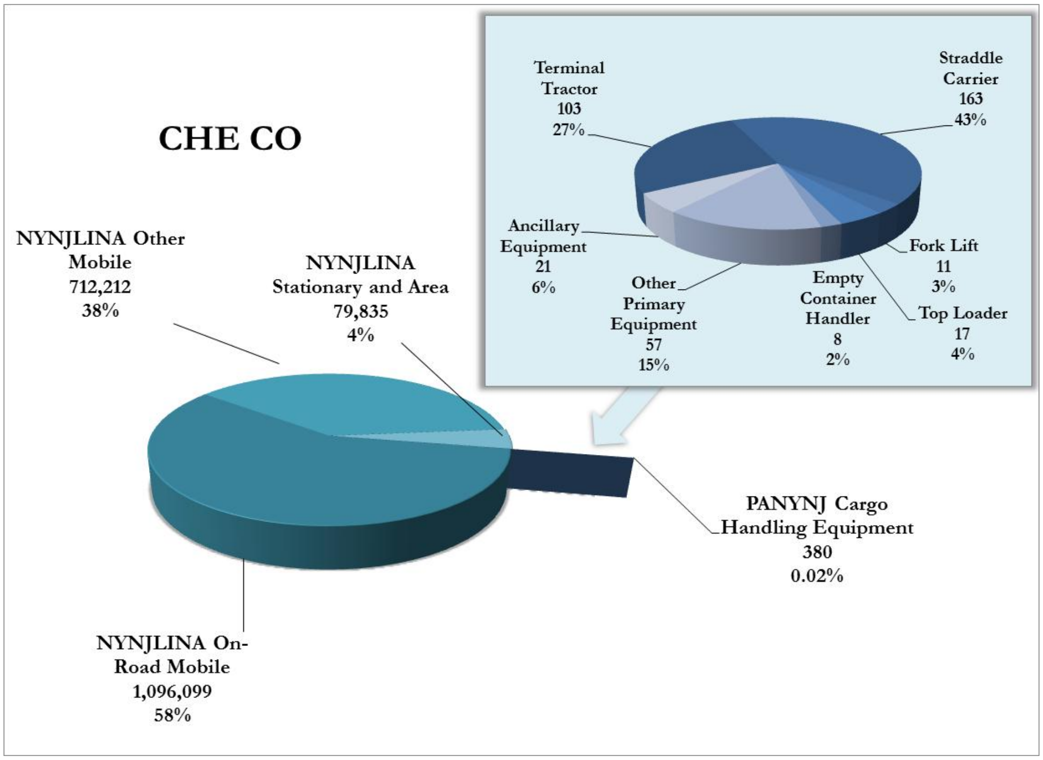


Figure ES2.6: Distribution and Comparison of SO_2 from CHE, tpy and percent

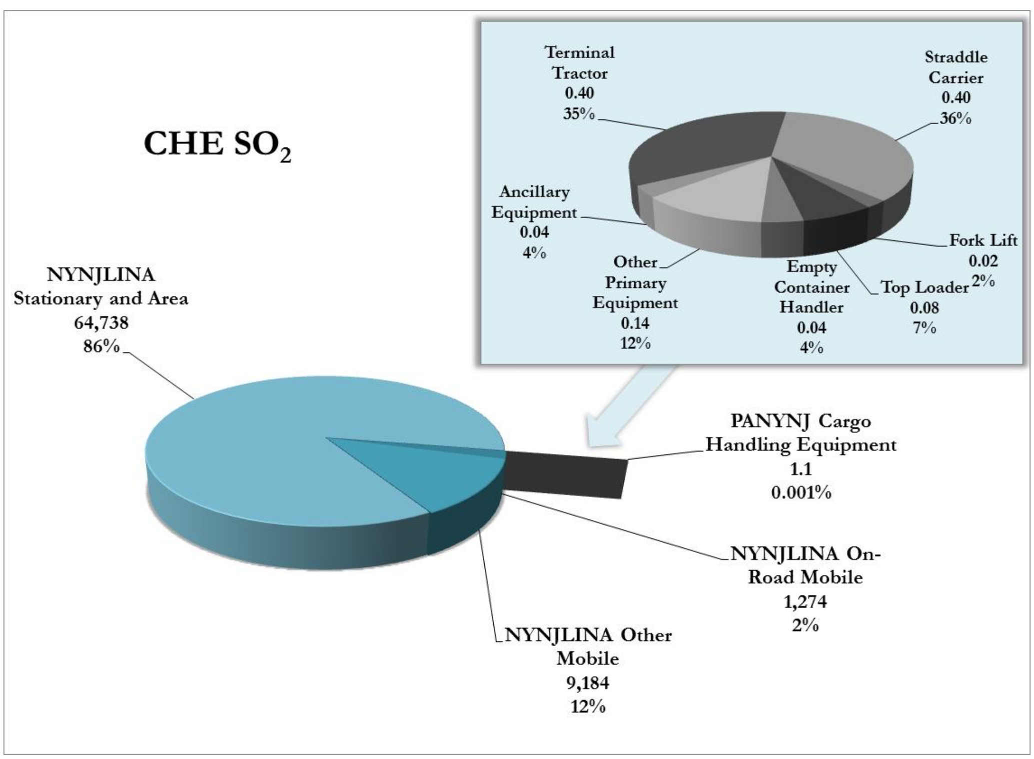
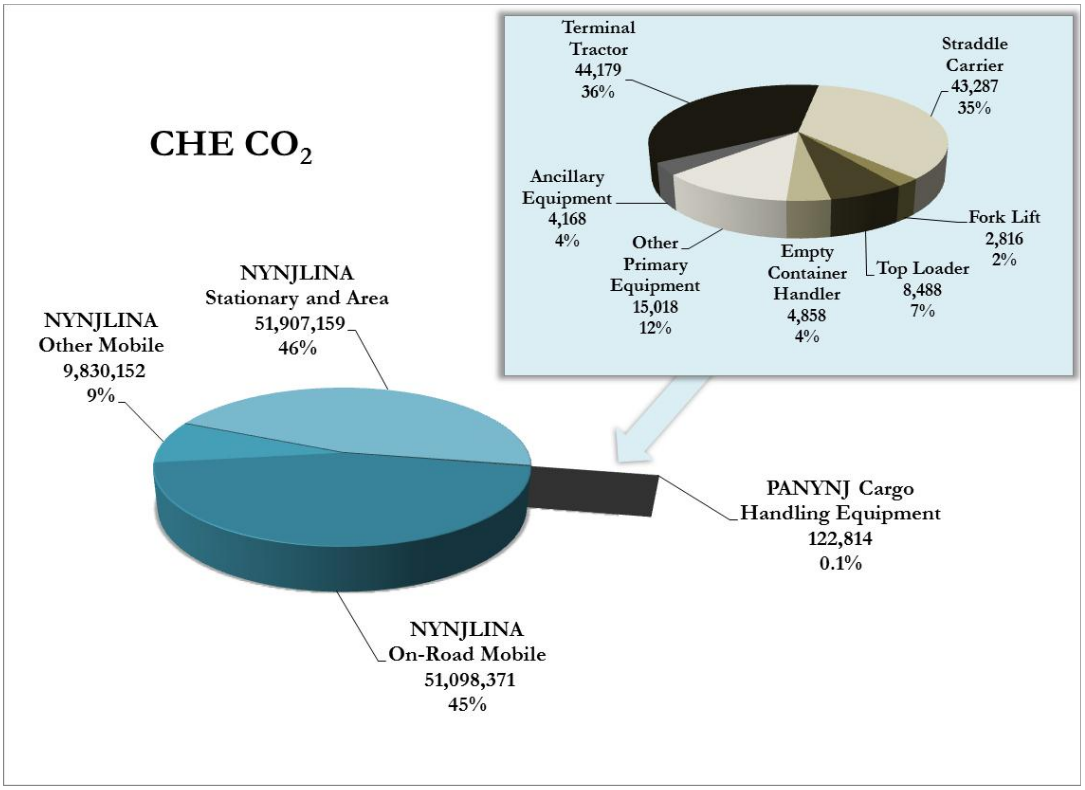


Figure ES2.7: Distribution of CO_2 equivalents from CHE, tpy and percent



2.1 Emission Estimates

This subsection presents the estimated emissions from cargo handling equipment operating at the terminals listed above. Table 2.1 presents criteria pollutant emissions of NO_x, PM_{10}, $PM_{2.5}$, VOCs, CO, and SO_2 sorted by equipment type for all container terminals combined. The equipment types are described later in this section. Estimated greenhouse gas emissions of CO_2, N_2O, and CH_4 are presented in Table 2.2. Figure 2.1 illustrates the distribution of NO_x emissions from the various equipment types. Because of the similarities in engine and fuel types among these equipment types, the distributions of other pollutants show substantially the same patterns – therefore charts have not been presented for the other criteria pollutants. Figure 2.2 illustrates the distribution of greenhouse gases as CO_2 equivalents.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

Table 2.1: Criteria Pollutant Emissions from CHE by Equipment Type, tpy

Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Terminal Tractor	378	20.5	19.9	26.1	103	0.40
Straddle Carrier	384	27.3	26.5	43.0	163	0.40
Fork Lift	27	1.9	1.8	2.2	11	0.02
Loaded Container Handler	35	2	2	2	7	0.03
Top Loader	36	1	1	2	10	0.05
Empty Container Handler	44	1.9	1.8	2.9	8	0.04
Other Primary Equipment	148	8.4	8.2	10.7	57	0.14
Ancillary Equipment	58	3.7	3.6	5.2	21	0.04
Totals	**1,109**	**67**	**65**	**94**	**380**	**1**

Figure 2.1: Emissions of NO_x from CHE by Equipment Type, tpy and percent

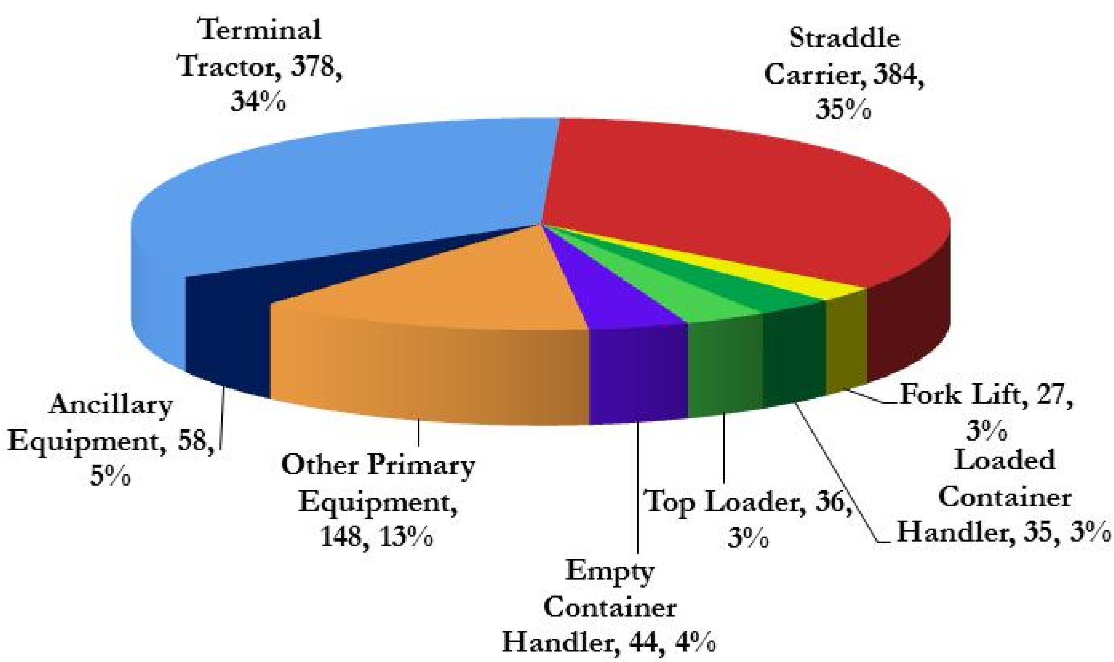
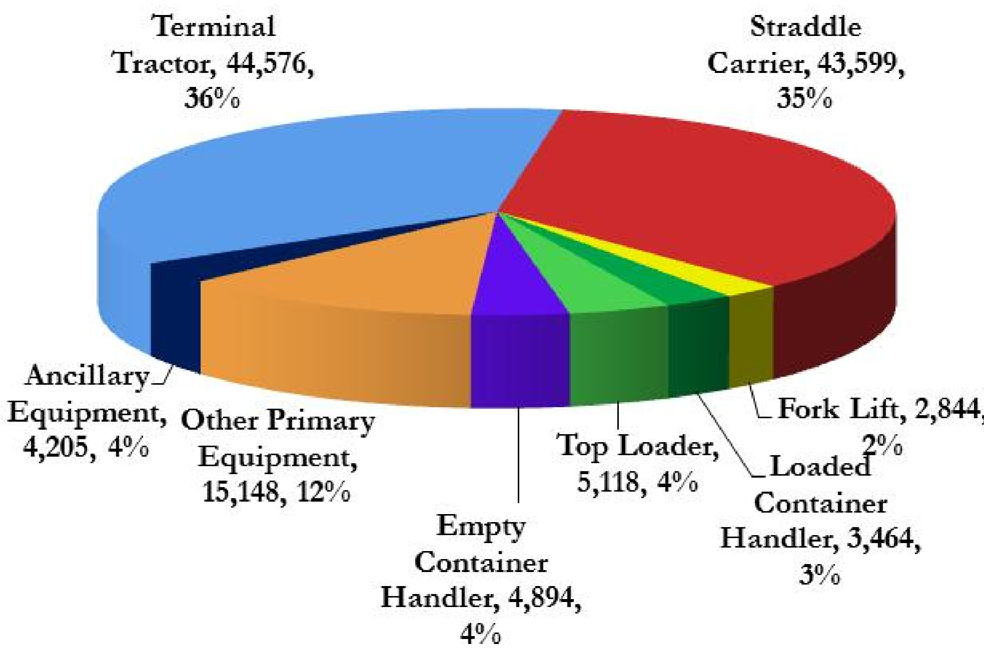


Table 2.2: GHG Emissions from CHE by Equipment Type, tpy

Equipment Type	CO_2	N_2O	CH_4	CO_2 Equivalent
Terminal Tractor	44,179	1.11	2.51	44,576
Straddle Carrier	43,287	0.87	1.97	43,599
Fork Lift	2,816	0.08	0.17	2,844
Loaded Container Handler	3,420	0.12	0.28	3,464
Top Loader	5,068	0.14	0.32	5,118
Empty Container Handler	4,858	0.10	0.23	4,894
Other Primary Equipment	15,018	0.36	0.82	15,148
Ancillary Equipment	4,168	0.10	0.23	4,205
Totals	**122,814**	**3**	**7**	**123,847**

Figure 2.2: Emissions of CO_2 Equivalents from CHE by Equipment Type, tpy and percent



2.2 Cargo Handling Equipment Emission Comparisons

This subsection compares Port Authority marine terminal cargo handling equipment emissions with county-level emission totals. Table 2.3 summarizes criteria pollutant and CO_2 emissions from cargo handling equipment operating at Port Authority marine terminals, broken down by county and state. Immediately following Table 2.3, there are a series of tables and charts (Tables 2.4 – 2.10 and Figures 2.3 – 2.9) that describe criteria pollutant impacts of Port Authority marine terminal CHE related activity within each respective county in the NYNJLINA (as described in Section 1). Overall county-level emissions were excerpted from the most recent National Emissions Inventory database[5].

For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

Table 2.3: Summary of CHE Criteria Pollutant Emissions by County within the NYNJLINA, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	0	0	0	0	0	0	0
Essex	NJ	247	14	13	18	98	0	26,077
Hudson	NJ	46	2	2	3	14	0	5,642
Middlesex	NJ	0	0	0	0	0	0	0
Monmouth	NJ	0	0	0	0	0	0	0
Union	NJ	608	39	38	59	208	1	66,970
New Jersey subtotal		**900**	**55**	**54**	**80**	**321**	**1**	**98,689**
Bronx	NY	0	0	0	0	0	0	0
Kings (Brooklyn)	NY	66	4	4	5	18	0	5,777
Nassau	NY	0	0	0	0	0	0	0
New York	NY	0	0	0	0	0	0	0
Orange	NY	0	0	0	0	0	0	0
Queens	NY	0	0	0	0	0	0	0
Richmond (Staten Island)	NY	143	8	7	9	42	0	18,349
Rockland	NY	0	0	0	0	0	0	0
Suffolk	NY	0	0	0	0	0	0	0
Westchester	NY	0	0	0	0	0	0	0
New York subtotal		**209**	**11**	**11**	**14**	**59**	**0**	**24,125**
TOTAL		**1,109**	**67**	**65**	**94**	**380**	**1**	**122,814**

[5] See: 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table 2.4: Comparison of CHE NO_x Emissions with Overall NO_x Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	0	0.0%
Essex	NJ	22,236	247	1.1%
Hudson	NJ	32,088	46	0.1%
Middlesex	NJ	20,821	0	0.0%
Monmouth	NJ	13,899	0	0.0%
Union	NJ	19,833	608	3.1%
New Jersey Subtotal		**128,097**	**900**	**0.70%**
Bronx	NY	11,643	0	0.0%
Kings (Brooklyn)	NY	26,732	66	0.2%
Nassau	NY	24,574	0	0.0%
New York	NY	30,058	0	0.0%
Orange	NY	12,424	0	0.0%
Queens	NY	31,662	0	0.0%
Richmond (Staten Island	NY	9,273	143	1.5%
Rockland	NY	6,529	0	0.0%
Suffolk	NY	39,738	0	0.0%
Westchester	NY	18,692	0	0.0%
New York Subtotal		**211,324**	**209**	**0.1%**
TOTAL		**339,421**	**1,109**	**0.33%**

Figure 2.3: Comparison of CHE NO_x Emissions with Overall NO_x Emissions by County, tpy

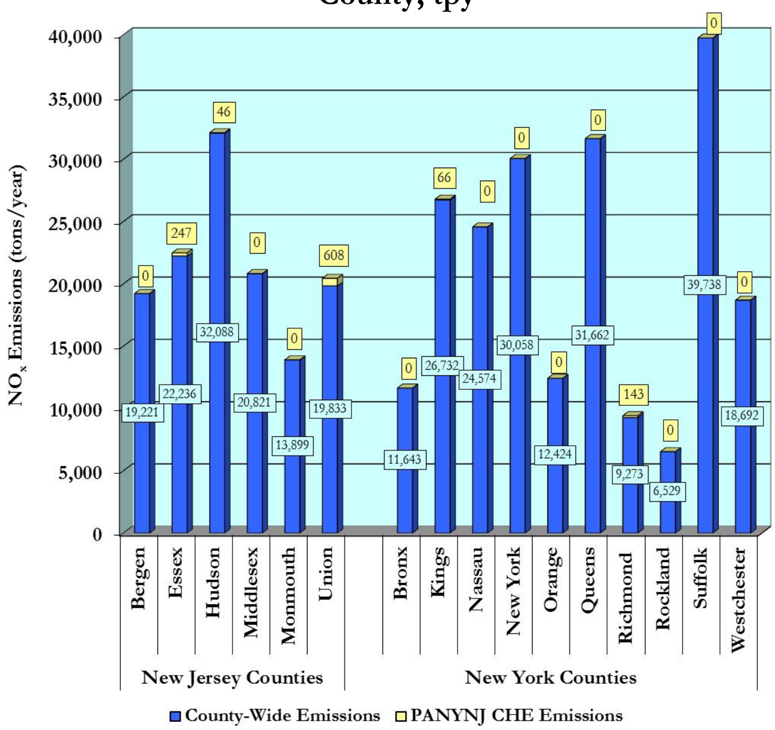


Table 2.5: Comparison of CHE PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	0.0	0.0%
Essex	NJ	2,818	13.6	0.5%
Hudson	NJ	4,781	2.3	0.0%
Middlesex	NJ	6,117	0.0	0.0%
Monmouth	NJ	4,133	0.0	0.0%
Union	NJ	3,276	39.2	1.2%
New Jersey Subtotal		**24,911**	**55**	**0.22%**
Bronx	NY	5,001	0.0	0.0%
Kings (Brooklyn)	NY	9,931	3.8	0.0%
Nassau	NY	6,991	0.0	0.0%
New York	NY	8,373	0.0	0.0%
Orange	NY	11,812	0.0	0.0%
Queens	NY	9,814	0.0	0.0%
Richmond (Staten Islanc	NY	2,446	7.6	0.3%
Rockland	NY	1,890	0.0	0.0%
Suffolk	NY	12,124	0.0	0.0%
Westchester	NY	9,427	0.0	0.0%
New York Subtotal		**77,809**	**11**	**0.01%**
TOTAL		**102,720**	**67**	**0.06%**

Figure 2.4: Comparison of CHE PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

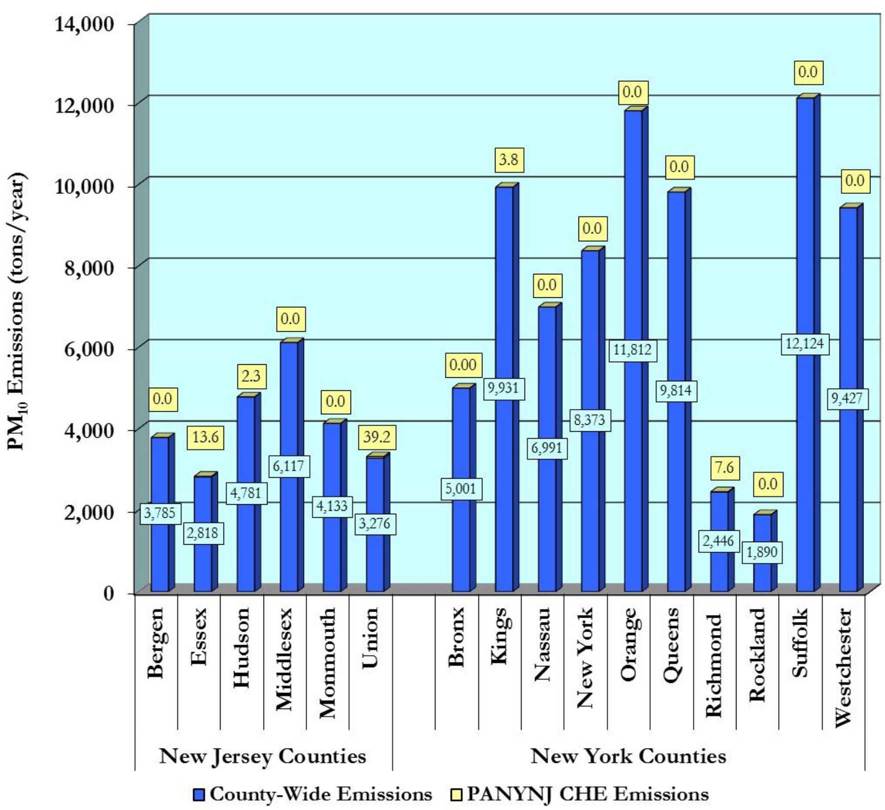


Table 2.6: Comparison of CHE $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	0.0	0.0%
Essex	NJ	1,202	13.2	1.1%
Hudson	NJ	3,577	2.3	0.1%
Middlesex	NJ	1,784	0.0	0.0%
Monmouth	NJ	1,116	0.0	0.0%
Union	NJ	1,578	38.0	2.4%
New Jersey Subtotal		**10,416**	**54**	**0.5%**
Bronx	NY	1,480	0.0	0.0%
Kings (Brooklyn)	NY	2,966	3.7	0.1%
Nassau	NY	2,006	0.0	0.0%
New York	NY	3,430	0.0	0.0%
Orange	NY	2,351	0.0	0.0%
Queens	NY	3,108	0.0	0.0%
Richmond (Staten Island)	NY	801	7.4	0.9%
Rockland	NY	552	0.0	0.0%
Suffolk	NY	3,757	0.0	0.0%
Westchester	NY	2,111	0.0	0.0%
New York Subtotal		**22,563**	**11**	**0.05%**
TOTAL		**32,978**	**65**	**0.20%**

Figure 2.5: Comparison of CHE $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

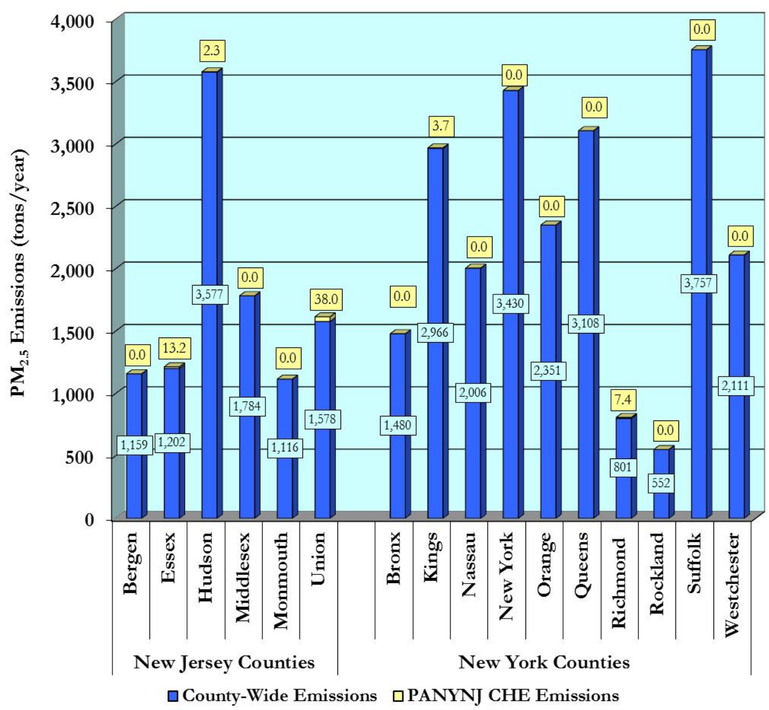


Table 2.7: Comparison of CHE VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	0.0	0.0%
Essex	NJ	15,376	18.1	0.1%
Hudson	NJ	11,073	3.4	0.0%
Middlesex	NJ	21,598	0.0	0.0%
Monmouth	NJ	16,478	0.0	0.0%
Union	NJ	14,043	59.0	0.4%
New Jersey Subtotal		**100,878**	**80**	**0.1%**
Bronx	NY	26,550	0.0	0.0%
Kings (Brooklyn)	NY	47,212	4.6	0.01%
Nassau	NY	37,235	0.0	0.0%
New York	NY	45,066	0.0	0.0%
Orange	NY	13,320	0.0	0.0%
Queens	NY	47,241	0.0	0.0%
Richmond (Staten Island	NY	10,254	9.4	0.1%
Rockland	NY	8,375	0.0	0.0%
Suffolk	NY	55,567	0.0	0.0%
Westchester	NY	27,906	0.0	0.0%
New York Subtotal		**318,727**	**14**	**0.004%**
TOTAL		**419,606**	**94**	**0.02%**

Figure 2.6: Comparison of CHE VOC Emissions with Overall VOC Emissions by County, tpy

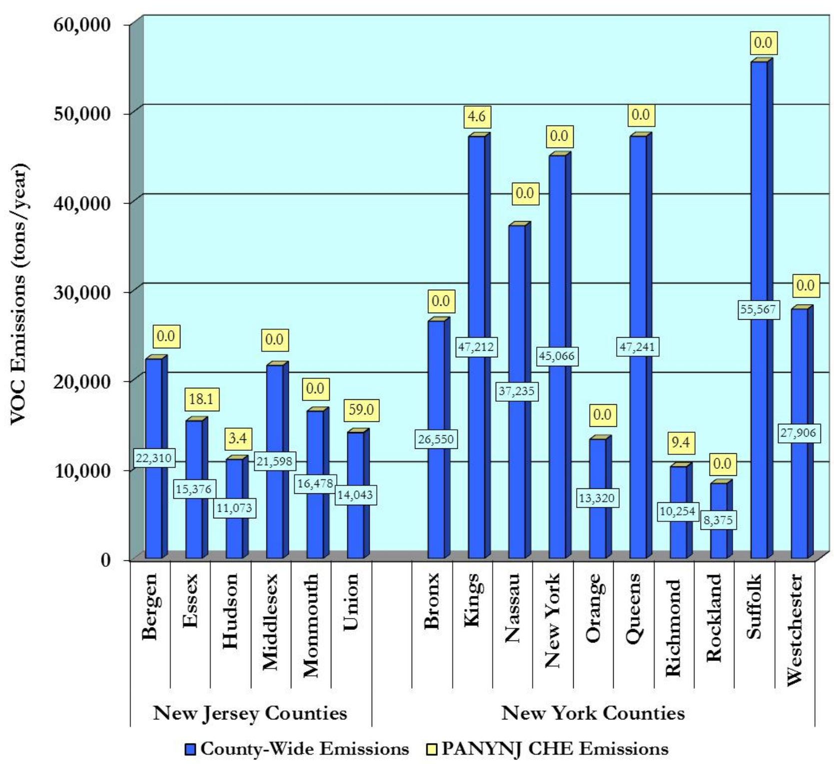


Table 2.8: Comparison of CHE CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	0.0	0.0%
Essex	NJ	89,041	98.0	0.1%
Hudson	NJ	48,521	14.4	0.0%
Middlesex	NJ	129,636	0.0	0.0%
Monmouth	NJ	108,040	0.0	0.0%
Union	NJ	75,762	208.3	0.3%
New Jersey Subtotal		**608,842**	**321**	**0.05%**
Bronx	NY	75,120	0.0	0.0%
Kings (Brooklyn)	NY	112,068	17.7	0.0%
Nassau	NY	183,911	0.0	0.0%
New York	NY	158,713	0.0	0.0%
Orange	NY	69,889	0.0	0.0%
Queens	NY	144,316	0.0	0.0%
Richmond (Staten Island)	NY	35,204	41.6	0.1%
Rockland	NY	43,672	0.0	0.0%
Suffolk	NY	307,921	0.0	0.0%
Westchester	NY	148,488	0.0	0.0%
New York Subtotal		**1,279,304**	**59**	**0.005%**
TOTAL		**1,888,145**	**380**	**0.02%**

Figure 2.7: Comparison of CHE CO Emissions with Overall CO Emissions by County, tpy

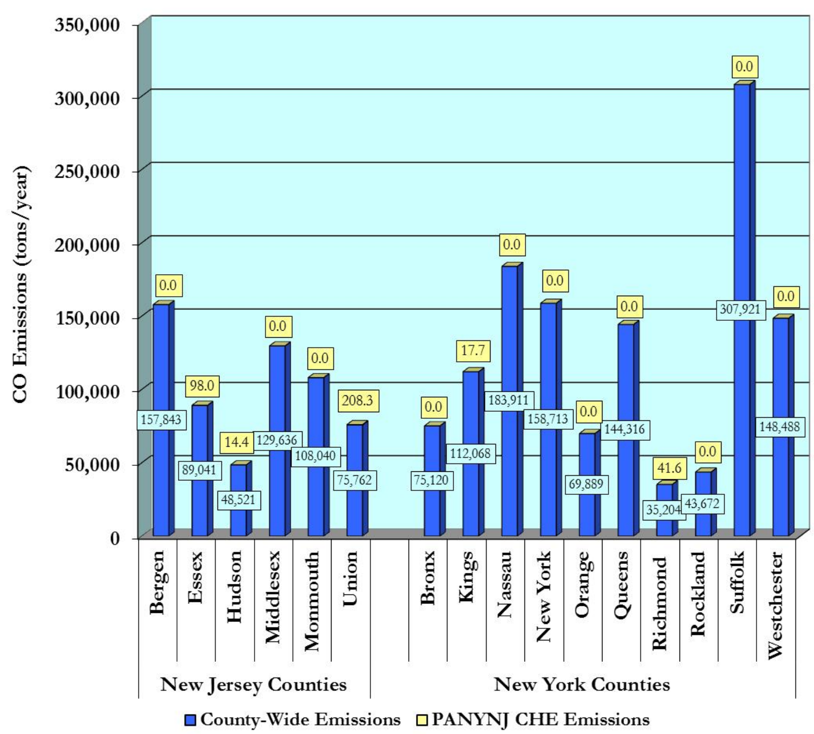


Table 2.9: Comparison of CHE SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	903	0.0	0.000%
Essex	NJ	1,974	0.2	0.012%
Hudson	NJ	5,415	0.1	0.001%
Middlesex	NJ	993	0.0	0.000%
Monmouth	NJ	787	0.0	0.000%
Union	NJ	1,870	0.6	0.033%
New Jersey Subtotal		**11,941**	**1**	**0.008%**
Bronx	NY	1,868	0.0	0.000%
Kings (Brooklyn)	NY	3,980	0.1	0.001%
Nassau	NY	3,770	0.0	0.000%
New York	NY	7,114	0.0	0.000%
Orange	NY	16,368	0.0	0.000%
Queens	NY	4,302	0.0	0.000%
Richmond (Staten Island	NY	912	0.2	0.018%
Rockland	NY	2,243	0.0	0.000%
Suffolk	NY	18,387	0.0	0.000%
Westchester	NY	4,310	0.0	0.000%
New York Subtotal		**63,255**	**0**	**0.000%**
TOTAL		**75,197**	**1**	**0.001%**

Figure 2.8: Comparison of CHE SO_2 Emissions with Overall SO_2 Emissions by County, tpy

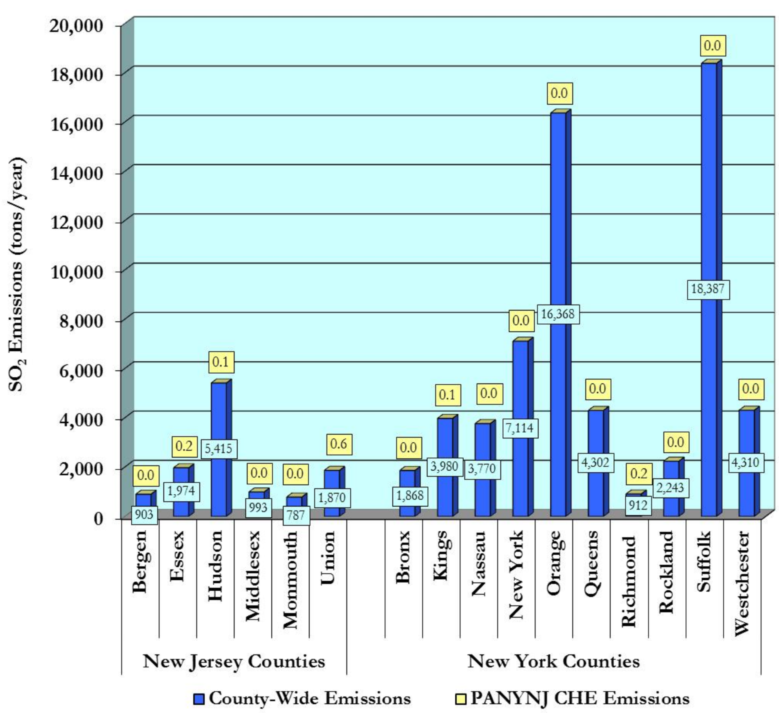
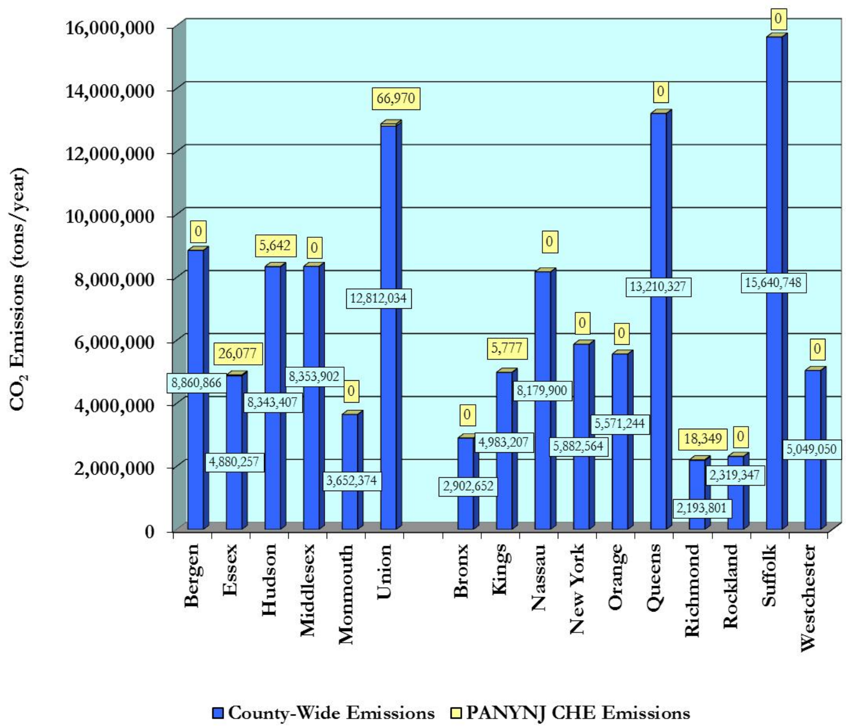


Table 2.10: Comparison of CHE CO_2 Emissions with Overall CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	0	0.00%
Essex	NJ	4,880,257	26,077	0.53%
Hudson	NJ	8,343,407	5,642	0.07%
Middlesex	NJ	8,353,902	0	0.00%
Monmouth	NJ	3,652,374	0	0.00%
Union	NJ	12,812,034	66,970	0.52%
New Jersey Subtotal		**46,902,841**	**98,689**	**0.21%**
Bronx	NY	2,902,652	0	0.00%
Kings (Brooklyn)	NY	4,983,207	5,777	0.12%
Nassau	NY	8,179,900	0	0.00%
New York	NY	5,882,564	0	0.00%
Orange	NY	5,571,244	0	0.00%
Queens	NY	13,210,327	0	0.00%
Richmond (Staten Islar	NY	2,193,801	18,349	0.84%
Rockland	NY	2,319,347	0	0.00%
Suffolk	NY	15,640,748	0	0.00%
Westchester	NY	5,049,050	0	0.00%
New York Subtotal		**65,932,841**	**24,125**	**0.04%**
TOTAL		**112,835,682**	**122,814**	**0.11%**

Figure 2.9: Comparison of CHE CO_2 Emissions with Overall CO_2 Emissions by County, tpy



2.3 Methodology

This subsection describes the methods used to collect information and estimate emissions from cargo handling equipment.

2.3.1 Data Collection

Data was collected through queries to the terminal operators requesting updates to the information they had provided for the previous emissions inventories, which had been conducted on the equipment fleets they operated in 2002, 2004, 2006, and 2008. As in the previous inventories, most container terminal operators provided average activity levels for types of equipment as opposed to reporting specific engine hour data. Thus, in many cases, various pieces of equipment were noted to have the same operating hours. This is not unusual for CHE emissions inventories as many operators do not record operating hours for individual pieces of equipment.

Equipment lists were derived from information maintained by the container terminal operators. Data custody was maintained by a single point of contact outside the Port Authority to allay confidentiality concerns.

2.3.2 Emission Estimating Model

Emissions were estimated using the NONROAD2008a emission estimating model.[6] The NONROAD model has been designed to accommodate a wide range of off-road equipment types and recognizes a defined list of equipment designations. To prepare for model input, the container terminal equipment was stratified into equipment types recognized by the model. For example, a "sweeper" corresponds directly to a single line item for the model, but container handling equipment described by various names by the terminals were grouped together; for example, straddle carriers, empty container handlers and top loaders were categorized under the modeling category "other industrial equipment" because the model does not include a more specific category for these equipment types.

The marine terminal equipment identified by survey was categorized into the most closely corresponding NONROAD equipment type, as illustrated in Table 2.11, which presents equipment types by Source Classification Code (SCC), load factor, and NONROAD category common name. The earlier categorizations were replicated for purposes of this inventory as much as possible. Table 2.12 then lists the population of equipment identified at port facilities, listed by common name and SCC code.

[6] See *http://www.epa.gov/otaq/nonrdmdl.htm.*

The model produces estimates of emissions from each piece of equipment based on its model year, horsepower range, annual hours of operation, and model-specific load factor assumptions – summaries of these estimates are presented in the following subsection. An engine's model year determines its emissions when new. These emissions are known as zero-hour emissions because a brand-new engine has zero hours of operation. Emissions from a new engine depend on the emission standards in place on the date of engine manufacture (its model year designation). An engine's model year, along with the known or estimated number of operating hours per year, also determines its total cumulative hours of operation (age in years multiplied by hours of operation per year). The NONROAD model uses total cumulative hours of operation to estimate a component of the emission estimate known as "deterioration," which is the increase in emissions from an engine that occurs over time as the engine's components and emission control systems wear. The model adds zero-hour emissions to emissions from deterioration to estimate a total emission rate in terms of mass of emissions (in grams) per horsepower-hour of engine operation (abbreviated g/hp-hr). A horsepower-hour (hp-hr) represents one horsepower operating for one hour. A 100-horsepower engine operating at its rated 100-horsepower capacity for one hour expends 100 hp-hrs. From this, it is easy to see why horsepower and hours of operation are important components of the emissions inventory data.

Table 2.11: NONROAD Engine Source Categories

Equipment Type	SCC	Load Factor	NONROAD Category
Portable light set	2270002027	0.43	Signal board / light plant
Wharf crane	2270002045	0.43	Crane
Non-road vehicle	2270002051	0.59	Off-road truck
Bucket loader	2270002060	0.59	Front end loader
Payloader	2270002060	0.59	Front end loader
Aerial platform	2270003010	0.21	Aerial lift
Fork lift	2270003020	0.59	Forklift
Propane Fork Lift	2270003020	0.30	LPG Forklift
Sweeper	2270003030	0.43	Sweeper / scrubber
Chassis rotator Container top loader Empty container handler	2270003040	0.43	Other industrial equipment
Rubber tired gantry crane Straddle carrier	2270003050	0.21	Other material handling equipment
Terminal tractor	2270003070	0.59	Terminal tractor
Generator	2270006005	0.43	Light commercial generator set

Table 2.12: NONROAD Equipment Category Population List

NONROAD Category	Source Category Code	2006 Count	2008 Count	2010 Count
Aerial Lift - Manlift	2270003010	11	11	10
Crane	2270002045	13	7	12
Diesel Forklift	2270003020	0	8	21
Propane Forklift	2270003020	87	108	93
Front End Loader	2270002060	13	7	4
General Industrial Equip	2270003040	130	143	147
Material Handling Equip	2270003050	260	293	297
Offroad Truck	2270002051	9	12	5
Portable Light Set or Sign	2270002027	12	12	12
Sweeper	2270003030	2	9	9
Terminal Tractor	2270003070	350	403	442
Total		**888**	**1,013**	**1,052**

Load factor is an estimate of the average percentage of an engine's rated power output that is required to perform its operating tasks. The NONROAD model contains a load factor for each source category as listed in Table 2.11.

The model's default ultra-low sulfur diesel sulfur content of 15 parts per million (ppm) was used. Particulate emissions were adjusted using a control factor of 0.87 (assuming a 13% reduction in PM emissions from the fuel switch, consistent with recent port inventories on the West Coast[7]). Ambient temperatures do not affect diesel exhaust emissions; therefore, they were estimated as ranging from approximately 40 to 85 degrees Fahrenheit.

While the NONROAD model estimated the emissions of CO_2 presented in this report, the model does not report emissions of the greenhouse gases N_2O or CH_4. Estimates of these pollutants were developed using emission factors reported by EPA[8] for non-highway equipment. The emission factors are published in terms of grams per kg of fuel, and the amount of fuel was calculated from the NONROAD estimate of CO_2 emissions, since those emissions are directly proportional to fuel consumption, using an average fuel carbon content of 86%.[9]

[7] Puget Sound Maritime Air Emissions Inventory, April 2007; Port of Long Beach Air Emissions Inventory – 2006, July 2006 ; Port of Los Angeles Inventory of Air Emissions for Calendar Year 2006, July 2008
[8] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006; April 15, 2008
[9] Derived from EPA: Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel; see*: http://www.epa.gov/oms/climate/420f05001.htm*

2.4 Description of Cargo Handling Equipment

The equipment inventoried for the container terminals was limited to diesel-powered landside equipment greater than 25 horsepower (hp) and not designed for highway use. While the equipment is generally termed "cargo handling equipment," the equipment used at these terminals can be separated into primary cargo handling equipment, used directly in handling cargo, and ancillary equipment, which has uses other than directly moving cargo (such as sweepers and fuel trucks).

Table 2.13 summarizes the 2010 fleet characteristics of primary and ancillary non-road equipment, respectively, in terms of equipment count, and averages of model year, horsepower, and annual operating hours. The averages presented are arithmetic means and are included here for comparison. As noted above, emissions were estimated using equipment-specific values for each piece of equipment – the average values were not used.

It should be noted that the equipment count increased in 2010 due to the inclusion of Global Marine Terminal for the first time in a PANYNJ multi-facility emissions inventory.

Figures 2.10 and 2.11 illustrate the population distribution of the CHE by equipment type. Equipment is categorized as primary and ancillary equipment. Primary equipment is used directly in the handling of cargo – examples include yard tractors, which move shipping containers around the marine terminals, and top loaders, which lift containers onto stacks for temporary storage. Ancillary equipment refers to equipment not directly used to move cargo but otherwise used to support terminal operations; examples include refueling trucks and yard sweepers. As a group, ancillary equipment makes up 4% of the total equipment population. This equipment is listed separately from primary equipment in Table 2.13 and presented visually in Figure 2.11. In addition to the "Ancillary" category, Figure 2.10 presents an additional category – "Other Primary Equipment" – which makes up 14% of all equipment; this category includes cranes of various types (rubber tired gantry cranes, wharf cranes and other cranes), stackers and reach stackers, RORO and empty container hustlers, and chassis flippers. A detailed list of all equipment on which this inventory is based, including model year, horsepower, and annual operating hours, is presented in Appendix B. This information is relevant as engine emissions vary according to these parameters – older engines generally emit more pollutants than new engines, high-horsepower engines typically emit more than lower-power engines. "Primary and "Ancillary" equipment are described in greater detail in the following subsections.

Table 2.13: Primary Cargo Handling Equipment Characteristics

Equipment Type	Count	Percent of Population	Average Model Year	Average hp	Average hrs/year
Primary Equipment					
Terminal Tractor	428	40.7%	2003	204	1,552
Straddle Carrier	248	23.6%	2003	230	3,219
Fork Lift	83	7.9%	2001	110	825
Loaded Container Handler	28	2.7%	2003	299	2,765
Top Loader	25	2.4%	2005	347	2,460
Empty Container Handler	46	4.4%	2004	199	1,865
Subtotal "Primary Equipment"	858	81.7%	2003	210	2,046
Other Primary Equipment					
Rubber Tired Gantry Crane	49	4.7%	2004	469	2,795
Small Fork lift	31	2.9%	1998	101	480
Reach Stacker	30	2.9%	2004	329	1,814
Stacker	13	1.2%	2002	161	600
RORO Hustler	8	0.8%	1999	215	406
Wharf Crane	6	0.6%	1987	870	1,063
Empty Transport Hustler	6	0.6%	2007	173	2,500
Chassis Flipper	5	0.5%	2002	156	1,400
Subtotal "Other Primary Equipment"	148	14.2%	2001	316	1,660
Ancillary Equipment					
Portable Light Set	12	1.1%	2001	50	1,000
Sweeper	9	0.86%	2001	90	487
Aerial Platform	8	0.8%	2002	47	1,000
Crane	6	0.6%	1998	1750	1,000
Diesel Fuel Truck	3	0.29%	2004	240	3,200
Nonroad Vehicle	2	0.19%	1996	288	1,800
Payloader	2	0.19%	2004	38	250
Front End Loader	2	0.19%	1987	125	0
Manlift	2	0.19%	2001	162	806
Subtotal "Ancillary Equipment"	46	4.4%	2000	309	993
Total Population	**1,052**				

Figure 2.10: Population Distribution of Primary CHE, by Number and Percent

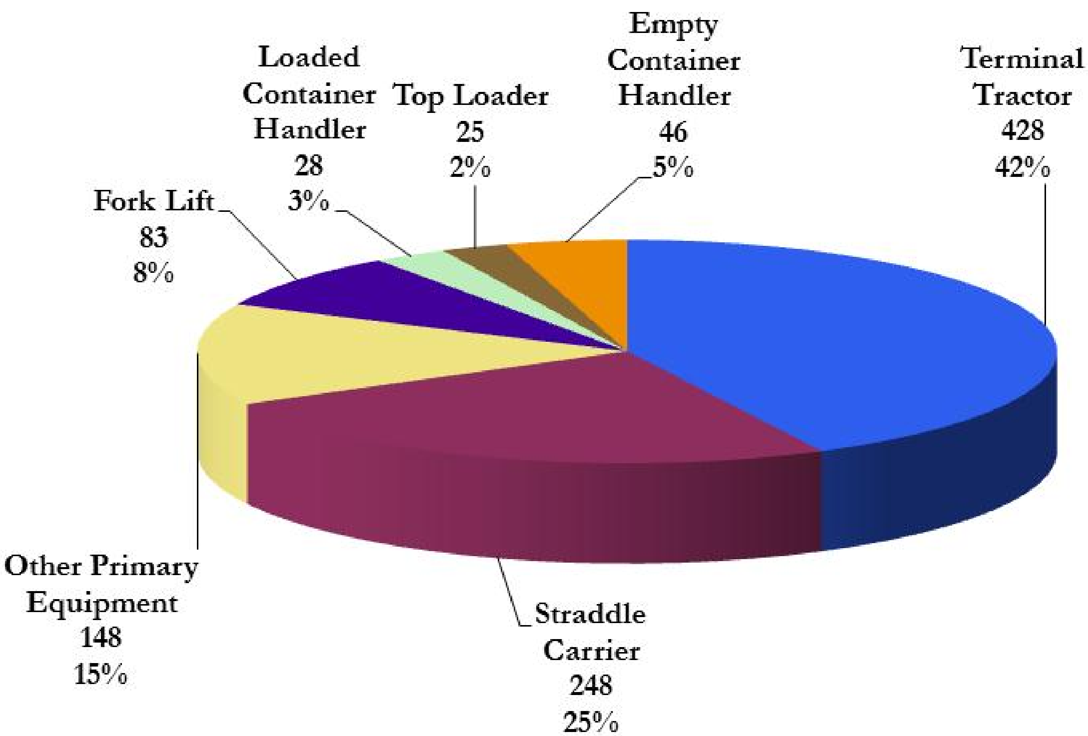
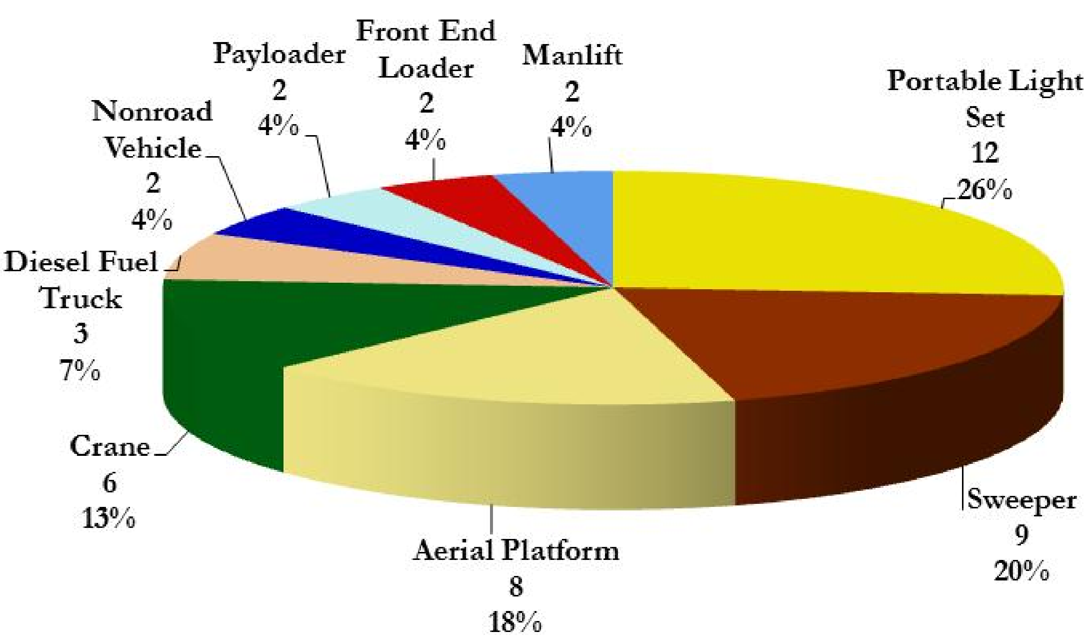


Figure 2.11: Population Distribution of Ancillary Equipment, by Number and Percent



2.4.1 Primary Cargo Handling Equipment

Primary cargo handling equipment is used directly in handling cargo. This equipment consists of terminal tractors, straddle carriers, fork lifts, top loaders, empty container handlers, rubber tired gantry cranes, wharf cranes, and chassis rotators. This equipment has been characterized in terms of several characteristics important to estimating emissions, including model year, horsepower, and annual hours of operation.

Table 2.14 presents information on the model years of the various types of primary cargo handling equipment – the average, the earliest (oldest) model year present, and the latest (newest) model year. Figures 2.12 and 2.13 illustrate the model year distributions of terminal tractors and straddle carriers, by far the two most numerous types of equipment in the inventory.

Table 2.14: Model Year Characteristics of Primary CHE

Equipment Type	Average Model Year	Min Model Year	Max Model Year
Terminal Tractor	2003	1995	2010
Straddle Carrier	2003	1999	2007
Fork Lift	2001	1986	2010
Loaded Container Handler	2003	1991	2008
Top Loader	2005	1996	2010
Empty Container Handler	2004	1989	2010
Rubber Tired Gantry Crane	2004	2001	2008
Small Fork lift	1998	1987	2006
Reach Stacker	2004	1999	2010
Stacker	2002	1999	2008
RORO Hustler	1999	1998	2000
Wharf Crane	1987	1980	1998
Empty Transport Hustler	2007	2007	2007
Chassis Flipper	2002	1998	2006

Figure 2.12: Model Year Distribution of Terminal Tractors

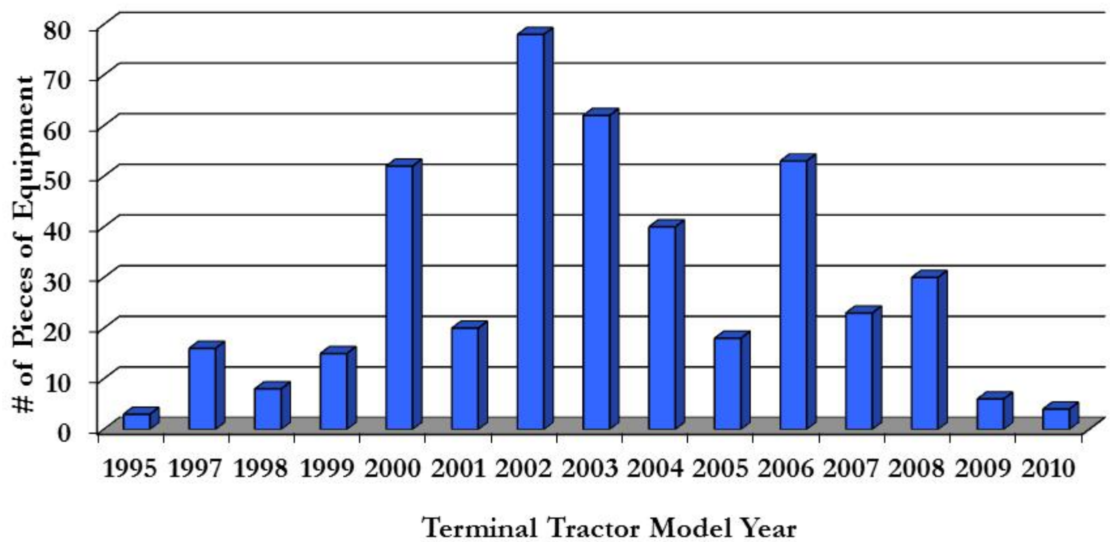


Figure 2.13: Model Year Distribution of Straddle Carriers

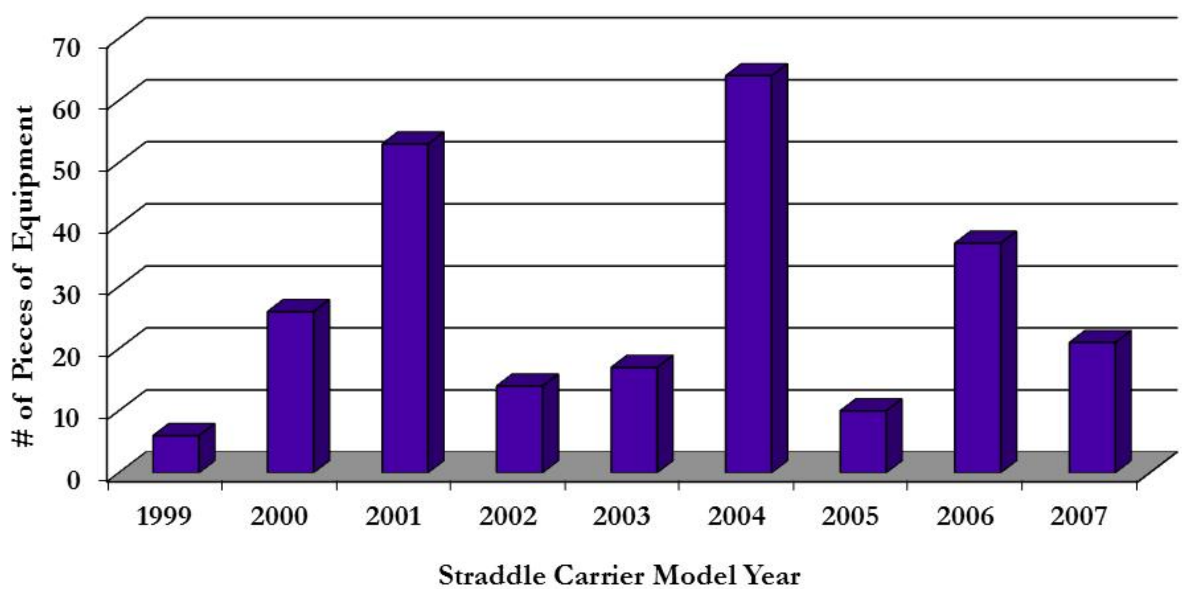


Table 2.15 presents information on the horsepower ratings of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.14 and 2.15 illustrate the number of terminal tractors and straddle carriers in each horsepower group. The straddle carriers in the larger horsepower groups (368, 370, and 386 hp) are equipped with two engines, each producing half the horsepower (i.e., the 368-hp straddle carriers have two 184-hp engines, etc.).

Table 2.15: Horsepower Characteristics of Primary CHE

Equipment Type	Average hp	Min hp	Max hp
Terminal Tractor	204	170	245
Straddle Carrier	230	184	320
Fork Lift	110	48	300
Loaded Container Handler	299	299	299
Top Loader	347	260	365
Empty Container Handler	199	160	240
Rubber Tired Gantry Crane	469	450	475
Small Fork lift	101	101	101
Reach Stacker	329	225	365
Stacker	161	152	200
RORO Hustler	215	215	215
Wharf Crane	870	835	950
Empty Transport Hustler	173	173	173
Chassis Flipper	156	152	160

Figure 2.14: Horsepower Distribution of Terminal Tractors

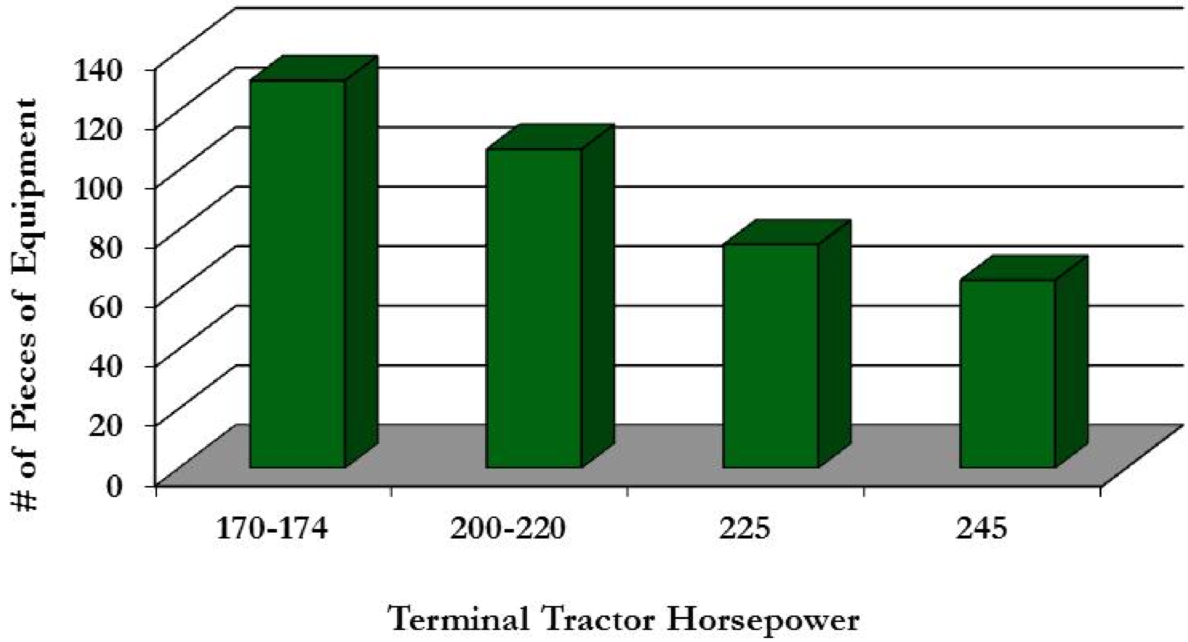


Figure 2.15: Horsepower Distribution of Straddle Carriers

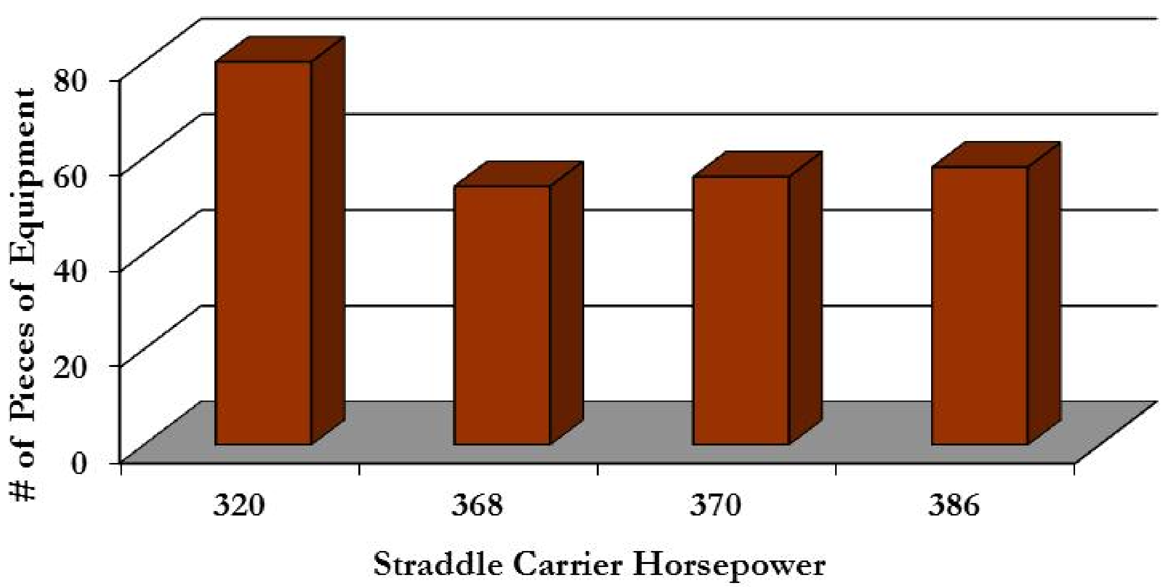


Table 2.16 presents information on the reported annual operating hours of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.16 and 2.17 illustrate the variation in reported terminal tractor and straddle carrier operating hours, respectively. Figure 2.16 does not include the straddle carriers that were reported as not operating in 2010 (represented by the zero minimum in Table 2.16).

Table 2.16: Reported Operating Hours of Primary CHE

Equipment Type	Average hrs/year	Min hrs/year	Max hrs/year
Terminal Tractor	1,552	0	4,504
Straddle Carrier	3,219	0	3,357
Fork Lift	825	0	3,055
Loaded Container Handler	2,765	491	3,991
Top Loader	2,460	200	4,204
Empty Container Handler	1,865	89	2,582
Rubber Tired Gantry Crane	2,795	1,240	5,245
Small Fork lift	480	0	1,373
Reach Stacker	1,814	100	3,600
Stacker	600	600	600
RORO Hustler	406	0	500
Wharf Crane	1,063	71	2,000
Empty Transport Hustler	2,500	2,500	2,500
Chassis Flipper	1,400	1,400	1,400

Figure 2.16: Distribution of Annual Operating Hours for Terminal Tractors

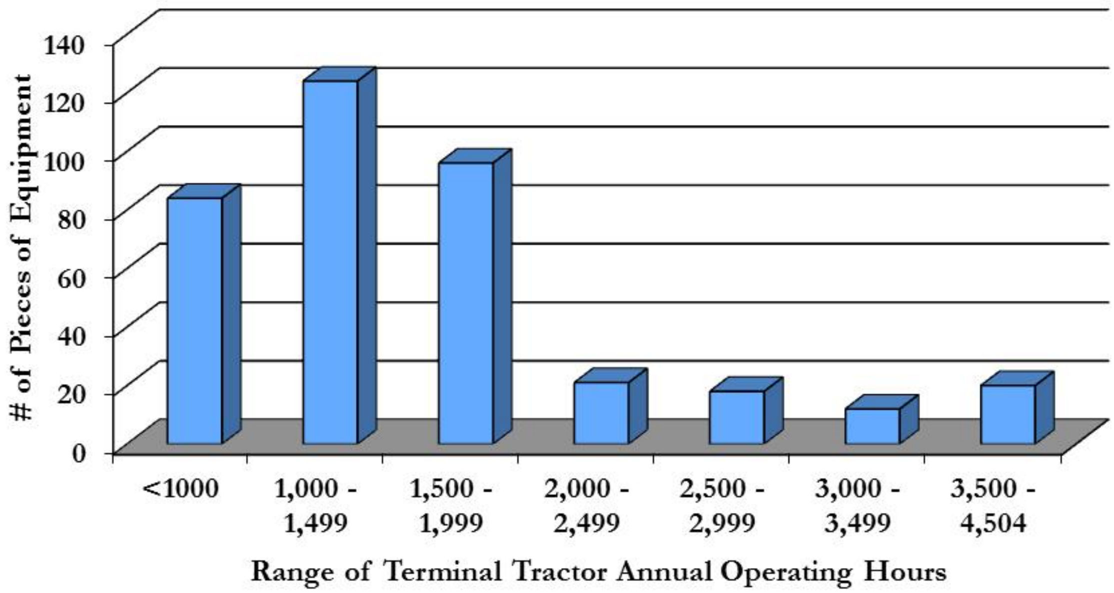
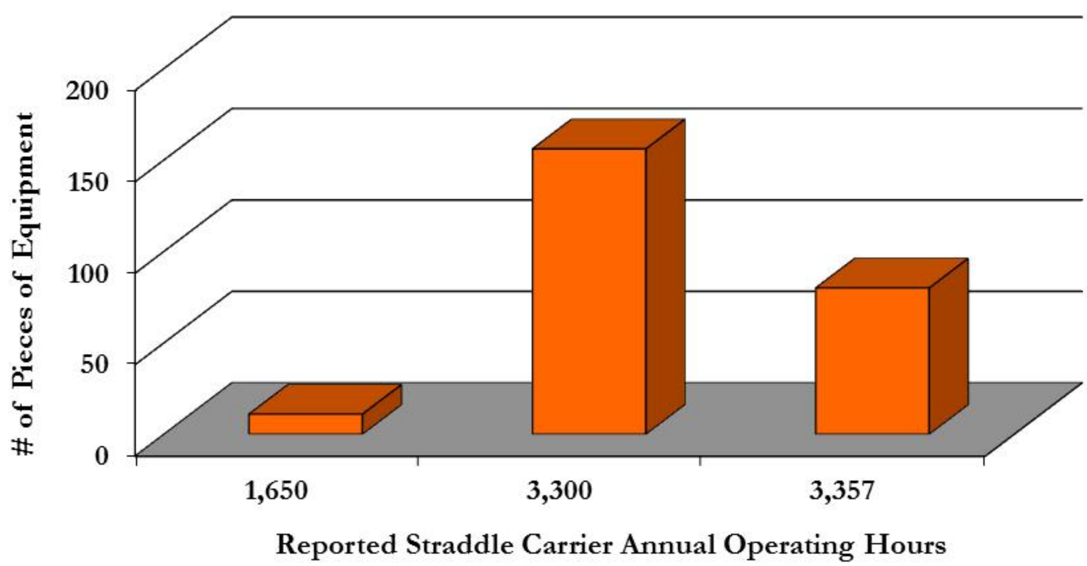


Figure 2.17: Distribution of Annual Operating Hours for Straddle Carriers



2.4.2 Ancillary Equipment

Ancillary equipment, or equipment not directly used to handle cargo, includes non-road vehicles, portable light sets, aerial platforms, payloaders, bucket loaders, sweepers, and generators. Tables 2.17 through 2.19 present the distribution of characteristics of this ancillary equipment in terms of model year, horsepower rating, and annual operating hours, respectively.

Table 2.17: Model Year Characteristics of Ancillary Equipment

Equipment Type	Average Model Year	Min Model Year	Max Model Year
Portable Light Set	2001	2001	2001
Sweeper	2001	1988	2008
Aerial Platform	2002	1998	2006
Crane	1988	1988	1990
Diesel Fuel Truck	2004	2002	2006
Nonroad Vehicle	1996	1985	2006
Payloader	2004	2004	2004
Front End Loader	1987	1987	1987
Manlift	2001	1998	2003

Table 2.18: Horsepower Characteristics of Ancillary Equipment

Equipment Type	Average hp	Min hp	Max hp
Portable Light Set	50	50	50
Sweeper	90	38	101
Aerial Platform	47	42	49
Crane	1,750	1,750	1,750
Diesel Fuel Truck	240	240	240
Nonroad Vehicle	288	250	325
Payloader	38	38	38
Front End Loader	125	125	125
Manlift	162	150	174

Table 2.19: Reported Operating Hours of Ancillary Equipment

Equipment Type	Average hrs/year	Min hrs/year	Max hrs/year
Portable Light Set	1,000	1,000	1,000
Sweeper	487	15	1,427
Aerial Platform	1,000	1,000	1,000
Crane	1,000	1,000	1,000
Diesel Fuel Truck	3,200	3,200	3,200
Nonroad Vehicle	1,800	1,800	1,800
Payloader	250	250	250
Front End Loader	0	0	0
Manlift	806	757	854

The following Figures 2.18 through 2.22 provide examples of the most common types of CHE: yard tractor, straddle carrier, fork lift, top loader, and empty container handler (also known as a side handler).

Figure 2.18: Example Yard Tractor

Photograph courtesy of New England Industrial Truck, Woburn, MA
http://www.neit.com/images/newcab.jpg

Figure 2.19: Example Straddle Carrier

Figure 2.20: Example Fork Lift

Figure 2.21: Example Top Loader

Figure 2.22: Example Empty Container Handler

SECTION 3: HEAVY DUTY DIESEL VEHICLES

This section presents estimated emissions from heavy-duty diesel vehicles (HDDVs) that visit the container terminals, warehouses, and automobile handling facilities within the Port Authority marine terminals. An example of an HDDV is the diesel-powered road truck that calls at a marine terminal to pick up or drop off a container. The following subsections present estimated HDDV emissions, describe the methodologies used to collect information and estimate emissions, and present a description of the equipment types.

Following an Executive Summary that presents an overview of HDDV emissions from PANYNJ sources, the following four subsections focus on:

- 3.1 - Emission Estimates
- 3.2 - Emission Comparisons
- 3.3 - Methodology
- 3.4 - Description of HDDVs

ES3.1 Executive Summary

Table ES3-1 presents the estimated HDDV criteria pollutant and CO_2 emissions in the context of overall emissions in the states of New York and New Jersey, and in the NYNJLINA, including emissions in tons per year and the percentage that PANYNJ HDDV emissions make up of overall NYNJLINA emissions.

For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

Table ES3.1: Comparison of PANYNJ HDDV Emissions with State and NYNJLINA Emissions, tpy

Geographical Extent / Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
New York and New Jersey	681,640	402,204	104,007	852,825	4,219,848	238,527	223,372,325
NYNJLINA	339,421	102,720	32,978	419,606	1,888,145	75,197	112,835,682
Heavy-Duty Diesel Vehicles	2,104	46	42	96	477	2	228,960
Percent of NYNJLINA Emissions	0.62%	0.04%	0.13%	0.02%	0.03%	0.003%	0.20%

The following figures illustrate the distribution of PANYNJ HDDV emissions by activity and location (on-road driving, on-terminal driving and idling) in terms of tons per year and percent of total HDDV emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure ES3.1: Distribution and Comparison of NOx from HDDVs, tpy and percent

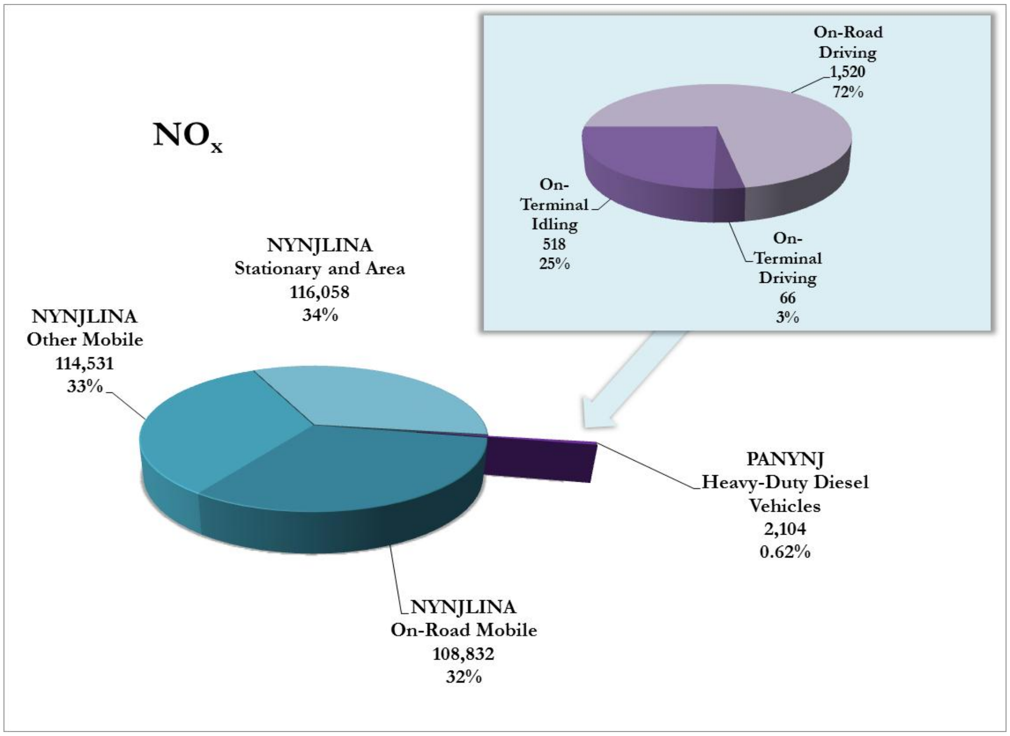


Figure ES3.2: Distribution and Comparison of PM10 from HDDVs, tpy and percent

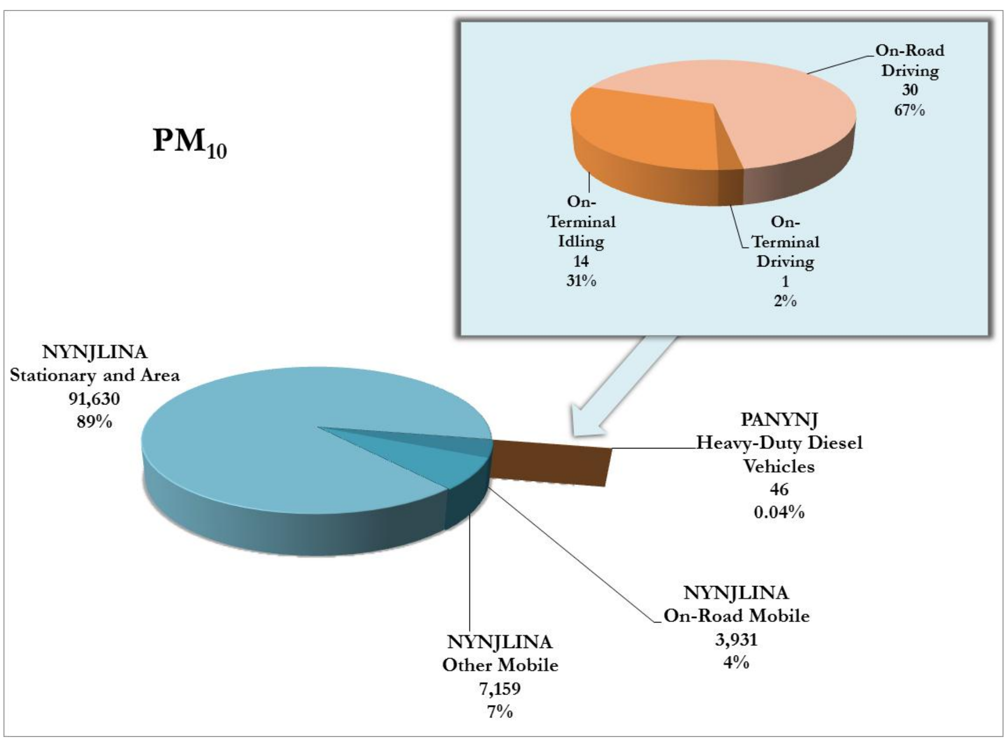


Figure ES3.3: Distribution and Comparison of PM2.5 from HDDVs, tpy and percent

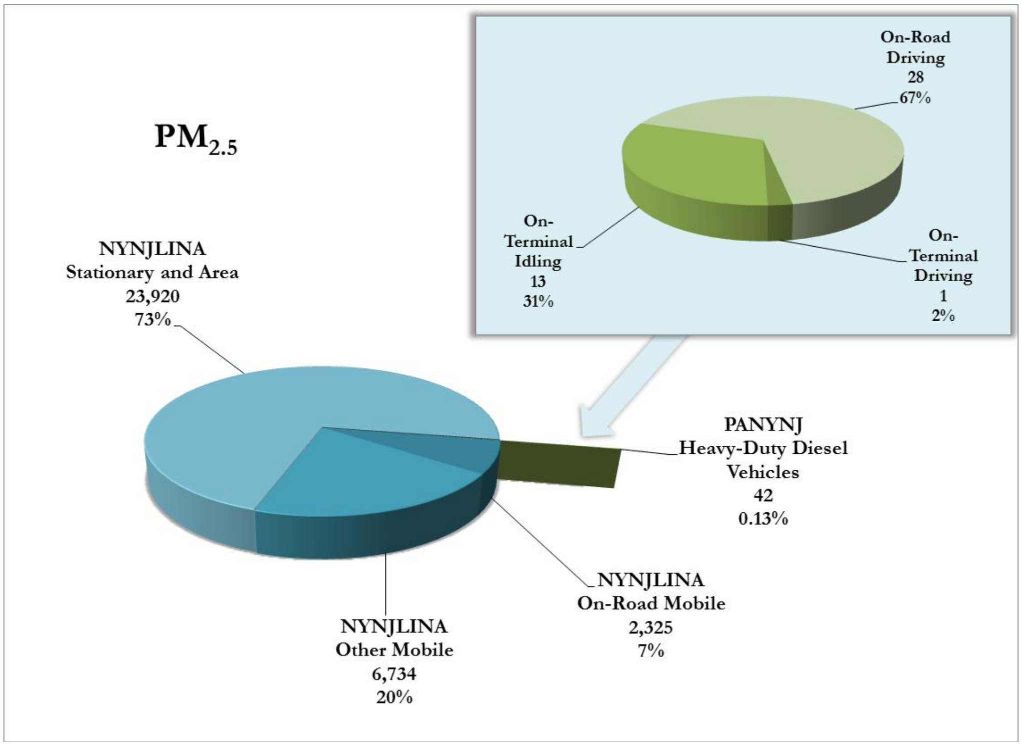


Figure ES3.4: Distribution and Comparison of VOC from HDDVs, tpy and percent

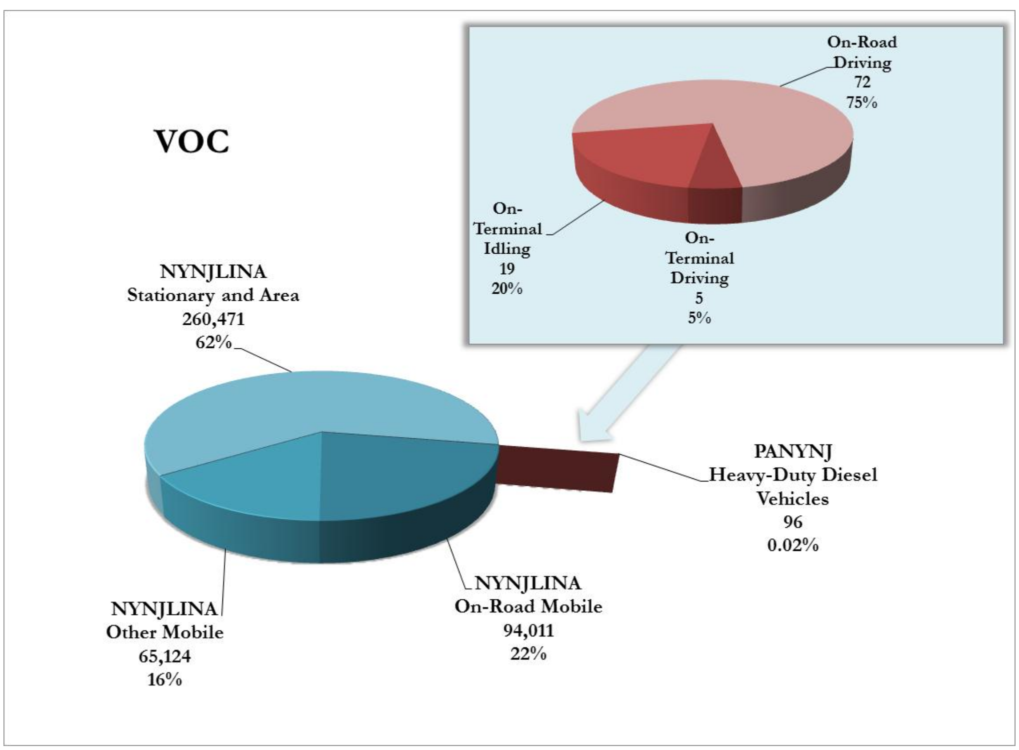


Figure ES3.5: Distribution and Comparison of CO from HDDVs, tpy and percent

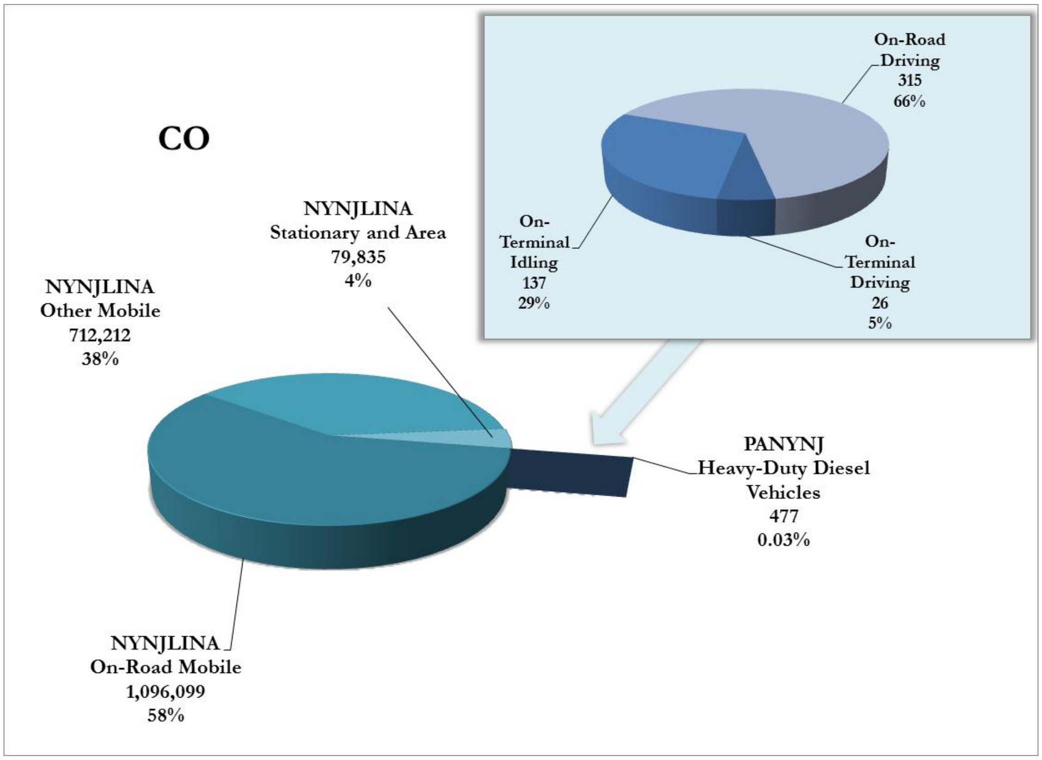


Figure ES3.6: Distribution and Comparison of SO_2 from HDDVs, tpy and percent

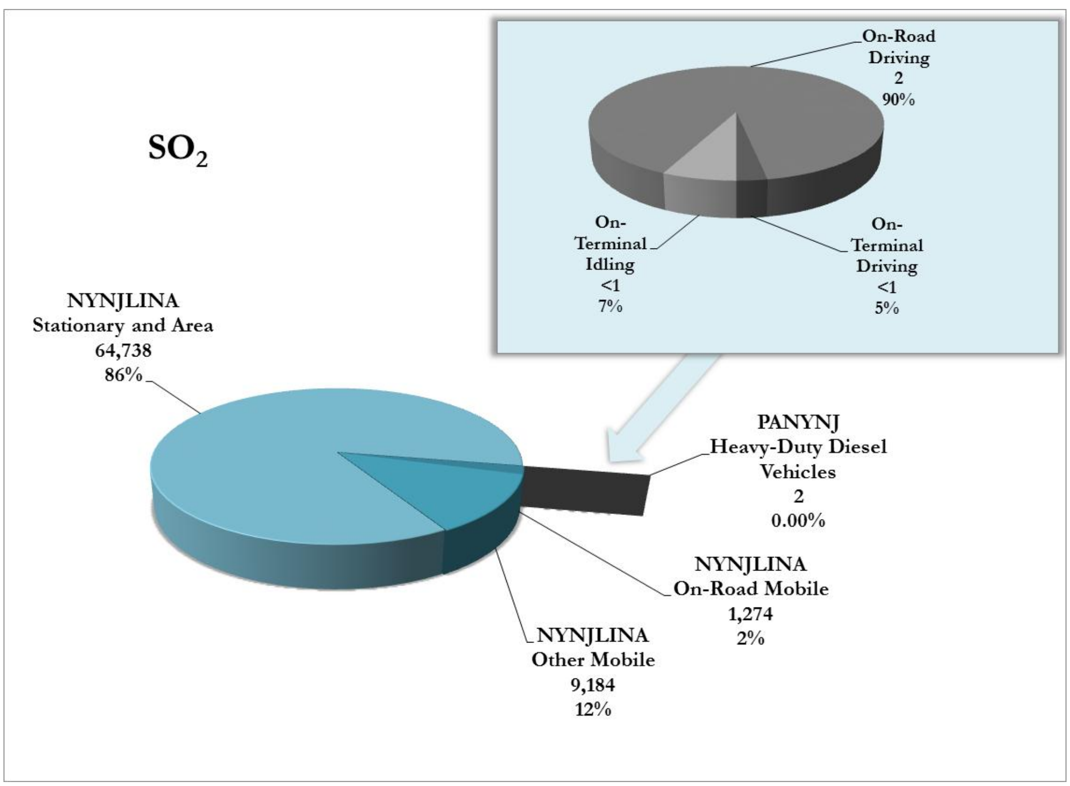
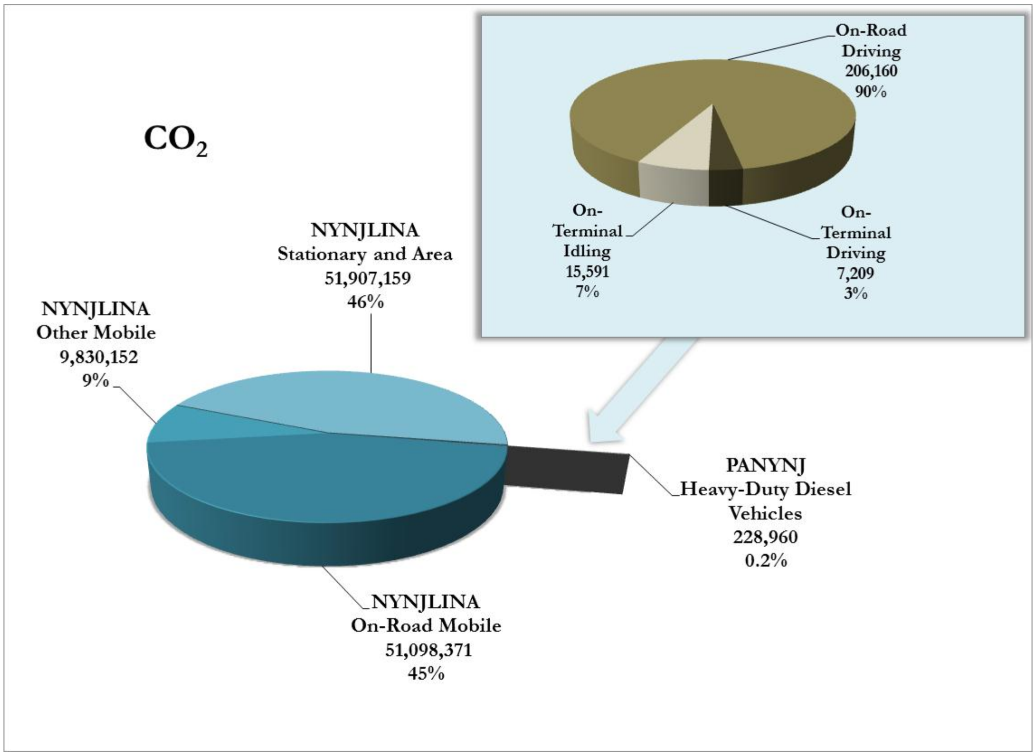


Figure ES3.7: Distribution of CO_2 Emissions from HDDVs, tpy and percent



3.1 Heavy Duty Diesel Vehicle Emission Estimates

On-terminal and on-road emissions have been estimated for HDDV operations associated with the Port Authority marine terminals. The following subsections detail the estimated emissions from these two categories of HDDV activity. On-terminal activity, which includes the operation of trucks while at warehouses as well as within the boundaries of the container and automobile terminals, has been evaluated to include driving emissions and emissions from idling trucks waiting for entry and to be loaded or unloaded. The on-road emission estimates include the idling assumptions built into the emission estimating model used (as described in subsection 3.3.2) so separate idling emissions are not presented for on-road HDDV operation.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal or facility type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

3.1.1 On-Terminal Emissions

Estimates of on-terminal driving emissions of criteria pollutants are presented in Tables 3.1, and of greenhouse gas emissions in Table 3.2. Tables 3.3 and 3.4 present estimates of on-terminal idling emissions of criteria pollutants and greenhouse gases, and summaries of combined driving and idling emissions are presented in Tables 3.5 and 3.6.

Table 3.1: Summary of HDDV On-Terminal Driving Criteria Pollutant Emissions (tpy)

Facility Type	VMT	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Auto Terminals	73,941	1.1	0.02	0.02	0.1	0.4	0.00
Container Terms	3,809,697	62.3	1.01	0.93	4.6	24.4	0.06
Warehouses	142,078	2.3	0.04	0.03	0.2	0.9	0.00
Overall Total	**4,025,715**	**65.7**	**1.1**	**1.0**	**4.9**	**25.7**	**0.06**

Table 3.2: Summary of HDDV On-Terminal Driving Greenhouse Gas Emissions (tpy)

Facility Type	VMT	CO_2	N_2O	CH_4	CO_2 Equivalent
Auto Terminals	73,941	127	0.0004	0.0004	127
Container Terms	3,809,697	6,829	0.020	0.021	6,836
Warehouses	142,078	253	0.001	0.001	253
Overall Total	**4,025,715**	**7,209**	**0.02**	**0.02**	**7,216**

Table 3.3: Summary of HDDV On-Terminal Idling Criteria Pollutant Emissions (tpy)

Facility Type	Idling Hours	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Auto Terminals	104,570	15.6	0.42	0.39	0.50	3.6	0.00
Container Terms	3,252,974	484	13	12	18	128	0.14
Warehouses	126,059	18.7	0.51	0.47	0.68	4.9	0.01
Overall Total	**3,483,603**	**518.4**	**14.13**	**13.00**	**19.07**	**136.7**	**0.15**

Table 3.4: Summary of HDDV On-Terminal Idling Greenhouse Gas Emissions (tpy)

Facility Type	Idling Hours	CO_2	N_2O	CH_4	CO_2 Equivalent
Auto Terminals	104,570	451	0.002	0.002	452
Container Terms	3,252,974	14,578	0.052	0.048	14,595
Warehouses	126,059	562	0.002	0.002	563
Overall Total	**3,483,603**	**15,591**	**0.06**	**0.05**	**15,609**

Table 3.5: Summary of Total HDDV On-Terminal Criteria Pollutant Emissions (tpy)

Facility Type	VMT	Idling Hours	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Auto Terminals	73,941	104,570	16.6	0.44	0.41	0.58	3.9	0.01
Container Terms	3,809,697	3,252,974	546	14	13	23	153	0.20
Warehouses	142,078	126,059	21.0	0.55	0.50	0.85	5.8	0.01
Overall Total	**4,025,715**	**3,483,603**	**583.6**	**14.99**	**13.91**	**24.43**	**162.7**	**0.22**

Table 3.6: Summary of Total HDDV On-Terminal Greenhouse Gas Emissions (tpy)

Facility Type	VMT	Idling Hours	CO_2	N_2O	CH_4	CO_2 Equivalent
Auto Terminals	73,941	104,570	578	0.002	0.002	578
Container Terms	3,809,697	3,252,974	21,408	0.072	0.069	21,431
Warehouses	142,078	126,059	815	0.003	0.003	816
Overall Total	**4,025,715**	**3,483,603**	**22,801**	**0.08**	**0.07**	**22,826**

3.1.2 On-Road Emissions

Table 3.7 presents estimates of on-road, off-terminal criteria pollutant emissions by state (tpy) for the container terminal truck calls, and Table 3.8 presents the greenhouse gas emission estimates for the same facilities. The geographical breakdown of these emissions by county is presented in Section 3.2.

Table 3.7: Summary of HDDV On-Road Criteria Pollutant Emissions by State (tpy)

State	VMT	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
New Jersey	93,039,652	1,230	24.7	22.7	58.6	254.5	1.6
New York	21,965,760	290	5.8	5.4	13.8	60.1	0.4
Total	**115,005,411**	**1,520**	**30.5**	**28.1**	**72.4**	**314.6**	**2.0**

Table 3.8: Summary of HDDV On-Road Greenhouse Gas Emissions by State (tpy)

State	VMT	CO_2	N_2O	CH_4	CO_2 Equivalent
New Jersey	93,039,652	166,784	0.49	0.52	166,798
New York	21,965,760	39,376	0.12	0.12	39,376
Total	**115,005,411**	**206,160**	**0.61**	**0.64**	**206,174**

3.1.3 Total HDDV On-Terminal and On-Road Related Emissions

The totals of on-terminal and on-road, off-terminal emissions (for container, auto and warehouse facilities) are presented in Table 3.9 (criteria pollutants) and Table 3.10 (greenhouse gases).

Table 3.9: Total Marine Terminal Criteria Pollutant Emission Estimates, tpy

Activity Component	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
On-Terminal Driving	66	1	1	5	26	0.06
On-Terminal Idling	518	14	13	19	137	0.15
On-Road Driving	1,520	30	28	72	315	2.0
Totals	**2,104**	**46**	**42**	**96**	**477**	**2**

Table 3.10: Total Marine Terminal Greenhouse Gas Emission Estimates, tpy

Activity Component	CO_2	N_2O	CH_4	CO_2 Equivalent
On-Terminal Driving	7,209	0.021	0.022	7,216
On-Terminal Idling	15,591	0.056	0.052	15,609
On-Road Driving	206,160	0.61	0.64	206,174
Totals	**228,961**	**0.69**	**0.72**	**228,999**

3.2 Heavy Duty Diesel Vehicle Emission Comparisons

This section presents the heavy-duty truck emission estimates detailed in section 3.1 in the context of countywide and non-attainment area-wide emissions. Port Authority marine terminal-related truck emissions are compared with all emissions in the NYNJLINA on a county-by-county basis. Overall county-level emissions were excerpted from the most recent National Emissions Inventory database.[10]
Table 3.11 summarizes estimated criteria pollutant emissions from the Port Authority marine terminal heavy-duty truck related activities reported in this current inventory, at the county level. Subsequent Tables 3.12 through 3.18 examine each pollutant individually, comparing Port Authority marine terminal-related truck activity with total county level emissions. Figures 3.1 through 3.7 summarize the same information visually on an individual county basis. Each column displays the countywide emissions and the Port Authority marine terminal truck contribution to total emissions is stacked on top of the countywide column.

Table 3.11: Summary of Heavy-duty Diesel Vehicle Criteria Pollutant Emissions by County (on-terminal and on-road), tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	103	2.1	1.9	4.9	21.3	0.1	13,969
Essex	NJ	514	10.9	10.0	23.9	114.4	0.6	59,680
Hudson	NJ	250	5.2	4.8	11.7	54.3	0.3	30,637
Middlesex	NJ	336	6.8	6.2	16.0	69.6	0.4	45,600
Monmouth	NJ	22	0.5	0.4	1.1	4.7	0.0	3,050
Union	NJ	489	11.8	10.9	21.2	126.0	0.3	33,518
New Jersey subtotal		**1,715**	**37.2**	**34.2**	**78.8**	**390.3**	**1.7**	**186,454**
Bronx	NY	34	0.7	0.6	1.6	7.1	0.0	4,661
Kings (Brooklyn)	NY	81	1.7	1.6	3.8	17.6	0.1	9,794
Nassau	NY	49	1.0	0.9	2.3	10.2	0.1	6,689
New York	NY	12	0.2	0.2	0.6	2.4	0.0	1,604
Orange	NY	31	0.6	0.6	1.5	6.5	0.0	4,256
Queens	NY	30	0.6	0.5	1.4	6.2	0.0	4,032
Richmond (Staten Island)	NY	96	2.5	2.3	3.7	25.0	0.0	3,874
Rockland	NY	4	0.1	0.1	0.2	0.8	0.0	537
Suffolk	NY	24	0.5	0.4	1.1	4.9	0.0	3,242
Westchester	NY	28	0.6	0.5	1.3	5.8	0.0	3,816
New York subtotal		**390**	**8.5**	**7.8**	**17.6**	**86.6**	**0.4**	**42,507**
TOTAL		**2,104**	**46**	**42**	**96**	**477**	**2**	**228,961**

[10] See: 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table 3.12: Comparison of Heavy-duty Diesel Vehicle NO_x Emissions with Overall NO_x Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	103	0.54%
Essex	NJ	22,236	514	2.31%
Hudson	NJ	32,088	250	0.78%
Middlesex	NJ	20,821	336	1.62%
Monmouth	NJ	13,899	22	0.16%
Union	NJ	19,833	489	2.47%
New Jersey Subtotal		**128,097**	**1,715**	**1.34%**
Bronx	NY	11,643	34	0.30%
Kings (Brooklyn)	NY	26,732	81	0.30%
Nassau	NY	24,574	49	0.20%
New York	NY	30,058	12	0.04%
Orange	NY	12,424	31	0.25%
Queens	NY	31,662	30	0.09%
Richmond (Staten Island)	NY	9,273	96	1.03%
Rockland	NY	6,529	4	0.06%
Suffolk	NY	39,738	24	0.06%
Westchester	NY	18,692	28	0.15%
New York Subtotal		**211,324**	**390**	**0.2%**
TOTAL		**339,421**	**2,104**	**0.62%**

Figure 3.1: Comparison of Heavy-duty Diesel Vehicle NO_x Emissions with Overall NO_x Emissions by County, tpy

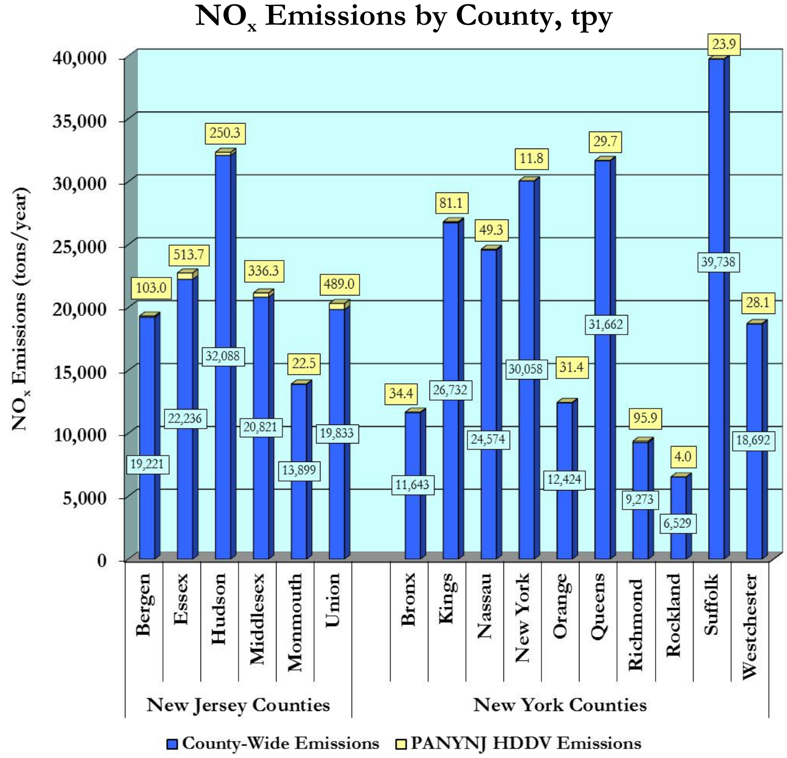


Table 3.13: Comparison of Heavy-duty Diesel Vehicle PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	2.1	0.05%
Essex	NJ	2,818	10.9	0.39%
Hudson	NJ	4,781	5.2	0.11%
Middlesex	NJ	6,117	6.8	0.11%
Monmouth	NJ	4,133	0.5	0.011%
Union	NJ	3,276	11.8	0.4%
New Jersey Subtotal		**24,911**	**37**	**0.15%**
Bronx	NY	5,001	0.7	0.01%
Kings (Brooklyn)	NY	9,931	1.7	0.02%
Nassau	NY	6,991	1.0	0.014%
New York	NY	8,373	0.2	0.003%
Orange	NY	11,812	0.6	0.005%
Queens	NY	9,814	0.6	0.006%
Richmond (Staten Island)	NY	2,446	2.5	0.10%
Rockland	NY	1,890	0.1	0.004%
Suffolk	NY	12,124	0.5	0.004%
Westchester	NY	9,427	0.6	0.006%
New York Subtotal		**77,809**	**9**	**0.01%**
TOTAL		**102,720**	**46**	**0.04%**

Figure 3.2: Comparison of Heavy-duty Diesel Vehicle PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

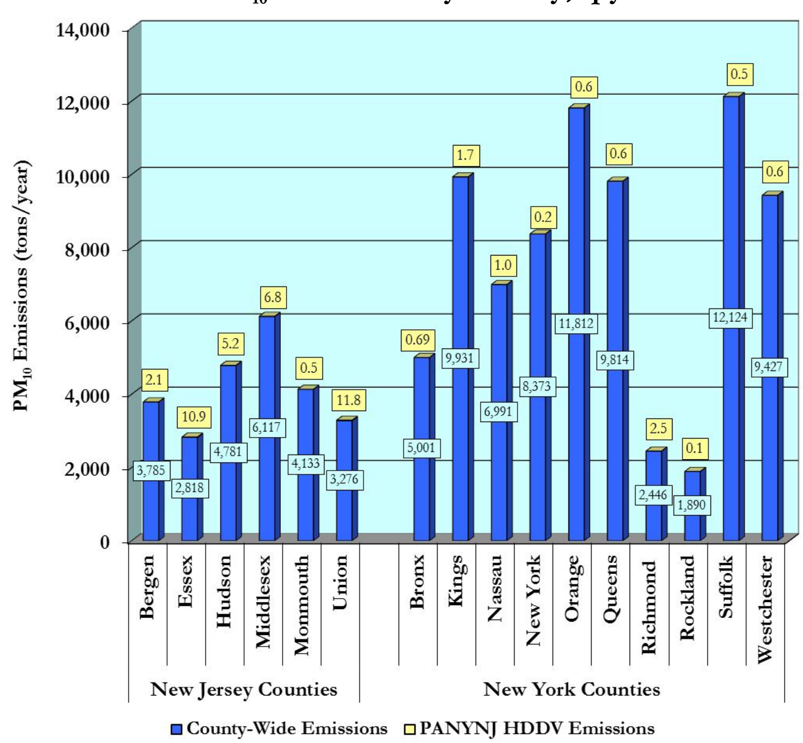


Table 3.14: Comparison of Heavy-duty Diesel Vehicle $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	1.9	0.16%
Essex	NJ	1,202	10.0	0.83%
Hudson	NJ	3,577	4.8	0.13%
Middlesex	NJ	1,784	6.2	0.35%
Monmouth	NJ	1,116	0.4	0.04%
Union	NJ	1,578	10.9	0.69%
New Jersey Subtotal		**10,416**	**34**	**0.3%**
Bronx	NY	1,480	0.6	0.04%
Kings (Brooklyn)	NY	2,966	1.6	0.05%
Nassau	NY	2,006	0.9	0.05%
New York	NY	3,430	0.2	0.006%
Orange	NY	2,351	0.6	0.02%
Queens	NY	3,108	0.5	0.02%
Richmond (Staten Island)	NY	801	2.3	0.29%
Rockland	NY	552	0.1	0.013%
Suffolk	NY	3,757	0.4	0.01%
Westchester	NY	2,111	0.5	0.02%
New York Subtotal		**22,563**	**8**	**0.03%**
TOTAL		**32,978**	**42**	**0.13%**

Figure 3.3: Comparison of Heavy-duty Diesel Vehicle $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by county, tpy

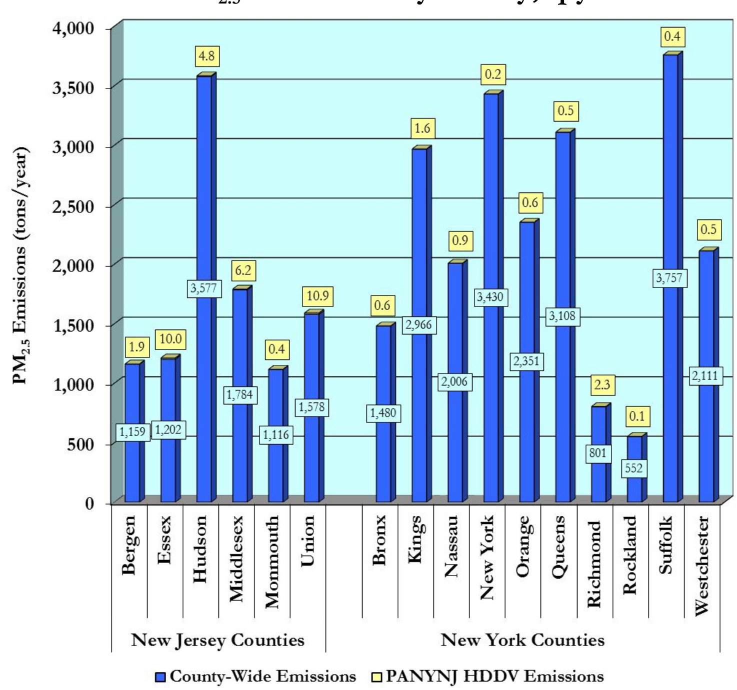


Table 3.15: Comparison of Heavy-duty Diesel Vehicle VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	4.9	0.02%
Essex	NJ	15,376	23.9	0.16%
Hudson	NJ	11,073	11.7	0.11%
Middlesex	NJ	21,598	16.0	0.07%
Monmouth	NJ	16,478	1.1	0.006%
Union	NJ	14,043	21.2	0.15%
New Jersey Subtotal		**100,878**	**79**	**0.08%**
Bronx	NY	26,550	1.6	0.006%
Kings (Brooklyn)	NY	47,212	3.8	0.008%
Nassau	NY	37,235	2.3	0.006%
New York	NY	45,066	0.6	0.001%
Orange	NY	13,320	1.5	0.011%
Queens	NY	47,241	1.4	0.003%
Richmond (Staten Island)	NY	10,254	3.7	0.036%
Rockland	NY	8,375	0.2	0.002%
Suffolk	NY	55,567	1.1	0.002%
Westchester	NY	27,906	1.3	0.005%
New York Subtotal		**318,727**	**18**	**0.006%**
TOTAL		**419,606**	**96**	**0.02%**

Figure 3.4: Comparison of Heavy-duty Diesel Vehicle VOC Emissions with Overall VOC Emissions by County, tpy

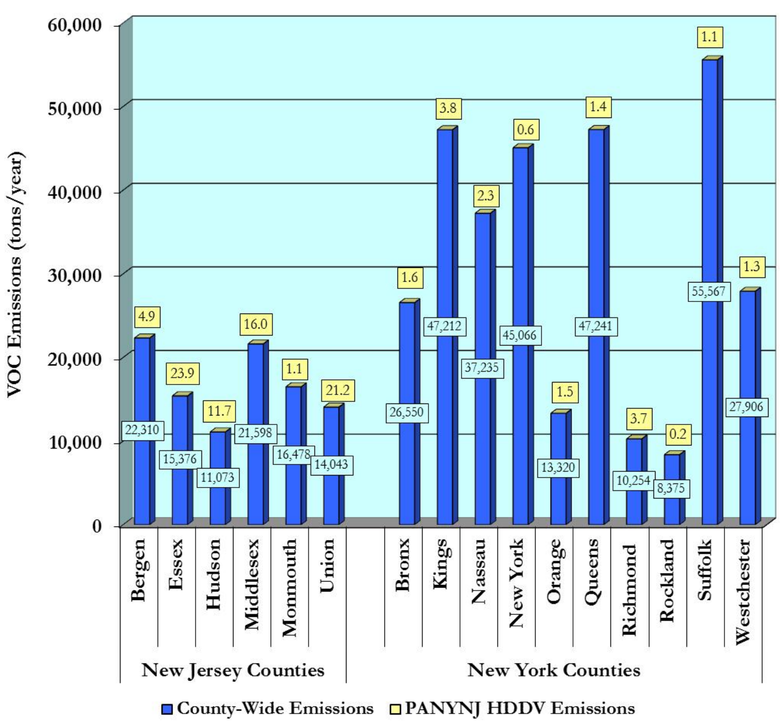


Table 3.16: Comparison of Heavy-duty Diesel Vehicle CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	21.3	0.014%
Essex	NJ	89,041	114.4	0.128%
Hudson	NJ	48,521	54.3	0.112%
Middlesex	NJ	129,636	69.6	0.054%
Monmouth	NJ	108,040	4.7	0.004%
Union	NJ	75,762	126.0	0.166%
New Jersey Subtotal		**608,842**	**390**	**0.06%**
Bronx	NY	75,120	7.1	0.009%
Kings (Brooklyn)	NY	112,068	17.6	0.016%
Nassau	NY	183,911	10.2	0.006%
New York	NY	158,713	2.4	0.002%
Orange	NY	69,889	6.5	0.009%
Queens	NY	144,316	6.2	0.004%
Richmond (Staten Island)	NY	35,204	25.0	0.071%
Rockland	NY	43,672	0.8	0.002%
Suffolk	NY	307,921	4.9	0.002%
Westchester	NY	148,488	5.8	0.004%
New York Subtotal		**1,279,304**	**87**	**0.007%**
TOTAL		**1,888,145**	**477**	**0.03%**

Figure 3.5: Comparison of Heavy-duty Diesel Vehicle CO Emissions with Overall CO Emissions by County, tpy

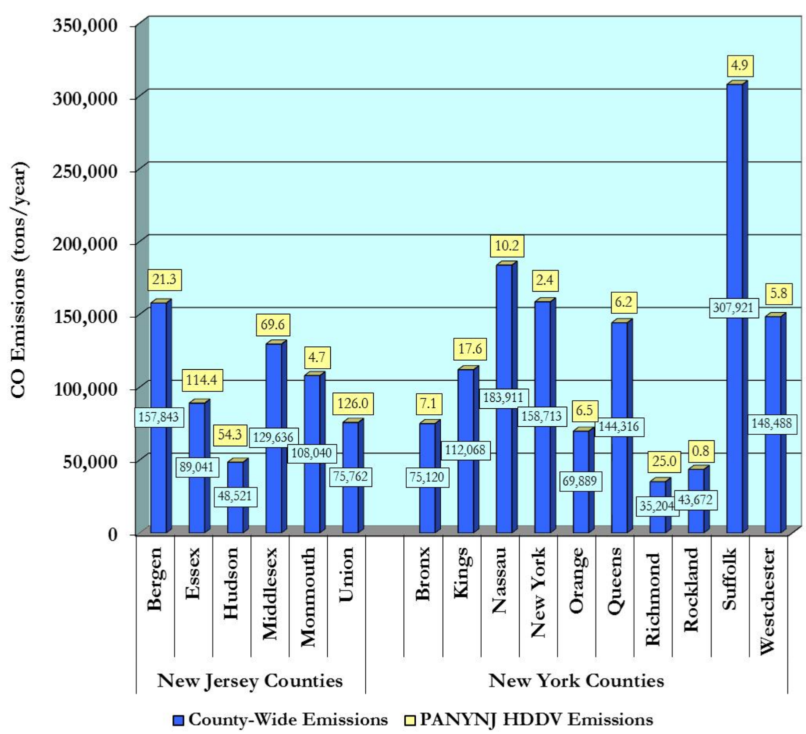


Table 3.17: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	903	0.1	0.014%
Essex	NJ	1,974	0.6	0.028%
Hudson	NJ	5,415	0.3	0.005%
Middlesex	NJ	993	0.4	0.043%
Monmouth	NJ	787	0.0	0.004%
Union	NJ	1,870	0.3	0.017%
New Jersey Subtotal		**11,941**	**2**	**0.015%**
Bronx	NY	1,868	0.0	0.002%
Kings (Brooklyn)	NY	3,980	0.1	0.002%
Nassau	NY	3,770	0.1	0.002%
New York	NY	7,114	0.0	0.000%
Orange	NY	16,368	0.0	0.000%
Queens	NY	4,302	0.0	0.001%
Richmond (Staten Islar	NY	912	0.0	0.004%
Rockland	NY	2,243	0.0	0.000%
Suffolk	NY	18,387	0.0	0.000%
Westchester	NY	4,310	0.0	0.001%
New York Subtotal		**63,255**	**0**	**0.001%**
TOTAL		**75,197**	**2**	**0.003%**

Figure 3.6: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy

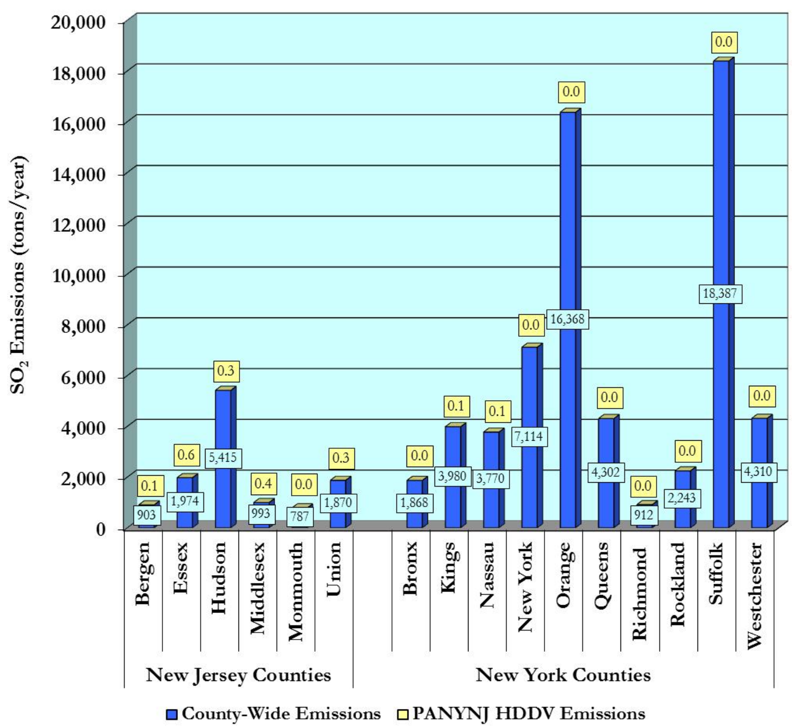
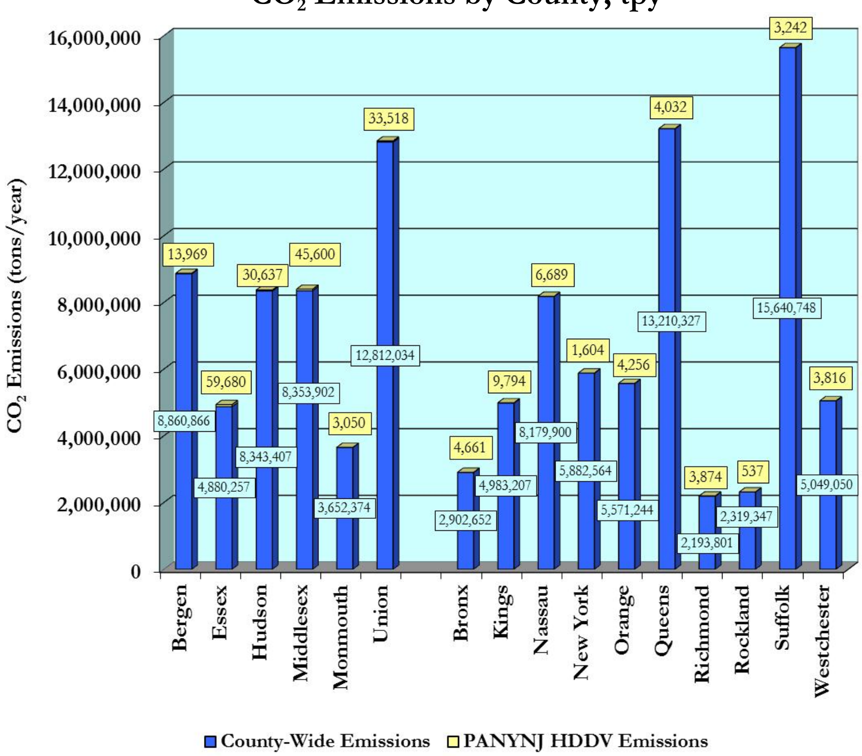


Table 3.18: Comparison of Heavy-duty Diesel Vehicle CO_2 Emissions with Overall CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	13,969	0.2%
Essex	NJ	4,880,257	59,680	1.2%
Hudson	NJ	8,343,407	30,637	0.4%
Middlesex	NJ	8,353,902	45,600	0.5%
Monmouth	NJ	3,652,374	3,050	0.1%
Union	NJ	12,812,034	33,518	0.3%
New Jersey Subtotal		**46,902,841**	**186,454**	**0.40%**
Bronx	NY	2,902,652	4,661	0.2%
Kings (Brooklyn)	NY	4,983,207	9,794	0.2%
Nassau	NY	8,179,900	6,689	0.1%
New York	NY	5,882,564	1,604	0.0%
Orange	NY	5,571,244	4,256	0.1%
Queens	NY	13,210,327	4,032	0.0%
Richmond (Staten Island)	NY	2,193,801	3,874	0.2%
Rockland	NY	2,319,347	537	0.0%
Suffolk	NY	15,640,748	3,242	0.0%
Westchester	NY	5,049,050	3,816	0.1%
New York Subtotal		**65,932,841**	**42,507**	**0.06%**
TOTAL		**112,835,682**	**228,961**	**0.20%**

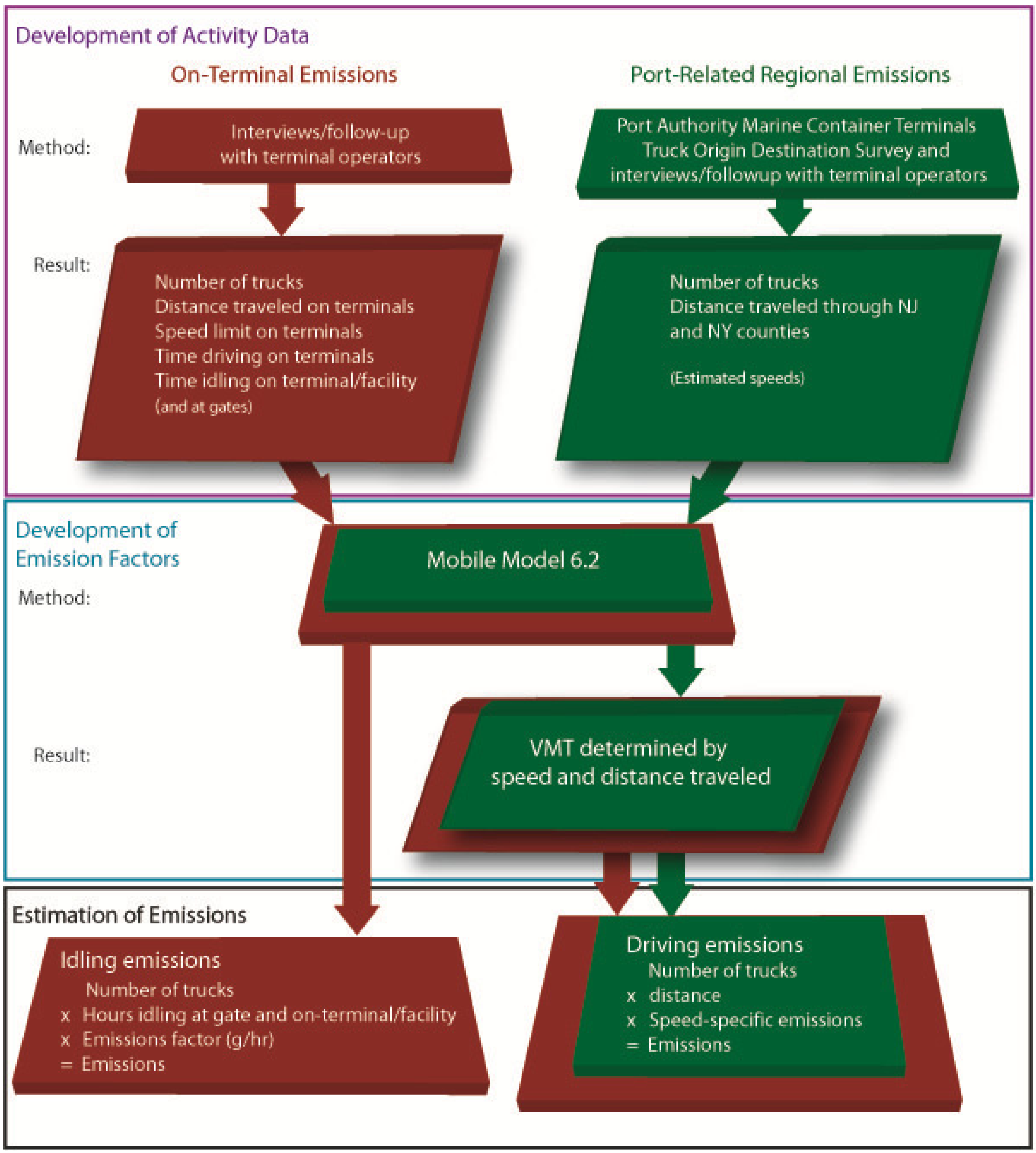
Figure 3.7: Comparison of Heavy-duty Diesel Vehicle CO_2 Emissions with Overall CO_2 Emissions by County, tpy



3.3 Heavy Duty Diesel Vehicle Emission Calculation Methodology

This section contains a description of the methodology used to collect data and the process in which emission estimates were developed. Figure 3.8 illustrates this process in a flow diagram for on-terminal and off-terminal activity.

Figure 3.8: HDDV Emission Estimating Process



3.3.1 Data Acquisition

Data for the HDDV emission estimates came from contacting the operator of each facility and requesting an update of the information provided for the previous inventory. Table 3.18 illustrates the range and average of reported characteristics of on-terminal HDDV activities at Port Authority marine terminals, which are leased to private operators for auto handling, container terminal, and warehouse operations.

Table 3.18: Summary of Reported On-Terminal Operating Characteristics

Maritime Operation	Annual Trips	Vehicle Miles Traveled	Average Speed (mph)	Average Idling Time (hours)
Auto-Handling Facilities	77,212	73,941	5	1.4
Container Terminals	3,540,469	3,809,697	15	0.9
Warehouses	208,020	142,078	12	0.6

The average idling times were based on information provided by the terminals. In addition, the prevalence of idling by trucks waiting at warehouses has been evaluated by site observations made on two different days, to account for the fact that not all trucks idle while they are being unloaded or loaded at the warehouses. On average, 35% of trucks were observed to be idling while at the warehouses – the idling time figure in the table above reflects a weighted average idling time for all trucks, idling or not (i.e., the average was calculated by dividing total idling hours by total number of truck calls). The average idling time for an individual truck that does idle is 1.7 hours, according to survey responses.

On-Road

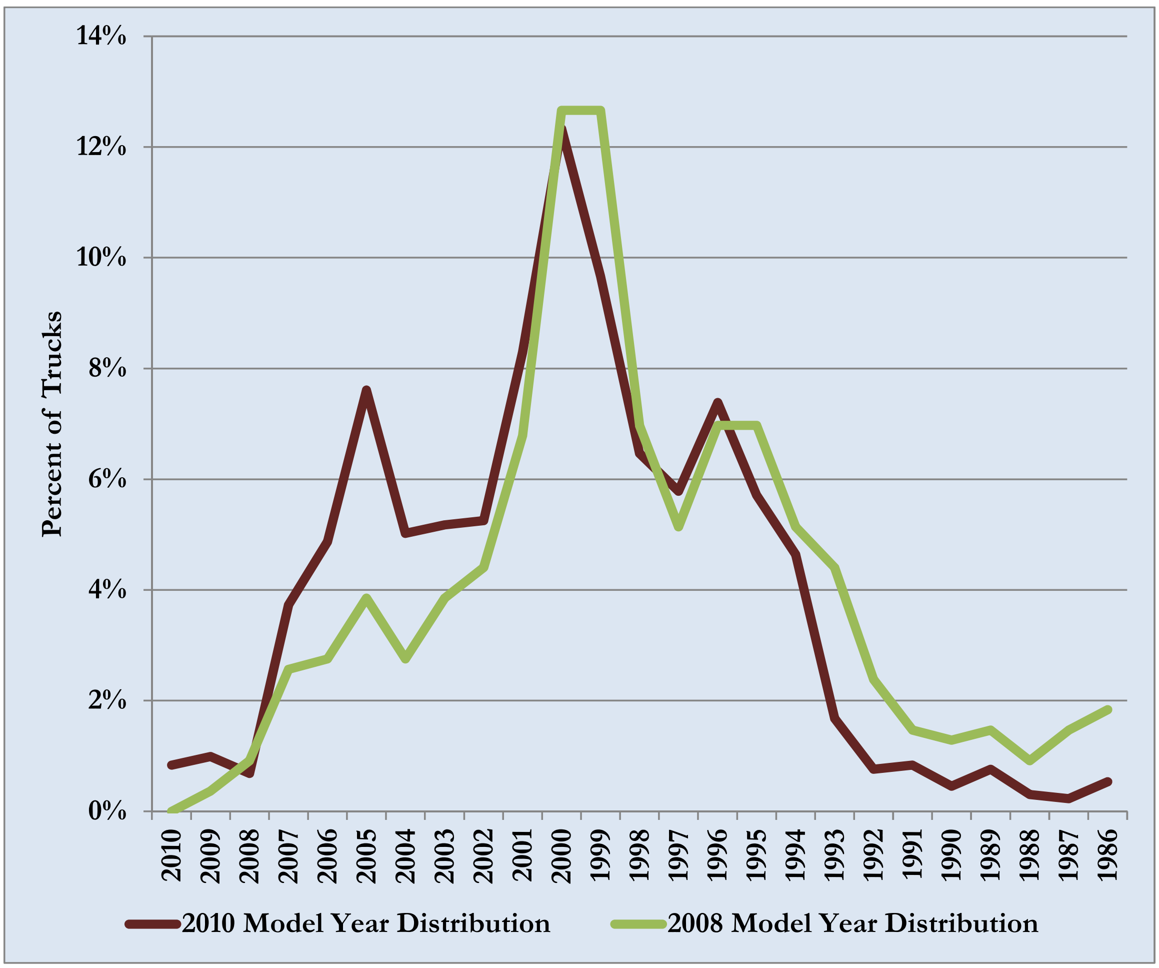
As used previously in the 2008 HDDV Emissions Inventories, Vollmer's origin/destination study[11] was used for the 2010 emissions inventory update to determine travel distance characteristics in developing the on-road emission estimates. Since annual gate counts, truck characteristics, and on-terminal activity information were collected for each of the six container terminals through the Container Truck Survey, the origin/destination study was referred to for its information on the percentages of trucks traveling to and from each of the counties. Based on this information, vehicle miles of travel (VMT) were estimated for regional HDDV activity by estimating the average distances for the terminals to the counties in the NYNJLINA. These VMT estimates were used with appropriate emission factors to estimate on-road emissions. On-road transport from on-terminal warehouses and the Port Authority auto marine terminal, which follow processing of the marine cargo with freight from other sources, are secondary in nature and are considered part of the regional traffic structure, and are therefore not included in this inventory

[11] Port Authority Marine Container Terminals – Truck Origin-Destination Survey 2005. Vollmer, November 2005, revised 2/27/2006

Model Year Distribution

In 2010, the Port Authority conducted a survey of the drayage trucks calling on Port Authority marine container terminals. This survey was an update to a similar survey conducted in 2008 to collect information on the age of the drayage trucks. The information derived from the 2008 and 2010 surveys includes the model year distribution illustrated in Figure 3.8 for the trucks serving the Port Authority terminals. Model year is an important characteristic of drayage trucks because emission standards are applicable on a model year basis and newer trucks are generally subject to stricter (lower) emission standards than older trucks. The 2010 model year distribution shows, in general, lower percentages of older model year trucks and higher percentages of newer model year trucks. These changes have resulted in reduced emissions overall from the trucks serving the Port Authority terminals.

Figure 3.9: Model Year Distribution



3.3.2 Emission Estimating Methodology

The general form of the equation for estimating vehicle emissions is:

E = EF * A

Where:

E = Emissions
EF = Emission Factor
A = Activity

Two types of activity are considered in estimating HDDV emissions: engine running with vehicle moving at a given speed, and engine idling with vehicle at rest. Running emission factors are expressed in terms of grams per mile (g/mi) while idling emission factors are expressed in terms of grams per hour (g/hr). Therefore, the activity measure used for estimating running emissions is miles and the activity measure used for estimating idling emissions is hours. The emission factor (g/mi or g/hr) is multiplied by the activity measure (VMT or hours) to estimate grams of emissions, which are then converted to pounds or tons as appropriate. The time period covered by the emission estimate corresponds to the time period of the activity measure. For example, an annual VMT figure (miles per year) multiplied by a gram per mile emission factor results in a gram per year emission estimate.

The emission factors have been developed using a software package called MOBILE6.2, which is the latest version of an emission factor model developed by EPA. MOBILE6.2 estimates speed-specific emission factors for the pollutants included in this study, in grams per mile and grams per hour, for a series of vehicle type classifications representing all types of on-road vehicles. The model includes EPA's information and assumptions regarding age distribution, annual mileage, and other operating parameters of the vehicle classes. According to the survey responses, the HDDVs associated with Port facilities are primarily in two weight capacity classes, termed HDDV8a and HDDV8b. The HDDV8b class is the highest weight class of HDDV, representing trucks with gross vehicle weight rating (GVWR) greater than 60,000 pounds, while HDDV8a is the next smaller weight rating class, representing trucks with GVWR greater than 33,000 pounds and up to 60,000 pounds. GVWR is a rating of the vehicle's total carrying capacity.

While separate estimates have been prepared for on-terminal idling as well as running (transit) emissions, the MOBILE6.2 emission factors include the effects of standard assumed amounts of idling that are encountered in travel on public roads so no additional on-road idling emissions have been estimated. EPA has proposed increased idling emission rates (for NO_x and PM emissions) for idling periods in excess of 15 minutes[12]. These rates have been used as appropriate in the on-terminal emission estimates.

[12] EPA, Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity, EPA420-B-04-001, January 2004.

Emissions from on-terminal and on-road HDDV activity were calculated in a similar manner, by multiplying the activity value by the relevant emission factor. As an example, a mileage total of 100,000 VMT would be multiplied by the relevant NO_x emission factor (e.g., 13.660 g/mi for 15 mph travel):

$$\frac{100{,}000 \text{ miles/yr} \times 14.846 \text{ g/mi}}{453.6 \text{ g/lb} \times 2{,}000 \text{ lb/ton}} = 1.6 \text{ tons/yr}$$

Similarly, for on-terminal idling emissions, total idling hours per year would be multiplied by the NOx emission factor for idling. As an example:

$$\frac{100{,}000 \text{ hours/yr} \times 135 \text{ g/hour}}{453.6 \text{g/lb} \times 2{,}000 \text{ lb/ton}} = 14.9 \text{ tons/yr}$$

The MOBILE6.2 emission factors for HDDV8a and HDDV8b vehicle classes used in the emission estimates are presented in Table 3.19.

Table 3.19: HDDV Emission Factors (g/hr and g/mi)

Component of Operation	Vehicle Class	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x	CO_2	N_2O	CH_4
Short-Term Idle (g/hr)	HDDV8a	48.770	0.602	0.554	4.240	29.747	0.036	3,880	0.0144	0.0134
	HDDV8b	55.166	0.602	0.554	4.989	35.741	0.038	4,066	0.0144	0.0134
Extended Idle (g/hr)	HDDV8a	135.000	3.680	3.386	4.240	29.747	0.036	3,880	0.0144	0.0134
	HDDV8b	135.000	3.680	3.386	4.989	35.741	0.038	4,066	0.0144	0.0134
On-Terminal (g/mi)	HDDV8a	13.075	0.241	0.221	0.939	4.833	0.014	1,552	0.0048	0.0051
(15 mph avg. speed)	HDDV8b	14.846	0.241	0.221	1.105	5.807	0.015	1,626	0.0048	0.0051
Off-Port Roads (g/mi)	HDDV8a	10.534	0.241	0.221	0.485	2.066	0.014	1,552	0.0048	0.0051
(35 mph avg. speed)	HDDV8b	11.994	0.241	0.221	0.571	2.482	0.015	1,626	0.0048	0.0051

Feedback on the surveys from the container, warehouse and auto handling facilities provided annual activity information for the on-terminal analysis. Emissions were calculated as tons per year for each maritime operation, with idling and transit activities estimated separately. Table 3.20 summarizes the terminal operating characteristics by terminal/facility type.

If a facility's information indicates that idling occurs for 15 minutes (0.25 hours) or longer the increased idling emission rates discussed above were used in the emission estimates. Otherwise, the emission estimates are based on the standard idling emission factors derived from MOBILE6.2.

On-road emissions have been calculated in the same manner as on-terminal emissions, the VMT multiplied by the appropriate emission factor, as listed above. Vehicle miles traveled within each county of the NYNJLINA have been estimated using the Vollmer origin-destination study for HDDVs servicing the container terminals.

Table 3.20: On-Terminal HDDV Operating Characteristics

Terminal Type	Number Truck Calls (annual)	Distance on Facility (miles)	Total Idle Time Each Visit	Vehicle Class	Total Distance (miles)	Total Idle Time (hours)	Extended Idling? (>15 mins)
Automobile	32,962	0.25	1.45	HDDV8A	8,241	47,795	Yes
Automobile	32,250	2.00	1.18	HDDV8A	64,500	38,055	Yes
Automobile	12,000	0.10	1.56	HDDV8B	1,200	18,720	Yes
Container	1,079,705	1.50	0.93	HDDV8B	1,619,558	1,004,126	Yes
Container	644,595	0.10	0.90	HDDV8B	64,460	580,136	Yes
Container	900,161	1.00	1.06	HDDV8B	900,161	954,171	Yes
Container	587,120	1.60	0.77	HDDV8B	939,392	636,487	Yes
Container	243,365	1.00	0.76	HDDV8B	243,365	184,957	Yes
Container	85,523	0.50	0.88	HDDV8B	42,762	118,181	Yes
Warehouse	80,000	0.25	2.31	HDDV8B	20,000	64,536	Yes
Warehouse	39,000	1.50	2.52	HDDV8B	58,500	34,227	Yes
Warehouse	38,000	0.50	1.05	HDDV8A	19,000	13,958	Yes
Warehouse	23,000	0.20	0.99	HDDV8B	4,600	7,940	Yes
Warehouse	12,000	2.00	0.37	HDDV8B	24,000	1,548	Yes
Warehouse	7,800	1.50	0.23	HDDV8B	11,700	626	No
Warehouse	3,120	0.90	1.30	HDDV8B	2,808	1,414	Yes
Warehouse	2,700	0.10	0.98	HDDV8A	270	923	Yes
Warehouse	2,400	0.50	1.06	HDDV8B	1,200	887	Yes

3.4 Description of Heavy Duty Diesel Vehicles

This section contains a description of HDDVs including their modes of operation in Port service, and the general types of vehicles. This emissions inventory includes emission estimates from HDDV operations at the following facilities in operation during 2010:

Table 3.21: Maritime Facilities by Type of HDDV Operation

Type of Operation	Marine Facility
Container Terminals	1. Port Newark Container Terminal (PNCT) at Port Newark 2. Maher Terminal at the Elizabeth PA Marine Terminal (EPAMT) 3. APM Terminal at EPAMT 4. New York Container Terminal at Howland Hook Marine Terminal 5. American Stevedoring, Inc (ASI) secondary barge depot at Port Newark 6. Global Marine Terminal
Auto Marine Terminals	1. Toyota Logistics at Port Newark 2. Foreign Auto Preparation Services (FAPS) at Port Newark 3. BMW at the Port Authority Auto Marine Terminal
On-Terminal Warehouses at Port Newark/EPAMT	1. Phoenix Beverage 2. Harbor Freight Transport 3. Eastern Warehouse 4. Export Transport Co. 5. ASA Apple Inc. 6. Van Brunt Port Jersey Warehouse Inc. 7. TRT International Ltd. 8. East Coast Warehouse & Distribution Corp. 9. P. Judge and Sons

3.4.1 Operational Modes

HDDVs are used extensively to move goods, particularly containerized cargo, to and from the marine terminals that serve as a bridge between land and sea transportation. HDDVs deliver goods to local, regional, and national destinations. Over the course of the day, HDDVs are driven onto and through these container, warehouse and/or auto-handling facilities where they deliver and/or pick up goods. They are also driven on the marine terminal roadways, which are roads situated within the boundaries of major, multi-facility terminal terminals such as Port Newark/EPAMT, and on the public roads outside these complexes.

Areas of activity for which emissions have been estimated include on-terminal (dropping off or picking up cargo) and on the public roads throughout the counties discussed in Section 1.

- On-terminal operations include driving through the terminal to drop off and/or pick up cargo, and idling while queuing, loading / unloading, and departing the terminal.
- On-road operations consist of HDDV origin/destination moves from/to the first point of rest within, or out to the limits of, the NYNJLINA region.

The "first point of rest" is the location at which import cargo (received from ships) is transferred from the first means of transport out of the arrival terminal to the ground or to another mode of transportation (such as truck-to-rail transfer). This occurs, for example, at the warehouse facilities when a container is moved from ship-side to a warehouse for transloading, which is the process of unloading import shipping containers and repacking them into other containers or enclosed trailers for transport to multiple destinations. Some warehouses are located in the vicinity of the Port Authority marine terminals while others are located within 100 miles of the Port. For example, HDDVs transport cargo from the port area to warehouses located in the lower Hudson Valley, New York, northeastern Pennsylvania, the Philadelphia area, and northern Baltimore /Delaware area.

3.4.2 Vehicle Types

This inventory deals exclusively with diesel-fueled HDDVs because these are the types of vehicles reported by the Port facilities and are by far the most prevalent type of vehicle in this service. The most common configuration of HDDV is the articulated tractor-trailer (truck and semi-trailer) having five axles, including the trailer axles. The most common type of trailer in this study area is the container trailer (known as a chassis), built to accommodate standard sized cargo containers. Another common configuration is the bobtail, which is a tractor traveling without an attached trailer. Other types include auto-carriers and flatbeds. These vehicles are all classified as HDDVs regardless of their actual weight because their classification is based on GVWR. The emissions estimates developed by the current regulatory model (discussed in subsection 3.2) do not distinguish among different configurations (e.g., whether loaded or unloaded). In the 2008 and 2010 HDDV model year surveys, most of the HDDVs were in the heaviest category, 60,000 - 80,000 pounds GVWR, with the remainder being in the 33,000 – 60,000-pound category.

Figure 3.10 is an illustration of a container truck transporting a container in a container terminal, while Figure 3.11 illustrates a truck without an attached trailer, known as a bobtail. These are typical of trucks in use at Port Authority marine terminals and are provided for illustrative purposes.

Figure 3.10: HDDV with Container

Figure 3.11: HDDV - Bobtail

SECTION 4: RAIL LOCOMOTIVES

This section presents estimated emissions from the locomotives that visit and serve the Port Authority's marine container terminals and discusses the methodologies used in developing the estimates. For the purpose of developing the emissions estimates, locomotive activity has been considered in two general categories, line haul and switching activity. Switching locomotive activity includes activity related to movement of cargo within the boundaries of the following Port Authority marine terminals:

- Port Newark
- The Elizabeth Port Authority Marine Terminal
- The Port Authority Auto Marine Terminal
- ExpressRail at Howland Hook, Staten Island

In addition, one container terminal operates a single switching locomotive to move rail cars on their terminal, and the Port Authority operates a service that uses switching locomotives to move rail cars onto and off of barges in a service that runs between Jersey City (in Hudson Co., NJ) and Brooklyn (in Kings Co., NY). These switching operations are also included in the emission estimates.

Line haul activity refers to the movement of import and export cargo from and to these Port Authority marine terminals to and from locations outside the boundary of the Port Authority facilities but within the NYNJLINA, or to and from the boundary of the NYNJLINA for trains that travel beyond the area.

After an executive summary, the following four subsections focus on:

- 4.1 - Locomotive Emission Estimates
- 4.2 - Locomotive Emission Comparisons
- 4.3 - Methodology
- 4.4 - Description of Train Activity and Locomotives

ES4.1 Executive Summary

Table ES4-1 presents the estimated locomotive criteria pollutant and CO_2 emissions in the context of overall emissions in the states of New York and New Jersey, and in the NYNJLINA, including emissions in tons per year and the percentage that PANYNJ locomotive emissions make up of overall NYNJLINA emissions. For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison.

Table ES4.1: Comparison of PANYNJ Locomotive Emissions with State and NYNJLINA Emissions, tpy

Geographical Extent / Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
New York and New Jersey	681,640	402,204	104,007	852,825	4,219,848	238,527	223,372,325
NYNJLINA	339,421	102,720	32,978	419,606	1,888,145	75,197	112,835,682
Railroad Locomotives	261	9	9	20	46	4	17,207
Percent of NYNJLINA Emissions	0.08%	0.01%	0.03%	0.005%	0.002%	0.005%	0.02%

The following figures illustrate the distribution of PANYNJ switching and line haul locomotive emissions in terms of tons per year and percent of total locomotive emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure ES4.1: Distribution and Comparison of NO_x from Locomotives, tpy and %

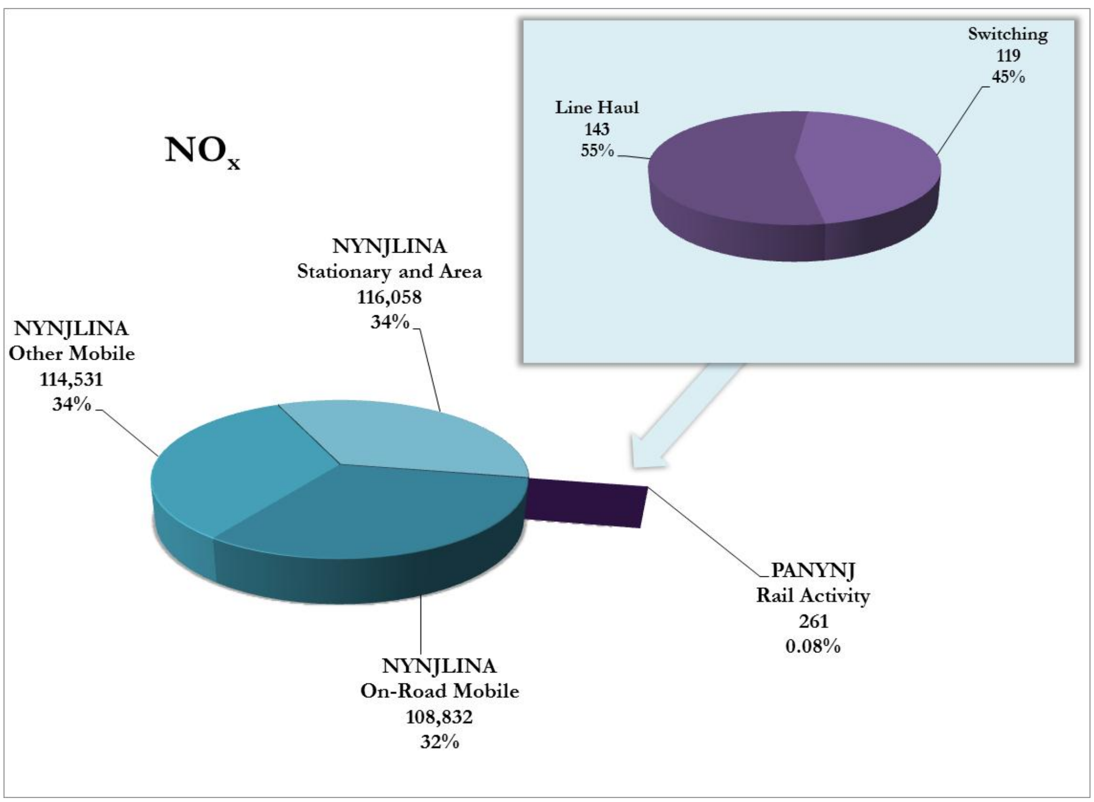


Figure ES4.2: Distribution and Comparison of PM_{10} from Locomotives, tpy and %

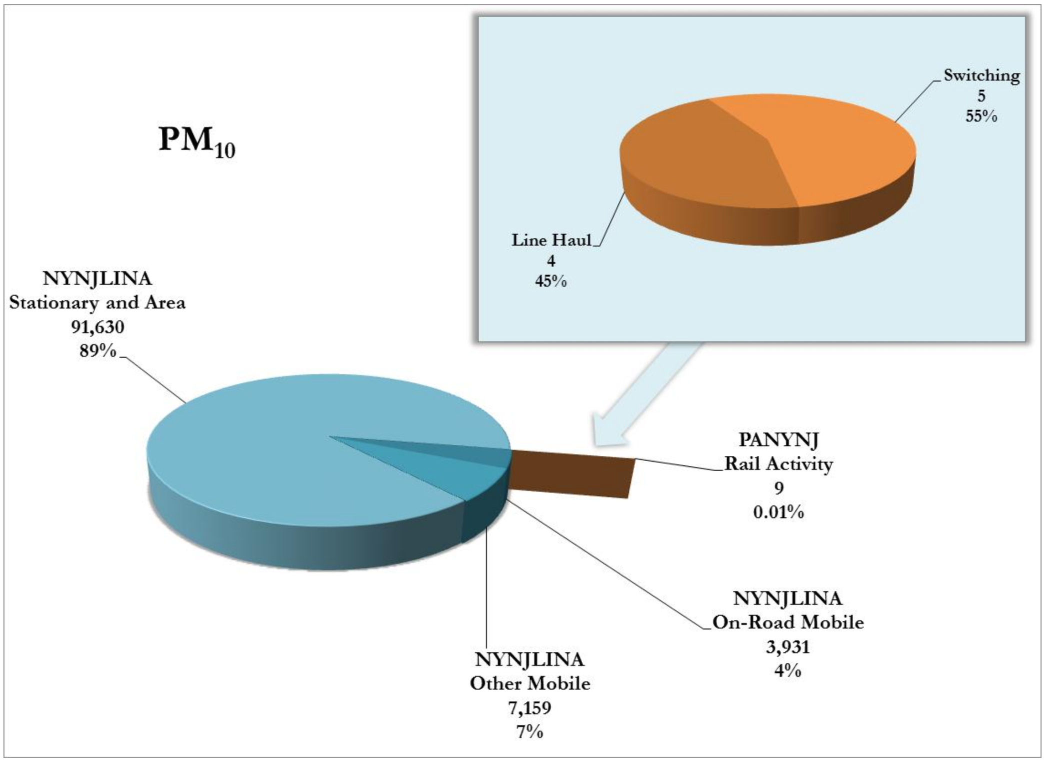


Figure ES4.3: Distribution and Comparison of $PM_{2.5}$ from Locomotives, tpy and %

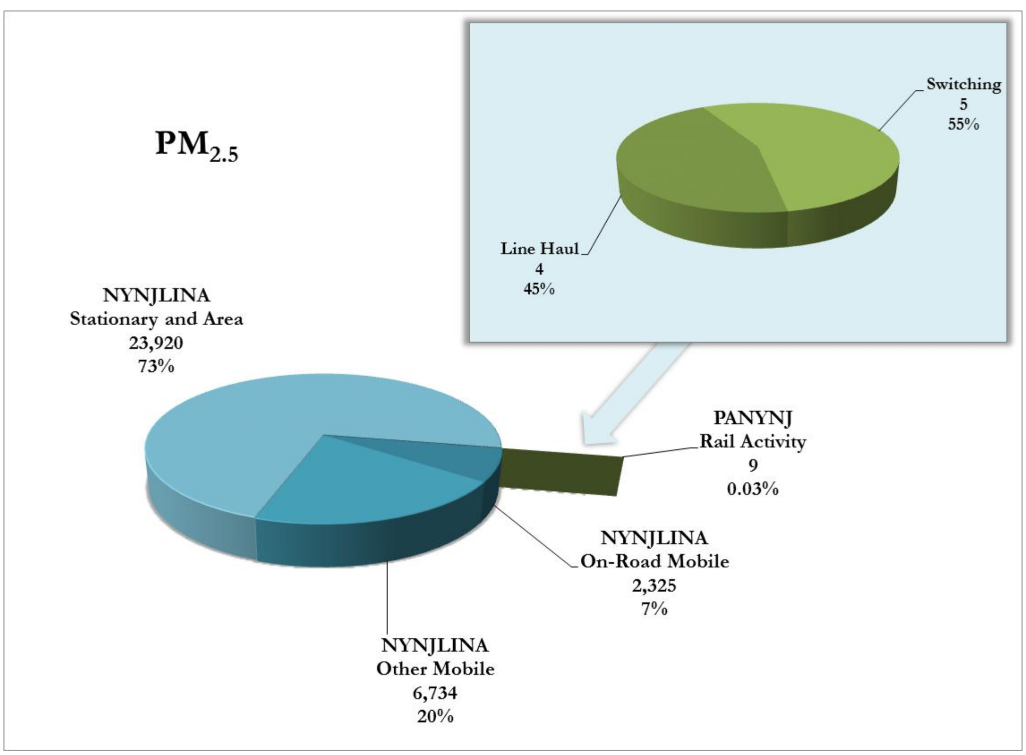


Figure ES4.4: Distribution and Comparison of VOC from Locomotives, tpy and %

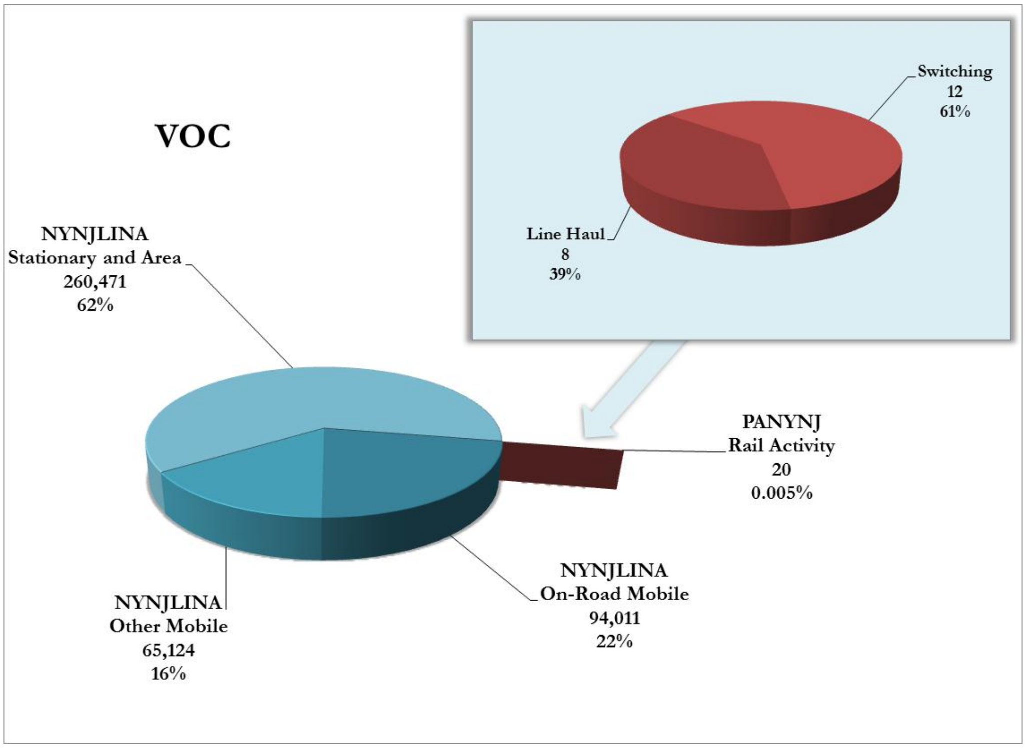


Figure ES4.5: Distribution and Comparison of CO from Locomotives, tpy and %

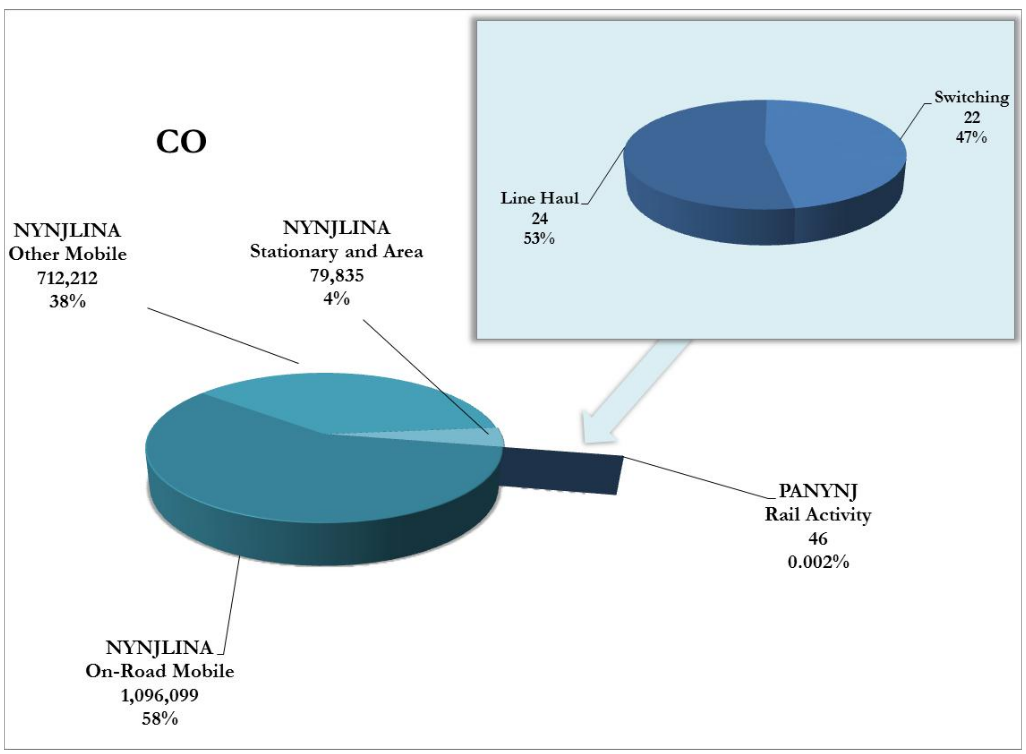


Figure ES4.6: Distribution and Comparison of SO_2 from Locomotives, tpy and %

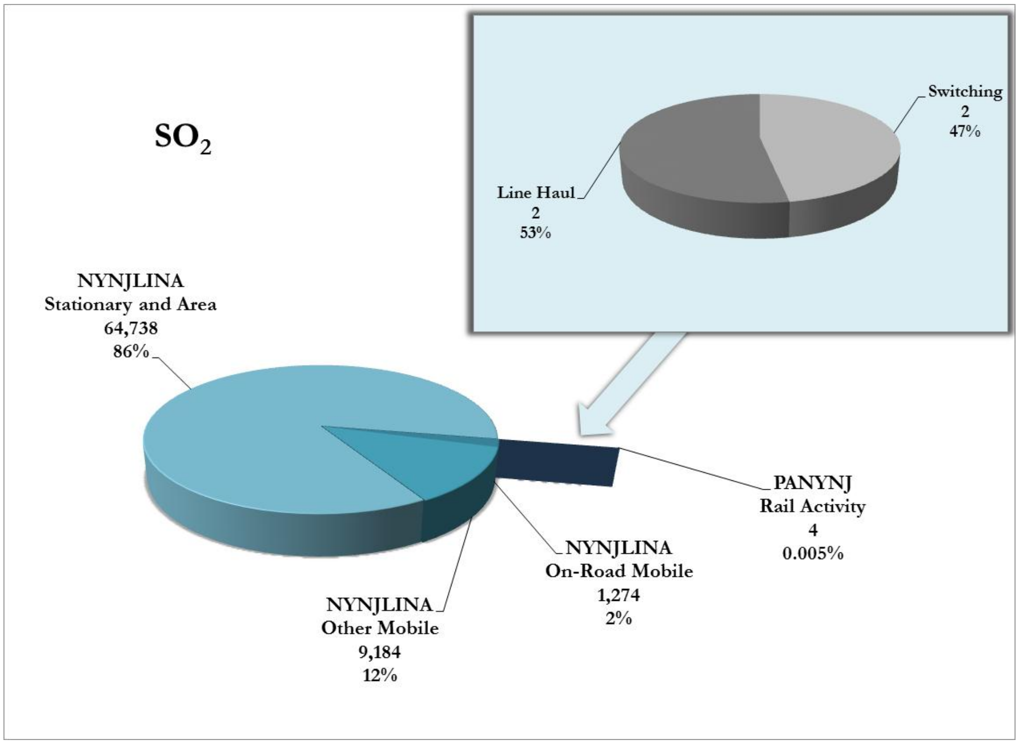
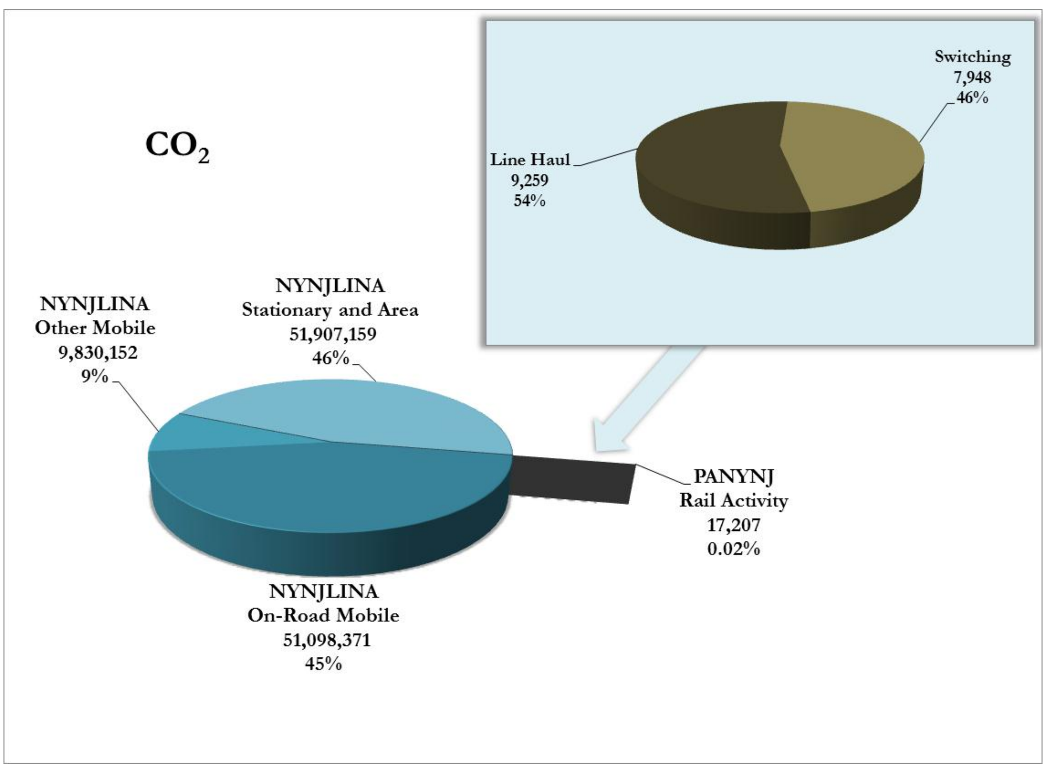


Figure ES4.7: Distribution of CO_2 from Locomotives, tpy and %



4.1 Locomotive Emission Estimates

This subsection presents the estimated emissions from line haul and switching activities associated with the Port Authority marine terminals. The relationships between these emissions and overall county and state emissions are presented and discussed in Section 4.2.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal or facility type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

Table 4.1 summarizes the line haul and criteria pollutant emissions, and Table 4.2 summarizes greenhouse gas emissions.

Table 4.1: Locomotive Criteria Pollutant Emission Estimates, tons per year

Emission Estimates	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Line Haul	143	4	4	8	24	2
Switching	119	5	5	12	22	2
Totals	**261**	**9**	**9**	**20**	**46**	**4**

Table 4.2: Locomotive Greenhouse Gas Emission Estimates, tons per year

Emission Estimates	CO_2	N_2O	CH_4	CO_2 Equivalent
Line Haul	9,259	0.22	0.73	9,343
Switching	7,948	0	1	8,021
Totals	**17,207**	**0.42**	**1.32**	**17,364**

4.2 Locomotive Emission Comparisons

This subsection presents locomotive emission estimates detailed in section 4.1 in the context of county-wide and non-attainment area-wide emissions. Port Authority marine terminal-related locomotive emissions are compared with all emissions in the NYNJLINA counties on a county-by-county basis. Overall county-level emissions were excerpted from the most recent National Emissions Inventory database.[13] Locomotive emissions are apportioned to the county level through a determination of the percentage of railroad track transiting individual counties vs. the regional track length. Thus emissions were calculated for rail trips at the county level, and were summed to yield the regional total. A more detailed discussion of the rail emission calculation methodology is presented in Section 4.3.

Table 4.3 presents estimated criteria pollutant emissions from the Port Authority marine terminal-related locomotive activity reported in this current inventory, at the county level. Subsequent Tables 4.4 through 4.10 present each pollutant individually, comparing Port related locomotive emissions with total county level emissions. Figures 4.1 through 4.7 summarize the same information visually on an individual county basis. Each column displays the county-wide emissions and stacked on top of the column is the Port Authority marine terminal locomotive contribution to total emissions.

Table 4.3: Summary of Locomotive Criteria Pollutant Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	32.1	1.0	0.9	1.7	5.5	0.4	2,082
Essex	NJ	75.4	3.1	2.9	7.1	13.8	1.2	5,085
Hudson	NJ	30.2	0.9	0.9	1.7	5.0	0.4	1,932
Middlesex	NJ	5.0	0.1	0.1	0.3	0.9	0.1	325
Monmouth	NJ	0.0	0.0	0.0	0.0	0.0	0.0	0
Union	NJ	46.3	1.8	1.7	4.0	8.4	0.7	3,099
New Jersey subtotal		**189.0**	**6.8**	**6.4**	**14.8**	**33.6**	**2.8**	**12,523**
Bronx	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
Kings (Brooklyn)	NY	1.8	0.1	0.1	0.1	0.3	0.0	97
Nassau	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
New York	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
Orange	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
Queens	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
Richmond (Staten Isld)	NY	19.3	0.8	0.8	1.9	3.4	0.3	1,256
Rockland	NY	51.3	1.5	1.4	2.7	8.7	0.7	3,331
Suffolk	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
Westchester	NY	0.0	0.0	0.0	0.0	0.0	0.0	0
New York subtotal		**72.4**	**2.4**	**2.2**	**4.7**	**12.4**	**1.0**	**4,684**
TOTAL		**261**	**9**	**9**	**20**	**46**	**4**	**17,207**

[13] See: 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Table 4.4: Comparison of Locomotive NO_x Emissions with Overall NO_x Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	32	0.17%
Essex	NJ	22,236	75	0.34%
Hudson	NJ	32,088	30	0.09%
Middlesex	NJ	20,821	5.0	0.02%
Monmouth	NJ	13,899	0.0	0.00%
Union	NJ	19,833	46	0.23%
New Jersey Subtotal		**128,097**	**189**	**0.15%**
Bronx	NY	11,643	0.0	0.00%
Kings (Brooklyn)	NY	26,732	1.8	0.01%
Nassau	NY	24,574	0.0	0.00%
New York	NY	30,058	0.0	0.00%
Orange	NY	12,424	0.0	0.00%
Queens	NY	31,662	0.0	0.00%
Richmond (Staten Isld)	NY	9,273	19.3	0.21%
Rockland	NY	6,529	51	0.79%
Suffolk	NY	39,738	0.0	0.00%
Westchester	NY	18,692	0.0	0.00%
New York Subtotal		**211,324**	**72**	**0.03%**
TOTAL		**339,421**	**261**	**0.08%**

Figure 4.1: Comparison of Locomotive NO_x Emissions with Overall NO_x Emissions by County, tpy

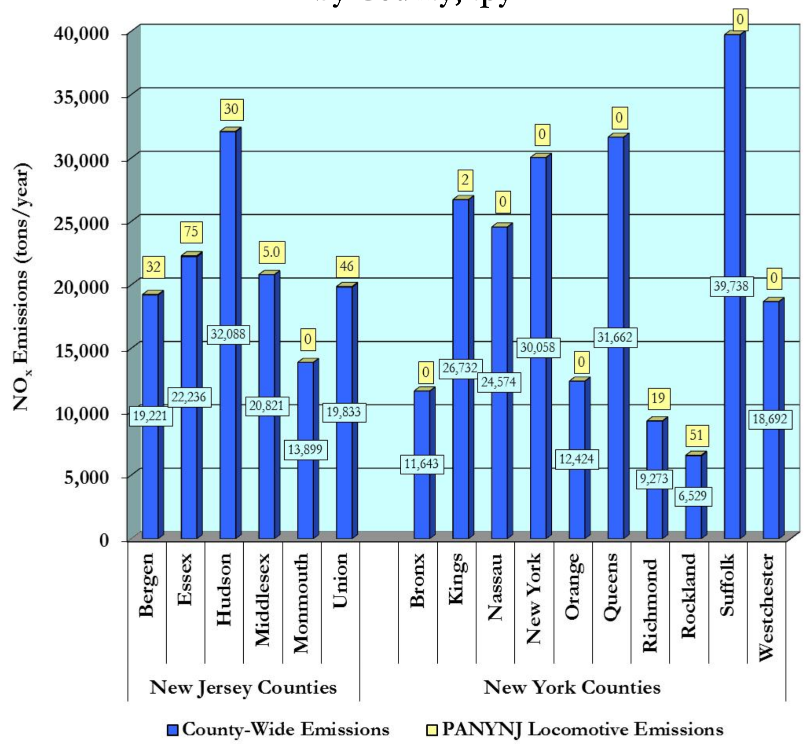


Table 4.5: Comparison of Locomotive PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	1.0	0.03%
Essex	NJ	2,818	3.1	0.11%
Hudson	NJ	4,781	0.8	0.02%
Middlesex	NJ	6,117	0.1	0.002%
Monmouth	NJ	4,133	0	0%
Union	NJ	3,276	1.8	0.05%
New Jersey Subtotal		**24,911**	**7**	**0.03%**
Bronx	NY	5,001	0	0%
Kings (Brooklyn)	NY	9,931	0	0%
Nassau	NY	6,991	0	0%
New York	NY	8,373	0	0%
Orange	NY	11,812	0	0%
Queens	NY	9,814	0	0%
Richmond (Staten Isld)	NY	2,446	1	0%
Rockland	NY	1,890	1.5	0.08%
Suffolk	NY	12,124	0	0%
Westchester	NY	9,427	0	0%
New York Subtotal		**77,809**	**2**	**0.003%**
TOTAL		**102,720**	**9**	**0.01%**

Figure 4.2: Comparison of Locomotive PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

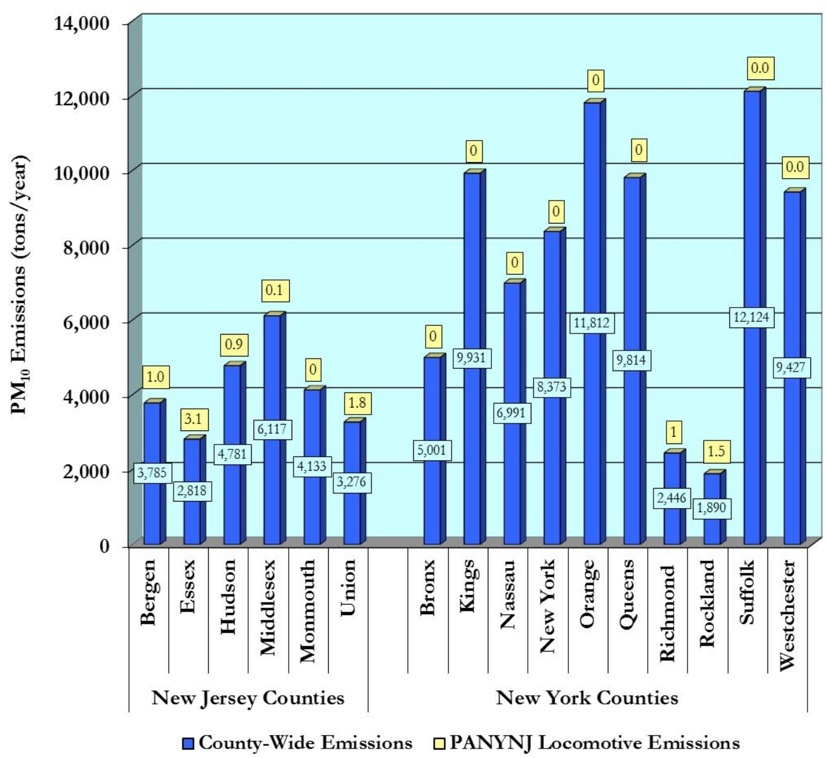


Table 4.6: Comparison of Locomotive $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	0.9	0.08%
Essex	NJ	1,202	2.9	0.24%
Hudson	NJ	3,577	0.8	0.02%
Middlesex	NJ	1,784	0.1	0.01%
Monmouth	NJ	1,116	0	0%
Union	NJ	1,578	1.7	0.11%
New Jersey Subtotal		**10,416**	**6**	**0.1%**
Bronx	NY	1,480	0	0%
Kings (Brooklyn)	NY	2,966	0	0%
Nassau	NY	2,006	0	0%
New York	NY	3,430	0	0%
Orange	NY	2,351	0	0%
Queens	NY	3,108	0	0%
Richmond (Staten Isld)	NY	801	1	0%
Rockland	NY	552	1.4	0.25%
Suffolk	NY	3,757	0	0%
Westchester	NY	2,111	0	0%
New York Subtotal		**22,563**	**2**	**0.01%**
TOTAL		**32,978**	**9**	**0.03%**

Figure 4.3: Comparison of Locomotive $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

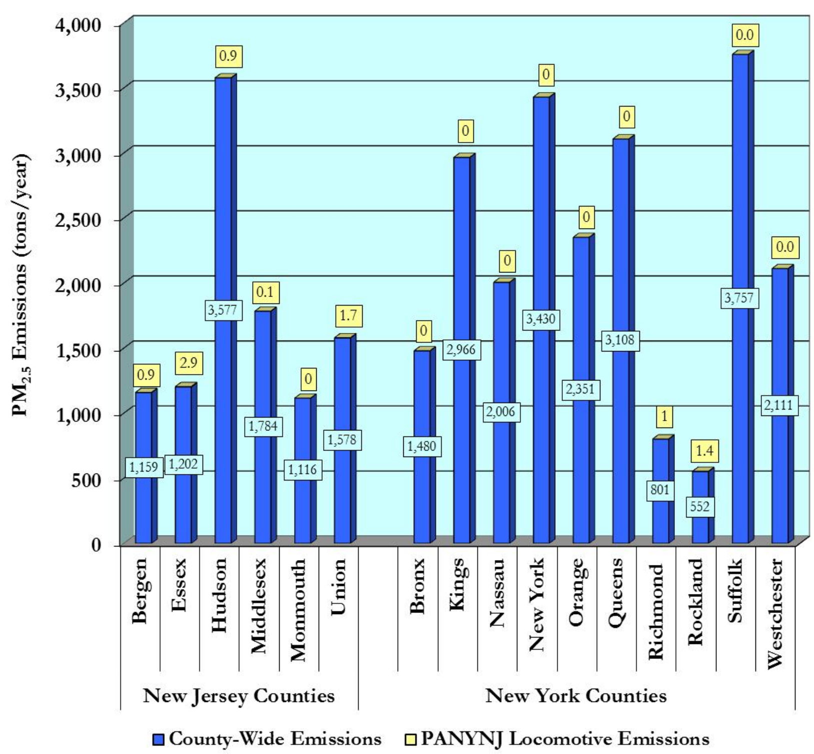


Table 4.7: Comparison of Locomotive VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	1.7	0.008%
Essex	NJ	15,376	7.1	0.046%
Hudson	NJ	11,073	1.7	0.015%
Middlesex	NJ	21,598	0.3	0.001%
Monmouth	NJ	16,478	0	0%
Union	NJ	14,043	4.0	0.03%
New Jersey Subtotal		**100,878**	**14.8**	**0.01%**
Bronx	NY	26,550	0	0%
Kings (Brooklyn)	NY	47,212	0	0%
Nassau	NY	37,235	0	0%
New York	NY	45,066	0	0%
Orange	NY	13,320	0	0%
Queens	NY	47,241	0	0%
Richmond (Staten Isld)	NY	10,254	2	0%
Rockland	NY	8,375	2.7	0.032%
Suffolk	NY	55,567	0	0%
Westchester	NY	27,906	0	0%
New York Subtotal		**318,727**	**4.7**	**0.001%**
TOTAL		**419,606**	**19.5**	**0.005%**

Figure 4.4: Comparison of Locomotive VOC Emissions with Overall VOC Emissions by County, tpy

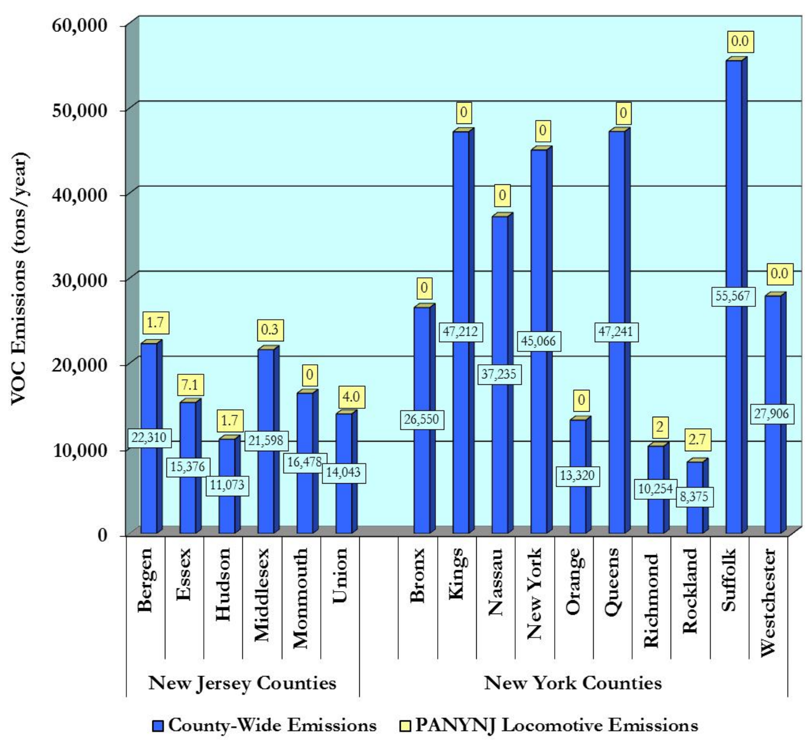


Table 4.8: Comparison of Locomotive CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	5.5	0.003%
Essex	NJ	89,041	13.8	0.016%
Hudson	NJ	48,521	5.0	0.010%
Middlesex	NJ	129,636	0.9	0.0007%
Monmouth	NJ	108,040	0.0	0.00%
Union	NJ	75,762	8.4	0.01%
New Jersey Subtotal		**608,842**	**34**	**0.006%**
Bronx	NY	75,120	0.0	0.000%
Kings (Brooklyn)	NY	112,068	0.3	0.000%
Nassau	NY	183,911	0.0	0.000%
New York	NY	158,713	0.0	0.000%
Orange	NY	69,889	0.0	0.000%
Queens	NY	144,316	0.0	0.000%
Richmond (Staten Isld)	NY	35,204	3.4	0.010%
Rockland	NY	43,672	8.7	0.020%
Suffolk	NY	307,921	0.0	0.000%
Westchester	NY	148,488	0.0	0.000%
New York Subtotal		**1,279,304**	**12**	**0.0010%**
TOTAL		**1,888,145**	**46**	**0.002%**

Figure 4.5: Comparison of Locomotive CO Emissions with Overall CO Emissions by County, tpy

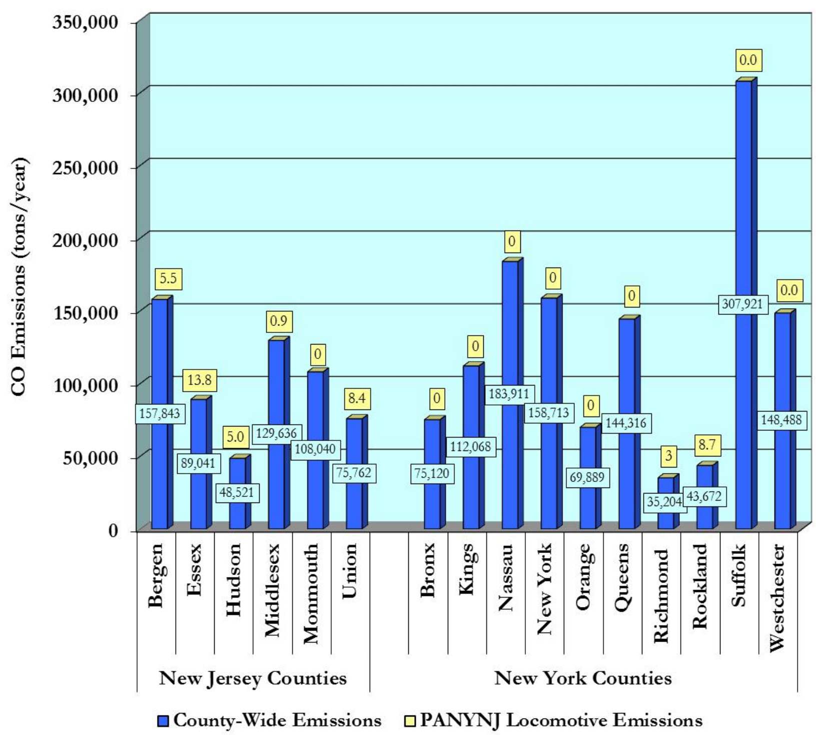


Table 4.9: Comparison of Locomotive SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	903	0.4	0.04%
Essex	NJ	1,974	1.2	0.06%
Hudson	NJ	5,415	0.4	0.01%
Middlesex	NJ	993	0.1	0.01%
Monmouth	NJ	787	0.0	0%
Union	NJ	1,870	0.7	0.04%
New Jersey Subtotal		**11,941**	**3**	**0.02%**
Bronx	NY	1,868	0.0	0.00%
Kings (Brooklyn)	NY	3,980	0.0	0.00%
Nassau	NY	3,770	0.0	0.00%
New York	NY	7,114	0.0	0.00%
Orange	NY	16,368	0.0	0.00%
Queens	NY	4,302	0.0	0.00%
Richmond (Staten Isld)	NY	912	0.3	0.03%
Rockland	NY	2,243	0.7	0.03%
Suffolk	NY	18,387	0.0	0.00%
Westchester	NY	4,310	0.0	0.00%
New York Subtotal		**63,255**	**1**	**0.002%**
TOTAL		**75,197**	**4**	**0.005%**

Figure 4.6: Comparison of Locomotive SO_2 Emissions with Overall SO_2 Emissions by County, tpy

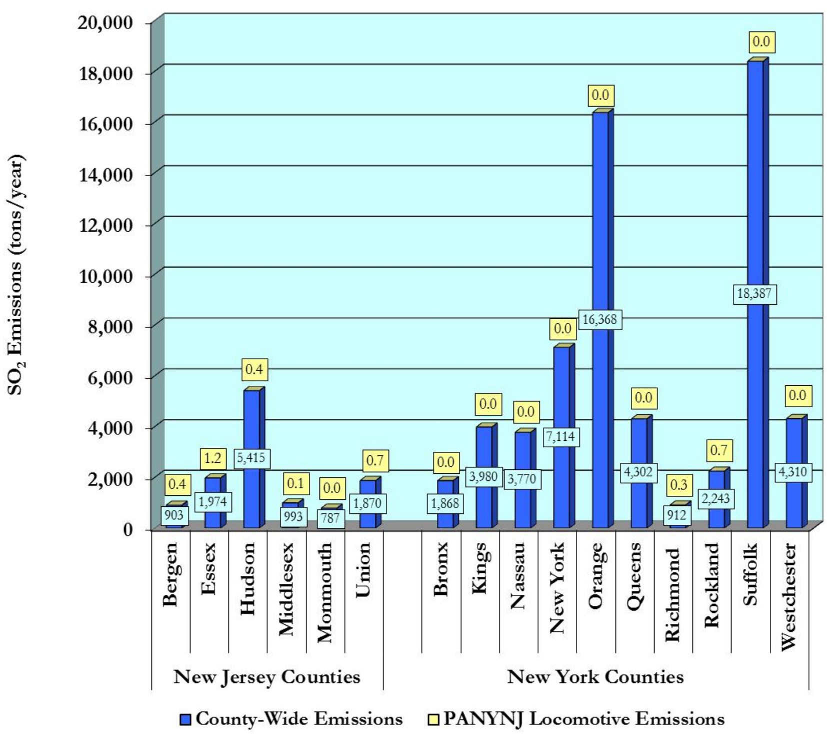
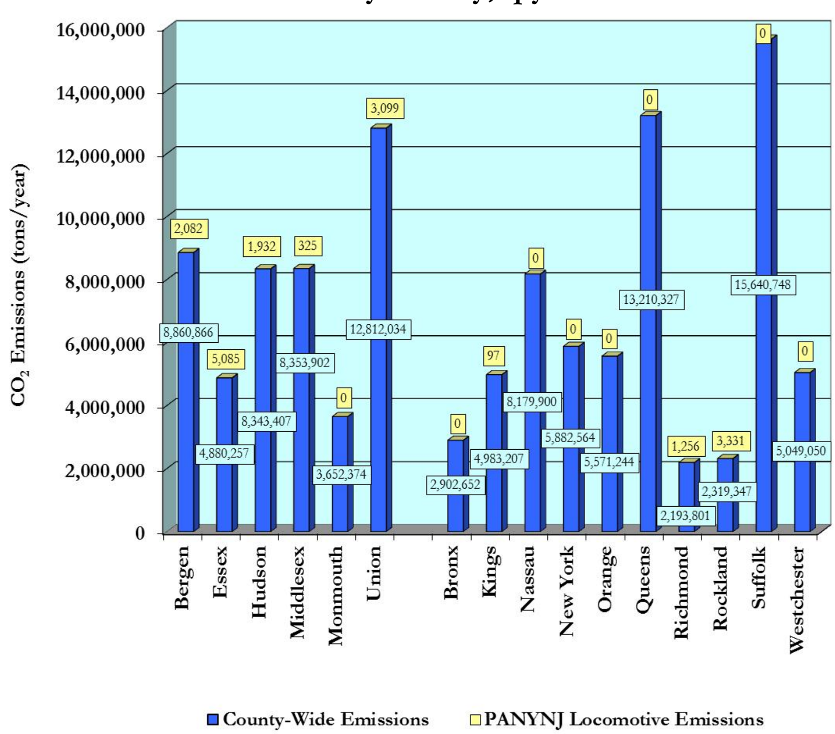


Table 4.10: Comparison of Locomotive CO_2 Emissions with Overall CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	2,082	0.02%
Essex	NJ	4,880,257	5,085	0.10%
Hudson	NJ	8,343,407	1,932	0.02%
Middlesex	NJ	8,353,902	325	0.00%
Monmouth	NJ	3,652,374	0	0.00%
Union	NJ	12,812,034	3,099	0.02%
New Jersey Subtotal		**46,902,841**	**12,523**	**0.03%**
Bronx	NY	2,902,652	0	0.00%
Kings (Brooklyn)	NY	4,983,207	97	0.00%
Nassau	NY	8,179,900	0	0.00%
New York	NY	5,882,564	0	0.00%
Orange	NY	5,571,244	0	0.00%
Queens	NY	13,210,327	0	0.00%
Richmond (Staten Isld)	NY	2,193,801	1,256	0.06%
Rockland	NY	2,319,347	3,331	0.14%
Suffolk	NY	15,640,748	0	0.00%
Westchester	NY	5,049,050	0	0.00%
New York Subtotal		**65,932,841**	**4,684**	**0.01%**
TOTAL		**112,835,682**	**17,207**	**0.02%**

Figure 4.7: Comparison of Locomotive CO_2 Emissions with Overall CO_2 Emissions by County, tpy



4.3 Locomotive Emission Calculation Methodology

There is no regulatory model available for determining rail emissions (such as the NONROAD model used for CHE and the MOBILE model used for HDDVs); therefore, emissions from locomotives have been estimated using available information and emission factors published by EPA. The following subsections detail the methodology used to develop line haul and switching emission estimates.

4.3.1 Line Haul Emissions

The information obtained regarding line haul rail service includes the total number of containers moved into and out of the Port Authority's marine terminals via rail,[14] the rail line routes used to transport these goods, an approximate schedule for these trains, and the average length of primary scheduled trains. This data has been used to estimate the total amount of fuel used by the locomotives and hence the associated emissions. Calculations were developed in three general stages, outlined in Figures 4.1, 4.2, and 4.3 in flowchart form and defined in equation form in the following discussion.

The basis of the line haul emission estimates is the amount of fuel used in the transport of cargo to and from the Port Authority marine terminals – fuel usage has been estimated using the number of train trips, train weights, and distance. Step one in this process estimates the number and lengths of trains used to transport this cargo. Step 2 estimates the weight of each of these trains (gross tons, the weight of cargo, rail cars, and locomotives); the final calculation of emissions from these trains is based on multiplying the weight moved by the distance over which the trains traveled, and multiplying the resulting estimate of gross ton-miles (GTM) by a conversion factor to estimate gallons of fuel and by fuel-based emission factors expressed as grams of emissions per million gross ton-miles (g/MMGTM)..

The emission factors for most pollutants (NO_x, PM, HC, CO) come from an EPA publication[15] issued in support of locomotive rulemaking. The EPA factors are published as energy-based factors, in units of grams per horsepower-hour. These factors have been converted to fuel-based factors using a conversion factor of 20.8 horsepower-hours per gallon of fuel, published in the same EPA document cited above. Emission factors for SO_2 and CO_2 have been developed using a mass balance approach (based on the typical amounts of sulfur and carbon in diesel fuel) and emission factors for N_2O and CH_4 were obtained from an EPA publication on greenhouse gases.[16] The emission factors for line haul locomotives are presented in Table 4.11.

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[14] "Port of NY/NJ On-Dock Rail 1991-2010," Port of New York/New Jersey Trade Statistics 1991-2010, and "Monthly Rail Report, 12/10, provided by D. Pastore, PANYNJ, 2011.

[15] "Emission Factors for Locomotives," EPA-420-F-09-025, Office of Transportation and Air Quality, April 2009

[16] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2009; April 2011; Table A- 129: Emission Factors for CH4 and N2O Emissions from Non-Highway Mobile Combustion (g gas/kg fuel).

Table 4.11: Line-Haul Locomotive Emission Factors

Units	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2	N_2O	CH_4
g/gal	157	4.7	4.3	8.3	26.7	2.2	10,186	0.25	0.79
g/hp-hr	7.5	0.23	0.21	0.40	1.28	0.11	489	0.012	0.038

Gross weights of the primary scheduled trains servicing the marine terminals have been estimated through the average number of containers carried by each train, an average weight value provided by the Port Authority, and the average length of the trains. Each railroad serving the marine terminals operates one inbound and one outbound primary train per day. Because the balance of trade favors imports, there is a need for an additional outbound train that carries fewer containers than the primary train. The process involves balancing the annual number and average capacity of the scheduled trains with the total number of containers moved by rail during the year. The starting point is the average length and schedule of primary trains servicing each marine terminal from the 2005 Port Authority rail utilization study.[17]

Using the nominal length of the scheduled trains as a starting point, the average length and capacity of the secondary trains was estimated for each of the two railroads. Table 4.12 presents the parameters and estimated average lengths of the inbound and outbound trains of both railroads. The terms in the column headings are the railroads' designations for the train service.

Table 4.12: Line-Haul Train Length Assumptions

Parameters	Q159 Outbound	Q162 Outbound	Q112 Inbound	25V Outbound	23M Outbound	24V Inbound
# of 5-platform cars per train	28	16	28	8	18	14
Length of 5-platform car, feet	300	300	300	300	300	300
Length of cargo, feet	8,400	4,800	8,400	2,400	5,400	4,200
Length of locomotive, feet	70	70	70	70	70	70
# of locomotives per train	2	2	2	1	2	2
Total locomotive length, feet	140	140	140	140	140	140
Total train length	**8,540**	**4,940**	**8,540**	**2,540**	**5,540**	**4,340**

[17] "New Jersey Marine Terminal Rail Facility 2005 Comparison Study," CH2MHILL, Port Authority of NJ&NJ, February 2006.

The total train length is calculated by multiplying the number of railcars by each car's length, and adding the number and length of locomotives, as listed in the table. In order to validate the length assumptions, the number of containers that would be carried by each length of train was calculated and annual volumes were estimated and compared with reported annual container throughputs for each railroad. These steps are illustrated in Tables 4.13 and 4.14.

Table 4.12 illustrates the estimated number of containers each average train would carry, based on 5-platform railcars, each platform capable of holding up to four TEUs (maximum load consisting of two 40-ft containers). In this table, the potential number of TEUs per train is estimated by multiplying the number of cars per train shown in the previous table by the number of platforms per car and the capacity number of TEUs per platform. Not all platforms are filled with 4 TEUs, however, and the term "density" is used to describe the percentage of potential capacity that is actually filled. The density assumptions are shown in Table 4.12. Multiplying the potential TEU capacity of the train by the density value estimates the actual TEU content of the typical train, and dividing by the average number of TEUs per container (most, but not all, containers are 40 feet, so the average is less than 2) estimates the number of containers that can be carried by the train sizes shown in the table.

Table 4.13: Line-Haul Train Container Capacities

Parameters	Q159 Outbound	Q162 Outbound	Q112 Inbound	25V Outbound	23M Outbound	24V Inbound
Platforms/car	5	5	5	5	5	5
TEUs/platform (capacity)	4	4	4	4	4	4
TEUs per train (potential)	560	320	560	160	360	280
Average "density"	85%	85%	85%	85%	85%	85%
TEUs per train (adjusted)	476	272	476	136	306	238
Average TEUs per container:	1.72	1.72	1.72	1.72	1.72	1.72
Containers per train (average)	**277**	**158**	**277**	**79**	**178**	**138**

Table 4.14 lists the train schedule assumptions, most of which are described in the rail utilization study. The secondary train schedule assumptions have been chosen to balance the total container throughputs estimated using the methods described in these paragraphs with the actual reported throughputs. The annual number of containers estimated for each railroad is the product of the number of trains per day, the days per week those trains run, and the number of containers each train can carry (from Table 4.13). The total estimated number of containers moved by the train configurations described above (and shown below in Table 4.14) corresponds to the reported 2010 on-dock rail throughput to within less than one percent. While not exact, the degree of correspondence between estimated and reported throughput provides a degree of confidence in the estimated train parameters on which the emission estimates are based.

Table 4.14: Line-Haul Train Schedules and Throughput

Parameters	Q159 Outbound	Q162 Outbound	Q112 Inbound	25V Outbound	23M Outbound	24V Inbound
Trains/day	1	1	1	1	1	1
Days/week	7	7	7	5	7	5
Trains per year	364	364	364	260	364	260
Containers/year	100,828	57,512	100,828	20,540	64,792	35,880
Total estimated contain	**259,168**			**121,212**		

The next step in estimating fuel usage is estimating the gross weight of each of the train sizes described by the previous tables. Information for these estimates was obtained from information reported by the Norfolk Southern and CSX railroads to the U.S. Surface Transportation Board in the 2010 submittals of an annual report known as the "R-1."[18] Among the details in this report are the total gross ton-miles moved by locomotives in freight service and the total freight moved in railcar-miles. Dividing gross ton-miles by car-miles provides an estimate of the average weight of a railcar in normal service (gross ton-miles / car-miles = gross tons/car). The average railcar weight estimated in this manner is shown in Table 4.15. In addition to average car weight, Table 4.15 lists the average number of railcars per train, estimated by multiplying the number of 5-platfom cars (shown in Table 4.15) by 5 (the railcars listed in the R-1 reports are analogous to a platform rather than the 5-platform railcar commonly used in container service). The average gross weight of each train type is the number of railcars multiplied by the average gross weight per car, as shown in Table 4.15.

Table 4.15: Line-Haul Train Gross Weight

Parameters	Q159 Outbound	Q162 Outbound	Q112 Inbound	25V Outbound	23M Outbound	24V Inbound
Cars per train (average)	140	80	140	40	90	70
Gross tons per car	83	83	83	83	83	83
Gross weight of train	**11,652**	**6,658**	**11,652**	**3,329**	**7,490**	**5,826**

Overall annual gross tonnage for each railroad is the gross weight of each train multiplied by the number of trains per year (shown in Table 4.14). These figures total approximately **10.9 million gross tons** for the railroad whose trains are represented by the left three columns in the previous tables, and approximately **5.1 million gross tons** for the railroad whose trains are represented by the three columns to the right.

[18] *Class I Railroad Annual Report to the Surface Transportation Board for the Year Ending Dec. 31, 2010* (Norfolk Southern Railroad) and *Class I Railroad Annual Report to the Surface Transportation Board for the Year Ending Dec. 31, 2010* (CSX Transportation, Inc.).

Since fuel use and emissions depend not only on the weight of the trains but also on the distance the trains travel, the primary routes taken by the two railroads were evaluate for distance within each county included in this inventory, and the annual number of gross tons for each railroad was multiplied by the distance. The result of this calculation is an estimate of the number of gross ton-miles associated with each county, as shown in Table 4.16. Fuel consumption in each county was estimated by multiplying the ton-miles by the factor of 1.18 gallons of fuel per thousand gross ton-miles, derived from information in the R-1 reports on fuel consumption as well as gross ton-miles. The result of this calculation step is also shown in the table below.

Table 4.16: Line Haul Locomotive Ton-Mile and Fuel Use Estimates

County	Track Mileage	Thousand Gross Ton-Miles	Gallons Fuel
North Route			
Essex	3	32,718	37,088
Hudson	13	141,776	160,717
Bergen	15	163,588	185,442
Rockland	24	261,740	296,708
South Route			
Essex	5	25,534	28,945
Union	15	76,601	86,834
Middlesex	5	25,534	28,945
Total	80	727,489	824,679

The last step is to apply the emission factors (Table 4.10) to the fuel use estimate to estimate the total locomotive emissions.

4.3.2 Switching Emissions

Switching emission estimates have been based primarily on the activity information developed for the previous Port Authority inventories of cargo handling equipment and rail emissions, and the change in Port Newark and Elizabeth PA Marine Terminal cargo throughputs between 2008 and 2010. The scaling of activity with growth in container throughput by rail should provide a reasonable estimate of activity growth.

The 2002 emission estimates were based on the number and duration of daily shift operations, and the 2006, 2008, and 2010 estimates have been made using the ratios of container throughputs by rail. For example, 2.665 million containers in 2010 divided by 2.700 million containers in 2008 results in a negative growth factor of 0.99; this was multiplied by the 2008 operating hours estimate of 38,914 for a 2010 estimate of 38,525 hours.

Emission factors for most pollutants are from the 2009 EPA publication cited above. Emission factors for SO_2 and CO_2 have been developed using a mass balance approach (based on the typical amounts of sulfur and carbon in diesel fuel) and emission factors for N_2O and CH_4 were obtained from the EPA publication on greenhouse gases cited previously. The emission factors are listed in Table 4.17. Estimates of locomotive engine emissions are based on their regulatory "Tier level," which is based on when they were built or rebuilt. The ExpressRail switchers are assumed to emit at an average of Tier 1 rates, which are applicable to locomotives built between approximately 2002 and 2004. Older locomotives would emit most pollutants at higher rates, newer locomotives would emit at lower rates; in the absence of specific fleet information, the Tier 1 rates represent a reasonably conservative approach to estimating overall switching emissions. The switching locomotives operated by the container terminal and by the rail-to-barge cross-harbor service pre-date the Tier 1 emission levels (they were manufactured in the 1960s and 1970s), so Tier 0 emission factors have been used for these locomotives.

Table 4.17: Switching Locomotive Emission Factors

Units	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x	CO_2	N_2O	CH_4
Tier 0 emission factors									
g/gal	191	6.1	6.1	15.2	27.3	3.0	10,182	0.00	1.52
g/hp-hr	12.6	0.40	0.40	1.00	1.80	0.20	672	0.000	0.100
Tier 1 emission factors									
g/gal	150	6.5	6.1	15.3	27.7	2.3	10,182	0.26	0.76
g/hp-hr	9.9	0.43	0.40	1.01	1.83	0.15	672	0.017	0.050

The emission factors are in units of grams per horsepower-hour. An estimate of annual horsepower-hours was developed from the adjusted operating hour estimate discussed above using data contained in an EPA dataset the lists average switching duty in-use horsepower for 20 locomotive models rated between 1,500 and 4,100 horsepower, averaging 3,030 horsepower. The in-use horsepower varies from 159 to 349 horsepower, with an average of 264 horsepower. Multiplying the estimate of 34,744 hours by the average in-use horsepower of 264 results in a horsepower-hour estimate of 10,265,418 for the year. The emission factors were multiplied by this total to estimate annual switching emissions. For the container terminal switching locomotive the horsepower-hours were estimated from the reported number of operating hours multiplied by the average in-use horsepower. The horsepower-hours of the rail-to-barge cross-harbor service switchers were estimated by converting the annual fuel consumption (in gallons) of these locomotives to horsepower-hours using a brake-specific fuel consumption factor, which represents the number of gallons of fuel consumed per horsepower-hour.

4.4 Description of Locomotives

This subsection describes the rail system as it served the Port Authority marine terminals in 2010 and the locomotives that were in service.

4.4.1 Operational Modes

Locomotives are used in two general modes of operation, terminal switching and line haul. Switching activities take place within a limited geographical area and are the activities related to preparing trains for transport to distant locations and to breaking up and distributing railcars from trains arriving from distant origins. Line haul refers to the movement of rail freight over long distances, between local rail yards and distant locations.

The rail activities associated with the six Port Authority marine terminals covered by this 2010 emissions inventory consist primarily of intermodal (containerized cargo) service associated with the container terminals at Port Newark and the Elizabeth PA Marine Terminal (i.e., Port Newark Container Terminal, Maher Terminal, APM Terminal), and at the Howland Hook Marine Terminal on Staten Island, New York. Switching takes place adjacent to the Port Newark Container Terminal (an operation known as ExpressRail Port Newark), at a rail facility between the APM and Maher Terminals (known as ExpressRail Elizabeth), and at the New York Container Terminal at Howland Hook (ExpressRail Staten Island). ExpressRail is operated by Consolidated Rail Corporation (Conrail), a jointly owned, private subsidiary of the Norfolk Southern and CSX Railroads, using switching locomotives owned by either Norfolk Southern or CSX.

Beyond the Port Authority marine terminals, container trains are transported to and from ExpressRail by Norfolk Southern and CSX. The primary route for CSX is north/south parallel to the Hudson River, while Norfolk Southern trains run east/west. Approximately 55 miles of the CSX route is within the counties covered by this emissions inventory, while the Norfolk Southern route includes approximately 25 miles within the area.

4.4.2 Locomotives

The locomotives used in these activities are essentially similar, although switching locomotives are usually smaller than the locomotives used in line haul service. Locomotives in switching service are often older line haul locomotives that are no longer suitable for the longer and heavier trains that are common in present-day train transport. Figure 4.8 illustrates a typical older switching locomotive, while Figure 4.9 presents a newer model switcher. These specific switch engines do not necessarily work on Port Authority marine terminals – the illustrations are provided as examples. Line haul locomotives, especially those in intermodal service (used in transporting containerized cargo) are typically in the range of 4,000 horsepower, while locomotives in switching use are smaller, typically under 3,000 horsepower. Figure 4.10 shows a typical line haul locomotive.

Locomotives operate somewhat differently than other types of land-based mobile sources in that their engines are not directly coupled to their wheels via a transmission and drive shaft; instead, the locomotive engine powers a generator or alternator that generates electricity which, in turn, powers an electric motor that turns the drive wheels. This method of operation means that locomotive engines operate under more steady-state operating conditions than more typical mobile source engines, which undergo frequent changes in speed and load during normal operation. By contrast, locomotives have been designed to operate in a series of discrete throttle positions, called notches, typically one through eight plus an idle position. Many locomotives also have an operating condition known as dynamic braking, in which the electric engine operates as a generator to help slow the train, with the generated power being dissipated as heat.

Because line haul locomotives are used to transport cargo across large areas of the country, they are dispatched by the railroads that own and operate them on the basis of where they are needed and not on the basis of any discrete operating area. Therefore, there are no "local fleets" of line haul locomotives. To a large extent this is also true of switching locomotives, which can be moved among several rail yards in the area, most of which are not directly associated with Port Authority marine terminals. For this reason, the emission estimates discussed in the previous subsections are based on activity patterns and general locomotive and train characteristics rather than locomotive-specific information.

Figure 4.8: Example Switching Locomotives at On-Dock Rail Facility

Photo courtesy of PANYNJ

Figure 4.9: Example Switching Locomotive

Photo courtesy of PANYNJ

Figure 4.10: Example Line Haul Locomotive

Photograph courtesy of Richard C. Borkowski, Pittsburgh, PA
http://www.railpictures.net/viewphoto.php?id=259556

SECTION 5: COMMERCIAL MARINE VESSELS

This section presents estimated emissions from ocean-going vessels and harbor craft, collectively known as commercial marine vessels (CMVs), calling at the following Port Authority marine terminals. These include:

- Port Newark
- Elizabeth Port Authority Marine Terminal
- Port Jersey Port Authority Marine Terminal
- Howland Hook Marine Terminal
- Brooklyn Port Authority Marine Terminal

The Port of New York and New Jersey also includes many marine terminals that are privately owned and operated, which do not come under the aegis of the Port Authority of New York and New Jersey – such as the various fuel and oil depots situated along the Arthur Kill/Kill Van Kull waterways. The emissions from vessels calling at these terminals are not included in this inventory.

The geographic area covered by this inventory remains unchanged from the 2000, 2006 and 2008 commercial marine vessel emissions inventories. It includes the counties within the New York New Jersey Long Island Non-Attainment Area (NYNJLINA) in which Port Authority marine terminal related CMV activity occurs, and is bounded on the ocean side by the three-nautical-mile demarcation line off the eastern coast of the U.S. This line (shown in Figure 5.1 below) is also the boundary of the New York – New Jersey Harbor System (NYNJHS), as designated by the U.S. Army Corps of Engineers. The NYNJHS encompasses the predominant CMV activity area within the region. The counties within this area that include marine vessel activity include the New York counties Bronx, Kings, Queens, Richmond, Nassau, New York, Orange, Rockland, Suffolk, Westchester; and the New Jersey counties Bergen, Monmouth, Ocean, Middlesex, Hudson, Essex, and Union. However, Ocean County, New Jersey, has not been included with the NYNJLINA counties listed in various tables in this report because there are no identified Port Authority marine terminal related CMV activities or emissions within the county.

In many cases, vessel travel lanes do not fall neatly within one or another county. Best efforts have been made to reasonably allocate emissions to the relevant counties (and states).

Following an Executive Summary that presents an overview of commercial marine vessel emissions from the PANYNJ activity compared with overall emissions in the NYNJLINA and New York/New Jersey, the following four subsections focus on:

- 5.1 - Emission Estimates
- 5.2 - Emission Comparisons
- 5.3 - Methodology
- 5.4 - Description of Vessels

ES5.1 Executive Summary

Table ES5.1 presents the estimated commercial marine vessel (CMV) criteria pollutant and CO_2 emissions in the context of overall emissions in the states of New York and New Jersey, and in the NYNJLINA, including emissions in tons per year and the percentage that PANYNJ CMV emissions make up of overall NYNJLINA emissions. For this inventory, the PANYNJ CO_2 emissions are compared to the latest NYNJLINA CO_2 emissions. The other greenhouse gases, N_2O and CH_4, have not been completely estimated on a county or regional level by EPA or the states and therefore are not included in the comparison. However, they make up a very small fraction of the greenhouse gases emitted by mobile sources.

Table ES5.1: Comparison of PANYNJ CMV Emissions with State and NYNJLINA Emissions, tpy

Geographical Extent / Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x	CO_2
New York and New Jersey	681,640	402,203	104,007	852,825	4,219,848	238,526	223,372,326
NYNJLINA	339,421	102,720	32,978	419,606	1,888,145	75,197	112,835,682
OGVs and Harbor Craft	3,419	315	255	152	332	2,707	175,233
% of NYNJLINA Emissions	**1.01%**	**0.31%**	**0.77%**	**0.04%**	**0.02%**	**3.60%**	**0.16%**

The following figures illustrate the distribution of PANYNJ CMV emissions by vessel type in terms of tons per year and percent of total CMV emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Note that the percentages shown in these charts do not always sum to 100% because of rounding. The charts are intended to illustrate the relative magnitude of emission sources at the port and in the region.

Figure ES5.1: Distribution and Comparison of NO_x from CMVs, tpy and percent

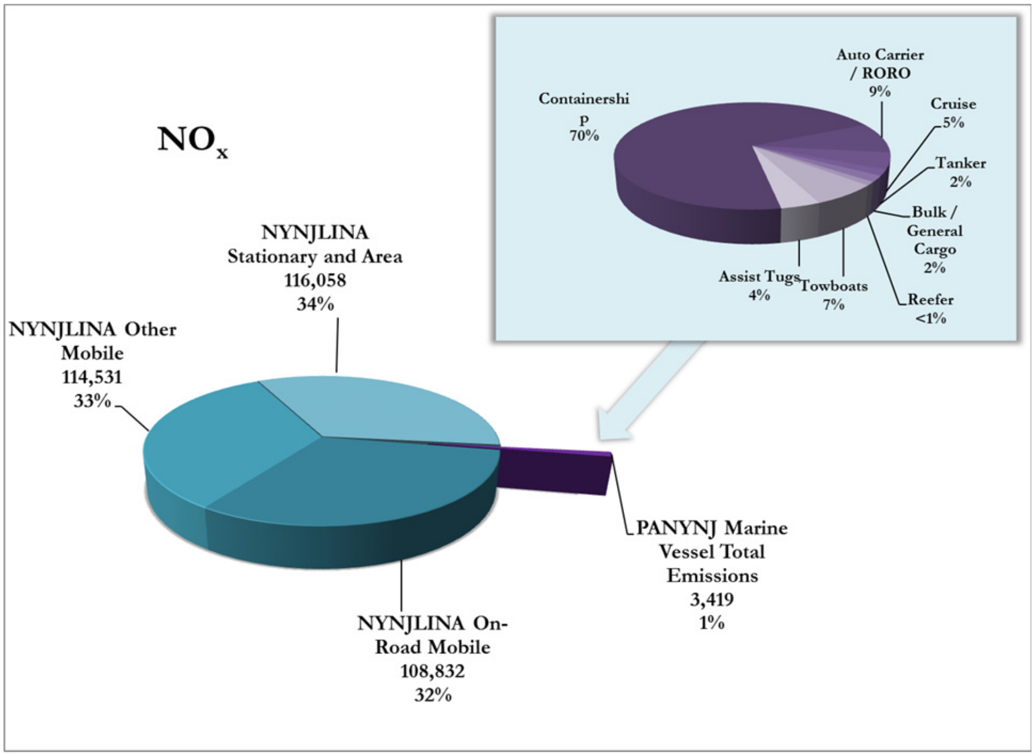


Figure ES5.2: Distribution and Comparison of PM_{10} from CMVs, tpy and percent

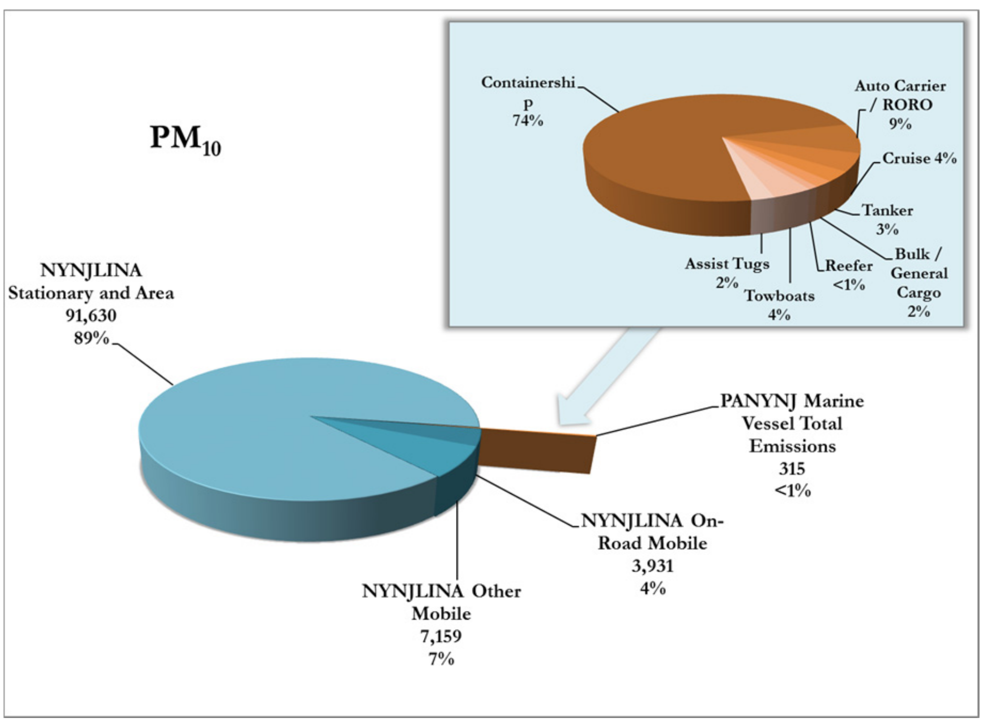


Figure ES5.3: Distribution and Comparison of $PM_{2.5}$ from CMVs, tpy and percent

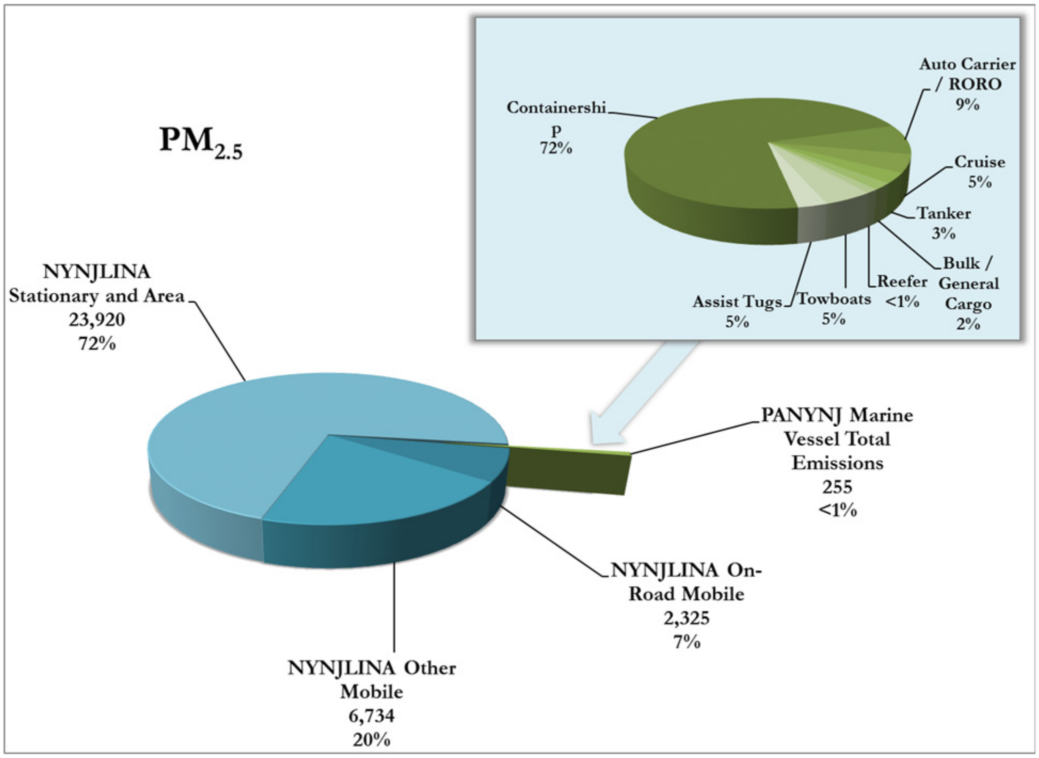


Figure ES5.4: Distribution and Comparison of VOC from CMVs, tpy and percent

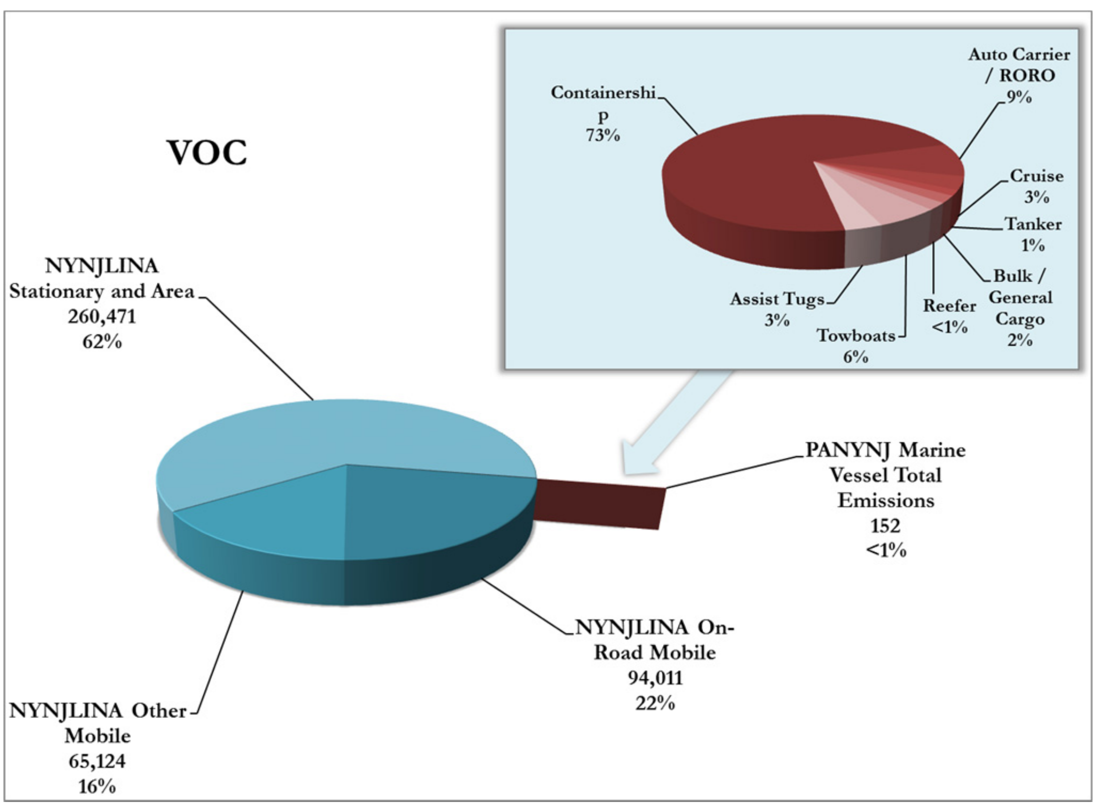


Figure ES5.5: Distribution and Comparison of CO from CMVs, tpy and percent

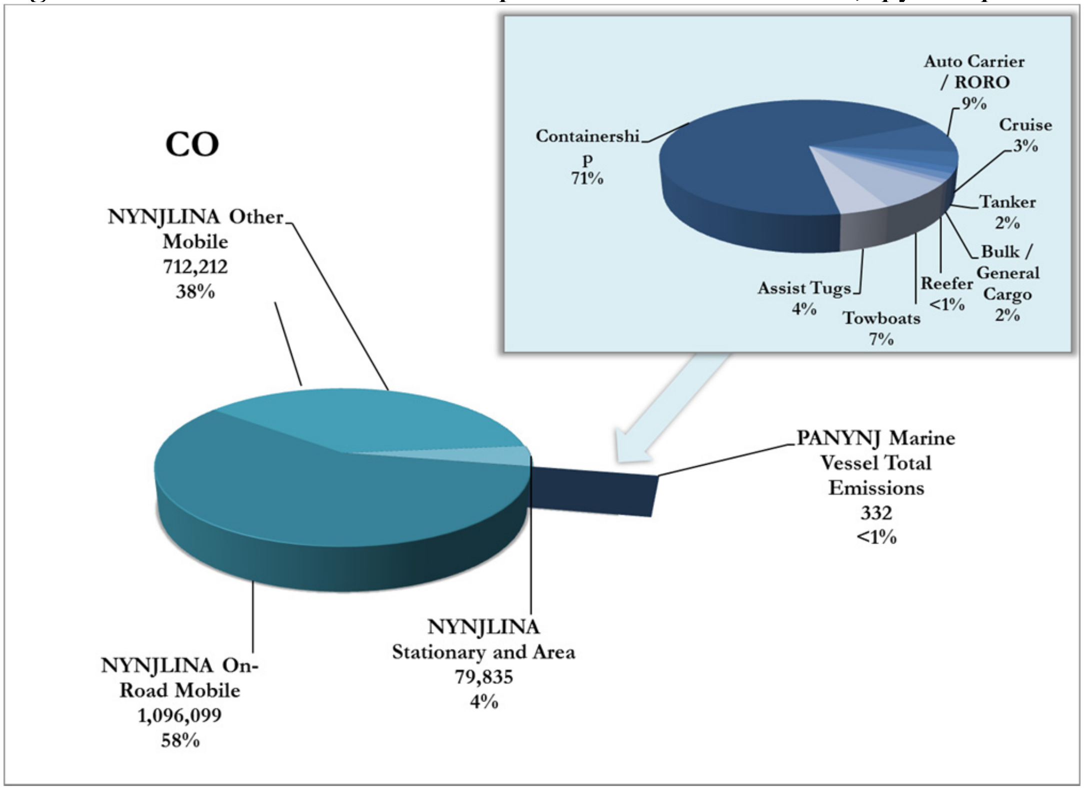


Figure ES5.6: Distribution and Comparison of SO_2 from CMVs, tpy and percent

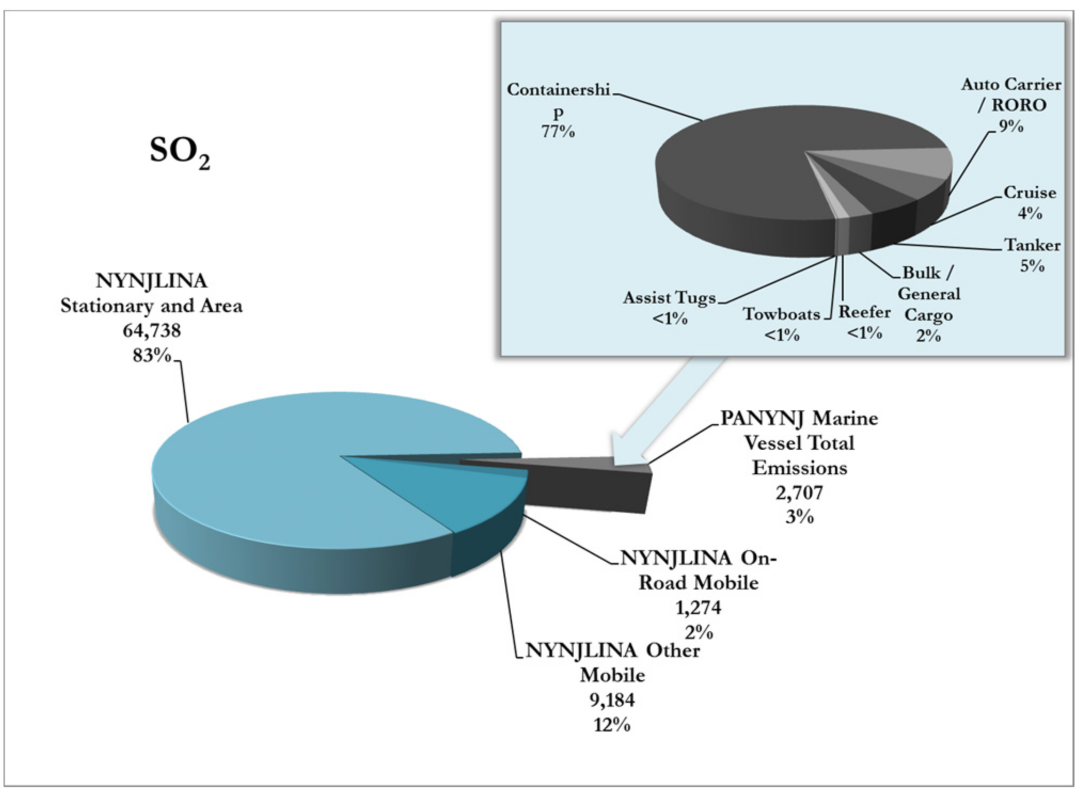
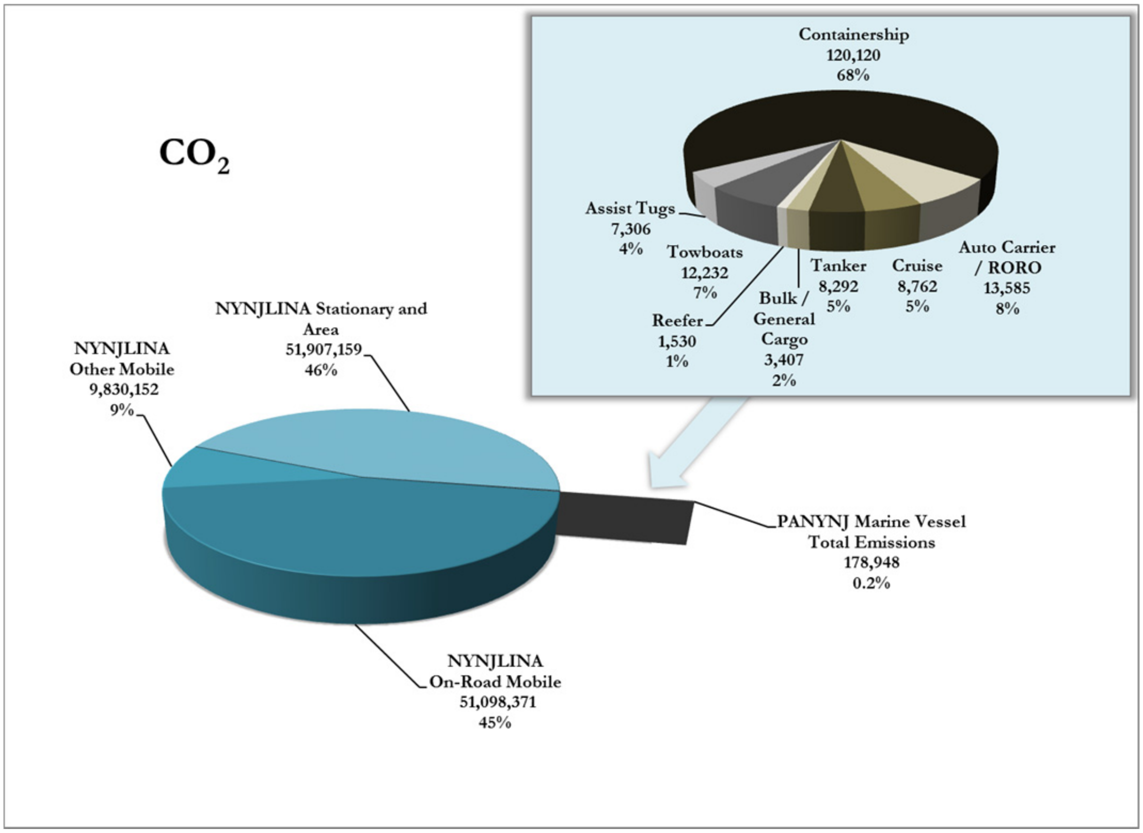


Figure ES5.7: Distribution and Comparison of CO_2 from CMVs, tpy and percent

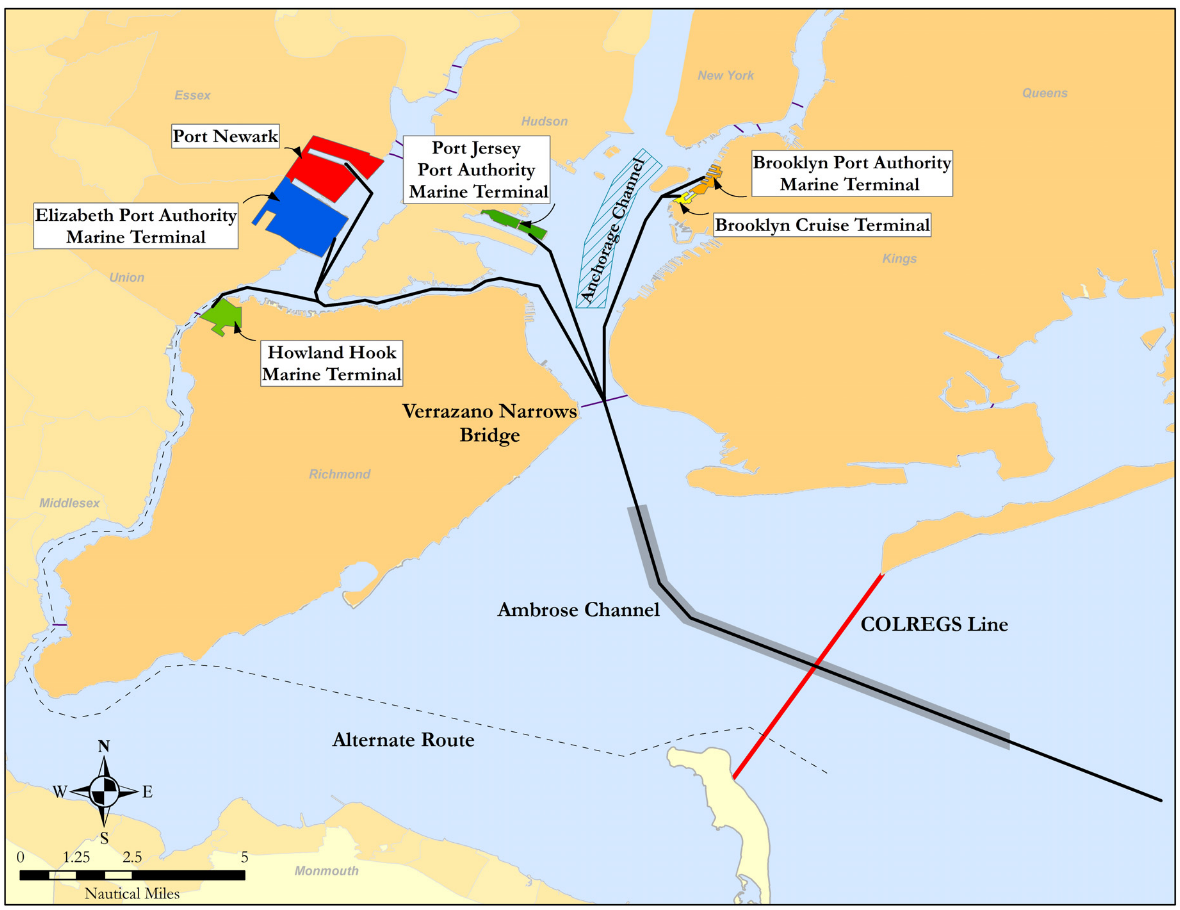


5.1 CMV Emission Estimates

Emission estimates have been developed for commercial marine vessels on the basis of vessel type and engine type. The vessel types include the following ocean-going vessels (OGVs): containerships, cruise ships, automobile and other vehicle carriers, tankers, and bulk carriers. In addition, estimates have been developed for the vessels that assist the ocean-going vessels in maneuvering and docking (assist tugs) and that move cargo barges within the NYNJHS (tugs, tow boats, push boats). The engines on board marine vessels for which emissions have been estimated are main engines, which provide propulsion power; auxiliary engines, which run electrical generators for auxiliary vessel power; and auxiliary boilers, which provide heat for fuel treatment and other on-board uses.

Figure 5.1 illustrates the outer limit of the study area on the ocean side for commercial marine vessels, and the routes taken by OGVs traveling to the terminals covered by this inventory. The outer limit is three nautical miles beyond the line indicated on the figure as the COLREG Line, off the eastern coast of the U.S.

Figure 5.1: Outer Limit of Study Area



The following tables present the estimated marine vessel emissions in several different aspects. Tables 5.1 and 5.2 list the estimated criteria pollutant and greenhouse gas emissions from OGVs by vessel type, Tables 5.3 and 5.4 present the OGV emissions by engine type, Tables 5.5 and 5.6 differentiate emissions according to transiting and dwelling activity, and Tables 5.7 and 5.8 present estimated criteria pollutant and greenhouse gas emissions from the tow boats and assist tugs.

The emission estimates presented in this document are listed in several ways to provide as much information to the reader as possible. The emissions are presented by terminal type, by type of activity, and by county and state. Because of these different modes of display, the numerical values must be rounded, displayed, and summed in different ways. Because of this, it is not always possible to display values in a table that sum exactly to the total shown at the bottom of the table. In developing the tables, priority has been given to maintaining consistent totals for each pollutant across table types.

Table 5.1: OGV Emissions of Criteria Pollutants by Vessel Type, tpy

Vessel Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Containership	2,412	232	185	112	235	2,080
Auto Carrier/RORO	316	28	22	14	29	236
Cruise	169	17	13	6	14	155
Tanker	62	9	8	2	5	143
Bulk	39	4	3	2	3	36
Reefer	37	3	3	2	3	27
General Cargo	24	2	2	1	2	23
Total	**3,059**	**295**	**236**	**138**	**293**	**2,699**

Table 5.2: OGV Emissions of Greenhouse Gases by Vessel Type, tpy

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Containership	120,120	7.0	2.2	122,341
Auto Carrier/RORO	13,585	0.8	0.3	13,829
Cruise	8,762	0.4	0.1	8,888
Tanker	8,292	0.6	0.0	8,480
Bulk	2,092	0.1	0.0	2,132
Reefer	1,530	0.1	0.0	1,556
General Cargo	1,315	0.1	0.0	1,336
Total	**155,696**	**9.1**	**2.8**	**158,562**

Table 5.3: OGV Emissions of Criteria Pollutants by Emission Source Type, tpy

Emission Source Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Main Engines	1,571	132	106	93	171	837
Auxiliary Engines	1,412	134	107	41	114	1,267
Boilers	76	29	23	4	7	595
Total	**3,059**	**295**	**236**	**138**	**293**	**2,699**

Table 5.4: OGV Emissions of Greenhouse Gases by Emission Source Type, tpy

Emission Source Type	CO_2	N_2O	CH_4	CO_2 Eq
Main Engines	49,616	2.9	1.9	50,566
Auxiliary Engines	70,843	3.2	0.8	71,857
Boilers	35,237	2.9	0.1	36,139
Total	**155,696**	**9.1**	**2.8**	**158,562**

Table 5.5: OGV Emissions of Criteria Pollutants by Operating Mode, tpy

Operating Mode	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Transit	2,193	194	156	111	222	1,467
Dwelling	866	101	81	27	71	1,232
Total	**3,059**	**295**	**236**	**138**	**293**	**2,699**

Table 5.6: OGV Emissions of Greenhouse Gases by Operating Mode, tpy

Operating Mode	CO_2	N_2O	CH_4	CO_2 Eq
Transit	85,040	4.7	2.2	86,551
Dwelling	70,656	4.3	0.5	72,011
Total	**155,696**	**9.1**	**2.8**	**158,562**

Table 5.7: Assist Tug/Towboat Emissions of Criteria Pollutants, tpy

Vessel Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Towboats/Pushboats	226	12	12	9	25	5
Assist Tugs	134	7	7	5	15	3
Totals	**360**	**20**	**19**	**14**	**40**	**8**

Table 5.8: Assist Tug/Towboat Emissions of Greenhouse Gases, tpy

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Towboats/Pushboats	12,232	1	4	12,757
Assist Tugs	7,306	1	2	7,619
Totals	**19,537**	**2**	**7**	**20,376**

Marine vessel emissions by county, and those emissions in relation to overall area emissions by pollutant, are presented and discussed in Section 5.2.

5.2 CMV Emission Comparisons

This subsection presents the marine vessel emission estimates detailed in Section 5.1 in the context of overall county-wide and area-wide emissions. Port Authority marine terminal related OGV and tug/tow boat emissions are compared with all emissions in the NYNJLINA on a county-by-county basis. Overall county-level emissions were excerpted from the most recent National Emissions Inventory (NEI) database.[19]

These emission comparisons are segregated into ocean going and assist vessel categories and are presented in sections 5.2.1 and 5.2.2 respectively. The 2010 PANYNJ CMV county level emissions were estimated by determining the time and distance marine vessels spend plying waterways within each county and multiplying these by the appropriate load and emission factors. A detailed discussion of calculation methods is presented in section 5.3.

5.2.1 Ocean Going Vessel Emission Comparisons

The following series of tables and charts display the contribution that Port Authority marine terminal related OGVs make to overall emissions in the counties and the region. Table 5.9 summarizes estimated criteria pollutant emissions from OGVs at the county level. The subsequent tables, 5.9 through 5.15, present each pollutant individually, comparing Port Authority marine terminal related OGV emissions with total county level emissions. Figures 5.2 through 5.8 summarize the same information visually on an individual county basis.

[19] 2008 National Emission Inventory Database, U.S. EPA, *http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydata*

Each column displays the county-wide emissions and on top of each column is the Port Authority marine terminal related OGV contribution to the total emissions.

Table 5.9: Summary of OGV Criteria Pollutant and GHG Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	0	0	0	0	0	0	0
Essex	NJ	454	50	40	18	41	562	32,237
Hudson	NJ	478	44	35	23	47	368	21,202
Middlesex	NJ	0	0	0	0	0	0	0
Monmouth	NJ	315	28	22	16	32	211	12,224
Union	NJ	492	52	42	18	43	571	33,128
New Jersey subtotal		**1,739**	**174**	**140**	**75**	**163**	**1,711**	**98,791**
Bronx	NY	0	0	0	0	0	0	0
Kings (Brooklyn)	NY	436	39	31	22	44	304	17,589
Nassau	NY	0	0	0	0	0	0	0
New York	NY	232	21	17	10	22	174	9,936
Orange	NY	0	0	0	0	0	0	0
Queens	NY	0	0	0	0	0	0	0
Richmond (Staten Isld)	NY	651	61	48	31	64	510	29,379
Rockland	NY	0	0	0	0	0	0	0
Suffolk	NY	0	0	0	0	0	0	0
Westchester	NY	0	0	0	0	0	0	0
New York subtotal		**1,320**	**121**	**97**	**63**	**130**	**988**	**56,905**
TOTAL		**3,059**	**295**	**236**	**138**	**293**	**2,699**	**155,696**

Table 5.10: Comparison of Ocean Going Vessel NO_x Emissions with Overall NO_x Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	0	0.0%
Essex	NJ	22,236	454	2.0%
Hudson	NJ	32,088	478	1.5%
Middlesex	NJ	20,821	0	0.0%
Monmouth	NJ	13,899	315	2.3%
Union	NJ	19,833	492	2.5%
New Jersey subtotal		**128,097**	**1,739**	**1.4%**
Bronx	NY	11,643	0	0.0%
Kings (Brooklyn)	NY	26,732	436	1.6%
Nassau	NY	24,574	0	0.0%
New York	NY	30,058	232	0.8%
Orange	NY	12,424	0	0.0%
Queens	NY	31,662	0	0.0%
Richmond (Staten Isld)	NY	9,273	651	7.0%
Rockland	NY	6,529	0	0.0%
Suffolk	NY	39,738	0	0.0%
Westchester	NY	18,692	0	0.0%
New York Subtotal		**211,324**	**1,320**	**0.6%**
TOTAL		**339,421**	**3,059**	**0.9%**

Figure 5.2: Comparison of Ocean Going Vessel NO_x Emissions with Overall NO_x Emissions by County, tpy

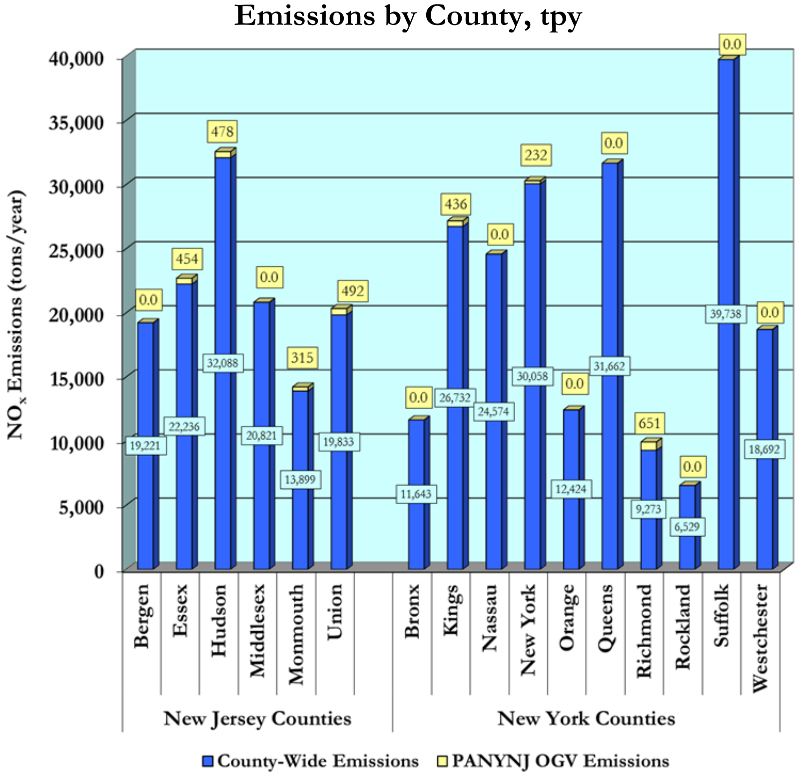


Table 5.11: Comparison of Ocean Going Vessel PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	0	0.0%
Essex	NJ	2,818	50	1.8%
Hudson	NJ	4,781	44	0.9%
Middlesex	NJ	6,117	0	0.0%
Monmouth	NJ	4,133	28	0.7%
Union	NJ	3,276	52	1.6%
New Jersey subtotal		**24,911**	**174**	**0.7%**
Bronx	NY	5,001	0	0.0%
Kings (Brooklyn)	NY	9,931	39	0.4%
Nassau	NY	6,991	0	0.0%
New York	NY	8,373	21	0.3%
Orange	NY	11,812	0	0.0%
Queens	NY	9,814	0	0.0%
Richmond (Staten Isld)	NY	2,446	61	2.5%
Rockland	NY	1,890	0	0.0%
Suffolk	NY	12,124	0	0.0%
Westchester	NY	9,427	0	0.0%
New York Subtotal		**77,809**	**121**	**0.2%**
TOTAL		**102,720**	**295**	**0.3%**

Figure 5.3: Comparison of Ocean Going Vessel PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

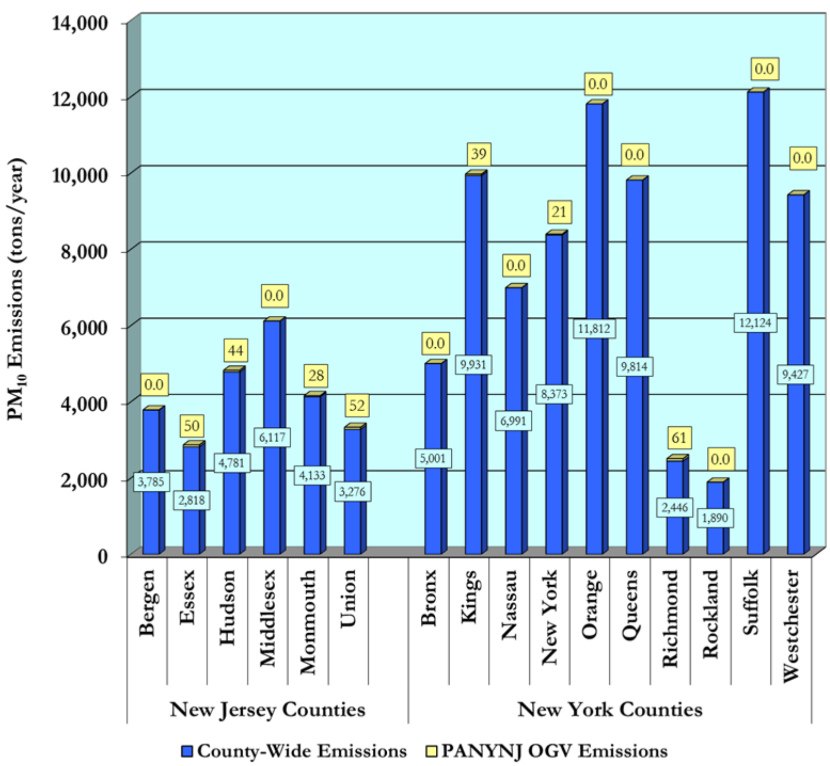


Table 5.12: Comparison of Ocean Going Vessel $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	0	0.0%
Essex	NJ	1,202	40	3.3%
Hudson	NJ	3,577	35	1.0%
Middlesex	NJ	1,784	0	0.0%
Monmouth	NJ	1,116	22	2.0%
Union	NJ	1,578	42	2.6%
New Jersey subtotal		**10,416**	**140**	**1.3%**
Bronx	NY	1,480	0	0.0%
Kings (Brooklyn)	NY	2,966	31	1.1%
Nassau	NY	2,006	0	0.0%
New York	NY	3,430	17	0.5%
Orange	NY	2,351	0	0.0%
Queens	NY	3,108	0	0.0%
Richmond (Staten Isld)	NY	801	48	6.0%
Rockland	NY	552	0	0.0%
Suffolk	NY	3,757	0	0.0%
Westchester	NY	2,111	0	0.0%
New York Subtotal		**22,563**	**97**	**0.4%**
TOTAL		**32,978**	**236**	**0.7%**

Figure 5.4: Comparison of Ocean Going Vessel $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

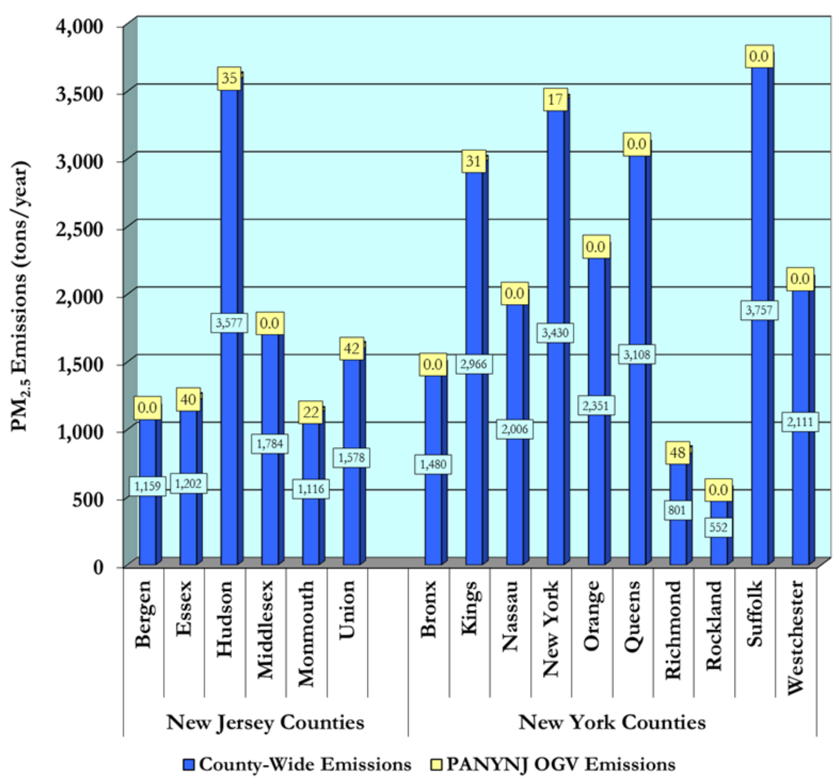


Table 5.13: Comparison of Ocean Going Vessel VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	0	0.00%
Essex	NJ	15,376	18	0.12%
Hudson	NJ	11,073	23	0.21%
Middlesex	NJ	21,598	0	0.00%
Monmouth	NJ	16,478	16	0.10%
Union	NJ	14,043	18	0.13%
New Jersey subtotal		**100,878**	**75**	**0.07%**
Bronx	NY	26,550	0	0.00%
Kings (Brooklyn)	NY	47,212	22	0.05%
Nassau	NY	37,235	0	0.00%
New York	NY	45,066	10	0.02%
Orange	NY	13,320	0	0.00%
Queens	NY	47,241	0	0.00%
Richmond (Staten Isld)	NY	10,254	31	0.30%
Rockland	NY	8,375	0	0.00%
Suffolk	NY	55,567	0	0.00%
Westchester	NY	27,906	0	0.00%
New York Subtotal		**318,727**	**63**	**0.02%**
TOTAL		**419,606**	**138**	**0.03%**

Figure 5.5: Comparison of Ocean Going Vessel VOC Emissions with Overall VOC Emissions by County, tpy

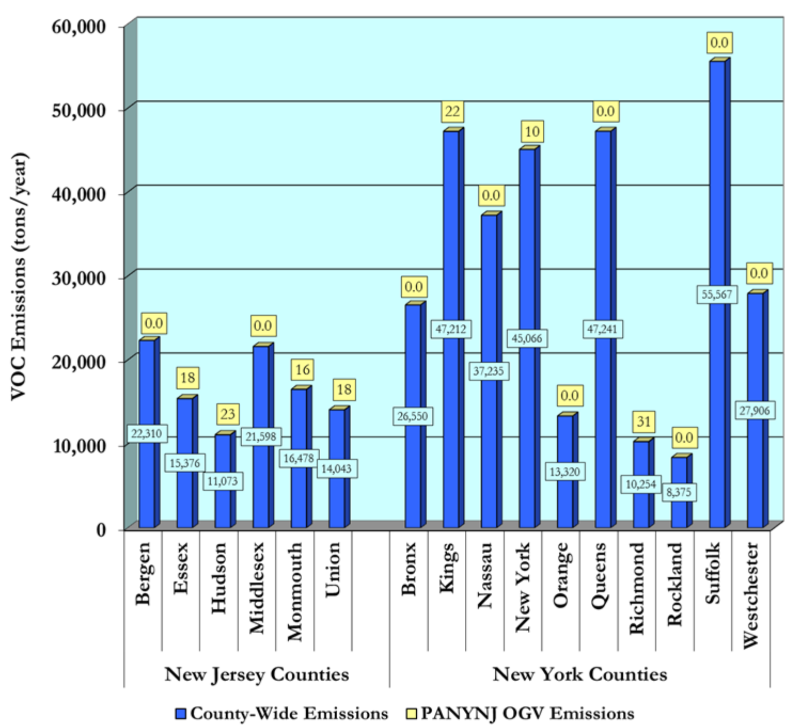


Table 5.14: Comparison of Ocean Going Vessel CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	0	0.00%
Essex	NJ	89,041	41	0.05%
Hudson	NJ	48,521	47	0.10%
Middlesex	NJ	129,636	0	0.00%
Monmouth	NJ	108,040	32	0.03%
Union	NJ	75,762	43	0.06%
New Jersey subtotal		**608,842**	**163**	**0.03%**
Bronx	NY	75,120	0	0.00%
Kings (Brooklyn)	NY	112,068	44	0.04%
Nassau	NY	183,911	0	0.00%
New York	NY	158,713	22	0.01%
Orange	NY	69,889	0	0.00%
Queens	NY	144,316	0	0.00%
Richmond (Staten Isld)	NY	35,204	64	0.18%
Rockland	NY	43,672	0	0.00%
Suffolk	NY	307,921	0	0.00%
Westchester	NY	148,488	0	0.00%
New York Subtotal		**1,279,304**	**130**	**0.01%**
TOTAL		**1,888,145**	**293**	**0.02%**

Figure 5.6: Comparison of Ocean Going Vessel CO Emissions with Overall CO Emissions by County, tpy

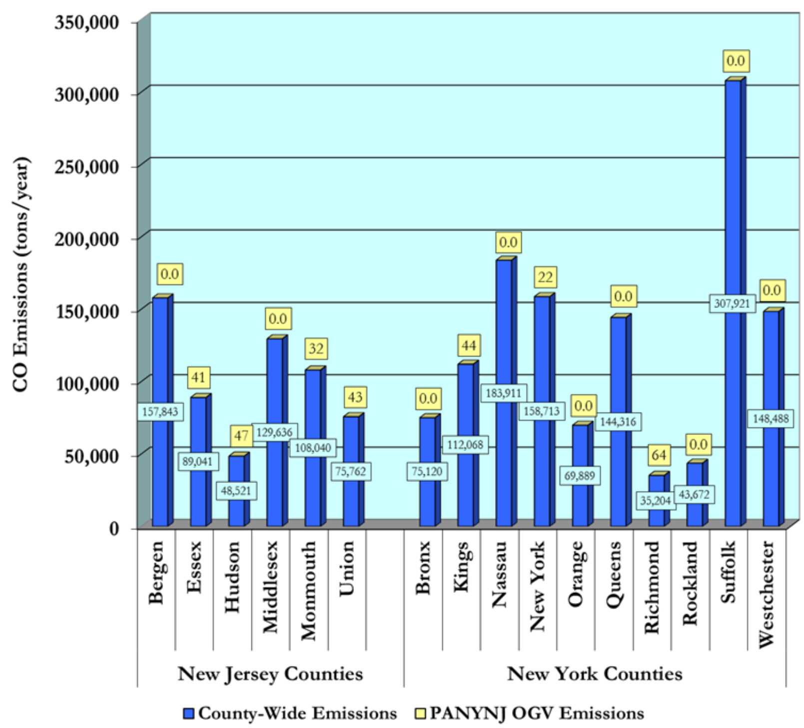


Table 5.15: Comparison of Ocean Going Vessel SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	903	0	0.0%
Essex	NJ	1,974	562	28.5%
Hudson	NJ	5,415	368	6.8%
Middlesex	NJ	993	0	0.0%
Monmouth	NJ	787	211	26.8%
Union	NJ	1,870	571	30.5%
New Jersey subtotal		**11,941**	**1,711**	**14.3%**
Bronx	NY	1,868	0	0.0%
Kings (Brooklyn)	NY	3,980	304	7.6%
Nassau	NY	3,770	0	0.0%
New York	NY	7,114	174	2.4%
Orange	NY	16,368	0	0.0%
Queens	NY	4,302	0	0.0%
Richmond (Staten Isld)	NY	912	510	55.9%
Rockland	NY	2,243	0	0.0%
Suffolk	NY	18,387	0	0.0%
Westchester	NY	4,310	0	0.0%
New York Subtotal		**63,255**	**988**	**1.6%**
TOTAL		**75,197**	**2,699**	**3.6%**

Figure 5.7: Comparison of Ocean Going Vessel SO_2 Emissions with Overall SO_2 Emissions by County, tpy

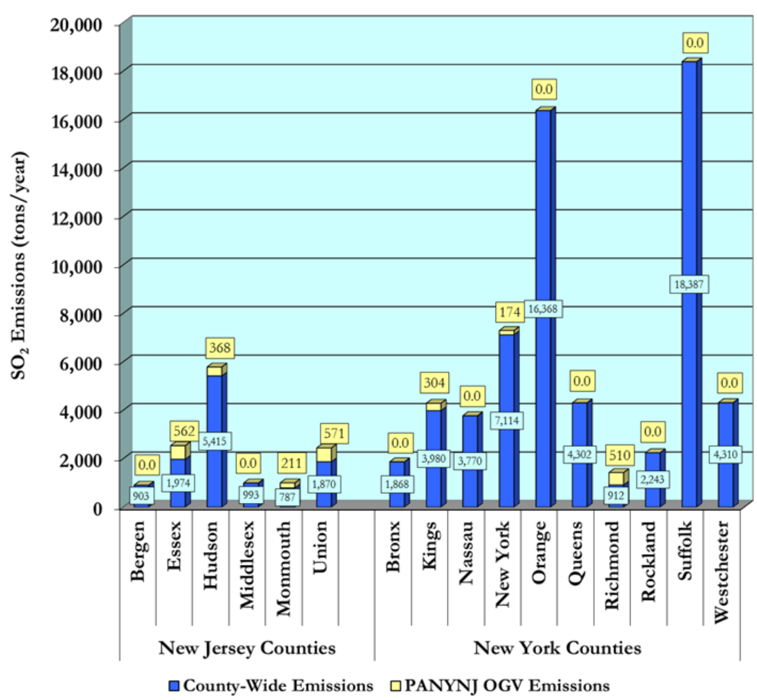
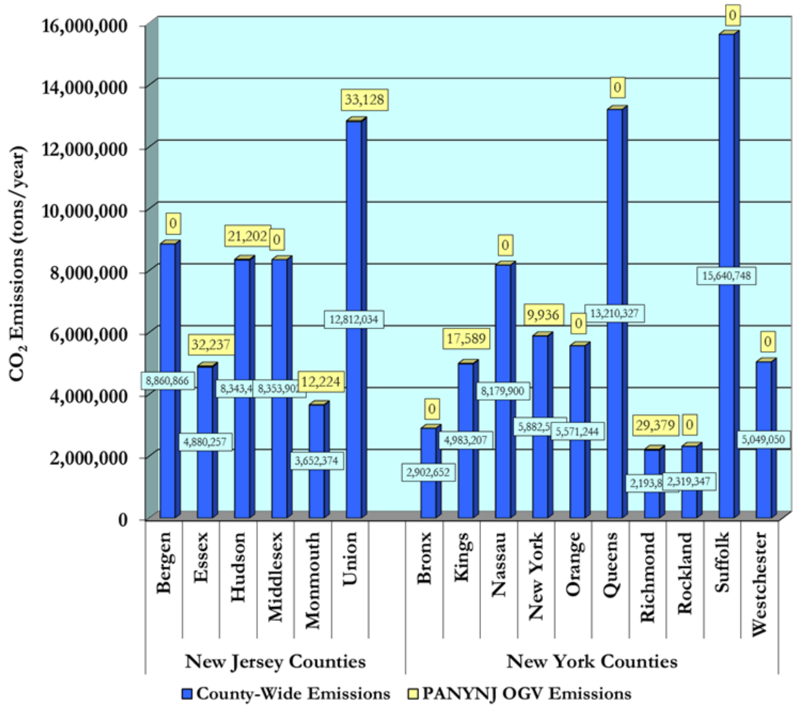


Table 5.16: Comparison of Ocean Going Vessel CO_2 Emissions with Overall CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	0	0.0%
Essex	NJ	4,880,257	32,237	0.7%
Hudson	NJ	8,343,407	21,202	0.3%
Middlesex	NJ	8,353,902	0	0.0%
Monmouth	NJ	3,652,374	12,224	0.3%
Union	NJ	12,812,034	33,128	0.3%
New Jersey subtotal		**46,902,841**	**98,791**	**0.2%**
Bronx	NY	2,902,652	0	0.0%
Kings (Brooklyn)	NY	4,983,207	17,589	0.4%
Nassau	NY	8,179,900	0	0.0%
New York	NY	5,882,564	9,936	0.2%
Orange	NY	5,571,244	0	0.0%
Queens	NY	13,210,327	0	0.0%
Richmond (Staten Isld)	NY	2,193,801	29,379	1.3%
Rockland	NY	2,319,347	0	0.0%
Suffolk	NY	15,640,748	0	0.0%
Westchester	NY	5,049,050	0	0.0%
New York Subtotal		**65,932,841**	**56,905**	**0.1%**
TOTAL		**112,835,682**	**155,696**	**0.1%**

Figure 5.8: Comparison of Ocean Going Vessel CO_2 Emissions with Overall CO_2 Emissions by County, tpy



5.2.2 Tug and Tow Boat Emission Comparisons

The following series of tables and charts display the contribution of Port Authority marine terminal related tug and tow boat emissions on regional emissions. Table 5.17 summarizes estimated criteria pollutant emissions from these vessels at the county level. The subsequent tables, 5.18 through 5.24, present each pollutant individually, comparing Port Authority marine terminal related OGV activity with total county level emissions. Figures 5.9 through 5.15 summarize the same information visually on an individual county basis. Each column displays the county wide emissions and at the top of the column is the contribution of Port Authority marine terminal related tug and tow boats to total area emissions.

Table 5.17: Summary of Harbor Craft Criteria Pollutant and GHG Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
Bergen	NJ	2	0.1	0.1	0.1	0.2	0.0	118.2
Essex	NJ	53	2.9	2.8	2.1	5.9	1.1	2,891.1
Hudson	NJ	61	3.3	3.2	2.4	6.7	1.3	3,288.9
Middlesex	NJ	15	0.8	0.8	0.6	1.7	0.3	832.1
Monmouth	NJ	11	0.6	0.6	0.4	1.2	0.2	613.1
Union	NJ	79	4.3	4.1	3.0	8.7	1.7	4,271.9
New Jersey subtotal		**221**	**12.0**	**11.7**	**8.6**	**24.6**	**4.7**	**12,015.3**
Bronx	NY	0	0.0	0.0	0.0	0.0	0.0	21.9
Kings (Brooklyn)	NY	14	0.8	0.8	0.6	1.6	0.3	773.0
Nassau	NY	3	0.2	0.2	0.1	0.3	0.1	157.7
New York	NY	5	0.3	0.3	0.2	0.5	0.1	257.7
Orange	NY	3	0.1	0.1	0.1	0.3	0.1	135.8
Queens	NY	4	0.2	0.2	0.2	0.5	0.1	240.9
Richmond (Staten Isld)	NY	93	5.0	4.9	3.6	10.3	2.0	5,024.2
Rockland	NY	3	0.2	0.2	0.1	0.3	0.1	166.4
Suffolk	NY	10	0.5	0.5	0.4	1.1	0.2	538.7
Westchester	NY	4	0.2	0.2	0.1	0.4	0.1	205.8
New York subtotal		**139**	**7.5**	**7.3**	**5.4**	**15.3**	**2.9**	**7,521.9**
TOTAL		**360**	**20**	**19**	**14**	**40**	**8**	**19,537**

Table 5.18: Comparison of Harbor Craft NO_x Emissions with Overall NO_x Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	19,221	2	0.01%
Essex	NJ	22,236	53	0.24%
Hudson	NJ	32,088	61	0.19%
Middlesex	NJ	20,821	15	0.07%
Monmouth	NJ	13,899	11	0.08%
Union	NJ	19,833	79	0.40%
New Jersey Subtotal		**128,097**	**221**	**0.17%**
Bronx	NY	11,643	0	0.00%
Kings (Brooklyn)	NY	26,732	14	0.05%
Nassau	NY	24,574	3	0.01%
New York	NY	30,058	5	0.02%
Orange	NY	12,424	3	0.02%
Queens	NY	31,662	4	0.01%
Richmond (Staten Isld)	NY	9,273	93	1.00%
Rockland	NY	6,529	3	0.05%
Suffolk	NY	39,738	10	0.03%
Westchester	NY	18,692	4	0.02%
New York Subtotal		**211,324**	**139**	**0.07%**
TOTAL		**339,421**	**360**	**0.11%**

Figure 5.9: Comparison of Harbor Craft NO_x Emissions with Overall NO_x Emissions by County, tpy

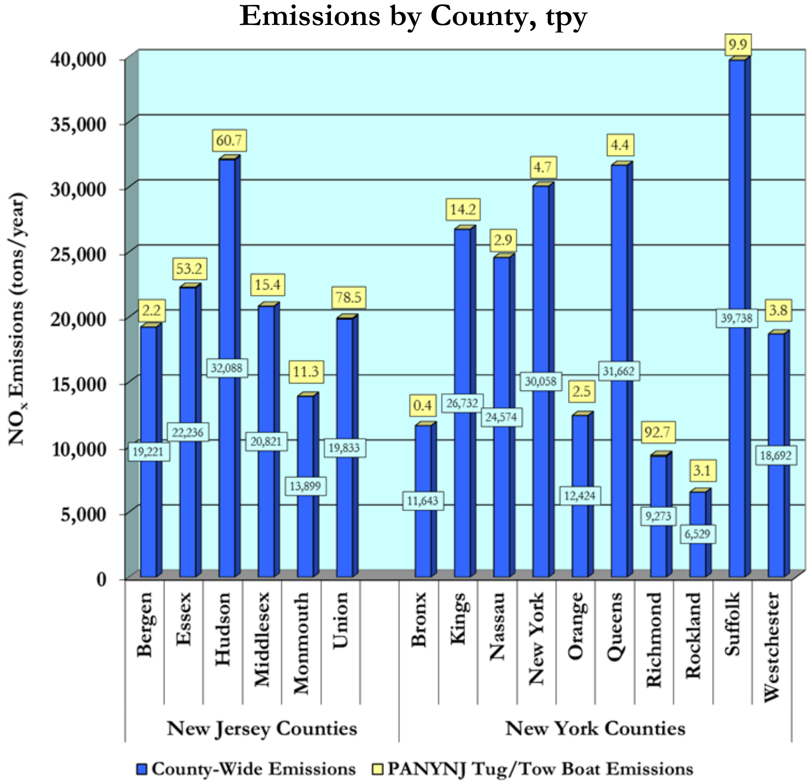


Table 5.19: Comparison of Harbor Craft PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	3,785	0	0.00%
Essex	NJ	2,818	3	0.10%
Hudson	NJ	4,781	4	0.08%
Middlesex	NJ	6,117	1	0.01%
Monmouth	NJ	4,133	1	0.01%
Union	NJ	3,276	4	0.13%
New Jersey Subtotal		**24,911**	**12**	**0.05%**
Bronx	NY	5,001	0	0.00%
Kings (Brooklyn)	NY	9,931	1	0.01%
Nassau	NY	6,991	0	0.00%
New York	NY	8,373	0	0.00%
Orange	NY	11,812	0	0.00%
Queens	NY	9,814	0	0.00%
Richmond (Staten Isld)	NY	2,446	5	0.21%
Rockland	NY	1,890	0	0.01%
Suffolk	NY	12,124	1	0.00%
Westchester	NY	9,427	0	0.00%
New York Subtotal		**77,809**	**8**	**0.01%**
TOTAL		**102,720**	**20**	**0.02%**

Figure 5.10: Comparison of Harbor Craft PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

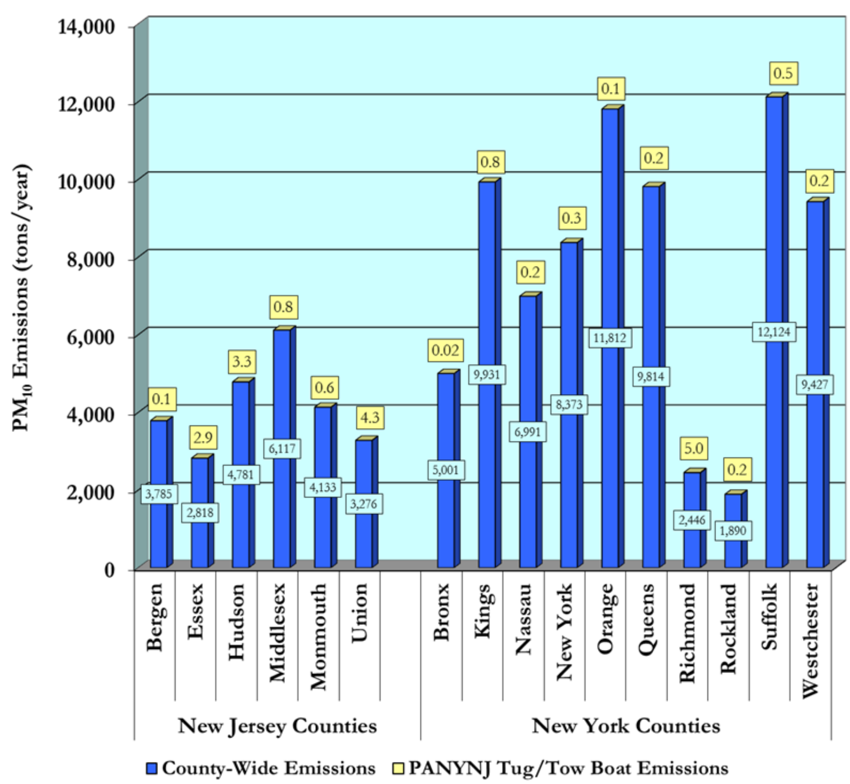


Table 5.20: Comparison of Harbor Craft $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	1,159	0	0.01%
Essex	NJ	1,202	3	0.23%
Hudson	NJ	3,577	4	0.10%
Middlesex	NJ	1,784	1	0.05%
Monmouth	NJ	1,116	1	0.05%
Union	NJ	1,578	4	0.26%
New Jersey Subtotal		**10,416**	**12**	**0.12%**
Bronx	NY	1,480	0	0.00%
Kings (Brooklyn)	NY	2,966	1	0.03%
Nassau	NY	2,006	0	0.01%
New York	NY	3,430	0	0.01%
Orange	NY	2,351	0	0.01%
Queens	NY	3,108	0	0.01%
Richmond (Staten Isld)	NY	801	5	0.61%
Rockland	NY	552	0	0.03%
Suffolk	NY	3,757	1	0.01%
Westchester	NY	2,111	0	0.01%
New York Subtotal		**22,563**	**7**	**0.03%**
TOTAL		**32,978**	**19**	**0.06%**

Figure 5.11: Comparison of Harbor Craft $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

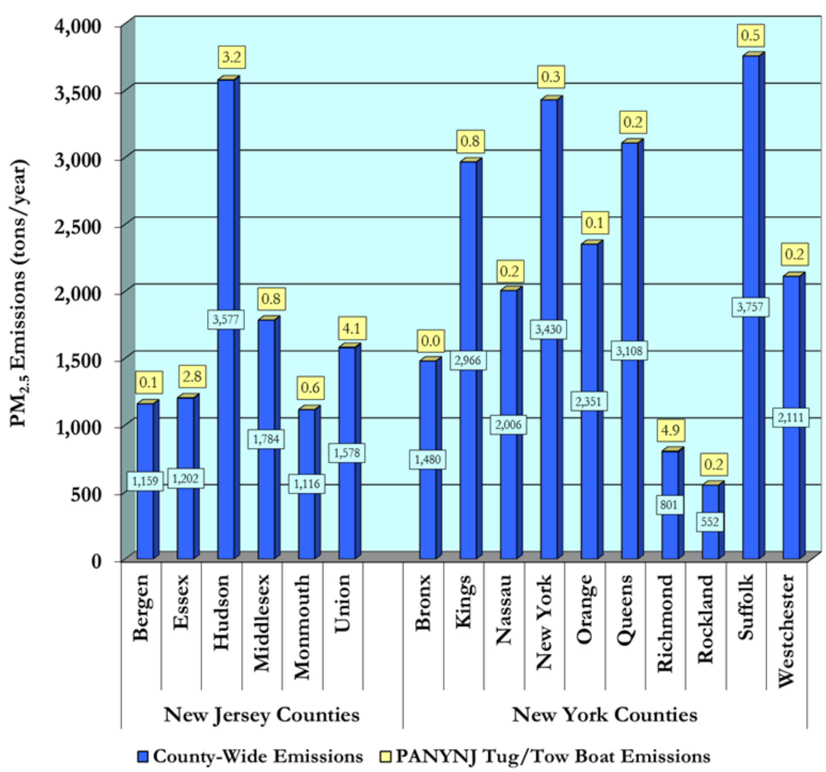


Table 5.21: Comparison of Harbor Craft VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	22,310	0	0.000%
Essex	NJ	15,376	2	0.013%
Hudson	NJ	11,073	3	0.024%
Middlesex	NJ	21,598	1	0.003%
Monmouth	NJ	16,478	0	0.003%
Union	NJ	14,043	3	0.022%
New Jersey Subtotal		**100,878**	**9**	**0.009%**
Bronx	NY	26,550	0	0.000%
Kings (Brooklyn)	NY	47,212	1	0.001%
Nassau	NY	37,235	0	0.000%
New York	NY	45,066	0	0.000%
Orange	NY	13,320	0	0.001%
Queens	NY	47,241	0	0.000%
Richmond (Staten Isld)	NY	10,254	4	0.035%
Rockland	NY	8,375	0	0.001%
Suffolk	NY	55,567	0	0.001%
Westchester	NY	27,906	0	0.001%
New York Subtotal		**318,727**	**5**	**0.002%**
TOTAL		**419,606**	**14**	**0.003%**

Figure 5.12: Comparison of Harbor Craft VOC Emissions with Overall VOC Emissions by County, tpy

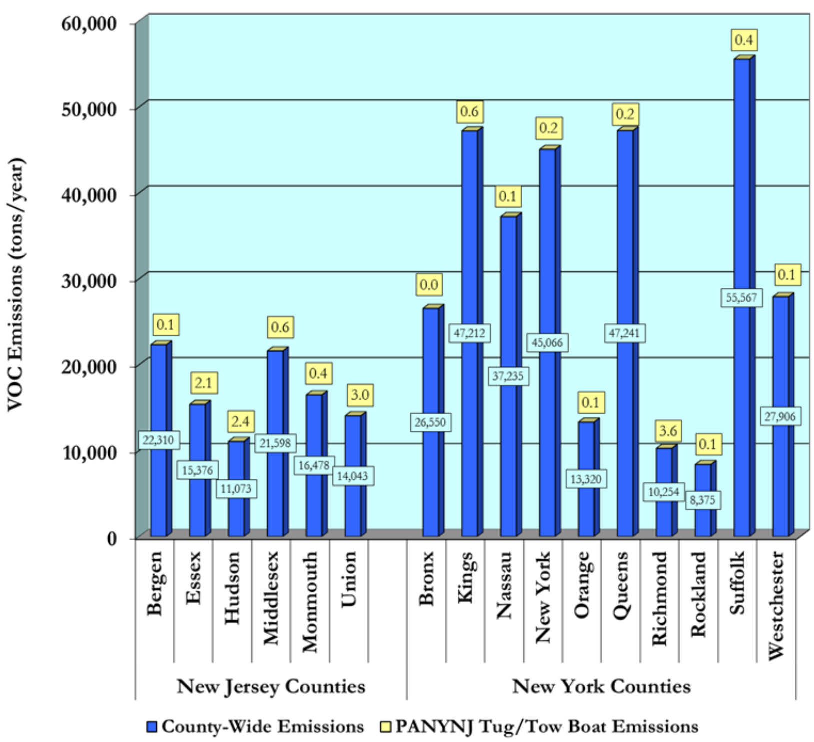


Table 5.22: Comparison of Harbor Craft CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	157,843	0	0.000%
Essex	NJ	89,041	6	0.007%
Hudson	NJ	48,521	7	0.014%
Middlesex	NJ	129,636	2	0.001%
Monmouth	NJ	108,040	1	0.001%
Union	NJ	75,762	9	0.012%
New Jersey Subtotal		**608,842**	**25**	**0.004%**
Bronx	NY	75,120	0	0.000%
Kings (Brooklyn)	NY	112,068	2	0.001%
Nassau	NY	183,911	0	0.000%
New York	NY	158,713	1	0.000%
Orange	NY	69,889	0	0.000%
Queens	NY	144,316	0	0.000%
Richmond (Staten Isld)	NY	35,204	10	0.029%
Rockland	NY	43,672	0	0.001%
Suffolk	NY	307,921	1	0.000%
Westchester	NY	148,488	0	0.000%
New York Subtotal		**1,279,304**	**15**	**0.001%**
TOTAL		**1,888,145**	**40**	**0.002%**

Figure 5.13: Comparison of Harbor Craft CO Emissions with Overall CO Emissions by County, tpy

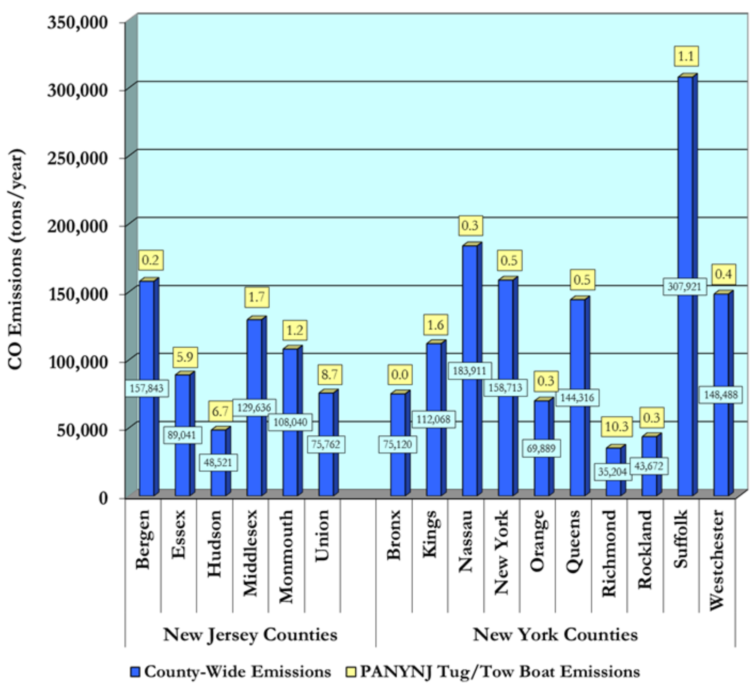


Table 5.23: Comparison of Harbor Craft SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	903	0	0.01%
Essex	NJ	1,974	1	0.06%
Hudson	NJ	5,415	1	0.03%
Middlesex	NJ	993	0	0.03%
Monmouth	NJ	787	0	0.03%
Union	NJ	1,870	2	0.09%
New Jersey Subtotal		**11,941**	**5**	**0.04%**
Bronx	NY	1,868	0	0.00%
Kings (Brooklyn)	NY	3,980	0	0.01%
Nassau	NY	3,770	0	0.00%
New York	NY	7,114	0	0.00%
Orange	NY	16,368	0	0.00%
Queens	NY	4,302	0	0.00%
Richmond (Staten Isld)	NY	912	2	0.22%
Rockland	NY	2,243	0	0.00%
Suffolk	NY	18,387	0	0.00%
Westchester	NY	4,310	0	0.00%
New York Subtotal		**63,255**	**3**	**0.00%**
TOTAL		**75,197**	**8**	**0.01%**

Figure 5.14: Comparison of Harbor Craft SO_2 Emissions with Overall SO_2 Emissions by County, tpy

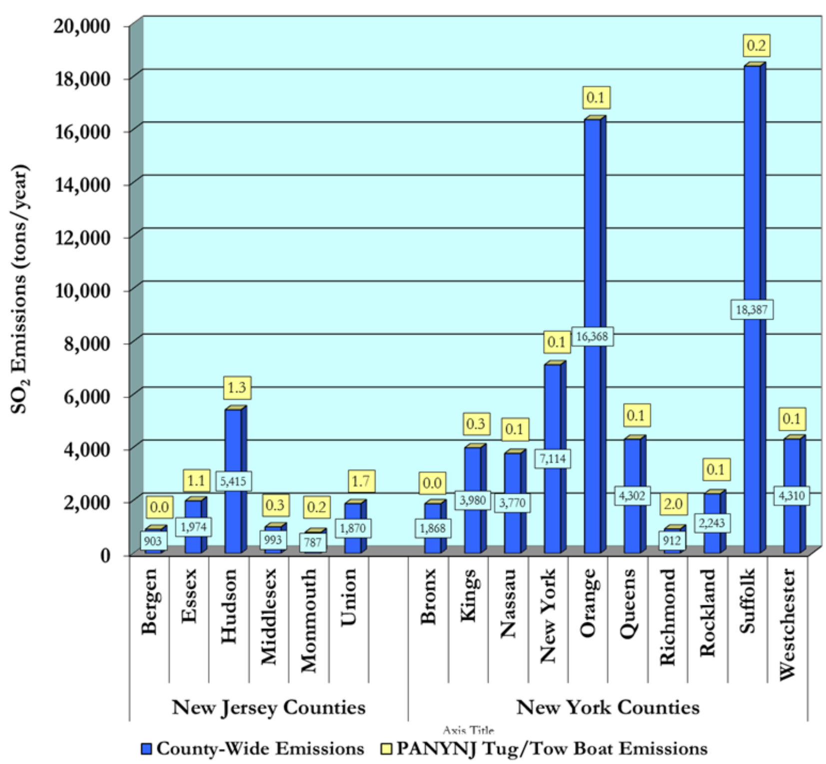
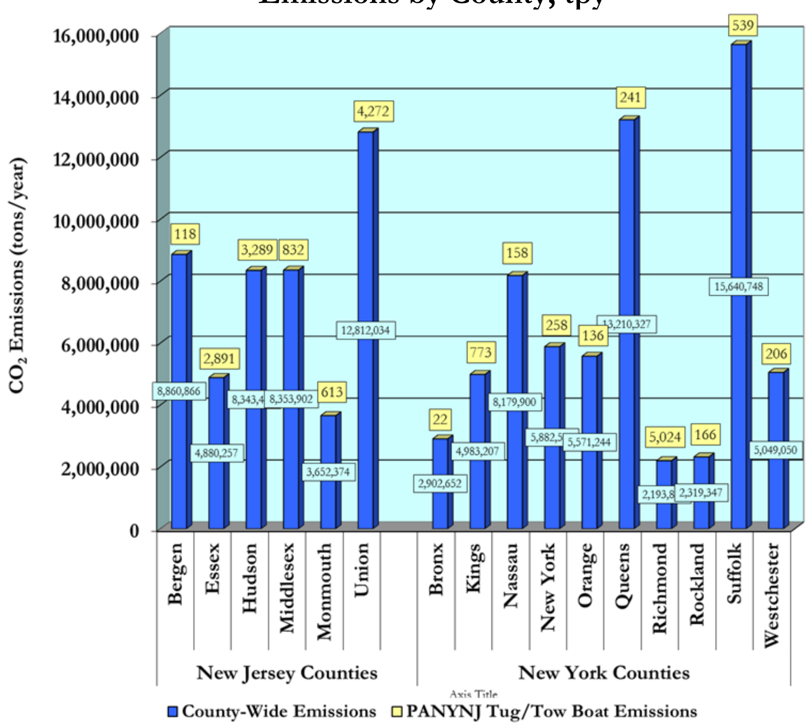


Table 5.24: Comparison of Harbor Craft CO_2 Emissions with Overall CO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	8,860,866	118	0.00%
Essex	NJ	4,880,257	2,891	0.06%
Hudson	NJ	8,343,407	3,289	0.04%
Middlesex	NJ	8,353,902	832	0.01%
Monmouth	NJ	3,652,374	613	0.02%
Union	NJ	12,812,034	4,272	0.03%
New Jersey Subtotal		**46,902,841**	**12,015**	**0.03%**
Bronx	NY	2,902,652	22	0.00%
Kings (Brooklyn)	NY	4,983,207	773	0.02%
Nassau	NY	8,179,900	158	0.00%
New York	NY	5,882,564	258	0.00%
Orange	NY	5,571,244	136	0.00%
Queens	NY	13,210,327	241	0.00%
Richmond (Staten Isld)	NY	2,193,801	5,024	0.23%
Rockland	NY	2,319,347	166	0.01%
Suffolk	NY	15,640,748	539	0.00%
Westchester	NY	5,049,050	206	0.00%
New York Subtotal		**65,932,841**	**7,522**	**0.01%**
TOTAL		**112,835,682**	**19,537**	**0.02%**

Figure 5.15: Comparison of Harbor Craft CO_2 Emissions with Overall CO_2 Emissions by County, tpy



5.3 CMV Emission Calculation Methodology

This section discusses the information sources used to develop physical and operational profiles of marine vessel activity, and the methods used to estimate emissions. The emission estimates are based on locally specific data on vessel movements to and from the Port Authority marine terminals listed above based on Automatic Identification System (AIS) information provided by the U.S. Coast Guard. Information from IHS–Fairplay (commonly known as "Lloyd's data" due to previous company ownership) has been used to develop profiles of the physical and operational parameters of OGVs.

A more accurate methodology was used for the first time in 2010 to determine the activity of OGVs, which resulted in higher OGV emission estimates for most pollutants as compared to estimates made for previous years. The improved methodology uses AIS data to track the position, course, and speed for port arrivals, shifts and departures. The use of actual speeds and distances versus the interview-based assumptions and vessel call data used in previous inventories resulted in higher main engine emission estimates for the 2010 OGV emissions compared with estimates of previous years' emissions.

The Port Authority anticipates using the more accurate AIS methodology for future PANYNJ emission inventory reports, so future comparisons to 2010 emissions will be a more apples to apples comparison than the current comparisons of 2010 emissions with earlier emission estimates. It should be noted that the higher estimates of OGV emissions do not necessarily reflect actual higher emissions in 2010 than in previous years; rather, the improved vessel movement data provides a more complete picture of vessel operations that was not available using the older methods. In fact, with a lower number of vessel calls and the Port Authority's implementation of their low sulfur fuel program, OGV emissions would be expected to be lower in 2010 than in earlier years, and future inventories developed in future years will determine whether decreases continue to occur.

5.3.1 Data Sources

This subsection discusses the sources of information used in developing the emission estimates for commercial marine vessels associated with the Port Authority marine terminals. The vessel categories of OGVs, assist tugs, and towboats are discussed in turn.

5.3.1.1 Ocean-Going Vessels

The year 2010 AIS data for vessels that called the Port Authority marine terminals forms the basis of the emission estimates presented in this report. Some of the terminals provided the number of calls for their terminals in 2010, which were used to check the AIS activity data results. The AIS vessel data for the Port Authority marine terminals was used to develop vessel type characteristic averages to be used for vessels that did not have specific data, and to determine speeds, routes, and dwelling times.

OGV emissions have been estimated for the two general modes of ship operations: transit and dwelling. Transit refers to the activity that occurs between the study area boundary and the terminal berth, while dwelling (also known as hotelling) refers to the vessel's operation while at berth. Activity levels have been evaluated based on the number of calls the vessels made to Port Authority marine terminals in 2010 and speed profiles within the channel based on information developed from the AIS data using geographical information system (GIS) data analysis. The vessel specific data was used to profile each vessel type's characteristics such as engine type, propulsion horsepower, onboard auxiliary horsepower, nation of registry, and other parameters.

Vessel call activity and main engine horsepower, along with estimated speed and time-in-mode data, have been used to estimate OGV emissions. Transit emissions have been differentiated by ship type and terminal of call. In addition, emissions have been estimated for the three primary ship-related emission sources: propulsion engines, auxiliary engines and auxiliary boilers. Different emission factors and calculation methods have been used for each emission source type, as appropriate.

Some of the findings and methods reported in the 2000, 2006 and 2008 marine vessel emissions inventories have been used in developing the 2010 emission estimates, with updates as appropriate to reflect improvements to emission estimating methodologies, the level of marine vessel activity in 2010, and the somewhat different scope of evaluation between the 2000 study and the more recent works (the 2000 study was concerned with commercial marine vessel activity over the entire harbor system, whereas the 2006, 2008, and 2010 studies have focused on marine vessel activity directly related to the marine terminals owned by the Port Authority and leased to private tenants).

The emission estimates developed for this report are based exclusively on the number of OGV calls to Port Authority-owned marine terminals, a subset of all NYNJHS calls. Based on AIS data, the numbers of calls of each vessel type to Port Authority owned marine terminals are listed in Table 5.25.

Table 5.25: 2010 Number of Calls to the Port Authority Marine Terminals

Vessel Type	Calls 2010
Auto Carrier/RORO	378
Bulk Carrier	64
Containership	1,986
Cruise Ship	46
General Cargo	41
Reefer	54
Tanker	49
Total	**2,618**

Average main engine and auxiliary engine power for each vessel type was derived from the Lloyd's data based on the specific vessels that called. For emission estimates, actual main and auxiliary engine power were used in the emission calculation. The averages in the table are shown as a summary of the data and were used as defaults in the circumstance that Lloyd's did not have information on a specific vessel. Auxiliary boiler capacity is not included in the Lloyd's data so values for this parameter were obtained from recently released marine vessel emissions inventories.[20] These values for the 2010 emission estimates are presented in Table 5.26.

Table 5.26: 2010 Average OGV Engine and Boiler Power (kW)

Vessel Type	Main Power (kW)	Auxiliary Power (kW)	Boiler Power (kW)
Auto Carrier	14,151	3,728	254
Bulk	8,202	1,573	130
Containership 1000	11,774	2,968	298
Containership 2000	21,915	5,338	253
Containership 3000	30,800	6,172	537
Containership 4000	40,966	7,478	578
Containership 5000	49,182	6,796	722
Containership 6000	57,120	14,111	667
Containership 8000	62,843	12,099	705
Containership 9000	68,639	11,520	705
Cruise	48,257	2,141	NA
General Cargo	7,163	1,577	130
Reefer	15,478	6,785	464
Ro-Ro	18,442	9,042	248
Tanker	9,031	2,133	3,000

[20] Port of Long Beach 2010 Air Emissions Inventory, July 2011.

5.3.1.2 Assist Tugs

Assist tug emissions have been estimated on the basis of typical assist tug activity associated with each OGV entering or exiting from the channel (e.g., how many tugs per call, the duration of assistance, etc.). The number of assist tugs per vessel type was updated during 2008 EI development based on discussions with assist tug operators and pilots. The emission factors (see section 5.3.2) were also updated to take into account the average model year of the assist tugs in the harbor. Table 5.27 lists the number of vessel assists and the average number of assist tugs per arrival or departure for the various vessel types.

Table 5.27: Assist Tug Operating Data and Assumptions

Vessel Type	Inbound trips	Outbound trips	Shifts	Total trips	Average Assists per Movement	Total Assists
Auto Carrier/RORO	373	366	96	835	2	1,670
Bulk Carrier	62	54	25	141	2	282
Containership	1,960	1,942	23	3,925	2	7,850
Cruise Ship	46	46	0	92	1	92
General Cargo	41	40	4	85	2	170
Reefer	54	53	0	107	2	214
Tanker	48	47	15	110	2	220
Total	**2,584**	**2,548**	**163**	**5,295**		**10,498**

5.3.1.3 Towboats/Pushboats

The various marine terminals provided a record of the towboat/pushboat arrivals and departures related to Port Authority marine terminals during 2010. The types of materials moved to or from the terminals included containers, fuel, dry bulk such as scrap metal, and dredged material from wharf maintenance dredging. The vessel operating characteristics such as onboard engine horsepower were updated from the previous inventory data while the average load factors were kept consistent with the 2006 and 2008 emissions inventory. The same emission factors were used for these vessels as for assist tugs, because the vessels share many of the same characteristics.

5.3.2 Estimating Methodology

Emission estimates have been developed for the three combustion emission source types associated with marine vessels: main (or propulsion) engines, auxiliary engines, and, for OGVs, auxiliary boilers. OGV emissions have been further segregated into transit (arrival/departure) and dwelling (at-berth) components. Operating data and the methods of estimating emissions are discussed below for the three source types – differences between transit and dwelling methodologies are discussed where appropriate. It should be noted that in 2008, all OGVs calling the port terminals were assumed to use residual fuel with an average 2.7% sulfur content. In 2008, assist tugs and towboats/pushboats burned off-road diesel fuel (500 ppm sulfur content).

5.3.2.1 OGV Main Engines

Main engine emissions are only estimated for transiting because in almost all cases a vessel's main engines are turned off while the vessel is tied up at berth. The emission calculation can be described using the following equation:

Equation 5.1

$$\textit{Emissions (grams)} = \textit{MCR power (kW)} \times \textit{LF} \times \textit{activity (hours)} \times \textit{EF (g/kW-hr)}$$

Where:

Emissions in grams are converted to tons by dividing by 453.59 grams per pound and 2,000 pounds per ton

MCR power = maximum continuous rated power

LF = load factor, calculated as $(\text{actual speed}/\text{sea speed})^3$

activity = hours at the given (actual) speed, calculated as distance/speed

EF = factor that expresses mass emissions (grams) in terms of kW-hrs (g/kW-hr)

The load factor is calculated using a relationship between vessel speed and power requirement known as the Propeller Law, which holds that the power required to move a vessel through the water varies with the cube of the ratio of the vessel's actual speed to its maximum speed. Therefore, the maximum power multiplied by the cube of actual speed divided by maximum speed provides an estimate of the actual power demand at that speed.

Most of the emission factors used in these estimates were reported in a 2002 Entec study[21] and have been used in recent vessel emissions inventories in the U.S. The particulate matter and GHG emission factors have been updated based on newer information.[22] The SO_2 emission factor is based on fuel with an average 2.7% sulfur content, with adjustments applied for trips made by vessels that participated in the Port Authority's Low Sulfur Fuel Program during 2010. The emission factors used for main and auxiliary engines and for auxiliary boilers are listed in Tables 5.28 (criteria pollutants) and 5.29 (greenhouse gases).

Table 5.28: OGV Criteria Pollutant Emission Factors (g/kW-hr)

Engine Category	Model Year Range	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Slow Speed Main	1999 and older	18.1	1.3	1.04	0.6	1.4	10.5
Slow Speed Main	2000 and newer	17	1.3	1.04	0.6	1.4	10.5
Medium Speed Main	1999 and older	14	1.3	1.04	0.5	1.1	11.5
Medium Speed Main	2000 and newer	13	1.3	1.04	0.5	1.1	11.5
Steam Main and Boiler	All	2.1	0.8	0.64	0.1	0.2	16.5
Auxiliary	1999 and older	14.7	1.3	1.04	0.4	1.1	12.3
Auxiliary	2000 and newer	13	1.3	1.04	0.4	1.1	12.3

Table 5.29: OGV Greenhouse Gas Emission Factors (g/kW-hr)

Engine Category	Model Year Range	CO_2	N_2O	CH_4
Slow Speed Main	1999 and older	620	0.031	0.012
Slow Speed Main	2000 and newer	620	0.031	0.012
Medium Speed Main	1999 and older	683	0.031	0.012
Medium Speed Main	2000 and newer	683	0.031	0.012
Steam Main and Boiler	All	970	0.08	0.002
Auxiliary	1999 and older	683	0.031	0.008
Auxiliary	2000 and newer	683	0.031	0.008

[21] Entec, UK Limited, *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community, Final Report*, July 2002. Prepared for the European Commission.
[22] IVL, Methodology for Calculating Emissions from Ships: Update on Emission Factors," February 2004. Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency. (IVL 2004)

Emission factors are adjusted upward for speeds at which loads are less than 20% because vessel emissions are believed to increase at very low loads due to lower engine operating efficiency. Table 5.30 lists the low load adjustment factors used in estimating slow speed emissions. These unitless adjustment factors are included in Equation 5.1 above as an additional multiplier. Currently, greenhouse gas emission factors are not adjusted for low load operation.

Table 5.30: OGV Low Load Adjustment Factors

Load	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
2%	4.63	7.29	7.29	21.18	9.68	1.00
3%	2.92	4.33	4.33	11.68	6.46	1.00
4%	2.21	3.09	3.09	7.71	4.86	1.00
5%	1.83	2.44	2.44	5.61	3.89	1.00
6%	1.6	2.04	2.04	4.35	3.25	1.00
7%	1.45	1.79	1.79	3.52	2.79	1.00
8%	1.35	1.61	1.61	2.95	2.45	1.00
9%	1.27	1.48	1.48	2.52	2.18	1.00
10%	1.22	1.38	1.38	2.18	1.96	1.00
11%	1.17	1.3	1.3	1.96	1.79	1.00
12%	1.14	1.24	1.24	1.76	1.64	1.00
13%	1.11	1.19	1.19	1.6	1.52	1.00
14%	1.08	1.15	1.15	1.47	1.41	1.00
15%	1.06	1.11	1.11	1.36	1.32	1.00
16%	1.05	1.08	1.08	1.26	1.24	1.00
17%	1.03	1.06	1.06	1.18	1.17	1.00
18%	1.02	1.04	1.04	1.11	1.11	1.00
19%	1.01	1.02	1.02	1.05	1.05	1.00
20%	1.00	1.00	1.00	1.00	1.00	1.00

5.3.2.2 OGV Auxiliary Engines

Auxiliary engine emissions are estimated using an equation similar to the main engine equation:

Equation 5.2

Emissions (grams) = total rated power (kW) x LF x activity (hours) x EF (g/kW-hr)

Where:

Emissions in grams are converted to tons by dividing by 453.59 grams per pound and 2,000 pounds per ton

total rated power = the sum of the rated power of all installed auxiliary engines

LF = load factor, the average load over all installed auxiliary engines

activity = hours at the given load, calculated as distance/speed for transit and average dwelling duration for time at berth

EF = factor that expresses mass emissions (grams) in terms of kW-hrs (g/kW-hr)

OGVs are equipped with two or more auxiliary engines, and they are operated to run at the most efficient level for a given load situation. For example, an OGV equipped with four auxiliary engines may run three at 75% load when power needs are high during maneuvering, to power bow thrusters as well as to meet general operating needs. While at berth the vessel's power needs are less – instead of running the three engines at greatly reduced load, typically only one or two will be operated, which saves wear and tear on the others, and allows the operating engine to run at its optimal and (higher) operating levels. The "total rated power" used in the calculation is the sum of the rated power of all the auxiliary engines, and the load factor is the load of operating auxiliary engines spread over all installed auxiliaries. This is done to account for the wide variety of auxiliary engine types, sizes and operating conditions. Table 5.31 list the OGV auxiliary load factor assumptions used in this inventory.

Table 5.31: OGV Auxiliary Engine Load Factors

Vessel Type	Auxiliary Engines Transit	Auxiliary Engines Maneuver	Auxiliary Engines Dwelling
Auto Carrier	15%	45%	25%
Bulk	17%	45%	10%
Containership 1000	13%	50%	18%
Containership 2000	13%	43%	22%
Containership 3000	13%	43%	22%
Containership 4000	13%	50%	18%
Containership 5000	13%	49%	15%
Containership 6000	13%	50%	15%
Containership 8000	13%	50%	15%
Cruise Ship (Diesel Electric)	varies, see table below		
Cruise Ship (Direct Drive)	50%	85%	50%
General Cargo	17%	45%	22%
Reefer	15%	45%	32%
Ro-Ro	15%	45%	26%
Tanker	24%	33%	26%

For diesel electric cruise ships, house load defaults are listed in Table 5.32. Most cruise ships that called the cruise terminal were diesel electric, with the exception of two small cruise ships.

Table 5.32: Diesel Electric Cruise Ship Auxiliary Engine Load, kW

	Auxiliary Engine Load Defaults (kW)			
Vessel Type	Passenger Count	Transit	Maneuver	Dwelling
Cruise, Diesel Electric	0-1,500	3,500	3,500	3,000
Cruise, Diesel Electric	1,500-2,000	7,000	7,000	6,500
Cruise, Diesel Electric	2,000-3,000	10,500	10,500	9,500
Cruise, Diesel Electric	3,000-3,500	11,000	11,000	10,000
Cruise, Diesel Electric	3,500-4,000	11,500	11,500	10,500
Cruise, Diesel Electric	4,000+	12,000	12,000	11,000

Operating hours (activity) are based on the same distance/speed calculation as for main engines for periods the vessels are in motion and on the specific dwell times provided by vessel call. Dwell times for this inventory were calculated from the AIS data for each call and these times were used in the emissions calculations. Table 5.33 lists the minimum, maximum, and average dwell times for the different vessel types and sizes that called at Port Authority terminals.

Table 5.33: Summary of Average Dwell Time, hours

Vessel Type	Dwell Times, hours Minimum	Maximum	Average
Auto Carrier	0	63	15
Bulk	0	195	48
Containership 1000	0	233	17
Containership 2000	0	48	18
Containership 3000	0	270	22
Containership 4000	0	135	21
Containership 5000	0	81	21
Containership 6000	0	66	32
Containership 8000	23	109	42
Containership 9000	42	42	42
Cruise	8	51	13
General Cargo	0	96	19
Reefer	0	269	13
Ro-Ro	0	51	10
Tanker	0	220	35

The preceding table includes zeroes as the minimum dwell time for several vessel types. A dwell time of zero hours might occur, for example, if a vessel arrives at a berth then immediately shifts to another berth – since all vessel activities have been included in the AIS data analysis, these vessel movements are included in the inventory as transit emissions but no dwelling emissions. If the vessel subsequently had a normal dwelling event at the second berth, the emissions associated with that dwelling event are included in the inventory.

5.3.2.3 OGV Auxiliary Boilers

The same basic equation is used to estimate auxiliary boiler emissions as main and auxiliary engines. Boilers typically are not needed when vessels are under way since most vessels are equipped with economizers (waste heat boilers) that recover main engine exhaust heat. The auxiliary boilers start up as exhaust temperatures decreases when vessel speed decreases upon arrival in the harbor system, and they are assumed to be fully operating during maneuvering conditions.

The boiler kW values shown in Table 5.26 have been converted from fuel consumption data to standardize the calculation methodology. The values presented are in-use estimates for normal operation, so the load factor for operating boilers is 100% except for tankers while maneuvering, in which case the load factor is 7%. This special treatment of tankers is made because many tankers operate very large boilers to run discharge pumps when they are off-loading cargo, so the kW value used for tanker boilers represents this high operating level for much of the tankers' dwelling time. During maneuvering the boilers are not operating at this high rate, so the load factor is reduced to account for the lower level of operation. Boiler load factor assumptions are presented below in Table 5.34.

Table 5.34: OGV Boiler Load Factors

Vessel Type	Boilers Harbor	Boilers Dwelling
Auto Carrier / RORO	100%	100%
Bulk Carrier	100%	100%
Containership	100%	100%
Cruise Ship (Diesel Electric)	100%	0%
Cruise Ship (Direct Drive)	100%	100%
General Cargo	100%	100%
Reefer	100%	100%
Tanker	7%	100%

5.3.2.4 Assist Tugs, Towboats, Pushboats

The emission estimating methodology for assist tugs and towboats/pushboats is similar, based on an estimate of operating time of the vessels in service related to the Port Authority owned marine terminals. The basic equation for estimating main and auxiliary engine emissions is similar, and is illustrated below.

Equation 5.3

Emissions (grams) = engine power (kW) x LF x activity (hours) x EF (g/kW-hr)

Where:

Emissions in grams are converted to tons by dividing by 453.59 grams per pound and 2,000 pounds per ton

engine power = the sum of the rated power of all installed main or auxiliary engines (many vessel are equipped with two main engines that work in tandem, most have only one auxiliary engine)

LF = load factor for each engine

activity = hours of engine operation at the given load

EF = factor that expresses mass emissions (grams) in terms of kW-hrs (g/kW-hr)

The load factors used for assist tugs are 31% for main engines and 43% for auxiliary engines. The 31% for assist tugs is based on empirical data first published in the Port of Los Angeles' 2001 vessel emission inventory,[23] and which has been used widely since that time. The 43% factor for auxiliary engines is based on the EPA NONROAD model guidance[24] and has also been used in this inventory for the towboat/pushboat emission estimates. The main engine

[23] 2001 POLA Baseline Emissions Inventory

[24] EPA, *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*, December 2002, EPA 420-P-02-014.

load factor for towboats and pushboats is 68% and is based on a California survey findings report[25] and has been used in previous inventories.

As discussed above, the operating time of assist tugs has been estimated on the basis of the amount of time spent assisting per OGV call, the average number of assist tugs per OGV call, and the total number of OGV calls to the Port Authority owned marine terminals in 2010. The operating time of towboats and pushboats has been estimated from the number of visits to the terminals and a profiled time from the 2006 towboat detailed activity data in which time was estimated by dividing trip length by speed in mode. Since detailed origination-destination data was not available for 2010 towboat activity as it was for 2006, the 2006 trip times were averaged and the resulting average trip time of 2.7 hours was used for 2010.

The emission factors used for assist tug, towboat, and pushboat main and auxiliary engines are listed in Table 5.35.

Table 5.35: Assist Tug and Towboat/Pushboat Emission Factors, g/kW-hr

Engine	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2	N_2O	CH_4
Main Engines	12.8	0.70	0.68	0.50	1.42	0.27	690	0.08	0.23
Auxiliary Engines	10.0	0.40	0.39	0.27	1.70	0.27	690	0.08	0.23

The base emission factors[26] are based on marine engine standards (i.e., Tier 1, Tier 2) and the EPA engine category. Main engines for the tugboat fleet in NYNJ harbor mainly fall into Category 2 and the auxiliary engines are typically Category 1. EPA identifies the engine category in terms of cylinder displacement. Category 1 engines have 1 to 5 liters per cylinder displacement, while category 2 engines have a cylinder displacement between 5 to 30 liters.

A list of 37 specific tugboats was provided by the predominant vessel assist tugboat companies in the harbor. The majority of these vessels have marine engines that are pre-regulation or Tier 0 engines (engines older than 1999). There were 5 vessels that had main engines with newer engines due vessel repower or due to new vessels in the fleet. The new engines fell into Tier 1 (IMO regulation for NO_x starting in the year 2000) and Tier 2 (EPA regulation that affects engines with model year 2005 and newer). In order to take into account the newer vessels and vessels with new engines, a weighted emission factor was calculated for the main engines using the number of vessels subject to each emission standard. The same emission factors are used for assist tugs, towboats, and pushboats. Information on specifically which boats work within the harbor is not available at this time, but is believed the assist tugs and towboats/pushboats have similar characteristics and the use of the same emission factors may be a conservative assumption since there have been numerous vessel repowers in the region.

[25] California Air Resources Board, *Statewide Commercial Harbor Craft Survey*, Final Report, March 2004.
[26] *Control of Emissions of Air Pollution from New CI Marine Engines at or above 37 kW*, 40CFR Parts 89, 92, 64 FR 64 73300-73373, 29 Dec 1999.

The SO_2 emission factor was calculated using a mass-balance method with an assumed diesel fuel sulfur content of 500 ppm in 2010.

5.4 Description of Marine Vessels and Vessel Activity

The types of marine vessel evaluated in this emissions inventory include ocean-going vessels (OGVs), their assist tugs, and associated towboats and pushboats, such as those that provide bunkering (refueling) services or transport materials from wharf maintenance dredging activities.

5.4.1 Ocean-Going Vessels

OGVs are seafaring vessels that are primarily involved in international trade. Generally, these vessels are over 300 feet in length and can make seaward passages greater than 25 miles. The following are types of OGVs that have been evaluated in this study:

Bulk and Break Bulk (General Cargo) Carriers carry granulated products in bulk (e.g., cement, sugar, coking coal) as well as goods known as break bulk such as machinery, steel, palletized goods, and livestock. In general, bulk carriers are slower and older than most other types of OGVs.

Figure 5.16: Bulk Carrier

Photograph courtesy of Petter Folkedahl Knutsen, Tuvika, Norway
http://home.nktv.no/petknu/skip.htm

Containerships carry standard-sized, steel-reinforced containers. Their capacity is measured in "twenty-foot equivalent units" (TEUs). Containers are an economical mode of marine transportation for a wide variety of dry and liquid cargos. Specialized containers can be equipped for refrigeration, and many ships have a number of electrical connections to store and power refrigerated units.

Figure 5.17: Containership at Berth

Passenger Cruise Ships have high diesel-powered generation capacities from auxiliary engines which are used to provide electricity, air conditioning, hot water, refrigeration, and other power-related demands associated with the ship.

Figure 5.18: Cruise Ship

Roll-on/Roll-off (RORO) Vessels and Car Carriers carry vehicles and other wheeled equipment. Some carry heavy-duty equipment such as military tanks, excavators, bulldozers and other similar equipment. Their unique feature is a moveable ramp that allows the vessel to load and unload wheeled vehicles and equipment. *Car Carriers* are a specialized type of RORO outfitted with lower deck heights specifically for the transport of cars, trucks, and other vehicles.

Figure 5.19: Car Carrier

Tankers carry crude oil, finished liquid petroleum products, and other liquids. Parcel tankers are specialized tankers that carry several different products at the same time in separate on-board tanks. Other liquids that may be carried include sewage, water, liquefied petroleum gas (LPG) and fruit juices.

Figure 5.20: Tanker

5.4.2 Assist Tugs, Towboats, Pushboats

Assist tugs help maneuver OGVs within the NYNJHS and during docking and departing from berths. Towboats are vessels that tow barges within the NYNJHS, moving cargo such as bunker fuel for refueling visiting OGVs. Boats used as assist tugs can also do duty as towboats. Pushboats are similar to towboats, except, as their name implies, they push barges rather than tow them. They can be used to move bulk liquids, scrap metal, bulk materials, rock, sand, dredged materials, and other materials.

Figure 5.21: Tugboat