THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

PORT COMMERCE DEPARTMENT

2008 MULTI-FACILITY EMISSIONS INVENTORY OF CARGO HANDLING EQUIPMENT, HEAVY-DUTY DIESEL VEHICLES, RAILROAD LOCOMOTIVES AND COMMERCIAL MARINE VESSELS

FINAL

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Prepared for:
The Port Authority of New York and New Jersey

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LIST OF ACRONYMS

CHE	Cargo handling equipment
HDDV	Heavy duty diesel vehicles
NYNJLINA	New York/New Jersey Non-Attainment Area
EPA	United States Environmental Protection Agency
NO_x	Oxides of nitrogen
CO	Carbon monoxide
PM_{10}	Particulate matter less than 10 microns in diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
VOCs	Volatile organic compounds
SO_2	Sulfur dioxide
GHGs	Greenhouse gases
CO_2	Carbon dioxide
N_2O	Nitrous oxide
CH_4	Methane
ASI	American Stevedoring, Inc.
NYCT	New York Container Terminal
PNCT	Port Newark Container Terminal
SCC	Source classification code
ppm	Parts per million
hp	Horsepower
g/hp-hr	Grams per horsepower hour
hp-hr	Horsepower hour
EPAMT	Elizabeth Port Authority Marine Terminal
FAPS	Foreign Auto Preparation Services
WWL	Wallenius Wilhelmsen Logistics
NEAT	Northeast Auto Terminal
tpy	Tons per year
VMT	Vehicle miles traveled
g/mi	Grams per mile
g/hr	Grams per hour
GVWR	Gross vehicle weight rating
TEUs	Twenty-foot equivalent units
GTM	Gross ton-miles
g/MMGTM	Grams of emissions per million gross ton-miles
NYNJHS	New York/New Jersey Harbor System
kW	Kilowatt
LPG	Liquefied petroleum gas

EXECUTIVE SUMMARY

The purpose of this inventory is to estimate air emissions generated in 2008 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 2006 Baseline Multi-Facility Emissions Inventory released in November 2008, which covers land-based mobile sources and commercial marine vessels associated with the Port Authority facilities leased to private operators.

This inventory represents an update to the emission estimates presented in the 2006 baseline emissions inventory, and is the first opportunity to evaluate the effects of measures the Port Authority and the Port Authority's tenants are voluntarily implementing to reduce their portion of maritime-related air emissions.

Key Findings

Although the primary purpose of this emissions inventory is to provide an update to the emission estimates presented in the previous 2006 baseline 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 constitute approximately one and a half percent (1.6%) of the overall NYNJLINA NO_x emissions. This represents a 0.2% reduction and improvement relative to the 1.8% in the 2006 baseline.
- Port Authority maritime emissions of particulate matter less than 10 microns (PM_{10}) related to the Port Authority marine terminals constitute two tenths of a percent (0.2%) of the overall NYNJLINA PM_{10} emissions. This represents a 0.1% reduction and improvement relative to the 0.3% in the 2006 baseline.
- Port Authority maritime emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) related to the Port Authority marine terminals constitute less than one percent (0.9%) of the overall NYNJLINA $PM_{2.5}$ emissions. This represents a 0.2% reduction and improvement relative to the 1.1% in the 2006 baseline.
- Port Authority maritime emissions of volatile organic compounds (VOCs) related to the Port Authority marine terminals constitute less than a tenth of a percent (0.07%) of the overall NYNJLINA VOC emissions. This represents a 0.03% reduction and improvement relative to the 0.1% in the 2006 baseline.
- Port Authority maritime emissions of carbon monoxide (CO) related to the Port Authority marine terminals constitute less than a tenth of a percent (0.05%) of the overall NYNJLINA CO emissions. This represents no change from the 0.05% in the 2006 baseline.
- Port Authority maritime emissions of sulfur dioxide (SO_2) related to the Port Authority marine terminals constitute less than two percent (1.7%) of the overall NYNJLINA SO_2 emissions. This represents a 0.4% reduction and improvement relative to the 2.1% in the 2006 baseline.

- Emissions of greenhouse gases (GHG) related to the Port Authority marine terminals were reduced by over 8% compared to the 2006 baseline.

Scope

This inventory includes emissions generated in 2008 that are linked to five Port Authority-associated marine terminals. Three of these terminals are in New Jersey:

- Port Newark,
- The Elizabeth Port Authority Marine Terminal, and
- The Port Authority Auto Marine Terminal (in Bayonne and Jersey City).

The remaining two marine terminals are in New York:

- The Howland Hook Marine Terminal (on Staten Island), and
- 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 – such as Global Marine Terminal, 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 $PM_{2.5}$.

Previous Inventories

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

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

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).

Overall Port Activity

The Port of New York and New Jersey is the largest 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 2008, nearly 5.3 million TEUs passed through the Port (including both Port Authority and non-Port Authority facilities), a 3.5% increase over the 5.1 million TUEs moved in 2006. In terms of total metric tons of cargo, throughput increased 8% from 31.2 million to 33.6 million metric tons, and the value of all cargo moved through the Port reached $190 billion, a 27% increase over the nearly $150 billion in 2006.

The emission estimates developed as described in this report are summarized below. Table ES.1 presents the criteria pollutant 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. Table ES.2 illustrates the percentage contribution of each source category to the total PANYNJ emissions of each pollutant. Tables ES.3 and ES.4 present the emissions and percentages of greenhouse gases. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states. Note that the columns in the percentage tables do not all add to exactly 100% due to rounding of the percentage values.

Table ES.1: Criteria Pollutant Emission Summary by Source Category, tpy - 2008

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	1,048	66	64	89	355	17
Heavy-Duty Diesel Vehicles	2,331	59	54	105	603	2
Railroad Locomotives	268	10	9	20	45	4
Ocean-Going Vessels	2,934	288	230	113	255	2,935
Harbor Craft	425	23	22	16	48	9
Total PANYNJ Emissions	**7,006**	**445**	**379**	**344**	**1,306**	**2,966**
NYNJLINA Emissions	**445,285**	**178,451**	**42,441**	**522,245**	**2,840,374**	**170,044**
PANYNJ Percentage	**1.6%**	**0.2%**	**0.9%**	**0.07%**	**0.05%**	**1.7%**

Table ES.2: Criteria Pollutant Emission Summary by Source Category, % - 2008

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	15%	15%	17%	26%	27%	1%
Heavy-Duty Diesel Vehicles	33%	13%	14%	31%	46%	0%
Railroad Locomotives	4%	2%	2%	6%	3%	0%
Ocean-Going Vessels	42%	65%	61%	33%	19%	99%
Harbor Craft	6%	5%	6%	5%	4%	0%
Totals	**100%**	**100%**	**100%**	**101%**	**99%**	**100%**

[2] See: *http://www.epa.gov/ttn/chief/net/2005inventory.htm*l

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	114,046	3	6	115,014
Heavy-Duty Diesel Vehicles	210,832	1	1	211,042
Railroad Locomotives	17,024	0	1	17,183
Ocean-Going Vessels	172,550	9	2	175,517
Harbor Craft	23,086	3	8	24,077
Totals	**537,537**	**16**	**17**	**542,834**

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

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	21%	19%	34%	21%
Heavy-Duty Diesel Vehicles	39%	4%	4%	39%
Railroad Locomotives	3%	3%	8%	3%
Ocean-Going Vessels	32%	58%	10%	32%
Harbor Craft	4%	17%	44%	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.

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

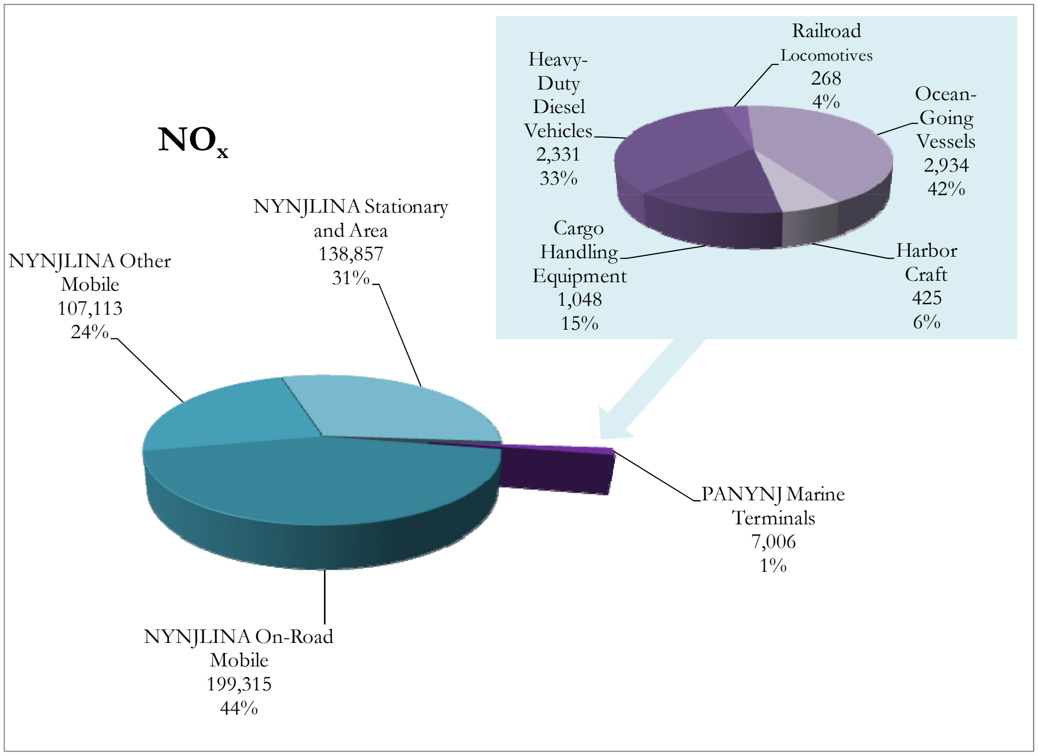


Figure ES.2: Distribution of PM_{10} Emissions by Source Category, tpy & percent

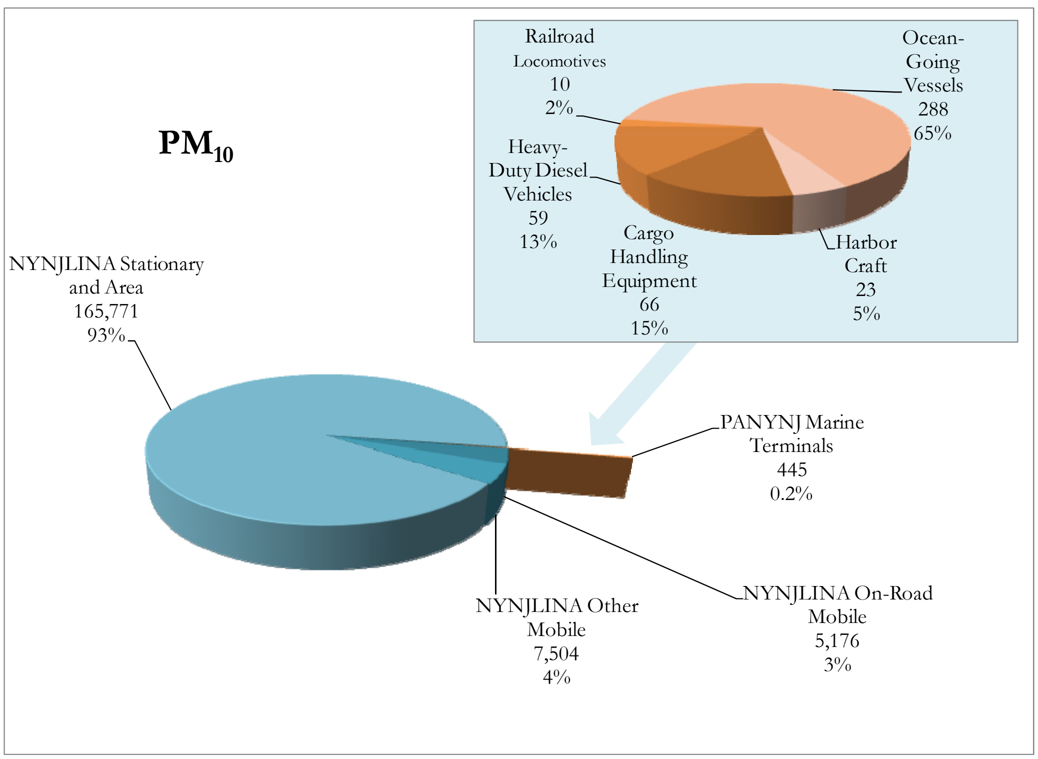


Figure ES.3: Distribution of $PM_{2.5}$ Emissions by Source Category, tpy & percent

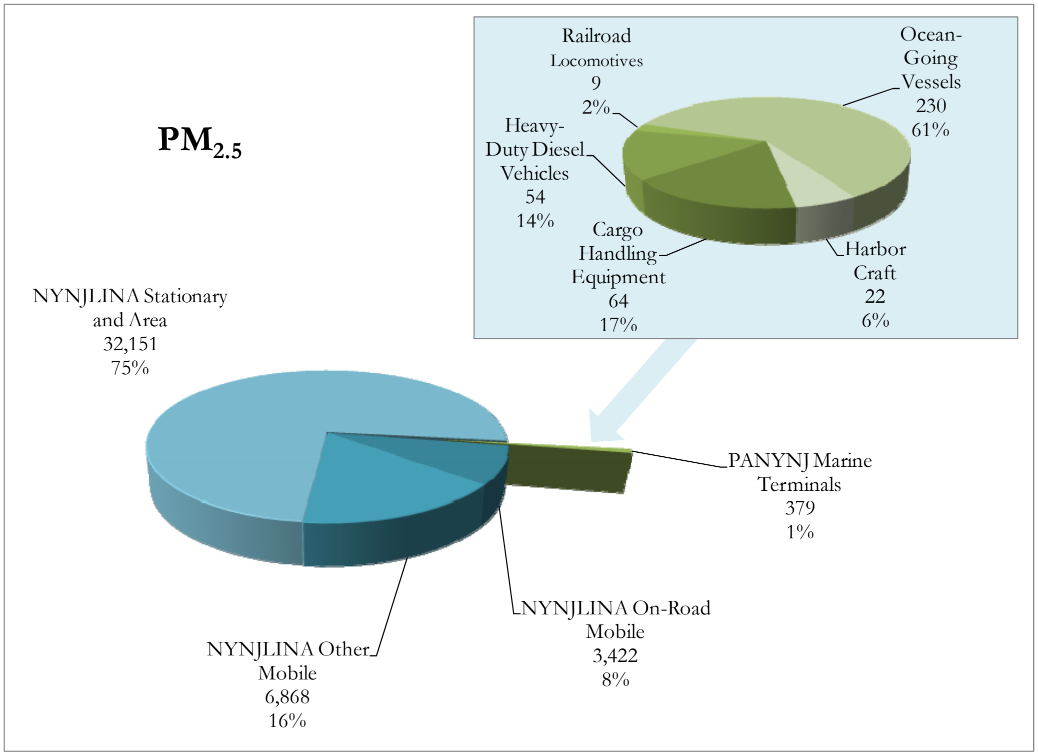


Figure ES.4: Distribution of VOC Emissions by Source Category, tpy & percent

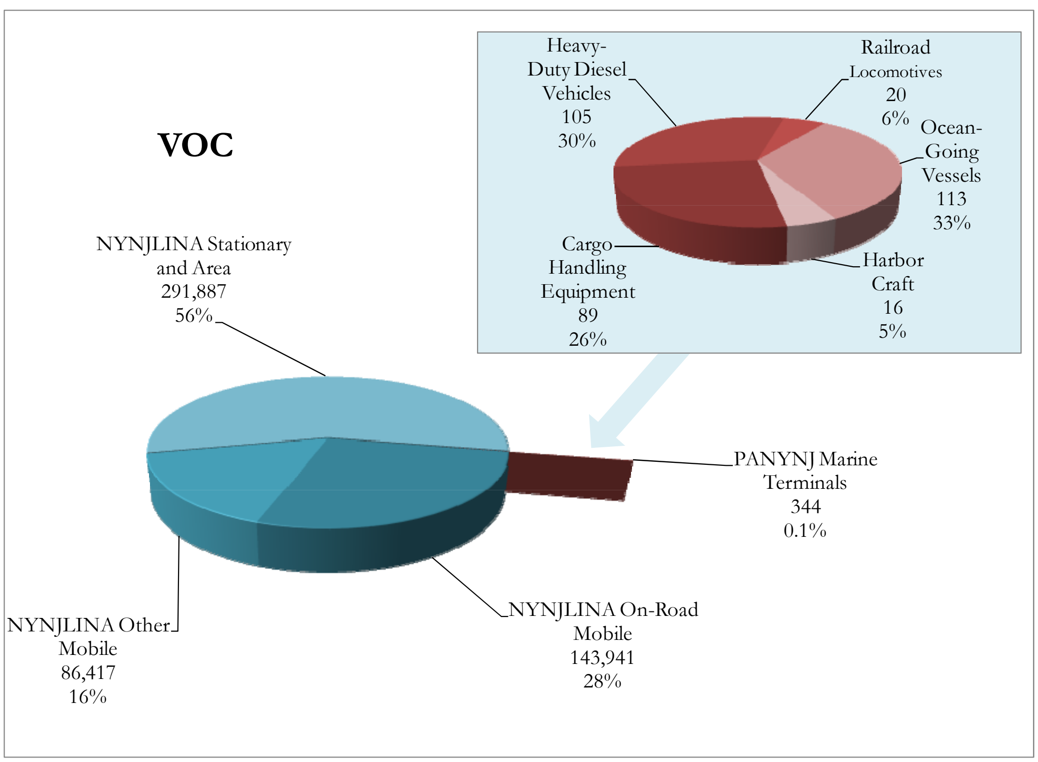


Figure ES.5: Distribution of CO Emissions by Source Category, tpy & percent

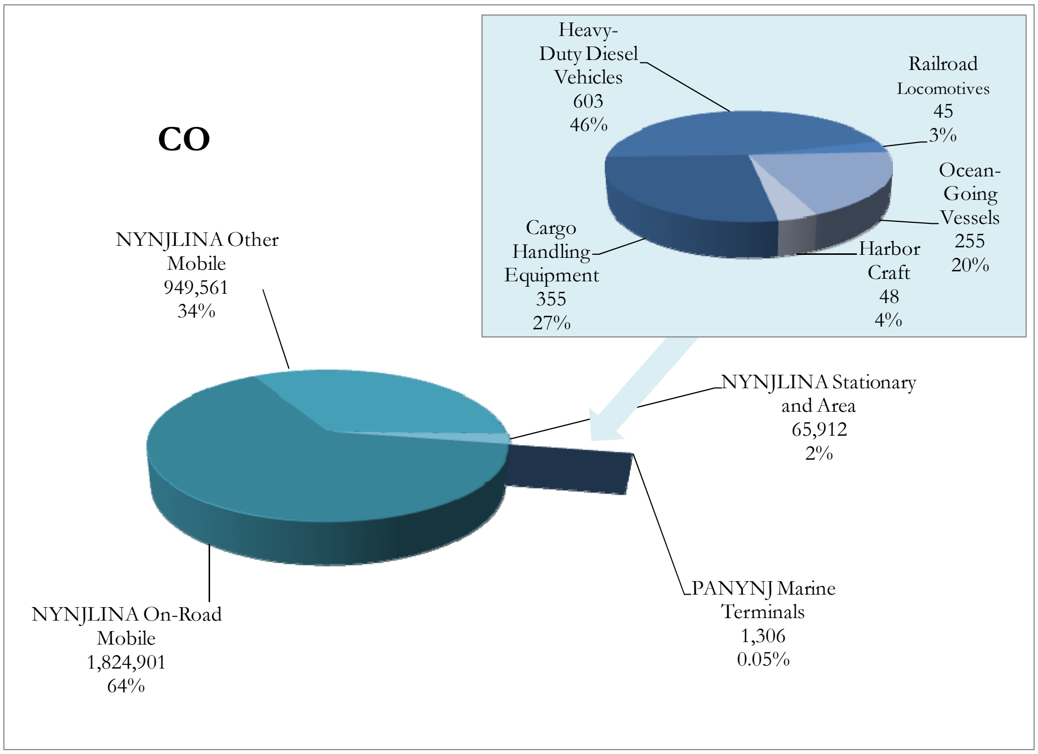
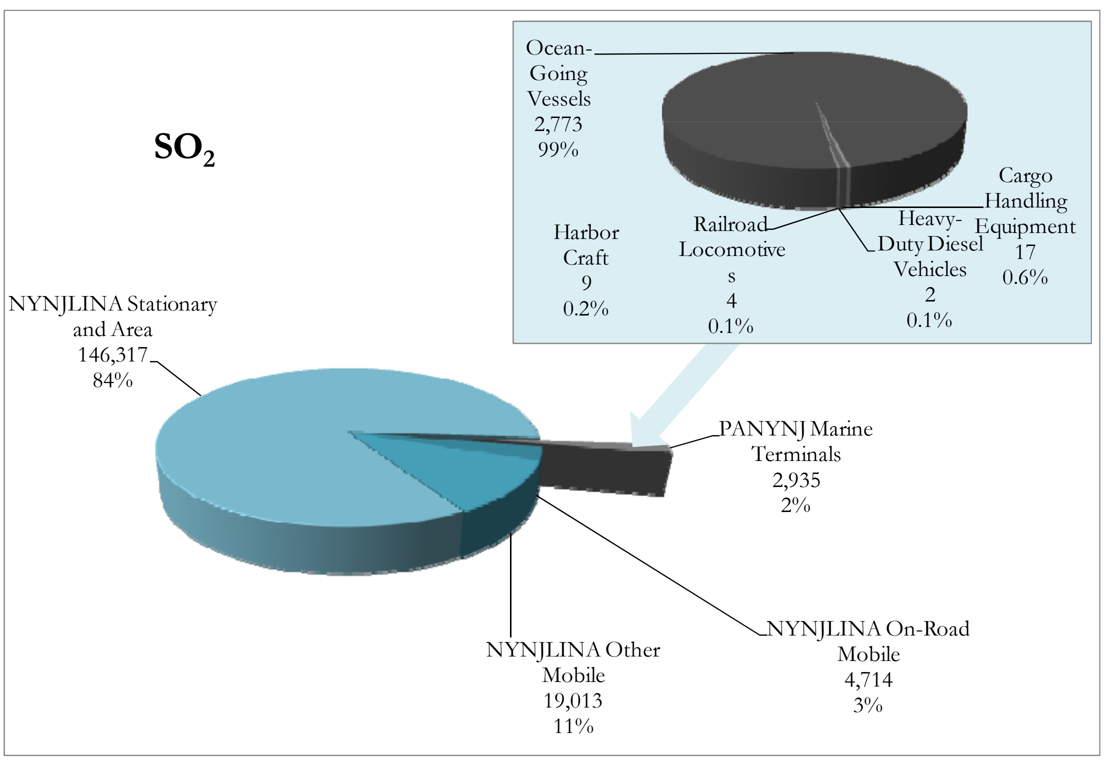
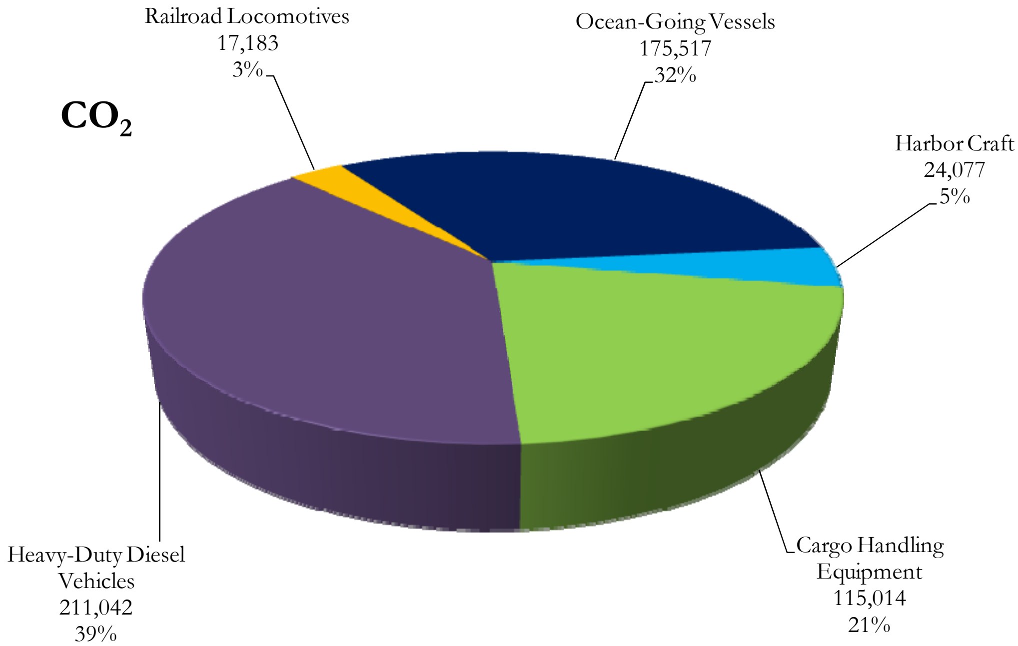


Figure ES.6: Distribution of SO_2 Emissions by Source Category, tpy & percent



The following figure shows only the breakdown of greenhouse gas emissions from Port Authority marine terminal related sources and not the relationship with overall emissions in the NYNJLINA because county-level (and area-level) emission estimates have not been prepared by the state agencies responsible for preparing the statewide inventories, or by EPA.

Figure ES.7: Distribution of CO_2 Equivalent 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, five 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 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).

This inventory does not include emissions from activities linked to the various marine terminals that are entirely privately owned and operated – such as Global Marine Terminal, 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 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 five marine terminals, including port-industry emissions from cargo handling equipment (CHE), heavy duty diesel vehicles (HDDV, i.e., trucks), locomotives, and commercial marine vessels (CMV) that visit these facilities. The inventory covers the activities discussed above associated with the Port Authority's five 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 ($PM_{2.5}$). A more detailed discussion of the NYNJLINA is presented in Appendix A. 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 marine vessels, including those associated with the five marine terminals maintained by the Port Authority and leased to private operators. The most recent of these inventories was the *2006 Baseline Multi-Facility Emissions Inventory* released in November 2008.

The purpose of this 2008 emissions inventory is to update the emission estimates presented in the 2006 baseline emissions inventory, which is focused on the five Port Authority marine terminals. This current study has evaluated the CHE, HDDV, railroad locomotive, and commercial marine vessel source categories for the year 2008, 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 marine vessel activity associated with the five 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, 2006.

1.1.1 Pollutants

This inventory estimates and reports the quantity of emissions from mobile emission sources tied to maritime facilities maintained by the Port Authority. The estimates are based on activities that occurred during calendar year 2008. 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 way 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 five of the Port of New York and New Jersey's marine terminals, three in New Jersey and two in New York (Figure 1). All five 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.

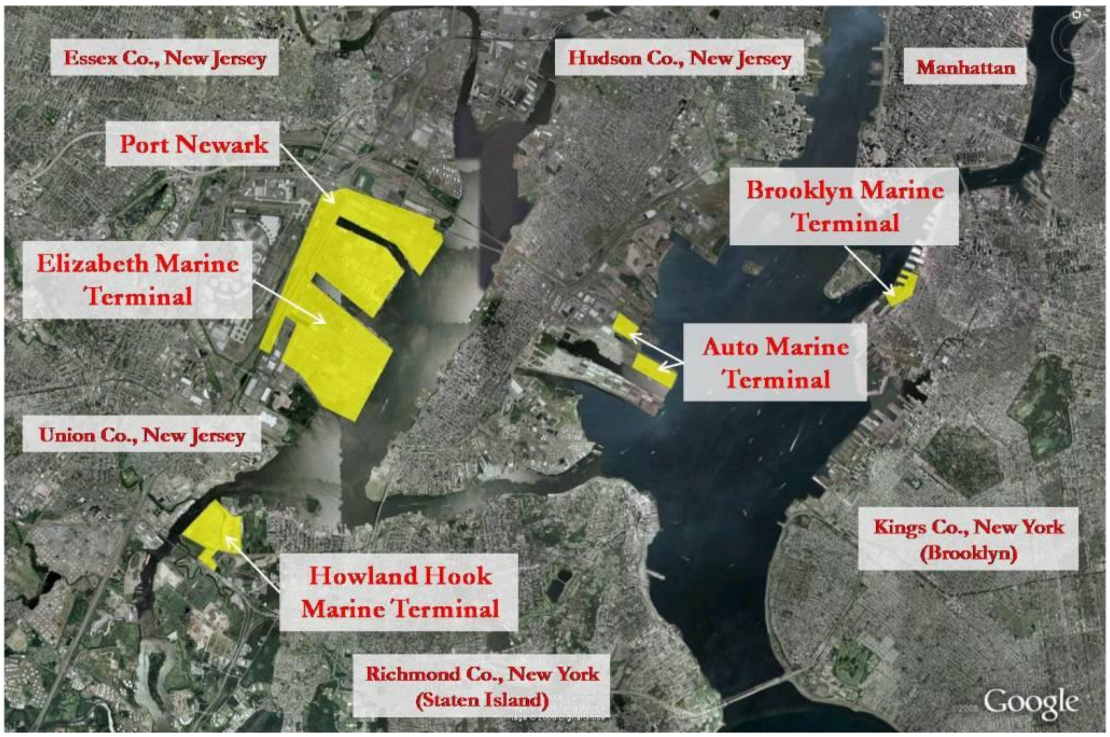
The Port Authority's New Jersey marine terminals are:

- Port Newark (which includes container, auto marine, and on-terminal warehousing operations),
- The Elizabeth Port Authority Marine Terminal or EPAMT (which includes container, auto marine, and on-terminal warehousing operations),
- The Port Authority Auto Marine Terminal (which includes auto marine operations).

The Port Authority's New York marine facilities are:

- The Howland Hook Marine Terminal (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



1.2 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), rail 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 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

[3] See: *http://www.epa.gov/ttn/chief/net/2005inventory.html*

the total NYNJLINA emissions. 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. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states.

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

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Heavy-Duty Diesel Vehicles	39%	4%	4%	39%
Railroad Locomotives	3%	3%	8%	3%
Ocean-Going Vessels	32%	60%	10%	32%
Harbor Craft	4%	17%	44%	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.

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

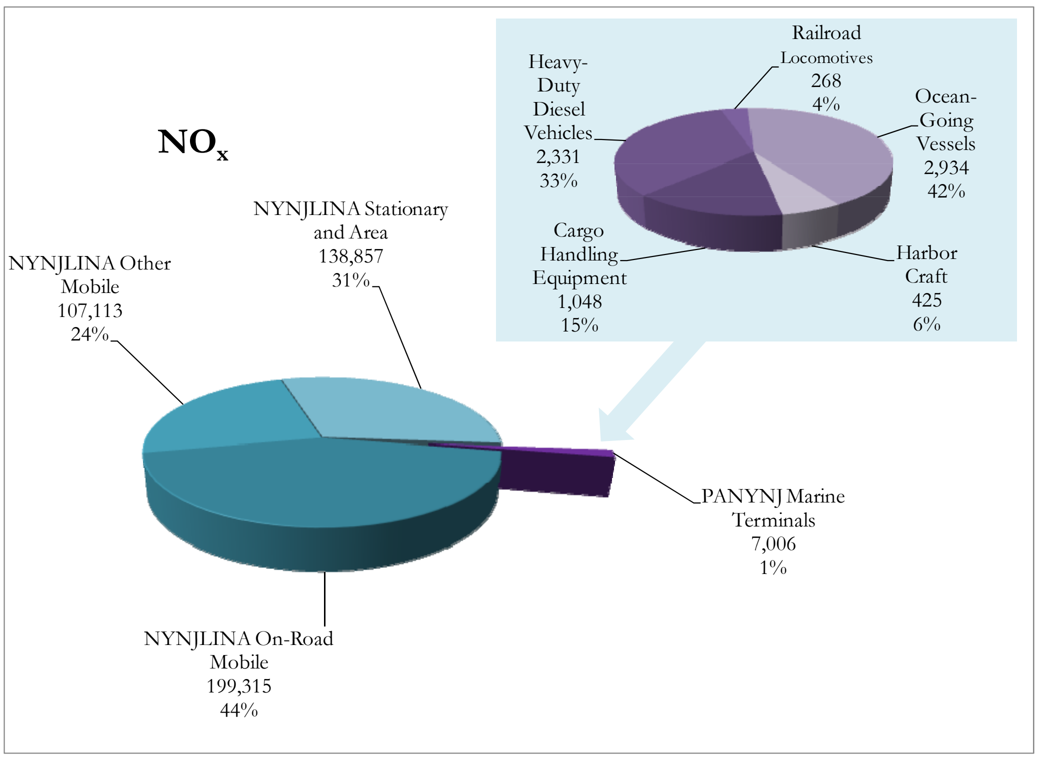


Figure 1.3: Distribution of PM_{10} Emissions by Source Category, tpy & percent

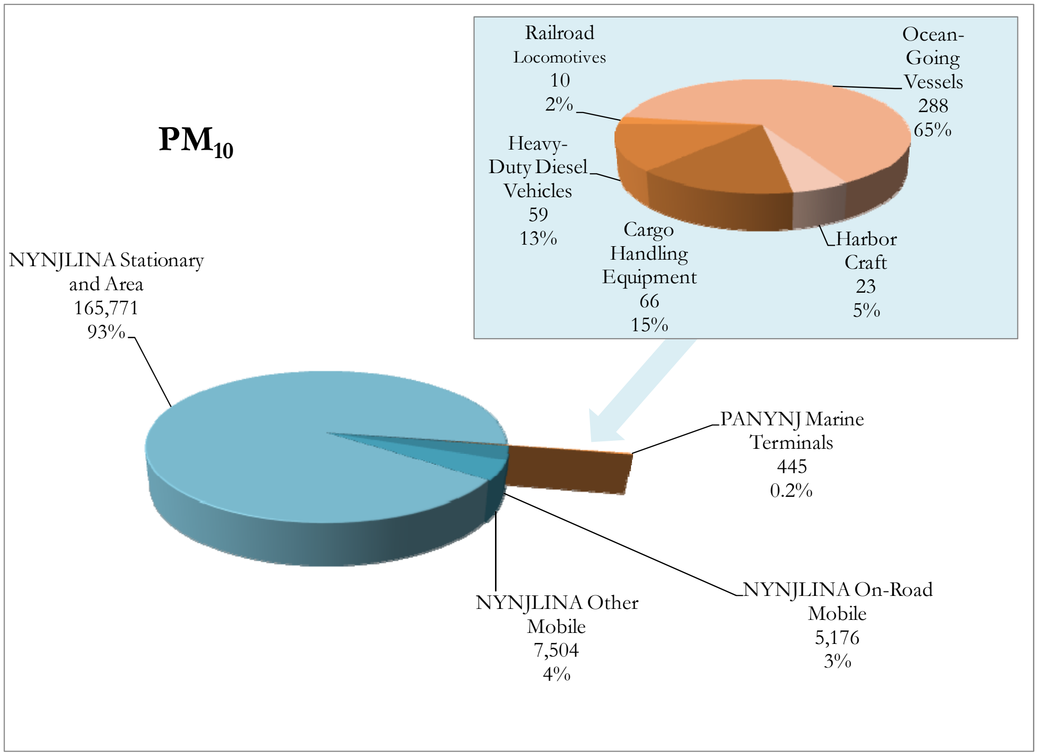


Figure 1.4: Distribution of $PM_{2.5}$ Emissions by Source Category, tpy & percent

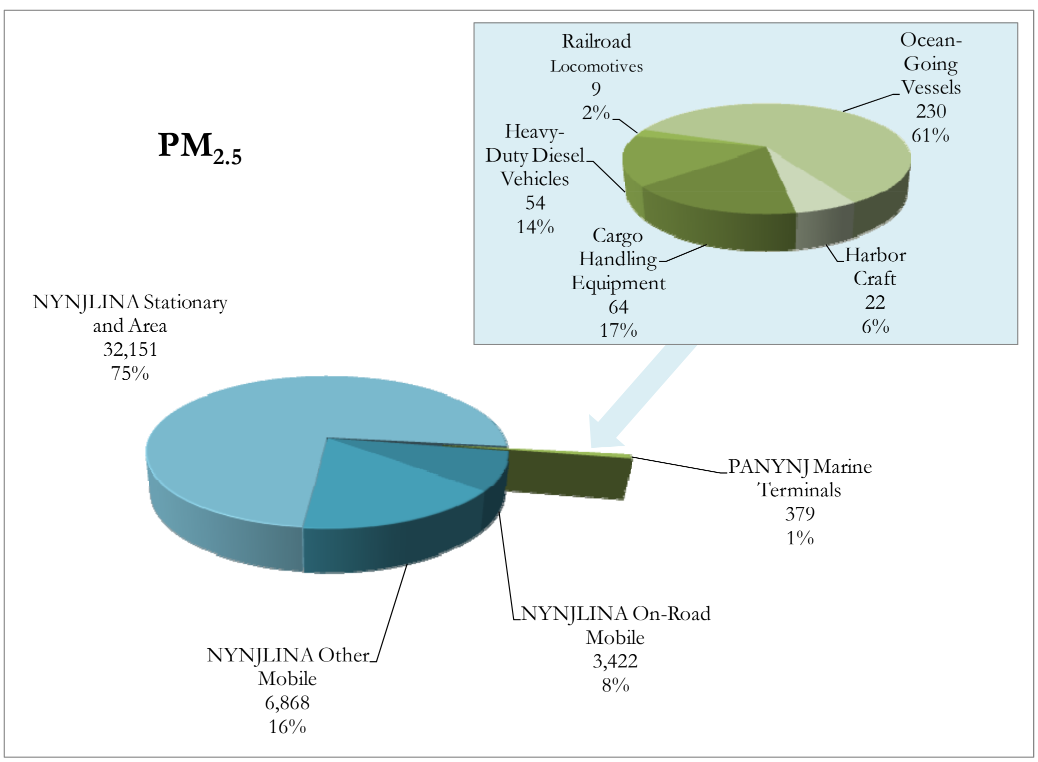


Figure 1.5: Distribution of VOC Emissions by Source Category, tpy & percent

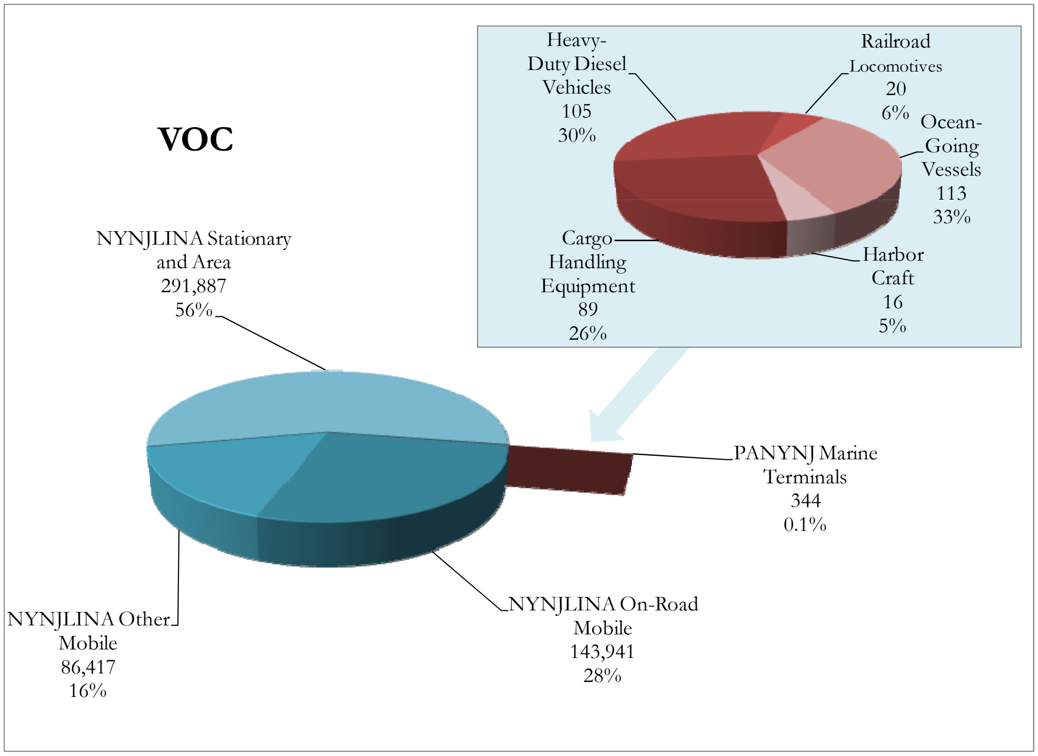


Figure 1.6: Distribution of CO Emissions by Source Category, tpy & percent

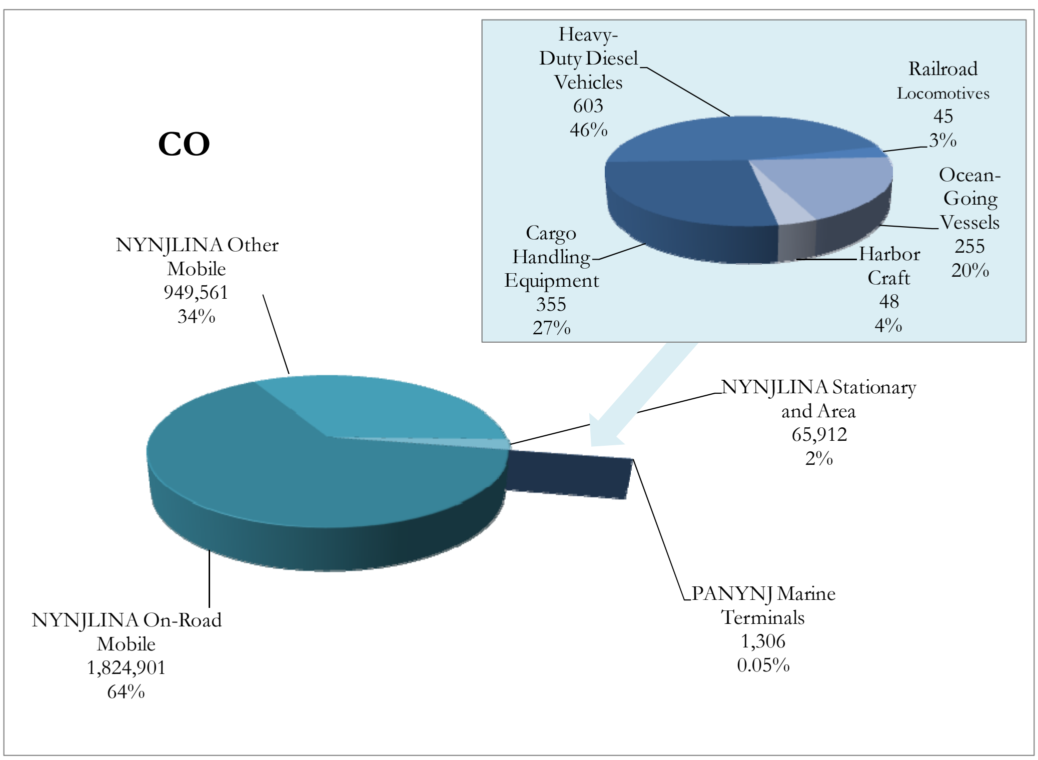
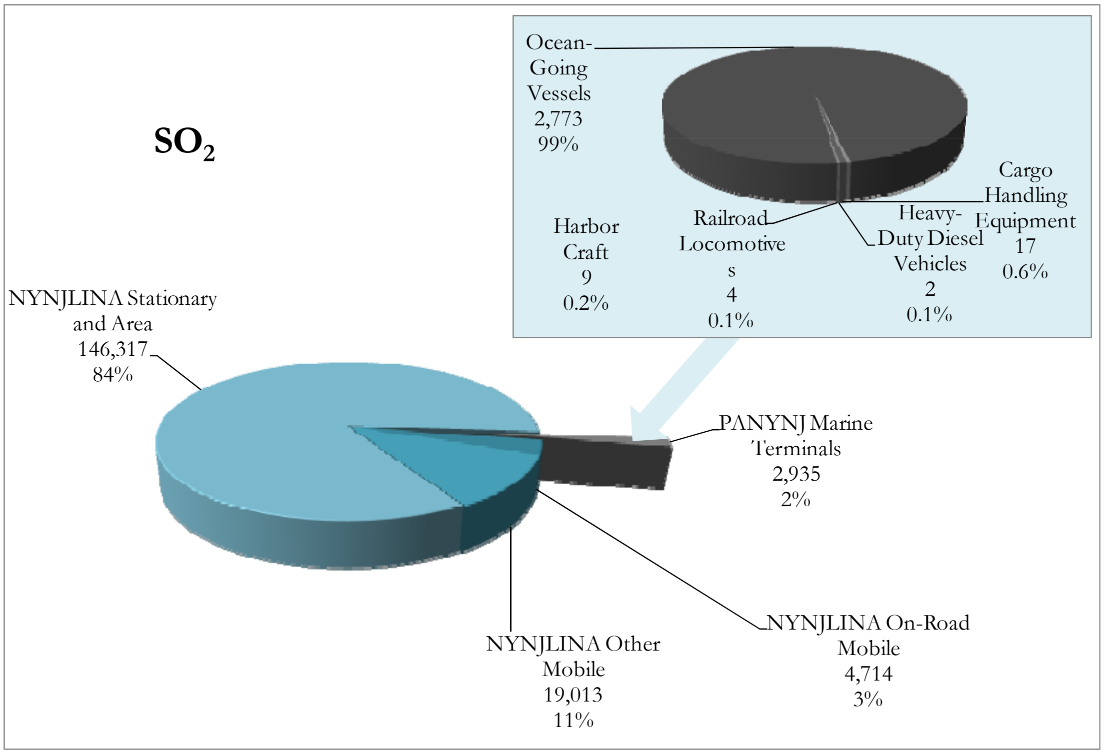
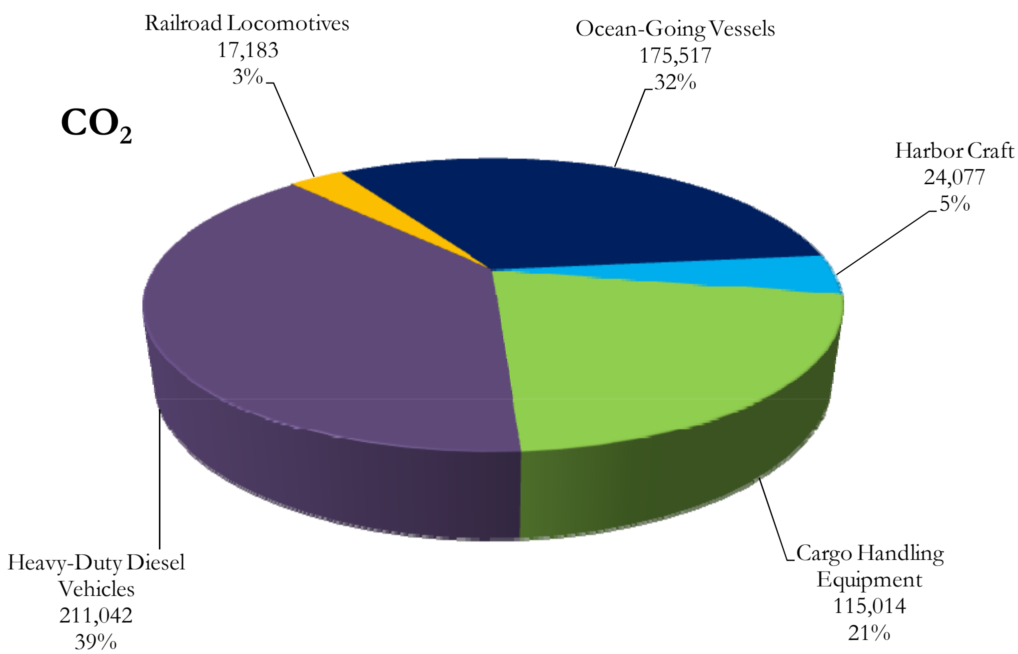


Figure 1.7: Distribution of SO_2 Emissions by Source Category, tpy & percent



The following figure shows only the breakdown of greenhouse gas emissions from Port Authority marine terminal related sources and not the relationship with overall emissions in the NYNJLINA because county-level (and area-level) emission estimates have not been prepared by the state agencies responsible for preparing the statewide inventories, or by EPA.

Figure 1.8: Distribution of CO_2 Equivalent 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 countywide and non-attainment area-wide emission, and in comparison to the emissions estimated for calendar year 2006 in the previous emissions inventory.

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 countywide 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] As of the date of this report, the 2005 inventory is the most current available.

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

[4] 2005 National Emission Inventory Database, US EPA, 2008
http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata
Note that this inventory has not been updated as of the date of this 2008 PANYNJ EI update.

criteria pollutant by county and state, as reported in the most recent National Emissions Inventory database. As noted above, EPA has not released updated countywide emission estimates since the release of the 2006 baseline emissions inventory, so the same countywide emissions are reported here as in the previous inventory. Greenhouse gases are not included in these tables because at the present time county-level estimates of overall greenhouse gas emissions are not available.

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

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	144	4	4	7	29	1
Essex	NJ	1,225	70	60	62	257	420
Hudson	NJ	627	37	31	28	91	236
Middlesex	NJ	370	10	9	17	80	1
Monmouth	NJ	254	20	16	11	27	159
Union	NY	2,064	141	123	117	460	896
New Jersey subtotal		**4,684**	**281**	**243**	**242**	**943**	**1,713**
Bronx	NY	39	1	1	2	9	0
Kings (Brooklyn)	NY	477	34	28	23	70	241
Nassau	NY	53	1	1	2	11	0
New York	NY	221	19	16	9	21	170
Orange	NY	35	1	1	2	7	0
Queens	NY	39	1	1	2	8	0
Richmond (Staten Island)	NY	1,324	102	85	57	213	841
Rockland	NY	63	2	2	3	10	1
Suffolk	NY	39	1	1	2	7	0
Westchester	NY	33	1	1	1	7	0
New York subtotal		**2,322**	**164**	**136**	**102**	**363**	**1,254**
PANYNJ Total		**7,006**	**445**	**379**	**344**	**1,306**	**2,966**

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

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	25,972	6,252	1,409	32,996	242,981	1,746
Essex	NJ	23,498	3,745	1,159	20,940	131,856	4,679
Hudson	NJ	27,776	6,764	3,754	14,428	69,129	22,299
Middlesex	NJ	33,000	9,927	2,150	30,357	196,869	2,691
Monmouth	NJ	19,177	7,935	1,623	22,727	166,309	1,848
Union	NJ	21,154	4,227	1,472	20,627	114,302	3,840
New Jersey subtotal		**150,577**	**38,850**	**11,567**	**142,075**	**921,446**	**37,103**
Bronx	NY	16,018	5,803	1,357	25,454	113,641	3,748
Kings (Brooklyn)	NY	29,788	8,312	2,676	54,809	158,527	8,296
Nassau	NY	36,258	14,142	2,727	47,865	282,348	5,965
New York	NY	39,082	8,689	4,017	45,292	220,345	13,141
Orange	NY	19,397	27,696	4,968	18,349	114,316	22,865
Queens	NY	41,172	9,615	3,655	47,262	207,255	10,254
Richmond (Staten Island)	NY	10,085	8,092	1,323	13,542	52,149	2,597
Rockland	NY	13,645	4,880	1,638	13,767	67,761	10,243
Suffolk	NY	61,223	39,210	6,057	77,071	472,083	50,962
Westchester	NY	28,040	13,162	2,456	36,759	230,503	4,870
New York subtotal		**294,708**	**139,601**	**30,874**	**380,170**	**1,918,928**	**132,941**
NYNJLINA Total		**445,285**	**178,451**	**42,441**	**522,245**	**2,840,374**	**170,044**

The subsequent tables and charts (Tables 1.7 through 1.12 and Figures 1.9 through 1.14, respectively) provide additional pollutant specific detail to this county level data for criteria pollutants, 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) 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.

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	25,972	144	0.6%
Essex	NJ	23,498	1,225	5.2%
Hudson	NJ	27,776	627	2.3%
Middlesex	NJ	33,000	370	1.1%
Monmouth	NJ	19,177	254	1.3%
Union	NY	21,154	2,064	9.8%
New Jersey subtotal		**150,577**	**4,684**	**3.1%**
Bronx	NY	16,018	39	0.2%
Kings (Brooklyn)	NY	29,788	477	1.6%
Nassau	NY	36,258	53	0.1%
New York	NY	39,082	221	0.6%
Orange	NY	19,397	35	0.2%
Queens	NY	41,172	39	0.1%
Richmond (Staten Island)	NY	10,085	1,324	13.1%
Rockland	NY	13,645	63	0.5%
Suffolk	NY	61,223	39	0.1%
Westchester	NY	28,040	33	0.1%
New York subtotal		**294,708**	**2,322**	**0.8%**
NYNJLINA and PANYNJ Totals		**445,285**	**7,006**	**1.6%**

Figure 1.9: Comparison of NO_x Emissions by County, tpy

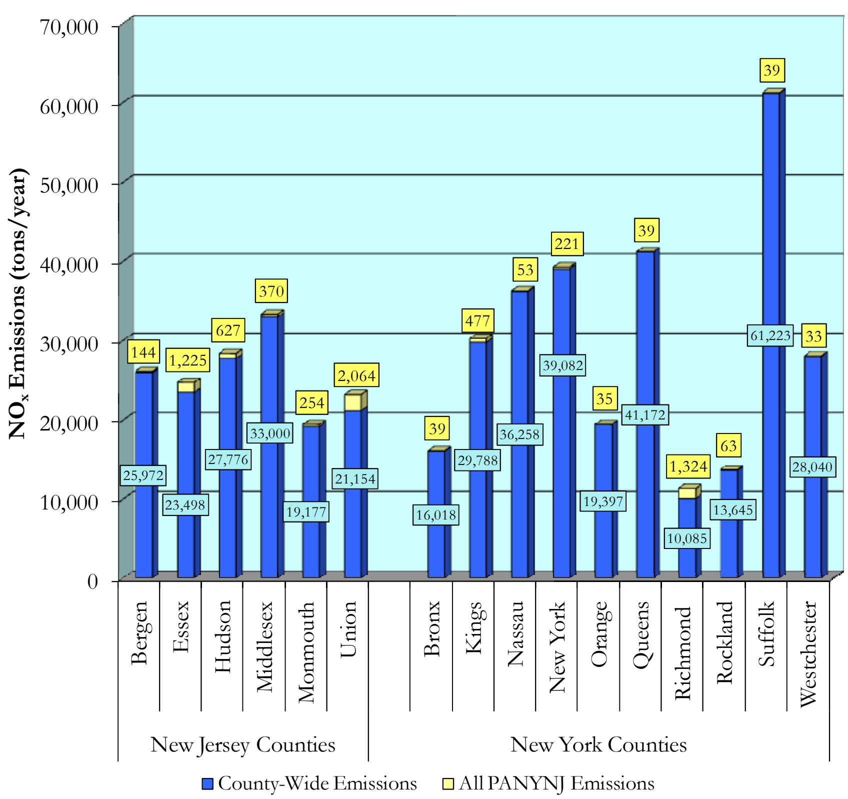


Table 1.8: Comparison of PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	4	0.1%
Essex	NJ	3,745	70	1.9%
Hudson	NJ	6,764	37	0.5%
Middlesex	NJ	9,927	10	0.1%
Monmouth	NJ	7,935	20	0.3%
Union	NY	4,227	141	3.3%
New Jersey subtotal		**38,850**	**281**	**0.7%**
Bronx	NY	5,803	1	0.02%
Kings (Brooklyn)	NY	8,312	34	0.4%
Nassau	NY	14,142	1	0.01%
New York	NY	8,689	19	0.2%
Orange	NY	27,696	1	0.003%
Queens	NY	9,615	1	0.01%
Richmond (Staten Island)	NY	8,092	102	1.3%
Rockland	NY	4,880	2	0.04%
Suffolk	NY	39,210	1	0.003%
Westchester	NY	13,162	1	0.01%
New York subtotal		**139,601**	**164**	**0.1%**
NYNJLINA and PANYNJ Totals		**178,451**	**445**	**0.2%**

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

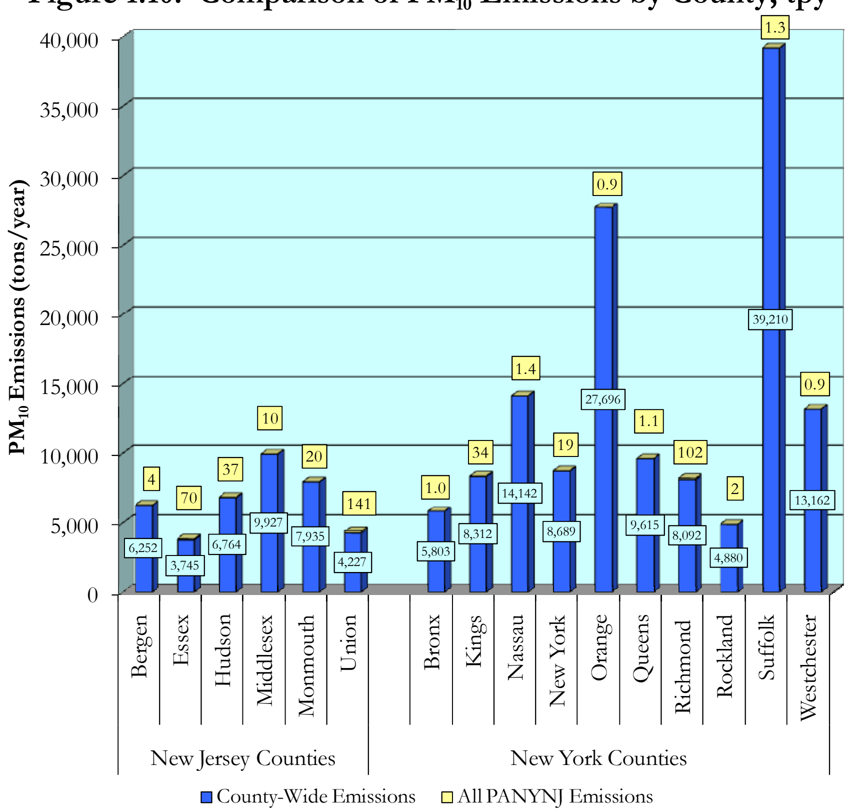


Table 1.9: Comparison of $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	3.5	0.3%
Essex	NJ	1,159	60.4	5.2%
Hudson	NJ	3,754	30.8	0.8%
Middlesex	NJ	2,150	8.9	0.4%
Monmouth	NJ	1,623	16.2	1.0%
Union	NY	1,472	123.1	8.4%
New Jersey subtotal		**11,567**	**243**	**2.1%**
Bronx	NY	1,357	0.9	0.1%
Kings (Brooklyn)	NY	2,676	28.4	1.1%
Nassau	NY	2,727	1.3	0.05%
New York	NY	4,017	15.7	0.4%
Orange	NY	4,968	0.9	0.02%
Queens	NY	3,655	1.0	0.03%
Richmond (Staten Island)	NY	1,323	84.5	6.4%
Rockland	NY	1,638	1.8	0.1%
Suffolk	NY	6,057	1.2	0.02%
Westchester	NY	2,456	0.9	0.04%
New York subtotal		**30,874**	**136**	**0.4%**
NYNJLINA and PANYNJ Totals		**42,441**	**379**	**0.9%**

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

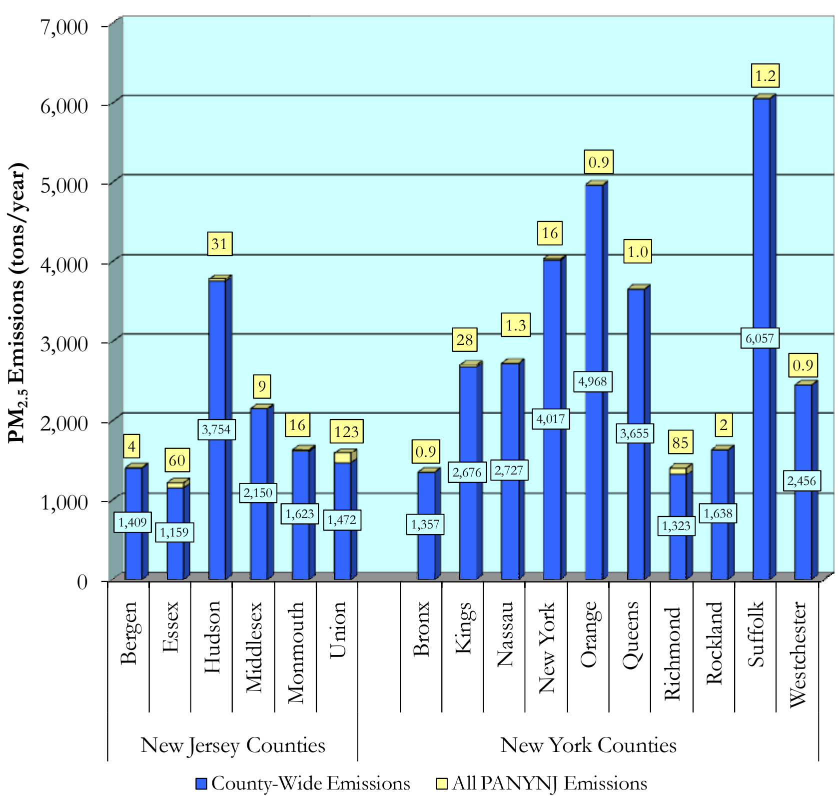


Table 1.10: Comparison of VOC Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	7	0.02%
Essex	NJ	20,940	62	0.3%
Hudson	NJ	14,428	28	0.2%
Middlesex	NJ	30,357	17	0.1%
Monmouth	NJ	22,727	11	0.1%
Union	NY	20,627	117	0.6%
New Jersey subtotal		**142,075**	**242**	**0.2%**
Bronx	NY	25,454	1.8	0.01%
Kings (Brooklyn)	NY	54,809	23	0.04%
Nassau	NY	47,865	2.4	0.01%
New York	NY	45,292	8.8	0.02%
Orange	NY	18,349	1.6	0.01%
Queens	NY	47,262	1.7	0.004%
Richmond (Staten Island)	NY	13,542	57	0.4%
Rockland	NY	13,767	3.3	0.02%
Suffolk	NY	77,071	1.7	0.002%
Westchester	NY	36,759	1.5	0.004%
New York subtotal		**380,170**	**102**	**0.0%**
NYNJLINA and PANYNJ Totals		**522,245**	**344**	**0.1%**

Figure 1.12: Comparison of VOC Emissions by County, tpy

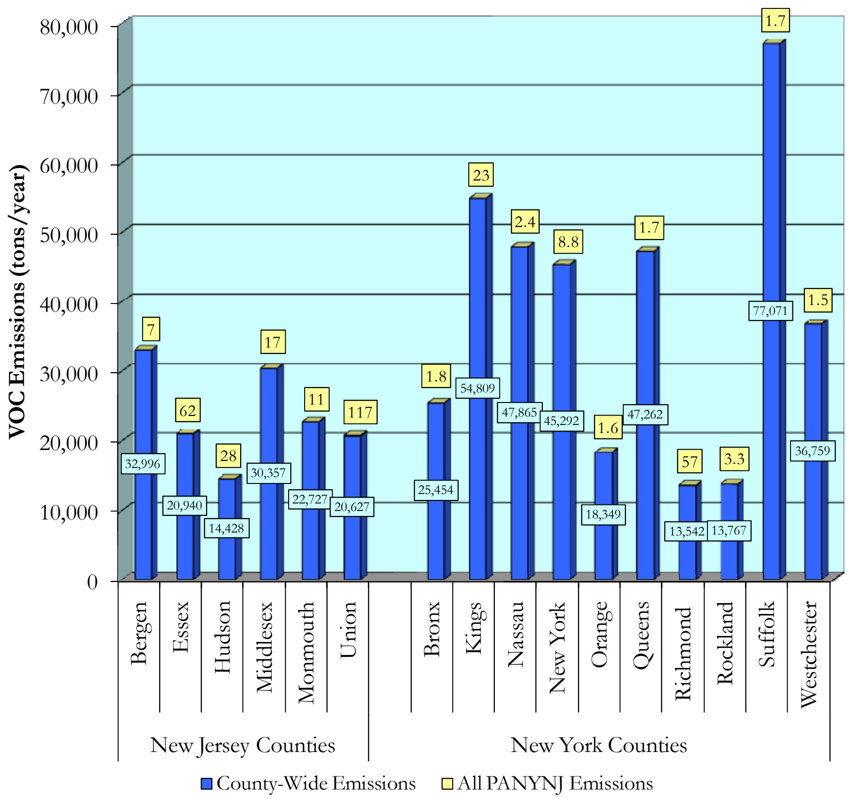


Table 1.11: Comparison of CO Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	29	0.01%
Essex	NJ	131,856	257	0.19%
Hudson	NJ	69,129	91	0.13%
Middlesex	NJ	196,869	80	0.04%
Monmouth	NJ	166,309	27	0.02%
Union	NY	114,302	460	0.40%
New Jersey subtotal		**921,446**	**943**	**0.10%**
Bronx	NY	113,641	9	0.008%
Kings (Brooklyn)	NY	158,527	70	0.04%
Nassau	NY	282,348	11	0.004%
New York	NY	220,345	21	0.010%
Orange	NY	114,316	7.4	0.01%
Queens	NY	207,255	8.0	0.004%
Richmond (Staten Island)	NY	52,149	213	0.41%
Rockland	NY	67,761	10	0.01%
Suffolk	NY	472,083	7.4	0.00%
Westchester	NY	230,503	6.9	0.003%
New York subtotal		**1,918,928**	**363**	**0.02%**
NYNJLINA and PANYNJ Totals		**2,840,374**	**1,306**	**0.05%**

Figure 1.13: Comparison of CO Emissions by County, tpy

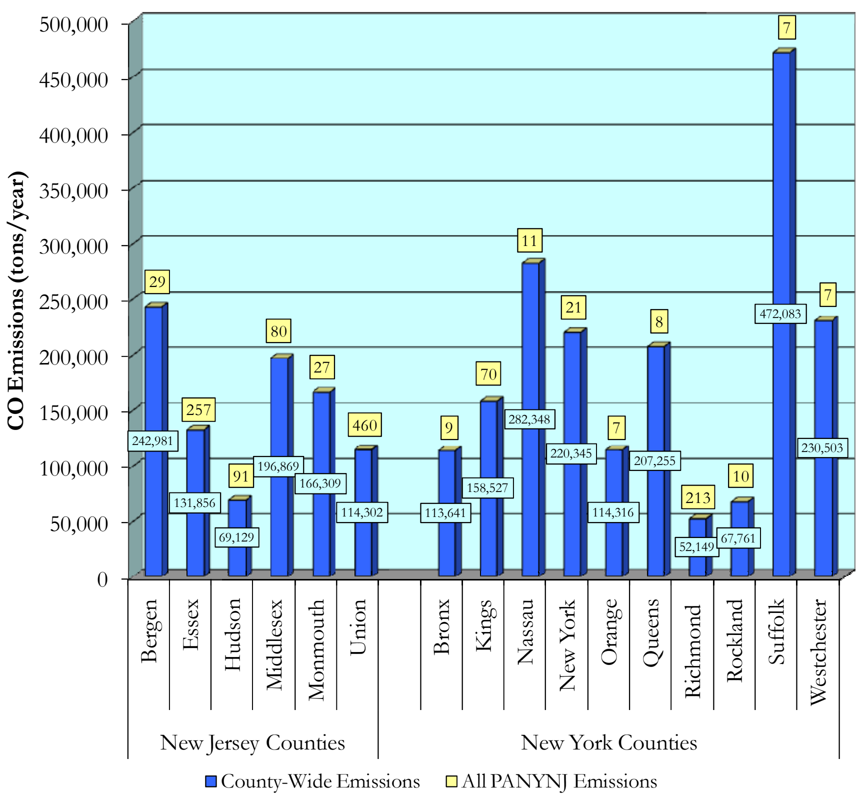
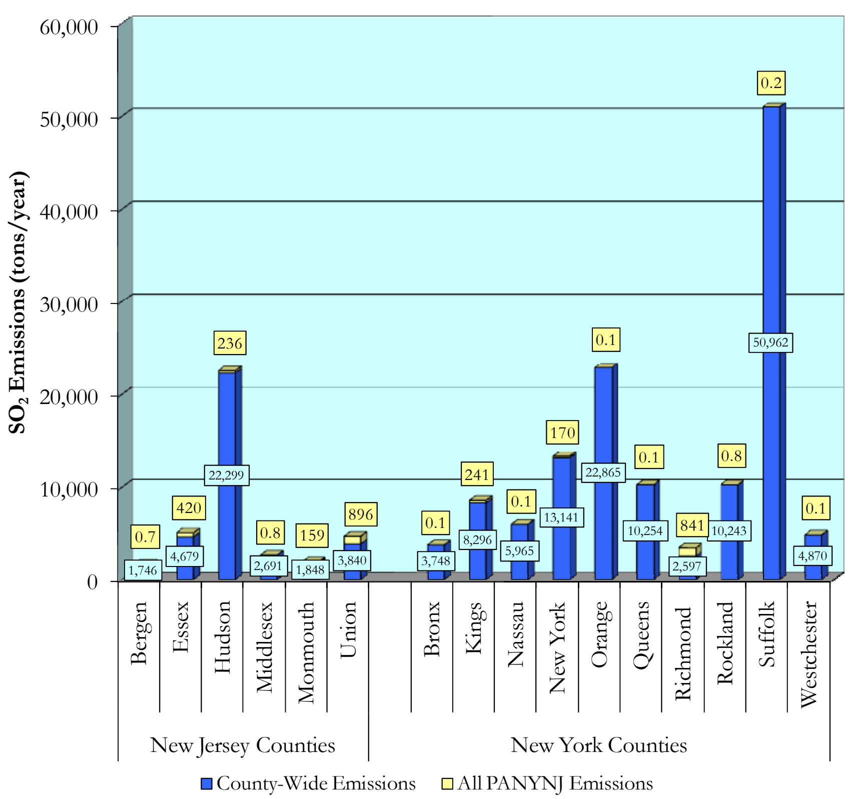


Table 1.12: Comparison of SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	1	0.0%
Essex	NJ	4,679	420	9.0%
Hudson	NJ	22,299	236	1.1%
Middlesex	NJ	2,691	1	0.0%
Monmouth	NJ	1,848	159	8.6%
Union	NY	3,840	896	23.3%
New Jersey subtotal		**37,103**	**1,713**	**4.62%**
Bronx	NY	3,748	0.1	0.001%
Kings (Brooklyn)	NY	8,296	241	2.9%
Nassau	NY	5,965	0	0.00%
New York	NY	13,141	170	1.30%
Orange	NY	22,865	0	0.00%
Queens	NY	10,254	0	0.00%
Richmond (Staten Island)	NY	2,597	841	32.4%
Rockland	NY	10,243	1	0.01%
Suffolk	NY	50,962	0	0.00%
Westchester	NY	4,870	0.1	0.002%
New York subtotal		**132,941**	**1,254**	**0.94%**
NYNJLINA and PANYNJ Totals		**170,044**	**2,966**	**1.74%**

Figure 1.14: Comparison of SO_2 Emissions by County, tpy



Comparison with 2006

In terms of Port throughput and activity levels, TEU throughput was approximately 1% higher in 2008 than in 2006, 4.66 million TEUs in 2006 and 4.71 million TEUs in 2008. Rail activity (ExpressRail) was approximately 12% higher in 2008 than in 2006, at approximately 339,000 lifts (containers moved) in 2006 compared with approximately 378,000 in 2008. The number of ocean-going vessel calls was 13% lower overall in 2008 than in 2006, down from 3,562 calls in 2006 to 3,091 calls in 2008, while the number of containership calls, the most numerous vessel type in both years, was 14% lower in 2008 than in 2006. The lower number of calls may have occurred despite very little difference in TEU throughput because of the use of larger vessels in 2008, or the more efficient use of vessels by off-loading and loading more of the vessels' capacity during each call. Table 1.13 illustrates the foregoing measures of Port activity for 2008 and 2006.

Table 1.13: Comparison of 2008 and 2006 Port Throughput and Activity Levels

	Units	2008	2006	Percent Difference
Overall Throughput	Million TEUs	4.71	4.66	1%
ExpressRail Throughput	Thousand Lifts	378	339	12%
OGV Calls	Calls	3,091	3,562	-13%
Containership Calls	Calls	2,191	2,552	-14%

Overall, the emissions estimated for 2008 were below the levels estimated for 2006. The estimates are not directly comparable for all source categories due to changes in emission estimating methods and emission factors, so any comparison between inventories should be made carefully. As a summary, Table 1.14 presents the emissions estimated for both years and the percentage difference between them. The following paragraphs generally describe the differences between the two inventories and some of the factors affecting the estimates.

Table 1.14: Comparison of 2008 and 2006 Emission Estimates

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2
2008 estimates							
CHE	1,048	66	64	89	355	17	114,045
HDV	2,331	59	54	105	603	2	210,832
Rail	268	10	9	20	45	4	17,024
OGVs	2,934	288	230	113	255	2,935	172,550
Harbor craft	425	23	22	16	48	9	23,086
Total	**7,006**	**445**	**379**	**344**	**1,306**	**2,966**	**537,536**
2006 estimates							
CHE	1,402	93	86	124	465	219	142,253
HDV	1,935	59	54	87	564	26	208,390
Rail	286	10	9	20	44	32	14,567
OGVs	3,691	348	279	165	319	3,270	195,763
Harbor craft	486	26	24	18	41	50	25,597
Total	**7,800**	**536**	**453**	**414**	**1,433**	**3,597**	**586,570**
Percent difference							
CHE	-25%	-29%	-26%	-28%	-24%	-92%	-20%
HDV	20%	0%	0%	21%	7%	-93%	1%
Rail	-6%	-5%	-4%	0%	4%	-88%	17%
OGVs	-21%	-17%	-17%	-31%	-20%	-10%	-12%
Harbor craft	-13%	-12%	-7%	-10%	15%	-82%	-10%
Overall Difference	**-10%**	**-17%**	**-16%**	**-17%**	**-9%**	**-18%**	**-8%**

CHE emissions as estimated for 2008 were lower than the 2006 estimates despite the slight overall increase in throughput. Reasons for this include newer equipment (on average one year newer), and an overall reduction in hours of usage, which may indicate more efficient utilization of resources, despite an increase in total equipment population (1,014 vs 888 reported pieces of equipment). In terms of estimating methodology, the 2006 estimates were prepared using the NONROAD model version NONROAD2005, whereas the 2008 estimates were prepared using the updated NONROAD2008a. EPA has reported that NONROAD2008a produces lower estimates of NO_x, PM, VOCs and CO, although these differences primarily affect gasoline engines and recreational marine diesel engines, not the off-road diesel engines used at the Port terminals.[5] With this in mind, some of the differences between the 2006 and 2008 estimates may be due to the effect of the model version difference, although this is not likely to be significant. SO_2 emissions estimated for 2008 are substantially lower than for 20076 because of the reduction in the sulfur content of off-road diesel fuel and the increasing use of on-road, ultra-low sulfur diesel (ULSD) fuel. CO_2 emissions were lower in 2008 than in 2006 largely because of the overall reduction in total operating hours.

[5] EPA NONROAD Model Updates of 2008; EPA-420-F-09-020, April 2009 International Emissions Inventory Conference.

HDV emissions as estimated for 2008 were higher than the 2006 estimates for several pollutants, including NO_x and VOC. SO_2 emissions estimated for 2008 are substantially lower than for 2006 because of the introduction of ultra-low sulfur diesel (ULSD) fuel, while the difference in CO_2 emissions reflects the overall difference in throughput. While the small increase in container throughput resulted in a corresponding 1% increase in overall miles traveled by HDVs, the major reason for higher NO_x and VOC is the change in vehicle age distribution used in the emission factor model MOBILE6.2. In developing the 2006 emission estimates, the default age distribution built into the MOBILE model was used to develop the composite emission factors. This is a distribution that EPA has developed to represent the overall distribution of heavy-duty trucks regardless of the work they are doing. More representative information was available for the 2008 emissions inventory, from the drayage truck survey that the Port Authority conducted that year. This survey provided an age distribution that was specific to the trucks serving the Port terminals during the year and provides a more appropriate picture of the fleet. The 2008 distribution showed a higher proportion of slightly older trucks that had higher NO_x and VOC emissions but similar PM emissions, resulting in the overall increases seen. It should be noted that these differences do not reflect real increases in emissions but only differences in the estimating method. Subsequent inventories that are able to take advantage of updated model year surveys will be more directly comparable.

Rail emissions as estimated for 2008 are generally slightly lower than the 2006 estimates despite the overall increase in throughput. The primary reasons for the decrease are an increase in fuel efficiency of line haul operations between 2006 and 2008 (as reported by the railroads in annual reports to the U.S. Department of Transportation), and revised emission factors published by EPA reflecting their revised estimates of locomotive fleet compositions by calendar year and the effects of new locomotive emission standards.[6] The SO_2 decrease reflects lowering fuel sulfur contents, while the higher CO_2 emissions reflect the increased rail throughput and a higher switching locomotive fuel consumption factor in the EPA document cited above (fuel consumption relates directly to CO2 emissions).

Emissions from OGVs as estimated for 2008 are lower than the 2006 estimates. This is primarily due to the decrease in the number of vessel calls and possibly also to a higher prevalence of newer ships that comply with the IMO emission standard for NO_x. The OGV emission calculations are complex and many variables affect the final estimates, so it is difficult to pinpoint all of the reasons for varying results. In addition, the vessel call available for the 2008 estimates was more detailed, enabling a finer resolution to the calculations – which normally results in lower estimates. The difference in emissions is probably due to a combination of methodology change (not a real reduction) and decreased activity in terms of fewer vessel calls (which resulted in an actual decrease in emissions). Subsequent inventories should be able to take advantage of the level of detail seen for the 2008 inventory, so these later results will be more directly comparable with the 2008 results.

Harbor craft emissions as estimated for 2008 are lower than the 2006 estimates. The level of reduction is approximately proportional to the reduction in the number of OGV calls, which

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

is reasonable because many of the harbor craft included in the inventory work as assist tugs, helping OGVs enter and depart the harbor system. The reduction can also be attributed to an overall reduction in the level of harbor vessel activity.

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 five 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; and
- Port Newark Container Terminal (PNCT), at Port Newark.

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

CHE Executive Summary

Table ES2-1 presents the estimated CHE criteria pollutant 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 2005 National Emissions Inventory, the latest available figures. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states.

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
New York and New Jersey	936,354	917,144	198,076	1,330,674	6,564,103	540,477
NYNJLINA	445,285	178,451	42,441	522,245	2,840,374	170,044
Cargo Handling Equipment	1,048	66	64	89	355	17
Percent of NYNJLINA Emissions	0.24%	0.04%	0.15%	0.02%	0.01%	0.01%

The following figures ES2.1 through ES2.6 illustrate the distribution of PANYNJ CHE emissions of NO_x, PM_{10}, $PM_{2.5}$, VOC, CO, and SO_2 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. Figure ES2.7 illustrates the distribution of CO_2 emissions but does not include the comparison with overall NYNJLINA emissions because these emissions have not been compiled.

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

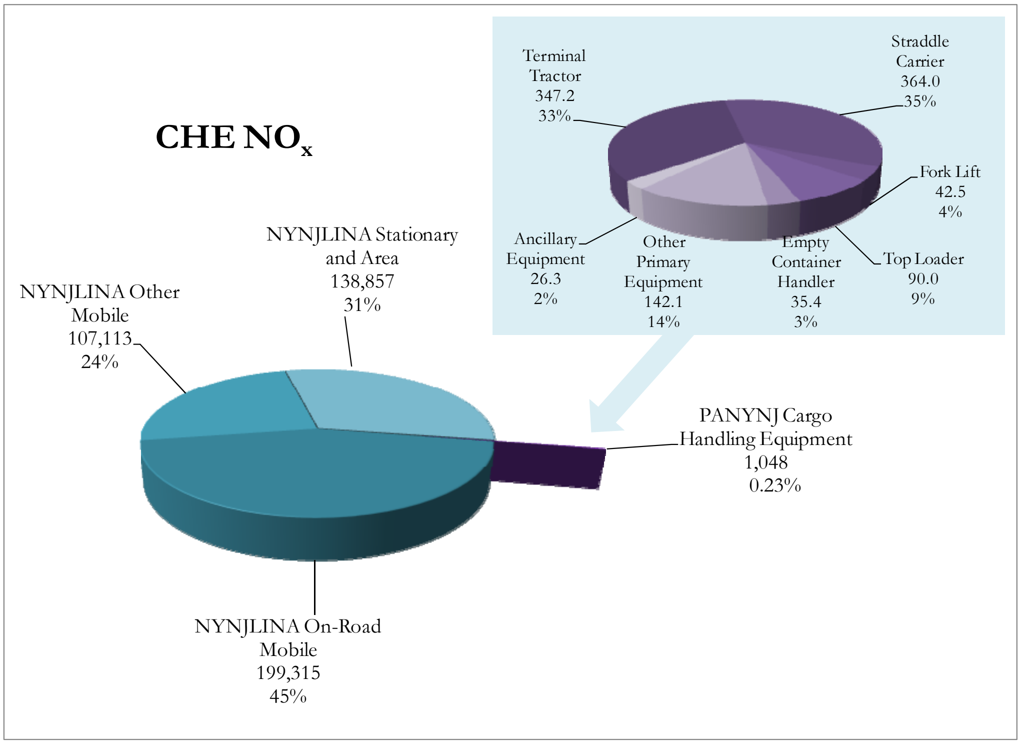


Figure ES2.2: Distribution and Comparison of PM_{10} from CHE, tpy and percent

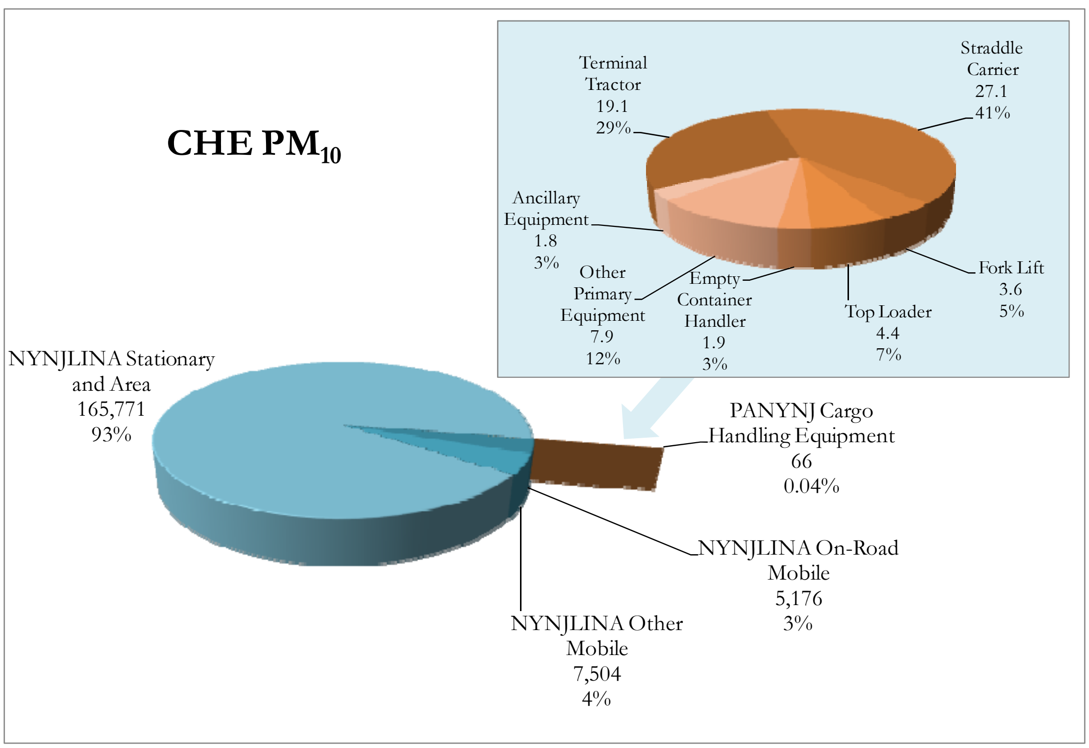


Figure ES2.3: Distribution and Comparison of $PM_{2.5}$ from CHE, tpy and percent

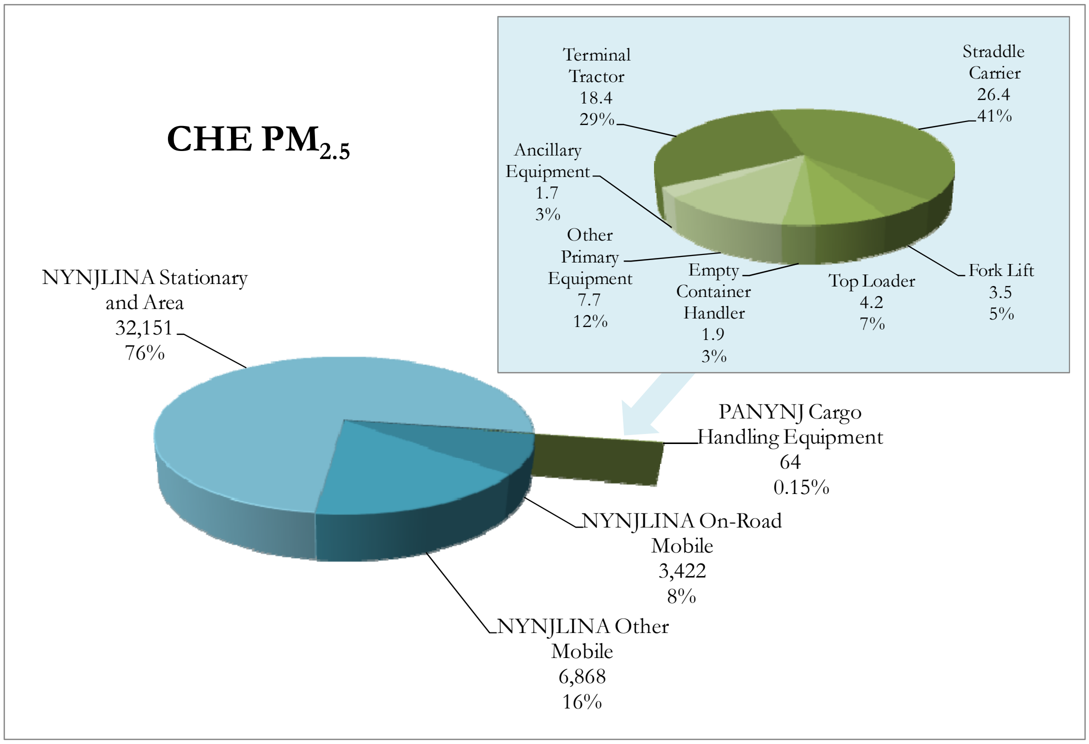


Figure ES2.4: Distribution and Comparison of VOC from CHE, tpy and percent

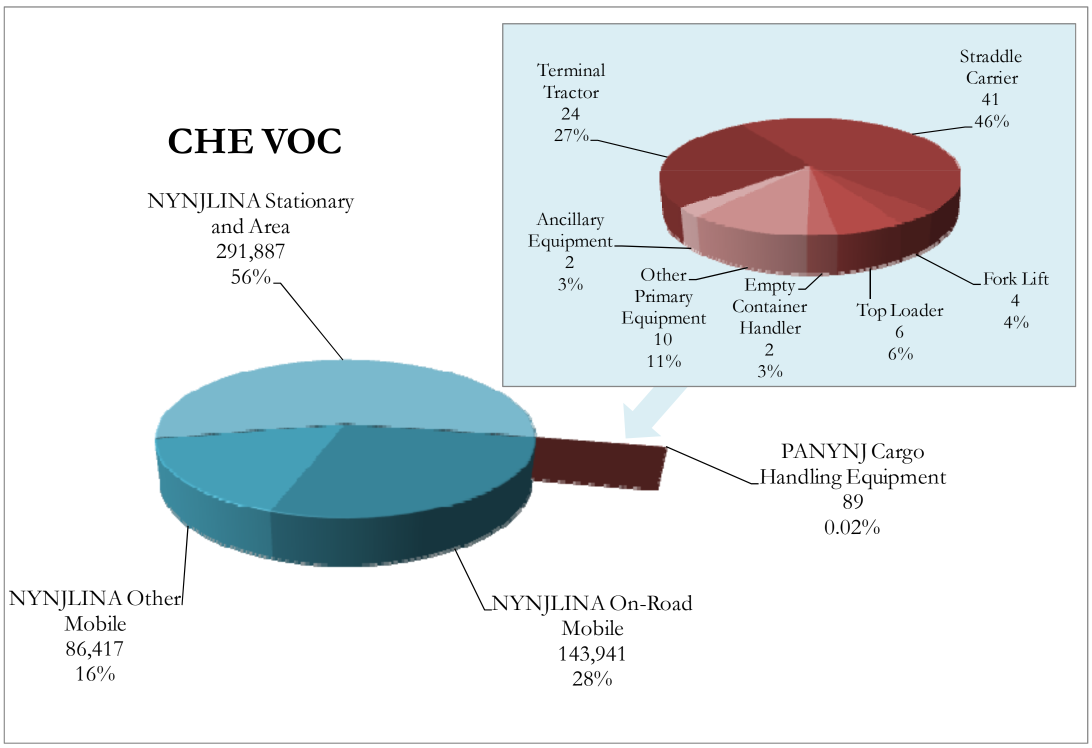


Figure ES2.5: Distribution and Comparison of CO from CHE, tpy and percent

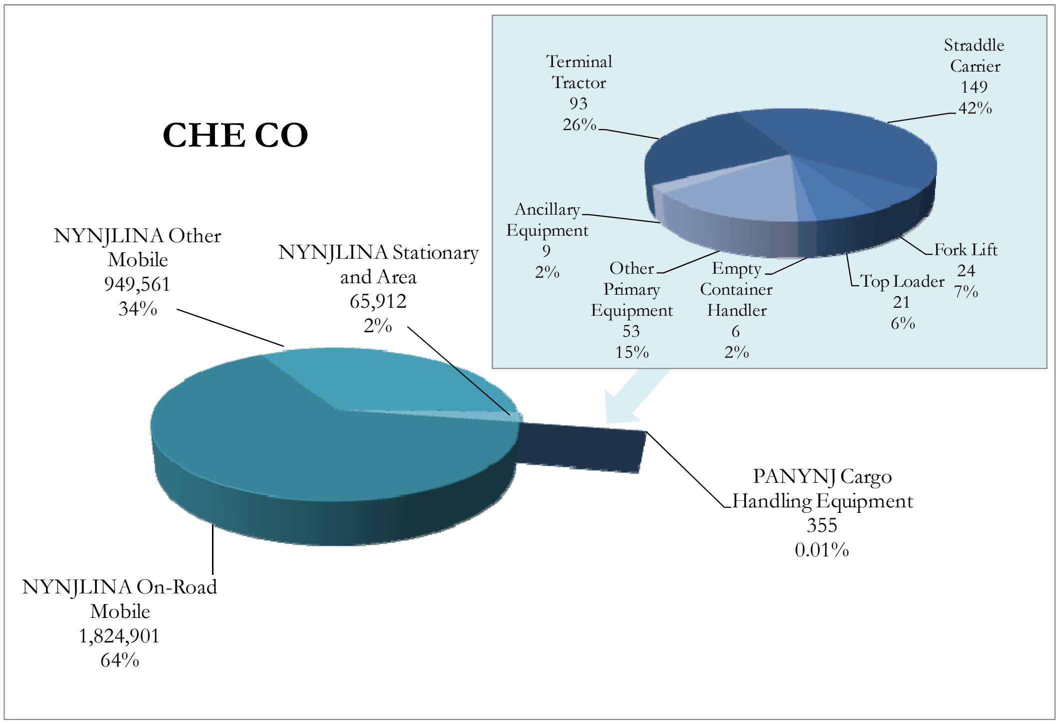


Figure ES2.6: Distribution and Comparison of SO_2 from CHE, tpy and percent

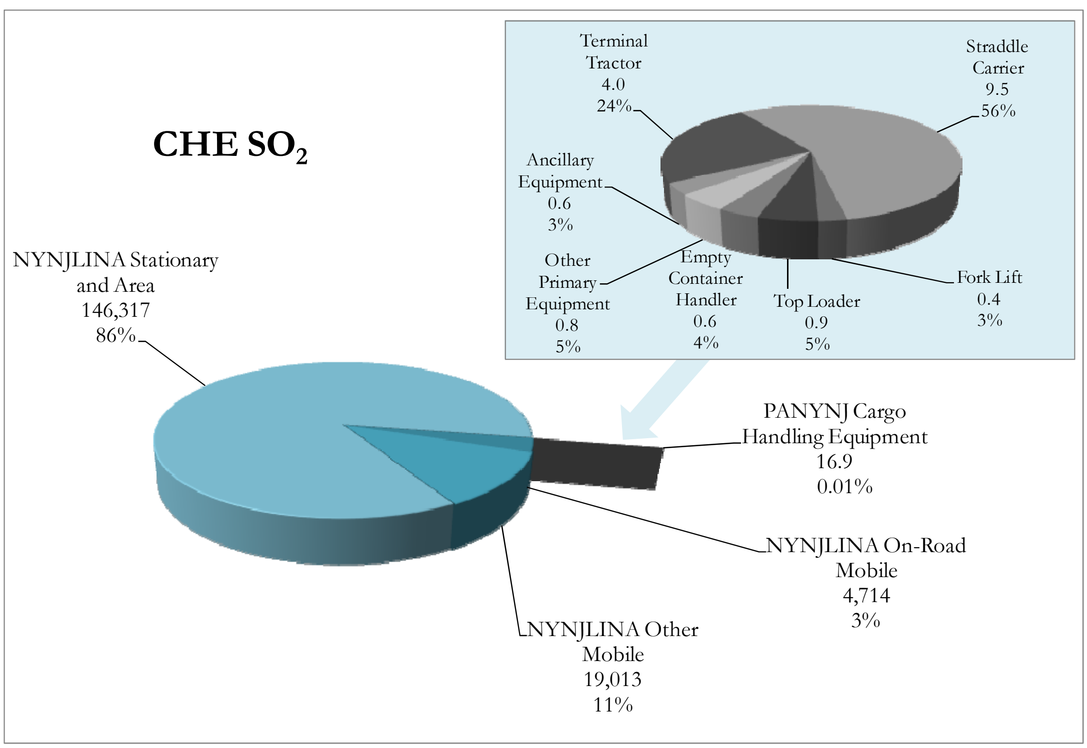
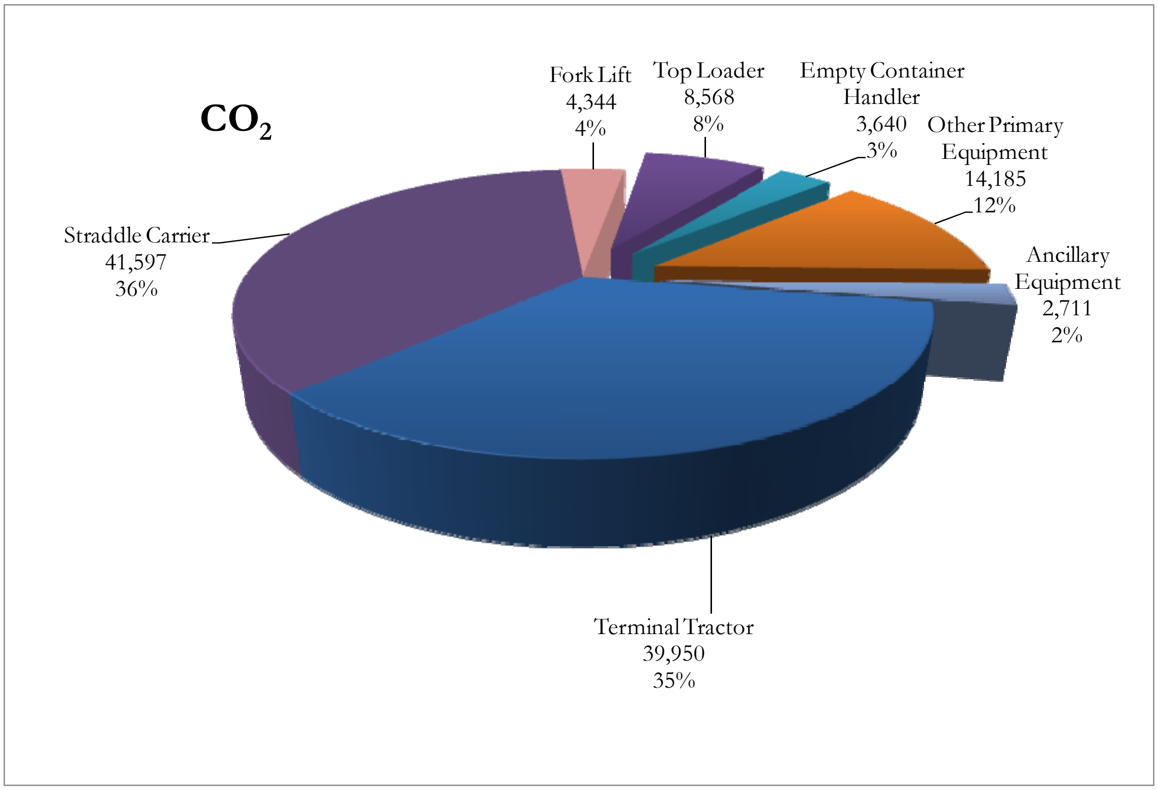


Figure ES2.7: Distribution of CO_2 equivalents from CHE, tpy and percent



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 total of CO_2 equivalents shown in these tables and figures may not exactly match totals shown elsewhere in this report because of rounding of numbers in the calculation of CO_2 equivalents.

Table 2.1: 2008 Criteria Pollutant Emissions from CHE by Equipment Type, tpy

Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Terminal Tractor	347	19.1	18.4	24.2	93	4.0
Straddle Carrier	364	27.1	26.4	41.4	149	9.5
Fork Lift	43	3.6	3.5	3.6	24	0.4
Top Loader	90	4.4	4.2	5.6	21	0.9
Empty Container Handler	35	1.9	1.9	2.4	6	0.6
Other Primary Equipment	142	7.9	7.7	9.9	53	0.8
Ancillary Equipment	26	1.8	1.7	2.3	9	0.6
	1,048	66	64	89	355	17

Figure 2.1: 2008 Emissions of NO_x from CHE by Equipment Type, tpy and percent

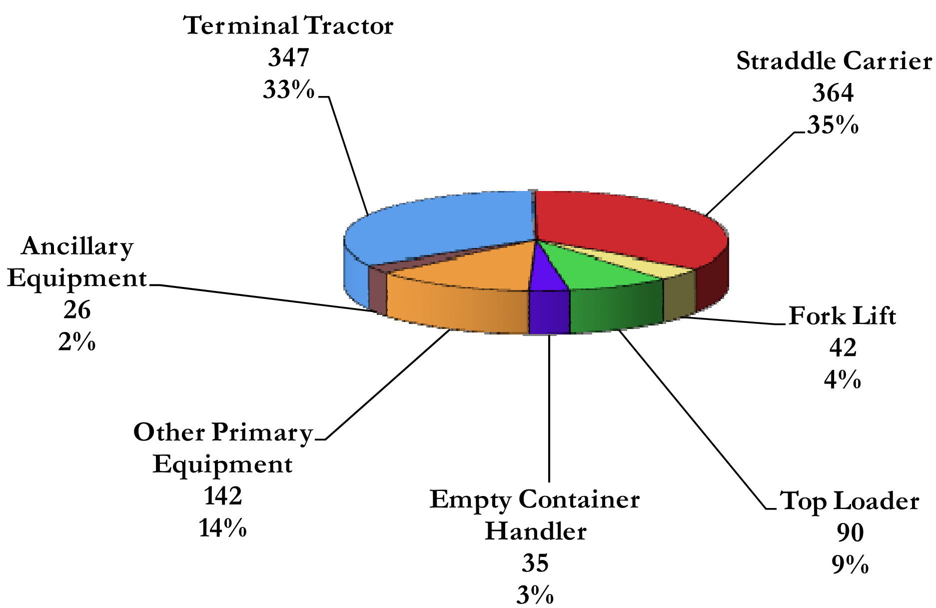
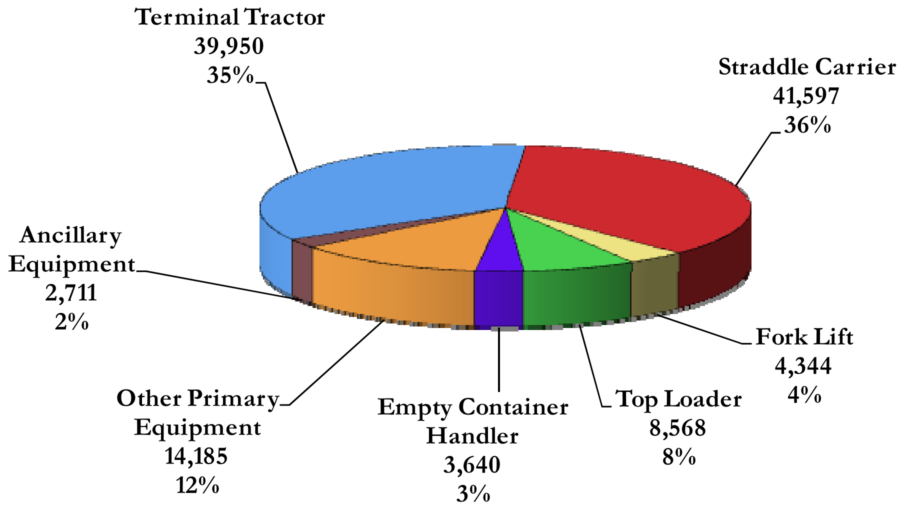


Table 2.2: 2008 GHG Emissions from CHE by Equipment Type, tpy

Equipment Type	CO_2	N_2O	CH_4	CO_2 Equivalent
Terminal Tractor	39,600	0.98	2.22	39,950
Straddle Carrier	41,283	0.88	1.98	41,597
Fork Lift	4,305	0.11	0.24	4,344
Top Loader	8,493	0.21	0.48	8,568
Empty Container Handler	3,608	0.09	0.20	3,640
Other Primary Equipment	14,070	0.32	0.73	14,185
Ancillary Equipment	2,686	0.07	0.15	2,711
Totals	**114,045**	**3**	**6**	**114,995**

Figure 2.2: 2008 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 emissions from cargo handling equipment operating at Port Authority marine terminals, broken down by county and state. Immediately following are a series of tables and charts (Tables 2.4 – 2.9 and Figures 2.3 – 2.8) 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).

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

County	State	NOx	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	0	0	0	0	0	0
Essex	NJ	190	12	11	14	77	4.4
Hudson	NJ	0	0	0	0	0	0
Middlesex	NJ	0	0	0	0	0	0
Monmouth	NJ	0	0	0	0	0	0
Union	NJ	656	42	41	62	219	9.3
New Jersey subtotal		**846**	**54**	**52**	**76**	**296**	**14**
Bronx	NY	0	0	0	0	0	0
Kings (Brooklyn)	NY	73	4	4	5	21	0
Nassau	NY	0	0	0	0	0	0
New York	NY	0	0	0	0	0	0
Orange	NY	0	0	0	0	0	0
Queens	NY	0	0	0	0	0	0
Richmond (Staten Island)	NY	129	8	8	9	38	3.1
Rockland	NY	0	0	0	0	0	0
Suffolk	NY	0	0	0	0	0	0
Westchester	NY	0	0	0	0	0	0
New York subtotal		**202**	**12**	**12**	**14**	**59**	**3**
TOTAL		**1,048**	**66**	**64**	**89**	**355**	**17**

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

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	25,972	0	0.0%
Essex	NJ	23,498	190	0.8%
Hudson	NJ	27,776	0	0.0%
Middlesex	NJ	33,000	0	0.0%
Monmouth	NJ	19,177	0	0.0%
Union	NJ	21,154	656	3.1%
New Jersey Subtotal		**150,577**	**845**	**0.56%**
Bronx	NY	16,018	0	0.0%
Kings (Brooklyn)	NY	29,788	73	0.2%
Nassau	NY	36,258	0	0.0%
New York	NY	39,082	0	0.0%
Orange	NY	19,397	0	0.0%
Queens	NY	41,172	0	0.0%
Richmond (Staten Island	NY	10,085	129	1.3%
Rockland	NY	13,645	0	0.0%
Suffolk	NY	61,223	0	0.0%
Westchester	NY	28,040	0	0.0%
New York Subtotal		**294,708**	**202**	**0.1%**
TOTAL		**445,285**	**1,048**	**0.24%**

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

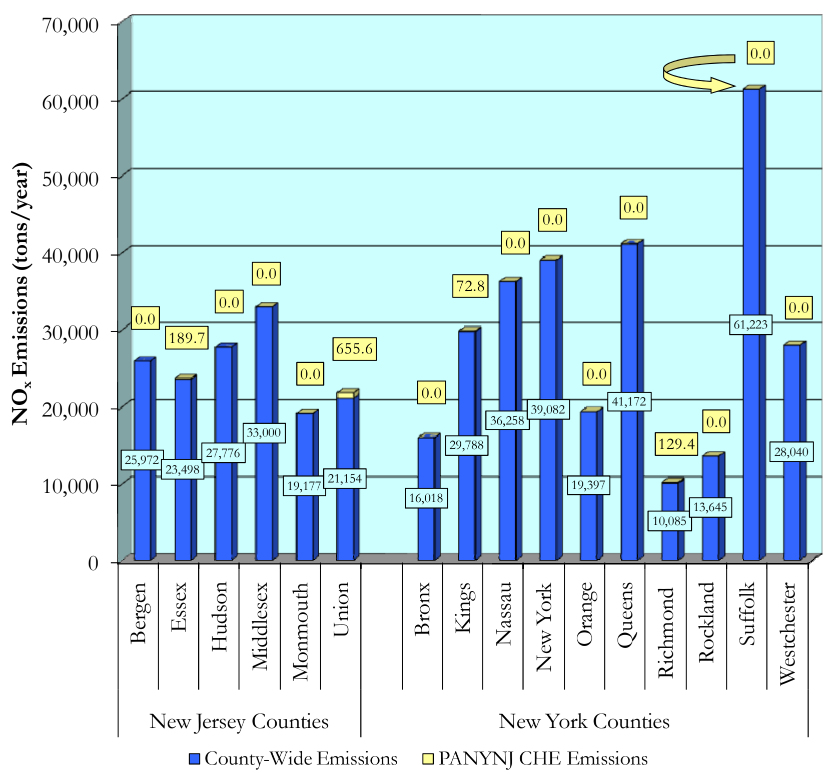


Table 2.5: Comparison of CHE PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0.0	0.0%
Essex	NJ	3,745	11.6	0.3%
Hudson	NJ	6,764	0.0	0.0%
Middlesex	NJ	9,927	0.0	0.0%
Monmouth	NJ	7,935	0.0	0.0%
Union	NJ	4,227	42.2	1.0%
New Jersey Subtotal		**38,850**	**54**	**0.14%**
Bronx	NY	5,803	0.0	0.0%
Kings (Brooklyn)	NY	8,312	4.0	0.0%
Nassau	NY	14,142	0.0	0.0%
New York	NY	8,689	0.0	0.0%
Orange	NY	27,696	0.0	0.0%
Queens	NY	9,615	0.0	0.0%
Richmond (Staten Island)	NY	8,092	7.9	0.1%
Rockland	NY	4,880	0.0	0.0%
Suffolk	NY	39,210	0.0	0.0%
Westchester	NY	13,162	0.0	0.0%
New York Subtotal		**139,601**	**12**	**0.01%**
TOTAL		**178,451**	**66**	**0.04%**

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

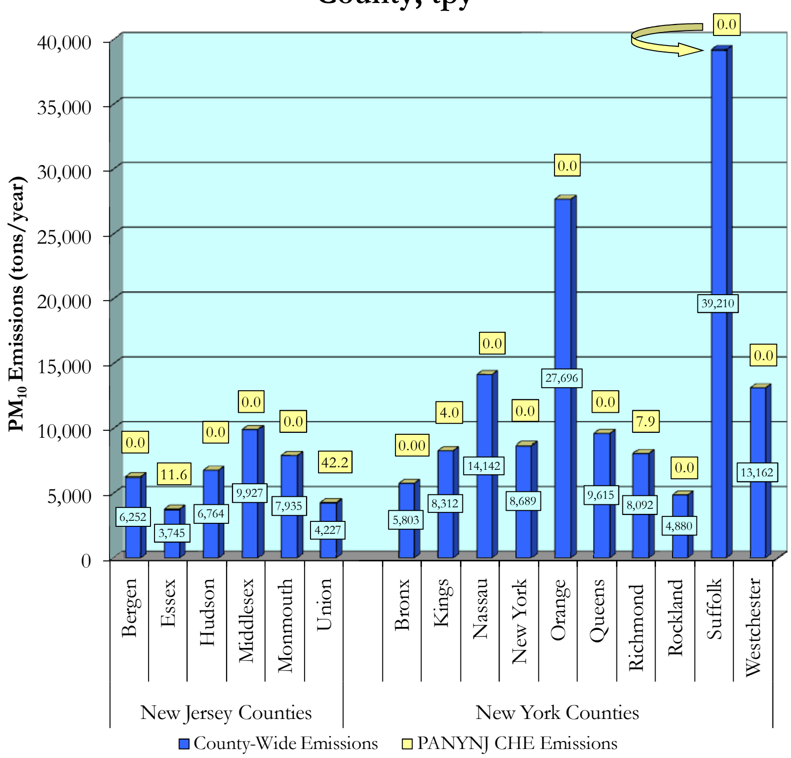


Table 2.6: Comparison of CHE $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0.0	0.0%
Essex	NJ	1,159	11.2	1.0%
Hudson	NJ	3,754	0.0	0.0%
Middlesex	NJ	2,150	0.0	0.0%
Monmouth	NJ	1,623	0.0	0.0%
Union	NJ	1,472	41.0	2.8%
New Jersey Subtotal		**11,567**	**52**	**0.5%**
Bronx	NY	1,357	0.0	0.0%
Kings (Brooklyn)	NY	2,676	3.9	0.1%
Nassau	NY	2,727	0.0	0.0%
New York	NY	4,017	0.0	0.0%
Orange	NY	4,968	0.0	0.0%
Queens	NY	3,655	0.0	0.0%
Richmond (Staten Island)	NY	1,323	7.6	0.6%
Rockland	NY	1,638	0.0	0.0%
Suffolk	NY	6,057	0.0	0.0%
Westchester	NY	2,456	0.0	0.0%
New York Subtotal		**30,874**	**12**	**0.04%**
TOTAL		**42,441**	**64**	**0.15%**

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

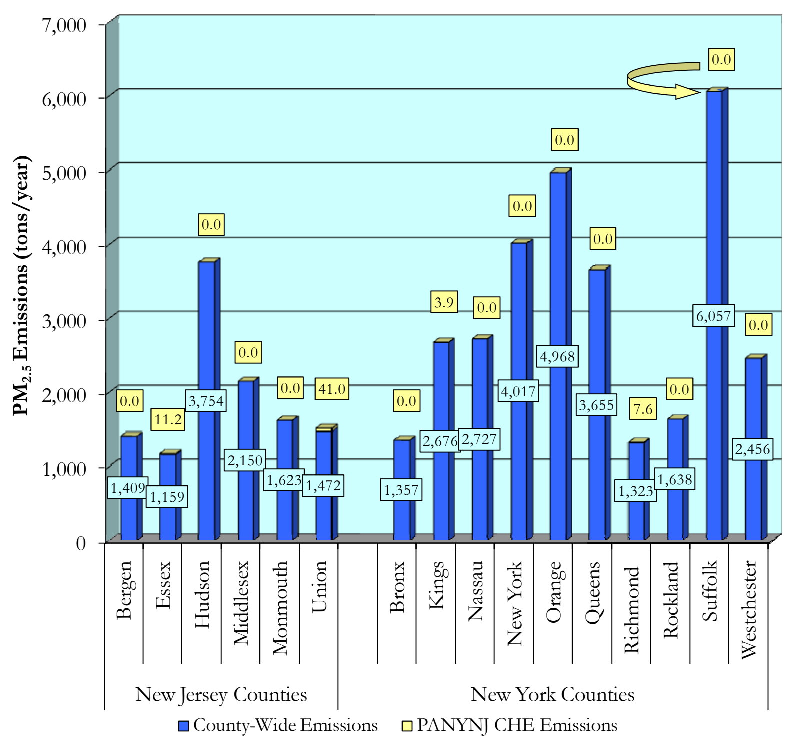


Table 2.7: Comparison of CHE VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0.0	0.0%
Essex	NJ	20,940	14.0	0.1%
Hudson	NJ	14,428	0.0	0.0%
Middlesex	NJ	30,357	0.0	0.0%
Monmouth	NJ	22,727	0.0	0.0%
Union	NJ	20,627	61.7	0.3%
New Jersey Subtotal		**142,075**	**76**	**0.1%**
Bronx	NY	25,454	0.0	0.0%
Kings (Brooklyn)	NY	54,809	4.9	0.01%
Nassau	NY	47,865	0.0	0.0%
New York	NY	45,292	0.0	0.0%
Orange	NY	18,349	0.0	0.0%
Queens	NY	47,262	0.0	0.0%
Richmond (Staten Island	NY	13,542	8.7	0.1%
Rockland	NY	13,767	0.0	0.0%
Suffolk	NY	77,071	0.0	0.0%
Westchester	NY	36,759	0.0	0.0%
New York Subtotal		**380,170**	**14**	**0.004%**
TOTAL		**522,245**	**89**	**0.02%**

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

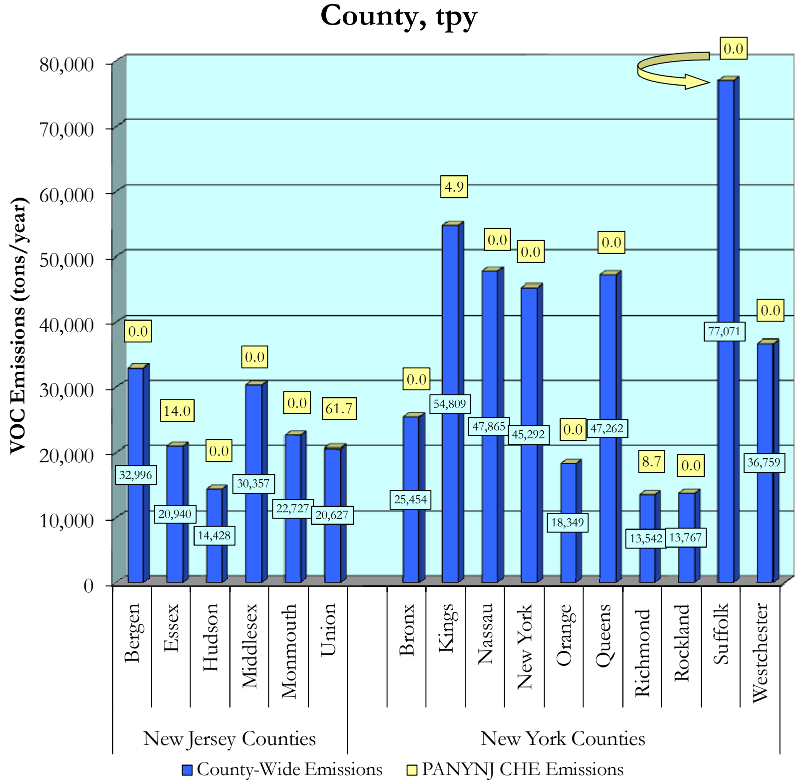


Table 2.8: Comparison of CHE CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	0.0	0.0%
Essex	NJ	131,856	77.4	0.1%
Hudson	NJ	69,129	0.0	0.0%
Middlesex	NJ	196,869	0.0	0.0%
Monmouth	NJ	166,309	0.0	0.0%
Union	NJ	114,302	219.5	0.2%
New Jersey Subtotal		**921,446**	**297**	**0.03%**
Bronx	NY	113,641	0.0	0.0%
Kings (Brooklyn)	NY	158,527	20.9	0.0%
Nassau	NY	282,348	0.0	0.0%
New York	NY	220,345	0.0	0.0%
Orange	NY	114,316	0.0	0.0%
Queens	NY	207,255	0.0	0.0%
Richmond (Staten Island)	NY	52,149	37.7	0.1%
Rockland	NY	67,761	0.0	0.0%
Suffolk	NY	472,083	0.0	0.0%
Westchester	NY	230,503	0.0	0.0%
New York Subtotal		**1,918,928**	**59**	**0.003%**
TOTAL		**2,840,374**	**355**	**0.01%**

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

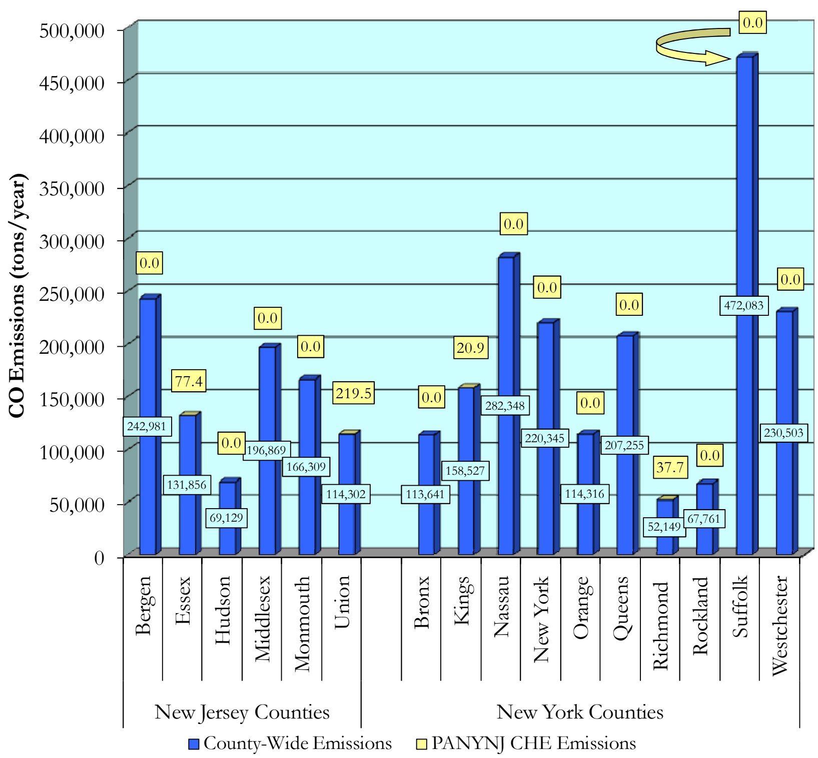
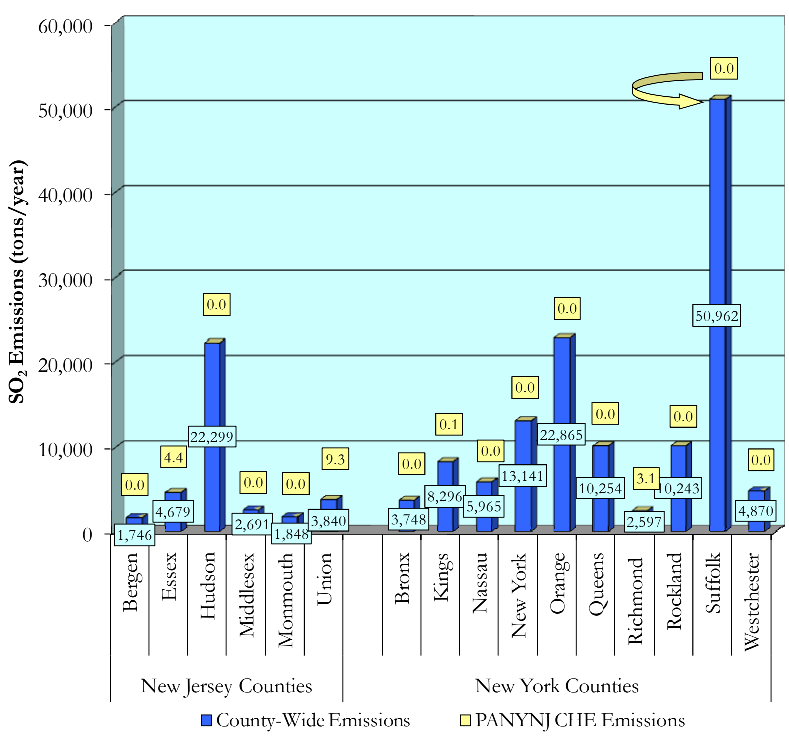


Table 2.9: Comparison of CHE SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0.0	0.0%
Essex	NJ	4,679	4.4	0.1%
Hudson	NJ	22,299	0.0	0.0%
Middlesex	NJ	2,691	0.0	0.0%
Monmouth	NJ	1,848	0.0	0.0%
Union	NJ	3,840	9.3	0.2%
New Jersey Subtotal		**37,103**	**14**	**0.0%**
Bronx	NY	3,748	0.0	0.0%
Kings (Brooklyn)	NY	8,296	0.1	0.0%
Nassau	NY	5,965	0.0	0.0%
New York	NY	13,141	0.0	0.0%
Orange	NY	22,865	0.0	0.0%
Queens	NY	10,254	0.0	0.0%
Richmond (Staten Island)	NY	2,597	3.1	0.1%
Rockland	NY	10,243	0.0	0.0%
Suffolk	NY	50,962	0.0	0.0%
Westchester	NY	4,870	0.0	0.0%
New York Subtotal		**132,941**	**3**	**0.00%**
TOTAL		**170,044**	**17**	**0.01%**

Figure 2.8: Comparison of CHE SO2 Emissions with Overall SO2 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, and 2006. As in the previous inventories, most container terminal operators estimated average activity levels for types of equipment as opposed to reporting unique engine hour data. Thus, in many cases, various types 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.[7] 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 2.10, which presents equipment types by Source Classification Code (SCC), source category, and NONROAD category common name. The earlier categorizations were replicated for purposes of this 2008 inventory as much as possible. Table 2.11 then lists the population of equipment identified at port facilities, listed by common name and SCC code.

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

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

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 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 2.10: NONROAD Diesel Engine Source Categories

Equipment Type	SCC	Source Category	NONROAD Category (common name)
Portable light set	2270002027	CDE	Signal board / light plant
Wharf crane	2270002045	CDE	Crane
Non-road vehicle	2270002051	CDE	Off-road truck
Bucket loader	2270002060	CDE	Front end loader
Payloader	2270002060	CDE	Front end loader
Aerial platform	2270003010	IDE	Aerial lift
Fork lift	2270003020	IDE	Forklift
Sweeper	2270003030	IDE	Sweeper / scrubber
Chassis rotator Container top loader Empty container handler	2270003040	IDE	Other industrial equipment
Rubber tired gantry crane Straddle carrier	2270003050	IDE	Other material handling equipment
Terminal tractor	2270003070	IDE	Terminal tractor
Generator	2270006005	Commercial	Light commercial generator set

Table 2.11: NONROAD Equipment Category Population List

NONROAD Category	Source Category Code	2006 Count	2008 Count
Aerial Lift - Manlift	2270003010	11	11
Crane	2270002045	13	7
Diesel Forklift	2270003020	0	8
Forklift	2269419687	87	108
Front End Loader	2270002060	13	7
General Industrial Equip	2270003040	130	143
Generator	2270006005	1	1
Material Handling Equip	2270003050	260	293
Offroad Truck	2270002051	9	12
Portable Light Set or Sign	2270002027	12	12
Sweeper	2270003030	2	9
Terminal Tractor	2270003070	350	403
Total		**888**	**1014**

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.

The model's default ultra-low sulfur diesel (ULSD) sulfur content of 15 parts per million (ppm) was used, and 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[8]) for equipment reported to be using that fuel. 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[9] 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%.[10]

[8] 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
[9] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006; April 15, 2008
[10] 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 non-road equipment, used directly in handling cargo, and ancillary equipment, which has uses other than directly moving cargo (such as sweepers and fuel trucks).

Table 2.12 summarizes the 2008 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.

Figures 2.9 and 2.10 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 5% of the total equipment population. This equipment is listed separately from primary equipment in Table 2.12 and presented visually in Figure 2.10. In addition to the "Ancillary" category, Figure 2.9 presents an additional category – "Other Primary Equipment" – which makes up 9% of all equipment that include 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 2.12: Primary Cargo Handling Equipment Characteristics

Equipment Type	Count	Percent of Population	Average Model Year	Average hp	Average hrs/year
Primary Equipment					
Terminal Tractor	395	39.0%	2002	204	1555
Straddle Carrier	263	25.9%	2003	228	3048
Fork Lift	116	11.4%	2000	108	846
Top Loader	52	5.1%	2001	287	2240
Empty Container Handler	48	4.7%	2002	194	1544
Other Primary Equipment					
Rubber Tired Gantry Crane	30	3.0%	2003	468	3905
Reach Stacker	27	2.7%	2003	326	1832
Stacker	11	1.1%	2000	161	600
RORO Hustler	7	0.7%	2000	215	500
Wharf Crane	7	0.7%	1986	867	854
Chassis Flipper	5	0.5%	2002	156	1400
RORO Stacker	1	0.1%	1998	215	250
Subtotal "Other Primary Equipment"	88	8.8%	2001	377	2,158
Ancillary Equipment					
Portable Light Set	12	1.2%	2001	50	1000
Aerial Platform	11	1.1%	2001	75	898
Bucket Loader	3	0.3%	1994	138	100
Nonroad Vehicle	9	0.89%	2000	262	1800
Diesel Fuel Truck	3	0.30%	2004	240	3200
Payloader	4	0.39%	1996	82	224
Sweeper	9	0.89%	2001	90	492
Portable Gen Set	1	0.10%	2003	610	0
Subtotal "Ancillary Equipment"	52	5.2%	2000	128	1,025
Total Population	1014				

Figure 2.9: Population Distribution of Primary CHE, by Number and Percent

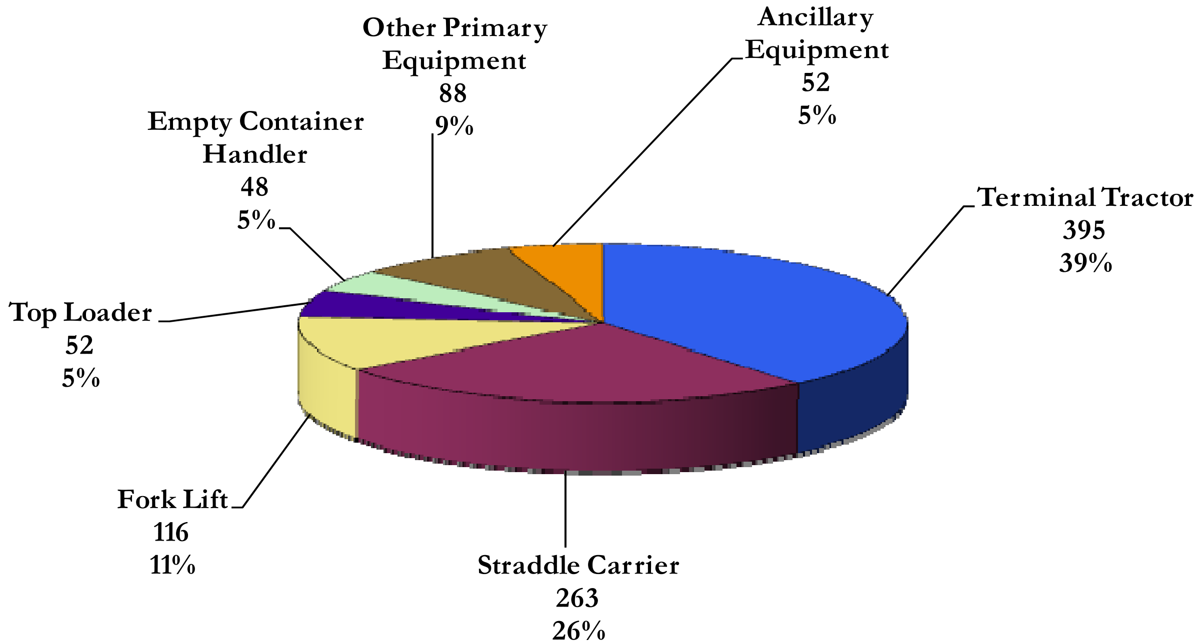
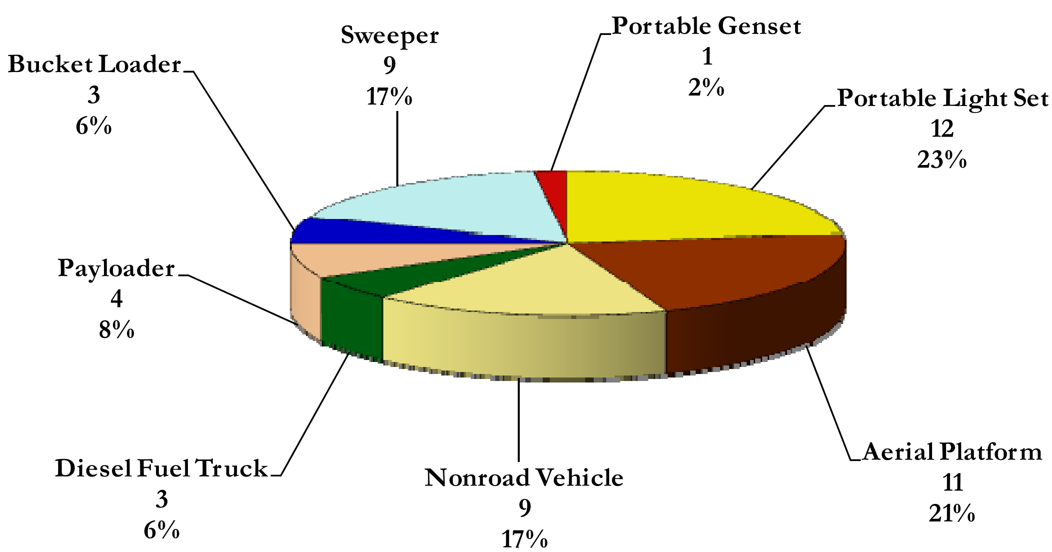


Figure 2.10: Population Distribution of Ancillary Equipment, by Number and Percent



2.4.1 Primary Non-road Equipment

Primary non-road 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 2.13 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 2.11 and 2.12 illustrate the model year distributions of terminal tractors and straddle carriers, by far the two most numerous types of equipment in the inventory.

Table 2.13: Model Year Characteristics of Primary CHE

Equipment Type	Average Model Year	Min Model Year	Max Model Year
Terminal Tractor	2002	1995	2008
Straddle Carrier	2003	1998	2007
Fork Lift	2000	1986	2008
Top Loader	2001	1991	2008
Empty Container Handler	2002	1989	2008
Rubber Tired Gantry Crane	2003	2001	2006
Reach Stacker	2003	1999	2006
Stacker	2000	1999	2004
RORO Hustler	2000	1999	2000
Wharf Crane	1986	1978	1998
Chassis Flipper	2002	1998	2006
RORO Stacker	1998	1998	1998

Figure 2.11: Model Year Distribution of Terminal Tractors

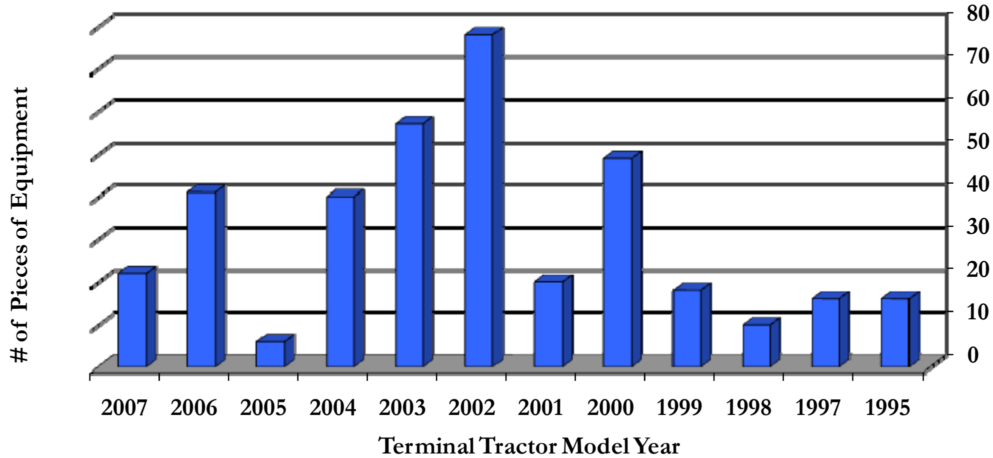


Figure 2.12: Model Year Distribution of Straddle Carriers

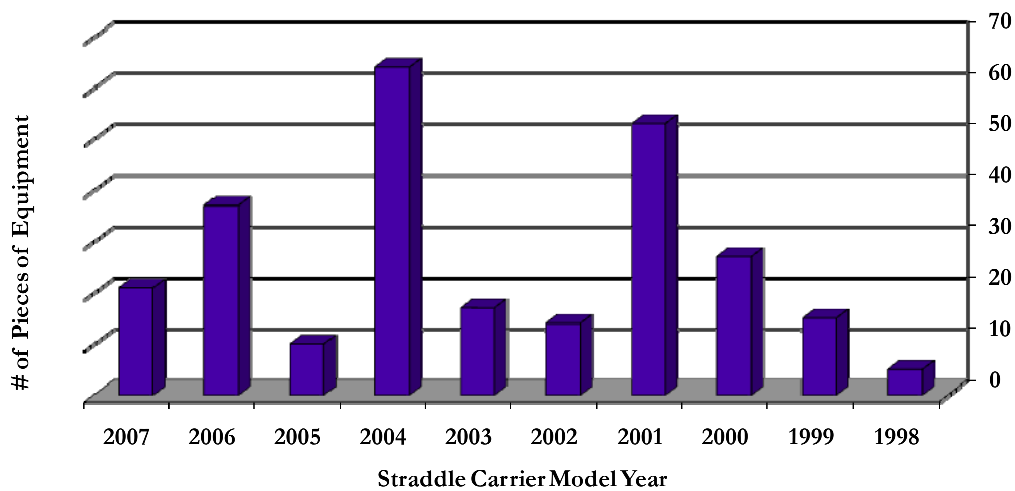


Table 2.14 presents information on the horsepower ratings of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.13 and 2.14 illustrate the number of terminal tractors and straddle carriers in each horsepower group. The straddle carriers in the 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 2.14: Horsepower Characteristics of Primary CHE

Equipment Type	Average hp	Min hp	Max hp
Terminal Tractor	204	170	245
Straddle Carrier	228	184	320
Fork Lift	108	48	226
Top Loader	287	172	330
Empty Container Handler	194	160	240
Rubber Tired Gantry Crane	468	450	475
Reach Stacker	326	225	330
Stacker	161	152	200
RORO Hustler	215	215	215
Wharf Crane	867	835	950
Chassis Flipper	156	152	160
RORO Stacker	215	215	215

Figure 2.13: Horsepower Distribution of Terminal Tractors

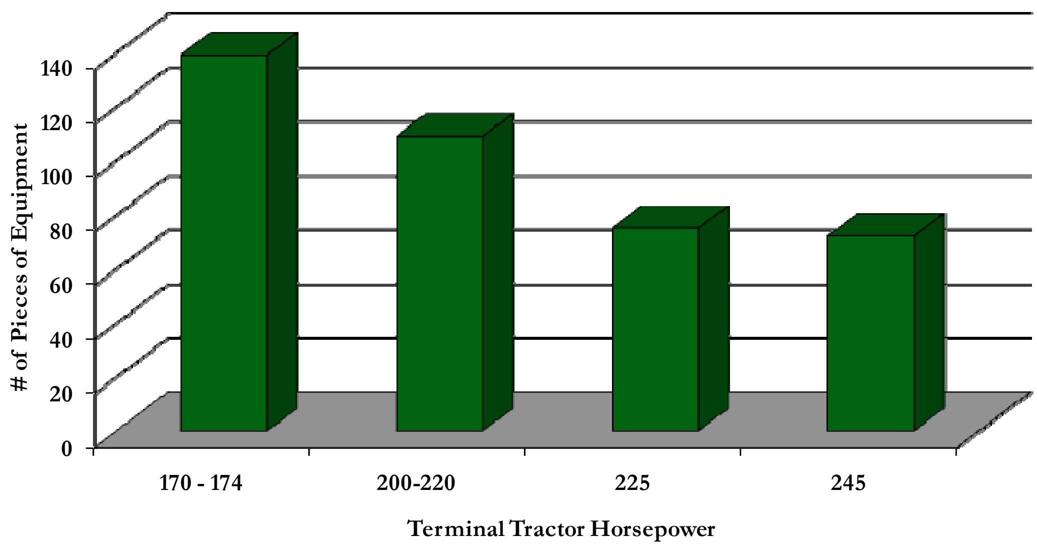


Figure 2.14: Horsepower Distribution of Straddle Carriers

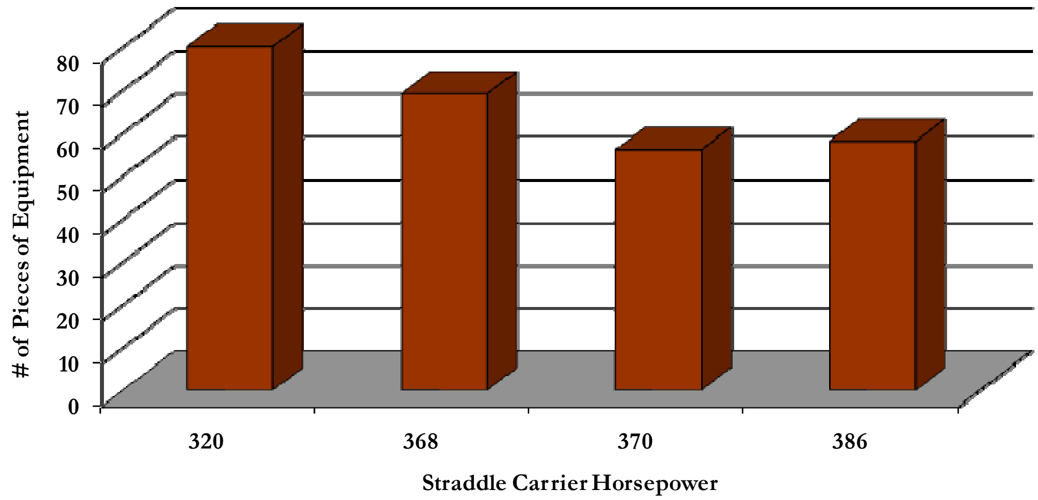


Table 2.15 presents information on the reported annual operating hours of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.15 and 2.16 illustrate the variation in reported terminal tractor and straddle carrier operating hours, respectively. Figure 2.16 does not include the 16 straddle carriers which were reported as not operating in 2008 (represented by the zeros in Table 2.15).

Table 2.15: Reported Operating Hours of Primary CHE

Equipment Type	Average hrs/year	Min hrs/year	Max hrs/year
Terminal Tractor	1,555	66	4,185
Straddle Carrier	3,048	0	3,357
Fork Lift	846	35	3,681
Top Loader	2,240	800	4,531
Empty Container Handler	1,544	128	2,657
Rubber Tired Gantry Crane	3,905	1,801	6,490
Reach Stacker	1,832	1,000	3,600
Stacker	600	600	600
RORO Hustler	500	500	500
Wharf Crane	854	0	1,800
Chassis Flipper	1,400	1,400	1,400
RORO Stacker	250	250	250

Figure 2.15: Distribution of Annual Operating Hours for Terminal Tractors

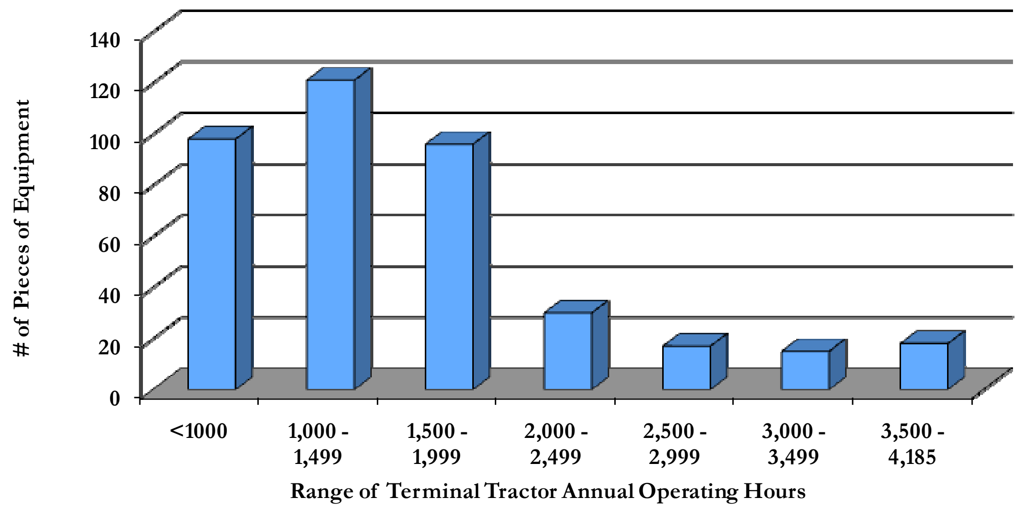
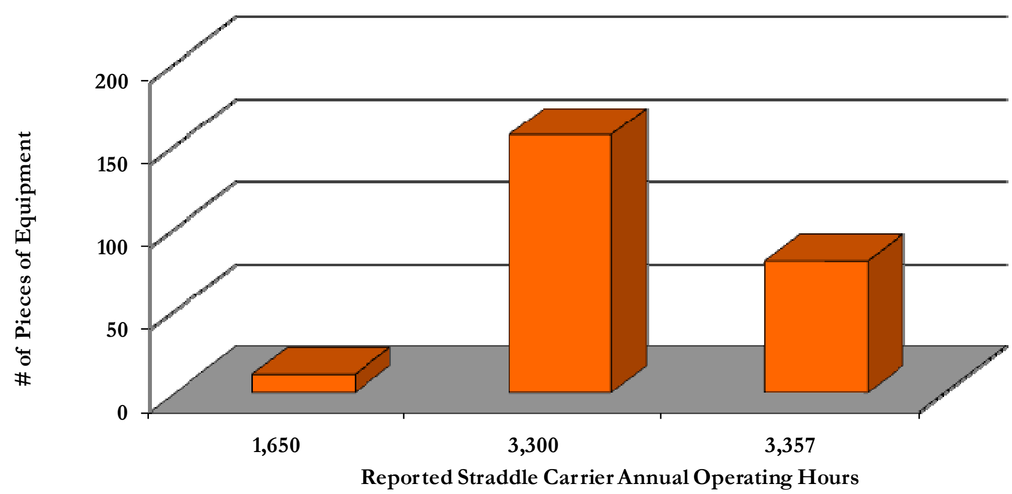


Figure 2.16: Distribution of Annual Operating Hours for Straddle Carriers



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 2.16 through 2.18 present the distribution of characteristics of this ancillary equipment in terms of model year, horsepower rating, and annual operating hours, respectively.

Table 2.16: Model Year Characteristics of Ancillary Equipment

Equipment Type	Average Model Year	Min Model Year	Max Model Year
Portable Light Set	2001	2001	2001
Aerial Platform	2001	1989	2006
Bucket Loader	1994	1987	1997
Nonroad Vehicle	2000	1985	2006
Diesel Fuel Truck	2004	2002	2006
Payloader	1996	1987	2004
Sweeper	2001	1988	2008
Portable Gen Set	2003	2003	2003

Table 2.17: Horsepower Characteristics of Ancillary Equipment

Equipment Type	Average hp	Min hp	Max hp
Portable Light Set	50	50	50
Aerial Platform	75	42	174
Bucket Loader	138	135	140
Nonroad Vehicle	262	210	325
Diesel Fuel Truck	240	240	240
Payloader	82	38	125
Sweeper	90	38	101
Portable Gen Set	610	610	610

Table 2.18: 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
Aerial Platform	898	123	1,042
Bucket Loader	100	100	100
Nonroad Vehicle	1,800	1,800	1,800
Diesel Fuel Truck	3,200	3,200	3,200
Payloader	224	155	250
Sweeper	492	70	1,078
Portable Gen Set	0	0	0

The following Figures 2.17 through 2.21 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 2.17: Example Yard Tractor

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

Figure 2.18: Example Straddle Carrier

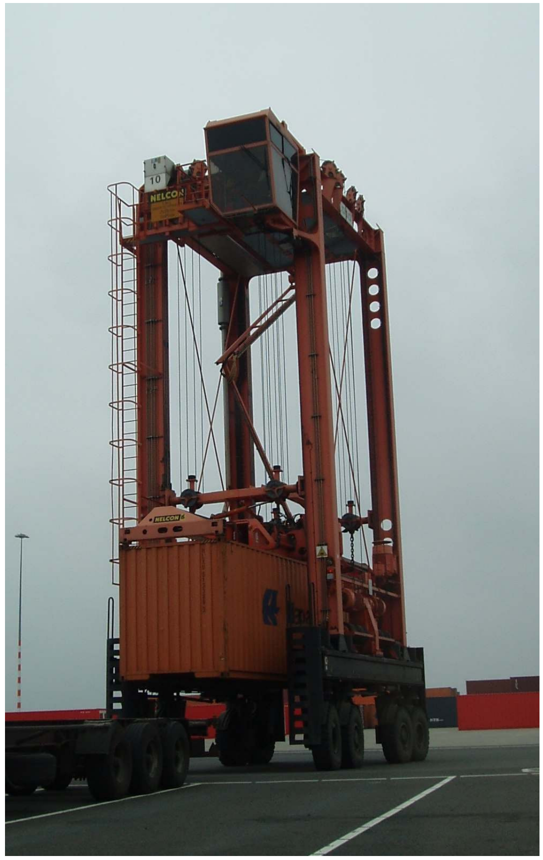


Figure 2.19: Example Fork Lift

Figure 2.20: Example Top Loader

Figure 2.21: 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

HDV Executive Summary

Table ES3-1 presents the estimated HDDV criteria pollutant 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. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states.

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
New York and New Jersey	936,354	917,144	198,076	1,330,674	6,564,103	540,477
NYNJLINA	445,285	178,451	42,441	522,245	2,840,374	170,044
Heavy-Duty Diesel Vehicles	2,331	59	54	105	603	2
Percent of NYNJLINA Emissions	0.52%	0.03%	0.13%	0.02%	0.02%	0.00%

The following figures ES3.1 through ES3.6 illustrate the distribution of PANYNJ HDDV emissions of NO_x, PM_{10}, $PM_{2.5}$, VOC, CO, and SO_2 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. Figure ES3.7 illustrates the distribution of CO_2 emissions but does not include the comparison with overall NYNJLINA emissions because these emissions have not been compiled.

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

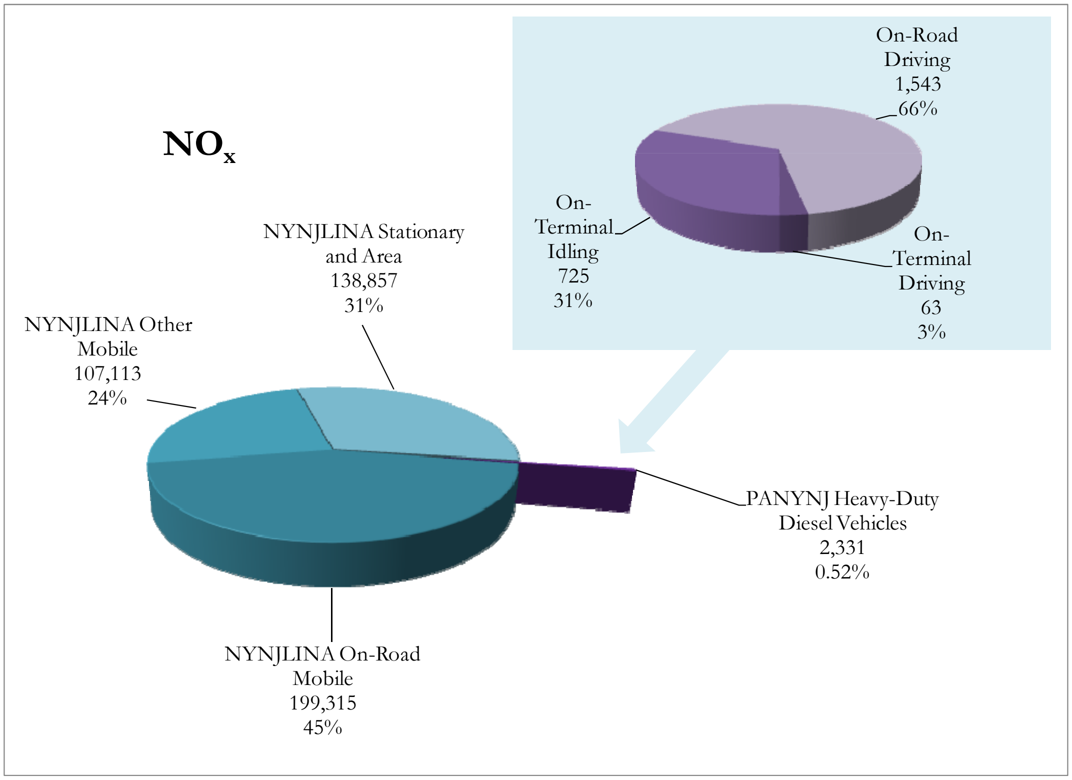


Figure ES3.2: Distribution and Comparison of PM10 from HDDVs, tpy and percent

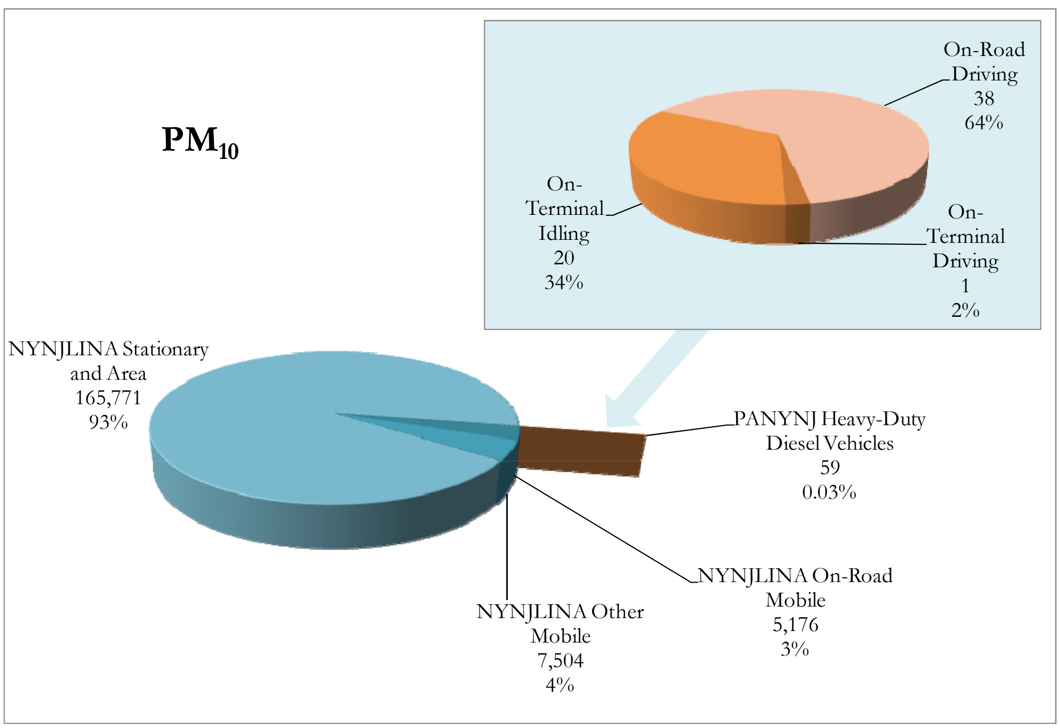


Figure ES3.3: Distribution and Comparison of PM2.5 from HDDVs, tpy and percent

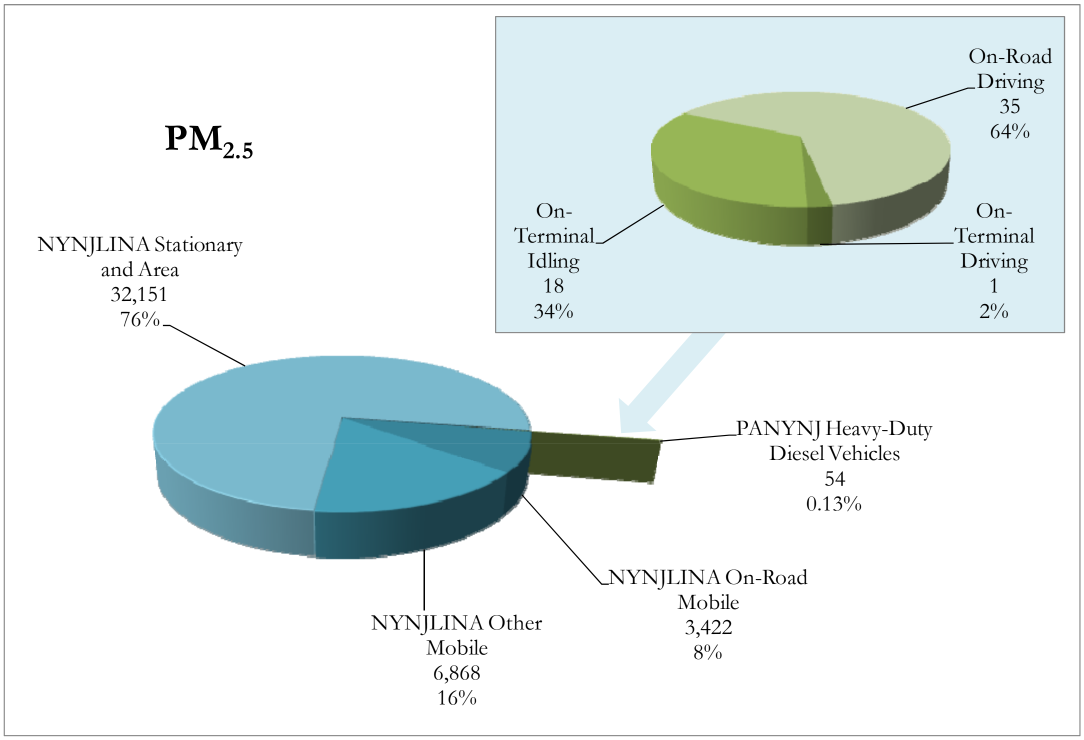


Figure ES3.4: Distribution and Comparison of VOC from HDDVs, tpy and percent

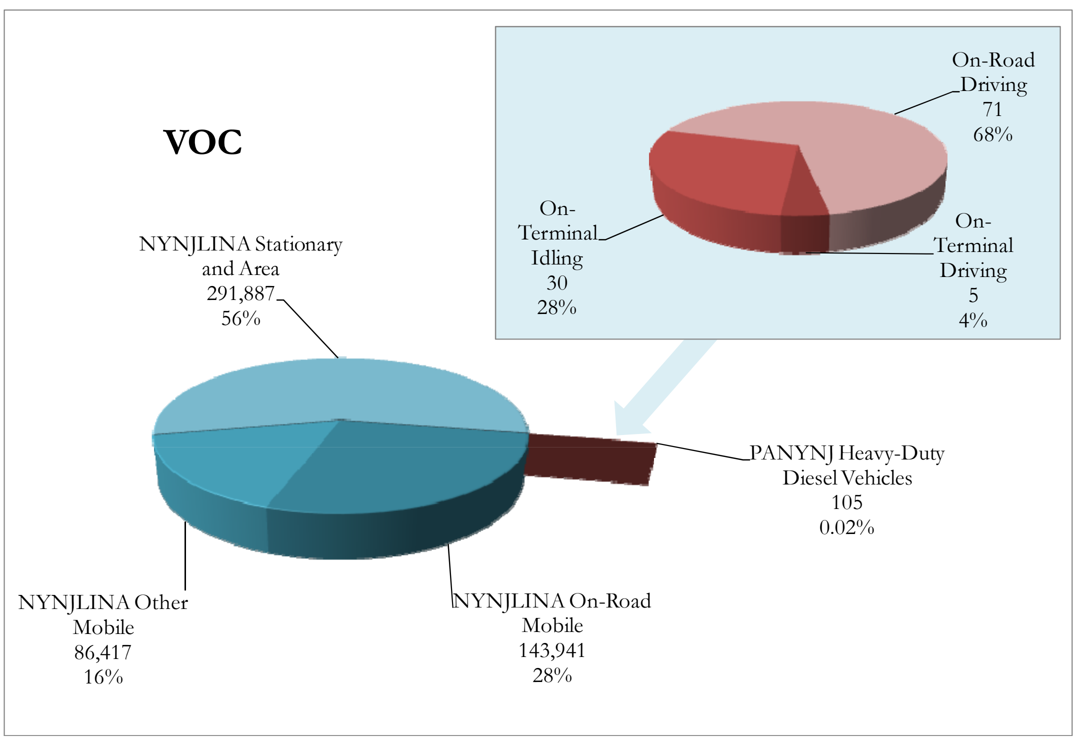


Figure ES3.5: Distribution and Comparison of CO from HDDVs, tpy and percent

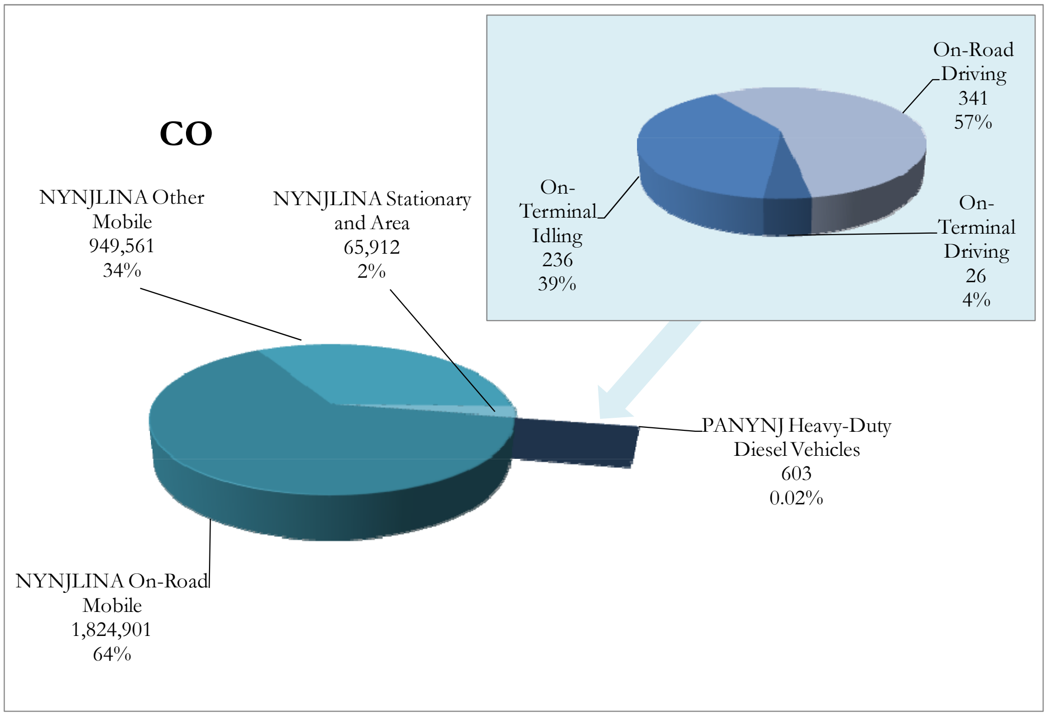


Figure ES3.6: Distribution and Comparison of SO_2 from HDDVs, tpy and percent

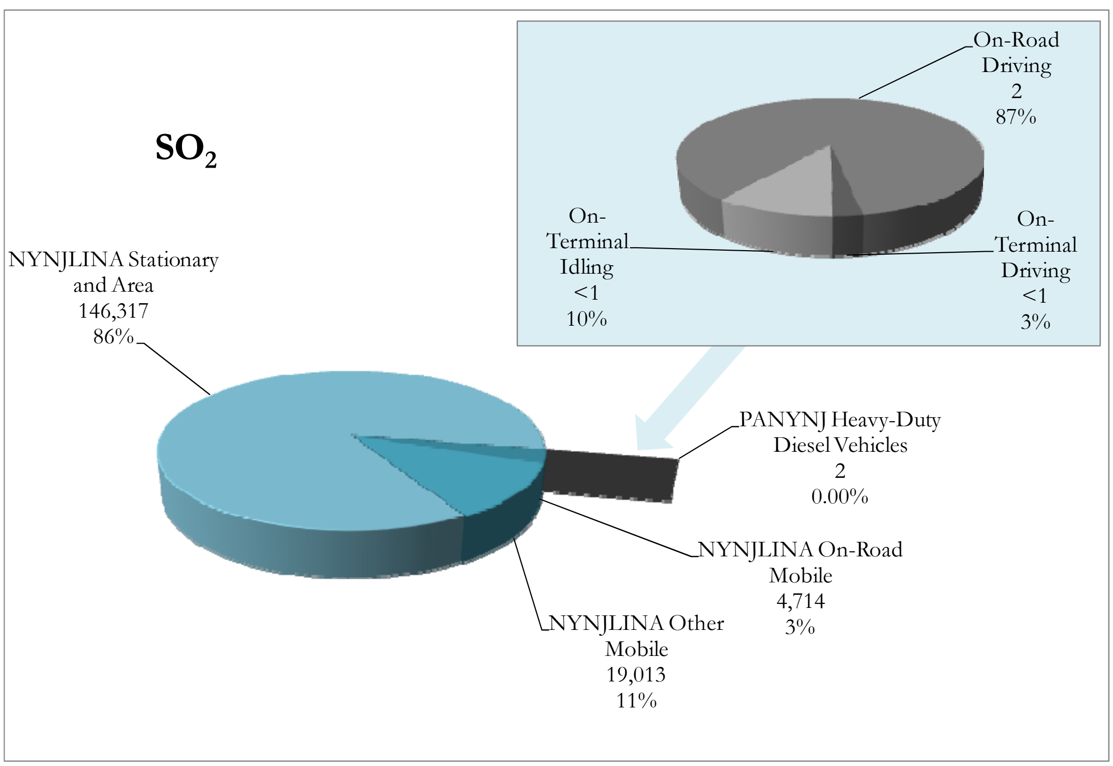
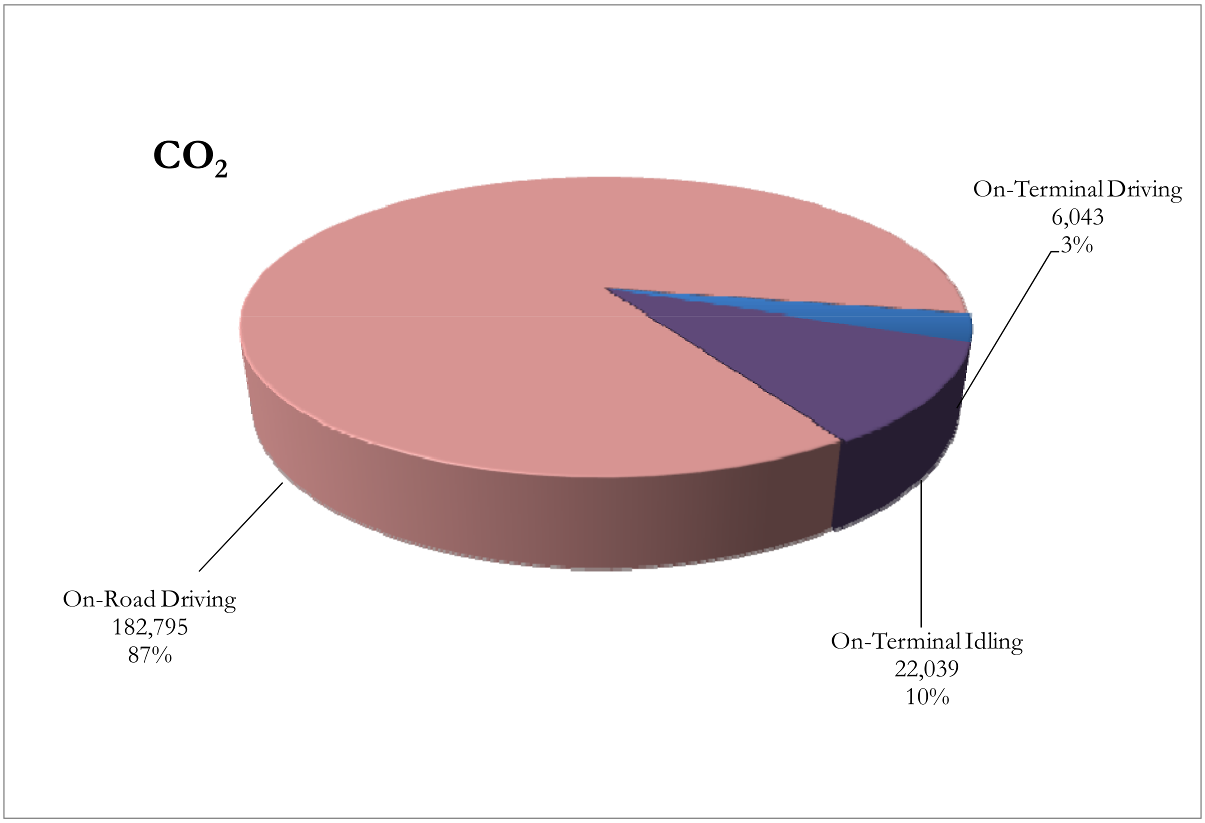


Figure ES3.7: Distribution of CO_2 Emissions from HDDVs, tpy and percent



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 3.3.3) so separate idling emissions are not presented for on-road HDDV operation.

3.1.1 On Terminal Emissions

Estimates of on-terminal driving emissions of criteria pollutants are presented in Table 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	55,670	0.9	0.02	0.02	0.07	0.4	0.00
Container Terms	3,134,958	58.9	1.18	1.08	4.25	24.8	0.05
Warehouses	149,119	2.7	0.06	0.05	0.20	1.1	0.00
Overall Total	**3,339,746**	**62.5**	**1.26**	**1.15**	**4.52**	**26.3**	**0.05**

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	55,670	96	0.0003	0.0003	96
Container Terms	3,134,958	5,674	0.017	0.018	5,679
Warehouses	149,119	267	0.001	0.001	268
Overall Total	**3,339,746**	**6,037**	**0.02**	**0.02**	**6,043**

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	157,654	23.5	0.64	0.59	0.87	6.6	0.01
Container Terms	4,607,094	685.6	18.69	17.19	28.23	224.1	0.19
Warehouses	107,299	15.9	0.43	0.40	0.64	5.0	0.00
Overall Total	**4,872,047**	**725.0**	**19.76**	**18.18**	**29.74**	**235.7**	**0.20**

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	157,654	687	0.003	0.002	688
Container Terms	4,607,094	20,845	0.073	0.068	20,869
Warehouses	107,299	481	0.002	0.002	481
Overall Total	**4,872,047**	**22,013**	**0.08**	**0.07**	**22,039**

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	55,670	157,654	24.4	0.66	0.61	0.94	7.0	0.01
Container Terms	3,134,958	4,607,094	744.5	19.87	18.28	32.49	248.9	0.25
Warehouses	149,119	107,299	18.7	0.49	0.45	0.84	6.2	0.01
Overall Total	**3,339,746**	**4,872,047**	**787.6**	**21.02**	**19.34**	**34.27**	**262.1**	**0.27**

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	55,670	157,654	783	0.003	0.003	784
Container Terms	3,134,958	4,607,094	26,519	0.090	0.086	26,548
Warehouses	149,119	107,299	748	0.002	0.002	749
Overall Total	**3,339,746**	**4,872,047**	**28,050**	**0.10**	**0.09**	**28,082**

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	80,819,937	1,235	30.3	27.9	56.7	273.0	1.4
New York	20,174,153	308	7.6	7.0	14.2	68.2	0.3
Total	**100,994,090**	**1,543**	**37.9**	**34.9**	**70.9**	**341.2**	**1.7**

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

State	VMT	CO_2	N_2O	CH_4	CO_2 Eq
New Jersey	80,819,937	146,270	0.43	0.45	146,283
New York	20,174,153	36,512	0.11	0.11	36,512
Total	**100,994,090**	**182,782**	**0.54**	**0.56**	**182,795**

3.1.3 Total HDDV On- and Off-Terminal Related Emissions

The totals of on-terminal and off-terminal, on-road 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_2
On-Terminal Driving	62.5	1.26	1.15	4.52	26.3	0.1
On-Terminal Idling	725.0	19.76	18.18	29.74	235.7	0.20
On-Road Driving	1,543	37.9	34.9	70.9	341.2	1.7
Totals	**2,331**	**59**	**54**	**105**	**603**	**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	6,037	0.018	0.019	6,043
On-Terminal Idling	22,013	0.078	0.072	22,039
On-Road Driving	182,782	0.54	0.56	182,795
Totals	**210,832**	**0.63**	**0.66**	**210,876**

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. [11]

[11] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008; no update currently available. *http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata*

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 3.17 examine each pollutant individually, comparing Port Authority marine terminal-related truck activity with total county level emissions. Figures 3.1 through 3.6 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
Bergen	NJ	107	2.6	2.4	4.9	23.6	0.1
Essex	NJ	501	12.4	11.4	23.1	123.0	0.5
Hudson	NJ	226	5.6	5.1	10.3	50.8	0.2
Middlesex	NJ	349	8.6	7.9	16.0	77.2	0.4
Monmouth	NJ	24	0.6	0.5	1.1	5.3	0.0
Union	NJ	534	13.9	12.8	23.9	162.8	0.3
New Jersey subtotal		**1,740**	**43.7**	**40.2**	**79.3**	**442.6**	**1.5**
Bronx	NY	38	0.9	0.9	1.8	8.5	0.0
Kings (Brooklyn)	NY	80	2.0	1.8	3.6	18.8	0.1
Nassau	NY	50	1.2	1.1	2.3	11.1	0.1
New York	NY	11	0.3	0.3	0.5	2.5	0.0
Orange	NY	32	0.8	0.7	1.5	7.1	0.0
Queens	NY	34	0.8	0.8	1.6	7.5	0.0
Richmond (Staten Islar	NY	283	7.7	7.1	11.8	91.5	0.1
Rockland	NY	4	0.1	0.1	0.2	0.9	0.0
Suffolk	NY	29	0.7	0.6	1.3	6.3	0.0
Westchester	NY	29	0.7	0.7	1.3	6.5	0.0
New York subtotal		**591**	**15.3**	**14.0**	**25.8**	**160.7**	**0.4**
TOTAL		**2,331**	**59**	**54**	**105**	**603**	**2**

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	25,972	107	0.41%
Essex	NJ	23,498	501	2.13%
Hudson	NJ	27,776	226	0.81%
Middlesex	NJ	33,000	349	1.06%
Monmouth	NJ	19,177	24	0.12%
Union	NJ	21,154	534	2.52%
New Jersey Subtotal		**150,577**	**1,740**	**1.16%**
Bronx	NY	16,018	38	0.24%
Kings (Brooklyn)	NY	29,788	80	0.27%
Nassau	NY	36,258	50	0.14%
New York	NY	39,082	11	0.03%
Orange	NY	19,397	32	0.17%
Queens	NY	41,172	34	0.08%
Richmond (Staten Islan	NY	10,085	283	2.81%
Rockland	NY	13,645	4	0.03%
Suffolk	NY	61,223	29	0.05%
Westchester	NY	28,040	29	0.10%
New York Subtotal		**294,708**	**591**	**0.2%**
TOTAL		**445,285**	**2,331**	**0.52%**

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

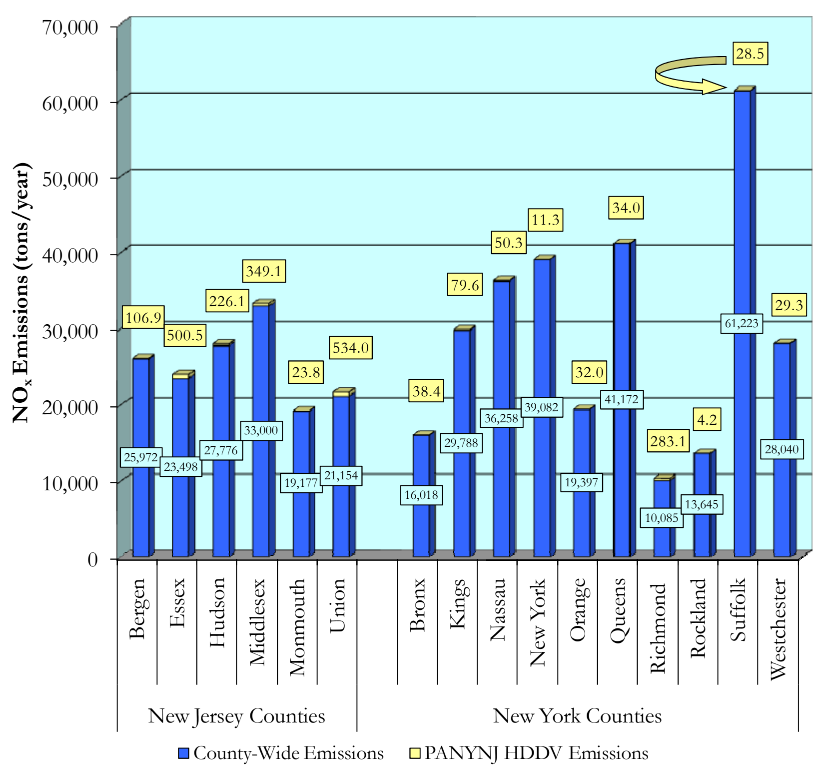


Table 3.13: Comparison of Heavy-duty Diesel Vehicle PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	2.6	0.04%
Essex	NJ	3,745	12.4	0.33%
Hudson	NJ	6,764	5.6	0.08%
Middlesex	NJ	9,927	8.6	0.09%
Monmouth	NJ	7,935	0.6	0.007%
Union	NJ	4,227	13.9	0.3%
New Jersey Subtotal		**38,850**	**44**	**0.11%**
Bronx	NY	5,803	0.9	0.02%
Kings (Brooklyn)	NY	8,312	2.0	0.02%
Nassau	NY	14,142	1.2	0.009%
New York	NY	8,689	0.3	0.003%
Orange	NY	27,696	0.8	0.003%
Queens	NY	9,615	0.8	0.009%
Richmond (Staten Islar	NY	8,092	7.7	0.09%
Rockland	NY	4,880	0.1	0.002%
Suffolk	NY	39,210	0.7	0.002%
Westchester	NY	13,162	0.7	0.005%
New York Subtotal		**139,601**	**15**	**0.01%**
TOTAL		**178,451**	**59**	**0.03%**

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

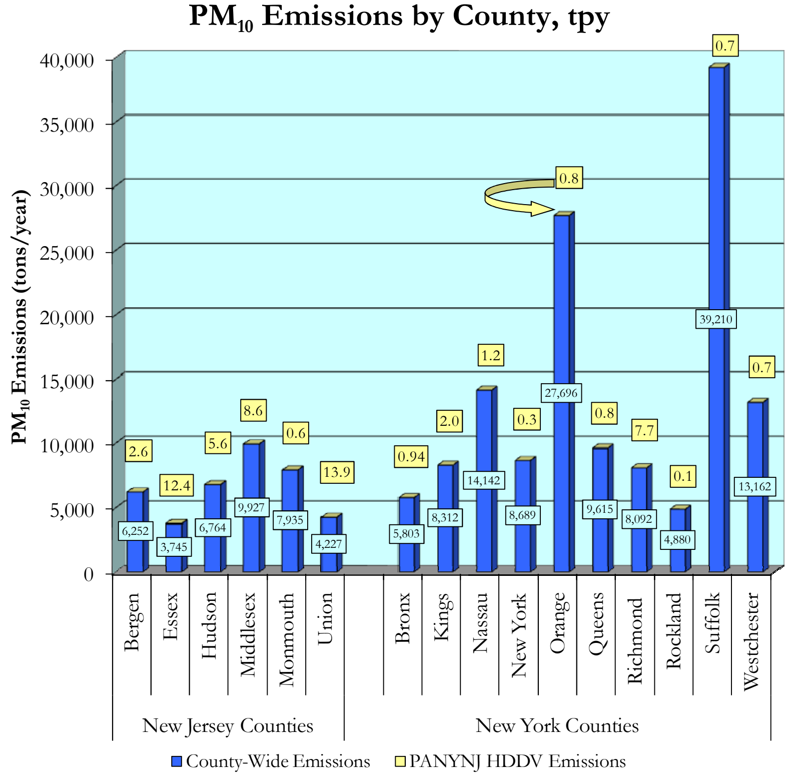


Table 3.14: Comparison of Heavy-duty Diesel Vehicle $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	2.4	0.17%
Essex	NJ	1,159	11.4	0.99%
Hudson	NJ	3,754	5.1	0.14%
Middlesex	NJ	2,150	7.9	0.37%
Monmouth	NJ	1,623	0.5	0.03%
Union	NJ	1,472	12.8	0.87%
New Jersey Subtotal		**11,567**	**40**	**0.3%**
Bronx	NY	1,357	0.9	0.06%
Kings (Brooklyn)	NY	2,676	1.8	0.07%
Nassau	NY	2,727	1.1	0.04%
New York	NY	4,017	0.3	0.006%
Orange	NY	4,968	0.7	0.01%
Queens	NY	3,655	0.8	0.02%
Richmond (Staten Islaı	NY	1,323	7.1	0.53%
Rockland	NY	1,638	0.1	0.006%
Suffolk	NY	6,057	0.6	0.01%
Westchester	NY	2,456	0.7	0.03%
New York Subtotal		**30,874**	**14**	**0.05%**
TOTAL		**42,441**	**54**	**0.13%**

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

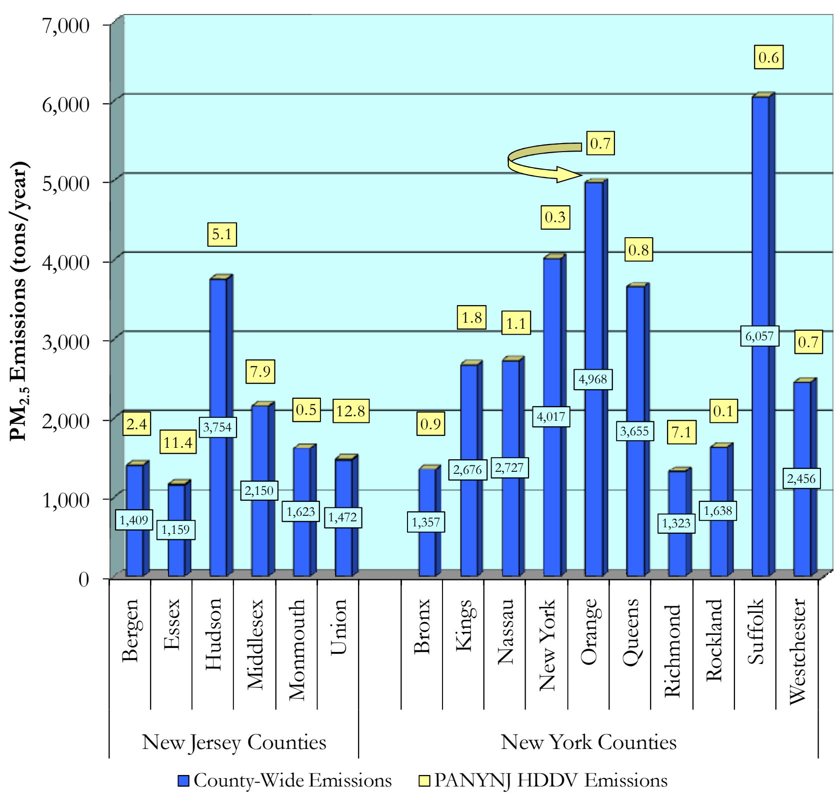


Table 3.15: Comparison of Heavy-duty Diesel Vehicle VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	5	0.01%
Essex	NJ	20,940	23	0.11%
Hudson	NJ	14,428	10	0.07%
Middlesex	NJ	30,357	16	0.05%
Monmouth	NJ	22,727	1	0.005%
Union	NJ	20,627	24	0.12%
New Jersey Subtotal		**142,075**	**79**	**0.06%**
Bronx	NY	25,454	1.8	0.007%
Kings (Brooklyn)	NY	54,809	3.6	0.007%
Nassau	NY	47,865	2.3	0.005%
New York	NY	45,292	0.5	0.001%
Orange	NY	18,349	1.5	0.008%
Queens	NY	47,262	1.6	0.003%
Richmond (Staten Islan	NY	13,542	11.8	0.087%
Rockland	NY	13,767	0.2	0.001%
Suffolk	NY	77,071	1.3	0.002%
Westchester	NY	36,759	1.3	0.004%
New York Subtotal		**380,170**	**26**	**0.007%**
TOTAL		**522,245**	**105**	**0.02%**

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

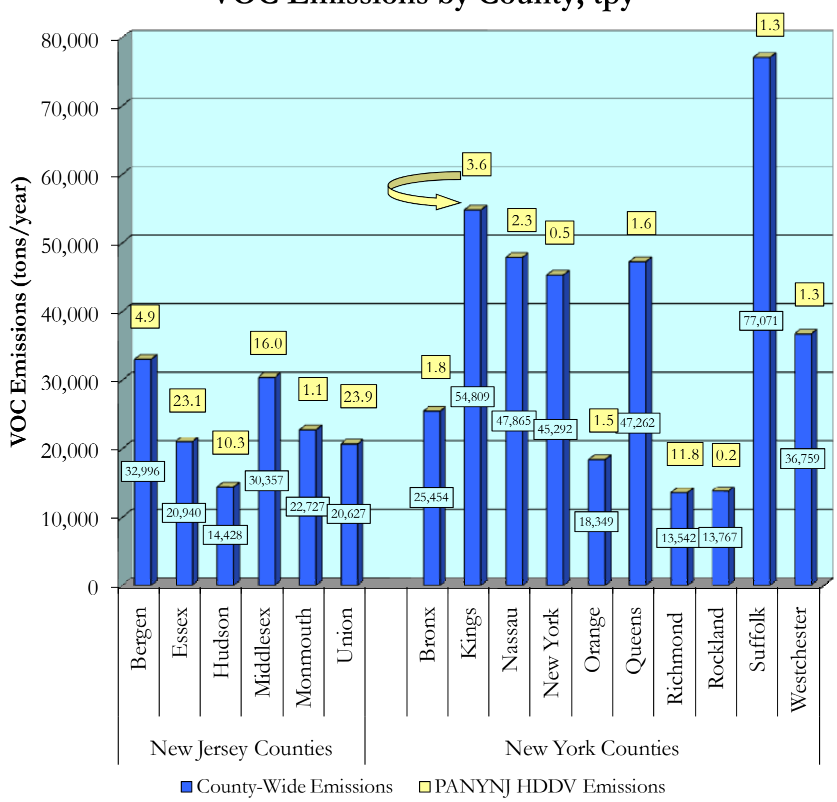


Table 3.16: Comparison of Heavy-duty Diesel Vehicle CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	24	0.010%
Essex	NJ	131,856	123	0.093%
Hudson	NJ	69,129	51	0.073%
Middlesex	NJ	196,869	77	0.039%
Monmouth	NJ	166,309	5	0.003%
Union	NJ	114,302	163	0.142%
New Jersey Subtotal		**921,446**	**443**	**0.05%**
Bronx	NY	113,641	8	0.007%
Kings (Brooklyn)	NY	158,527	19	0.012%
Nassau	NY	282,348	11	0.004%
New York	NY	220,345	3	0.001%
Orange	NY	114,316	7	0.006%
Queens	NY	207,255	8	0.004%
Richmond (Staten Islar	NY	52,149	92	0.175%
Rockland	NY	67,761	0.9	0.001%
Suffolk	NY	472,083	6	0.001%
Westchester	NY	230,503	6	0.003%
New York Subtotal		**1,918,928**	**161**	**0.008%**
TOTAL		**2,840,374**	**603**	**0.02%**

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

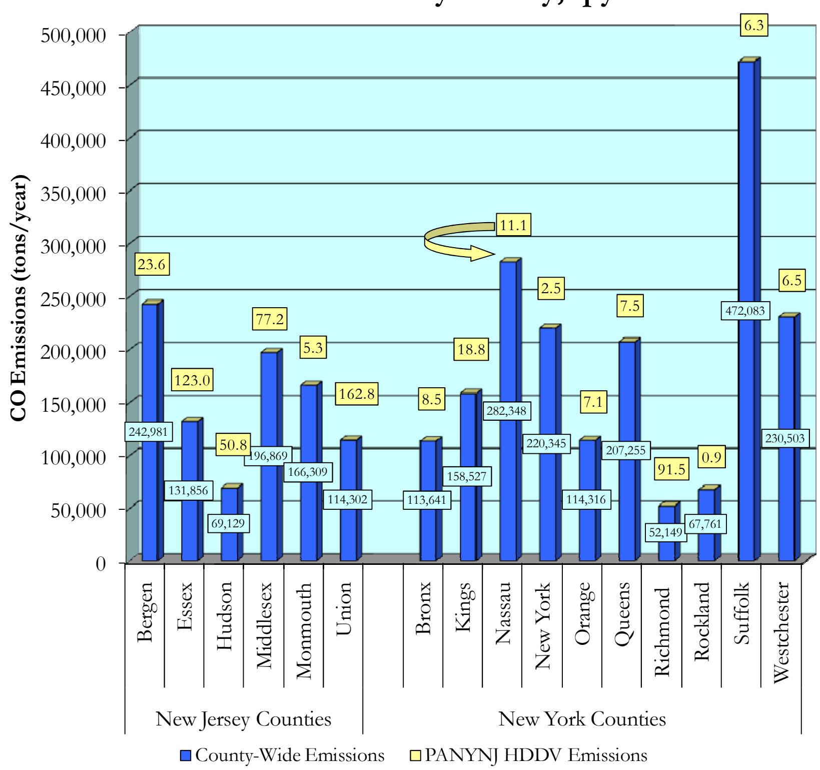
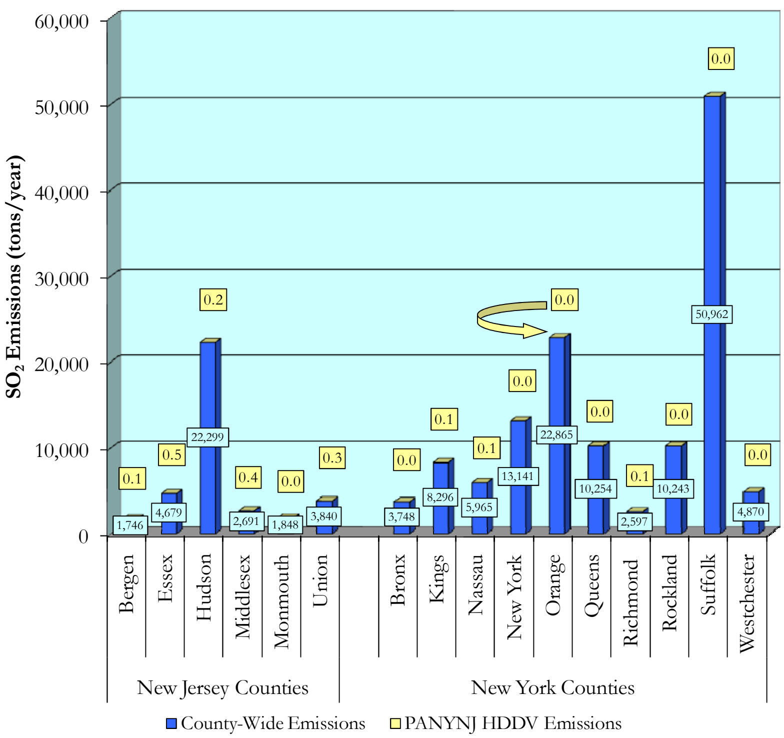


Table 3.17: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0.1	0.01%
Essex	NJ	4,679	0.5	0.01%
Hudson	NJ	22,299	0.2	0.00%
Middlesex	NJ	2,691	0.4	0.01%
Monmouth	NJ	1,848	0.0	0.00%
Union	NJ	3,840	0.3	0.01%
New Jersey Subtotal		**37,103**	**2**	**0.00%**
Bronx	NY	3,748	0.0	0.00%
Kings (Brooklyn)	NY	8,296	0.1	0.00%
Nassau	NY	5,965	0.1	0.00%
New York	NY	13,141	0.0	0.000%
Orange	NY	22,865	0.0	0.000%
Queens	NY	10,254	0.0	0.000%
Richmond (Staten Islan	NY	2,597	0.1	0.00%
Rockland	NY	10,243	0.0	0.000%
Suffolk	NY	50,962	0.0	0.000%
Westchester	NY	4,870	0.0	0.001%
New York Subtotal		**132,941**	**0**	**0.000%**
TOTAL		**170,044**	**2**	**0.00%**

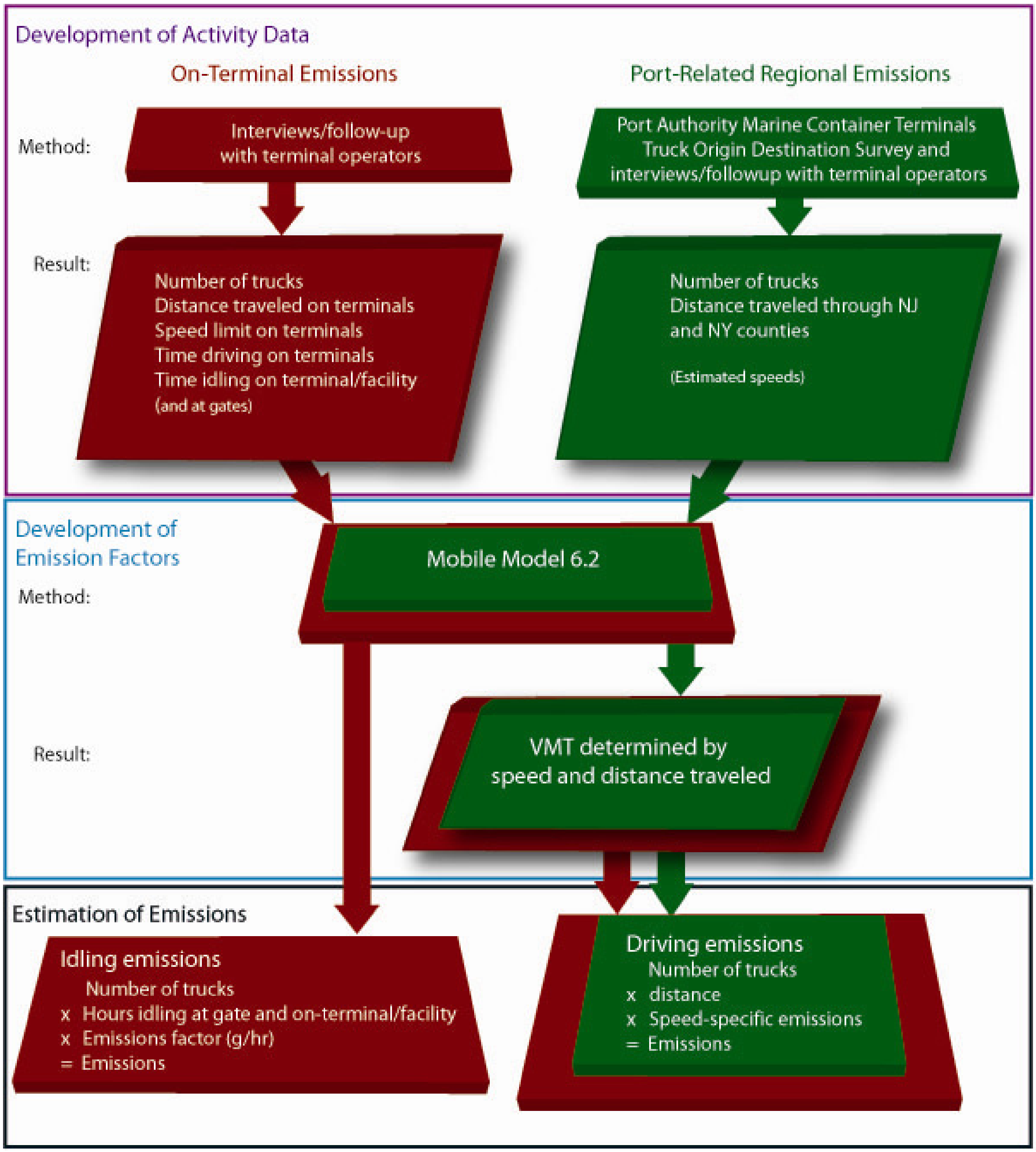
Figure 3.6: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy



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 3.7 illustrates this process in a flow diagram for on-terminal and off-terminal activity.

Figure 3.7: 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 2006 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	85,822	55,670	17.5	1.8
Container Terminals	3,098,986	3,134,958	15.0	1.5
Warehouses	204,028	149,119	13.0	0.4

The average idling times were based on information provided by the terminals. In addition, the prevalence of idling by trucks waiting at warehouses was 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, including non-idling trucks). The average idling time for an individual truck that does idle is 2 hours, according to terminal survey responses.

On-Road

As used previously in the 2005 and 2006 HDDV Emissions Inventories, Vollmer's origin/destination study[12] was used for the 2008 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 five 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

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

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 off-terminal (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[13]. These rates have been used as appropriate in the on-terminal emission estimates.

[13] 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 for 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):

$$\frac{100{,}000 \text{ miles/yr} \times 13.660 \text{ g/mi}}{453.6 \text{ g/lb} \times 2{,}000 \text{ lb/ton}} = 1.5 \text{ tons/yr}$$

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	55.424	0.8476	0.7798	4.8292	36.179	0.0364	3,906.1	0.0144	0.0134
	HDDV8b	62.756	0.8515	0.7833	5.5597	44.136	0.0383	4,104.7	0.0144	0.0134
Extended Idle (g/hr)	HDDV8a	135	3.68	3.3856	4.8292	36.179	0.0364	3,906.1	0.0144	0.0134
	HDDV8b	135	3.68	3.3856	5.5597	44.136	0.0383	4,104.7	0.0144	0.0134
On-Terminal (g/mi)	HDDV8a	14.964	0.3390	0.3119	1.0694	5.878	0.0146	1,562.5	0.0048	0.0051
(15 mph avg. speed)	HDDV8b	17.048	0.3406	0.3133	1.2312	7.171	0.0153	1,641.9	0.0048	0.0051
Off-Port Roads (g/mi)	HDDV8a	12.117	0.3390	0.3119	0.5528	2.512	0.0146	1,562.5	0.0048	0.0051
(35 mph avg. speed)	HDDV8b	13.866	0.3406	0.3133	0.6364	3.065	0.0153	1,641.9	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 for 2008.

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. As a note on scale and perspective, the reported number of truck visits to the warehouses and auto terminals totaled 289,850, less than 10% of the total number of container truck visits, 3,098,986.

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	30,542	0.25	1.48	HDDV8A	7,636	45,202	Yes
Automobile	21,910	0.10	1.73	HDDV8A	2,191	37,904	Yes
Automobile	19,439	2.00	2.47	HDDV8A	38,878	48,079	Yes
Automobile	13,931	0.50	1.90	HDDV8B	6,966	26,469	Yes
Container	901,832	1.50	1.49	HDDV8B	1,352,748	1,340,724	Yes
Container	799,476	0.10	2.27	HDDV8B	79,948	1,817,475	Yes
Container	755,092	1.00	1.25	HDDV8B	755,092	943,865	Yes
Container	568,979	1.60	0.77	HDDV8B	910,366	440,010	Yes
Container	73,607	0.50	0.88	HDDV8B	36,804	65,020	Yes
Warehouse	55,000	0.50	1.05	HDDV8A	27,500	20,202	Yes
Warehouse	40,000	0.25	2.31	HDDV8B	10,000	32,268	Yes
Warehouse	39,000	1.50	2.52	HDDV8B	58,500	34,227	Yes
Warehouse	30,000	0.20	0.99	HDDV8B	6,000	10,357	Yes
Warehouse	12,000	2.00	0.37	HDDV8B	24,000	1,548	Yes
Warehouse	7,750	1.50	0.23	HDDV8B	11,625	622	No
Warehouse	5,408	0.10	0.48	HDDV8B	541	905	Yes
Warehouse	3,120	0.90	1.30	HDDV8B	2,808	1,414	Yes
Warehouse	2,860	2.00	2.44	HDDV8B	5,720	2,433	Yes
Warehouse	2,700	0.10	0.98	HDDV8A	270	923	Yes
Warehouse	2,400	0.50	1.06	HDDV8B	1,200	887	Yes
Warehouse	2,350	0.10	1.14	HDDV8B	235	934	Yes
Warehouse	1,440	0.50	1.15	HDDV8B	720	577	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 survey includes emission estimates from HDDV operations at the following facilities, listed in Table 3.21, that were in operation during 2008.

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
Auto Marine Terminals	1. Toyota Logistics at Port Newark 2. Foreign Auto Preparation Services (FAPS) at Port Newark 3. Wallenius Wilhelmsen Logistics (WWL) at EPAMT 4. Northeast Auto Terminal (NEAT) at the Port Authority Auto Marine Terminal 5. BMW at the Port Authority Auto Marine Terminal
On-Terminal Warehouses at Port Newark/EPAMT	1. Phoenix Beverage 2. Linon Home Décor Products 3. Harbor Freight Transport 4. Port Newark Refrigerated Warehouse 5. Eastern Warehouse 6. Export Transport Co. 7. ASA Apple Inc. 8. Van Brunt Port Jersey Warehouse Inc. 9. Port Warehouse & Distribution Corp. 10. TRT International Ltd. 11. Tyler Distribution Centers Inc. 12. East Coast Warehouse & Distribution Corp. 13. 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 NYNJLINA 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 this study, 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 3.8 is an illustration of a container truck transporting a container in a container terminal, while Figure 3.9 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 3.8: HDDV with Container

Figure 3.9: 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 an emissions inventory, locomotive activity has been broken up into 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

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

The following four subsections focus on:

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

Rail Executive Summary

Table ES4-1 presents the estimated locomotive criteria pollutant 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. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states.

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
New York and New Jersey	936,354	917,144	198,076	1,330,674	6,564,103	540,477
NYNJLINA	445,285	178,451	42,441	522,245	2,840,374	170,044
Railroad Locomotives	268	10	9	20	45	4
Percent of NYNJLINA Emissions	0.06%	0.01%	0.02%	0.004%	0.002%	0.00%

The following figures ES4.1 through ES4.6 illustrate the distribution of PANYNJ switching and line haul locomotive emissions of NO_x, PM_{10}, $PM_{2.5}$, VOC, CO, and SO_2 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. Figure ES4.7 illustrates the distribution of CO_2 emissions but does not include the comparison with overall NYNJLINA emissions because these emissions have not been compiled.

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

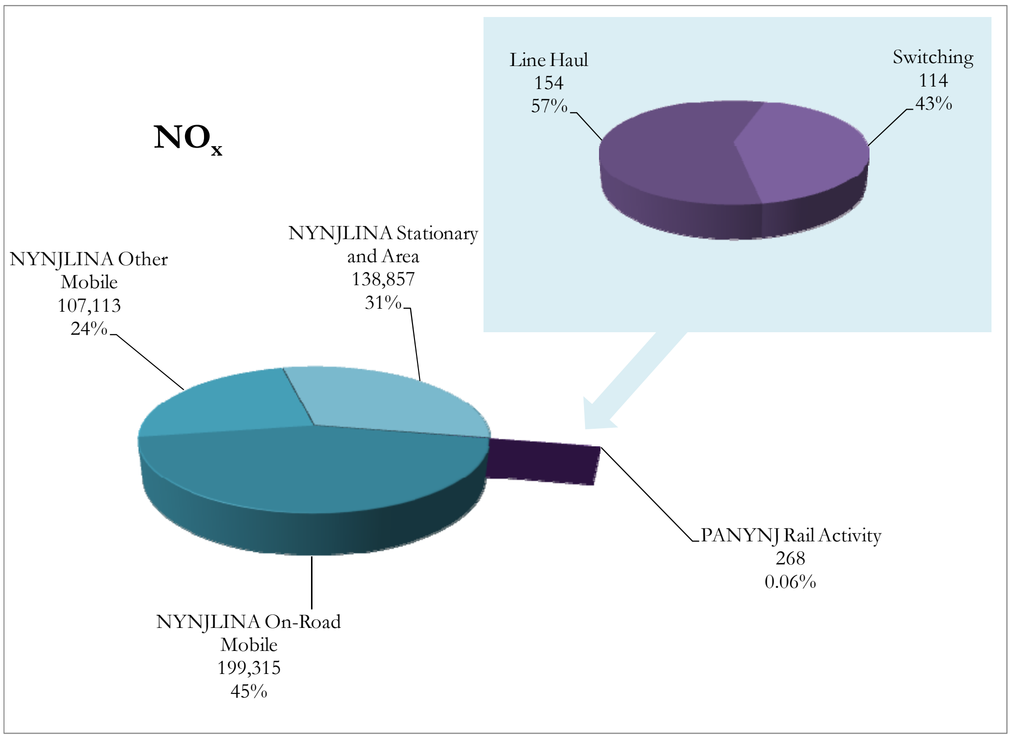


Figure ES4.2: Distribution and Comparison of PM_{10} from Locomotives, tpy and percent

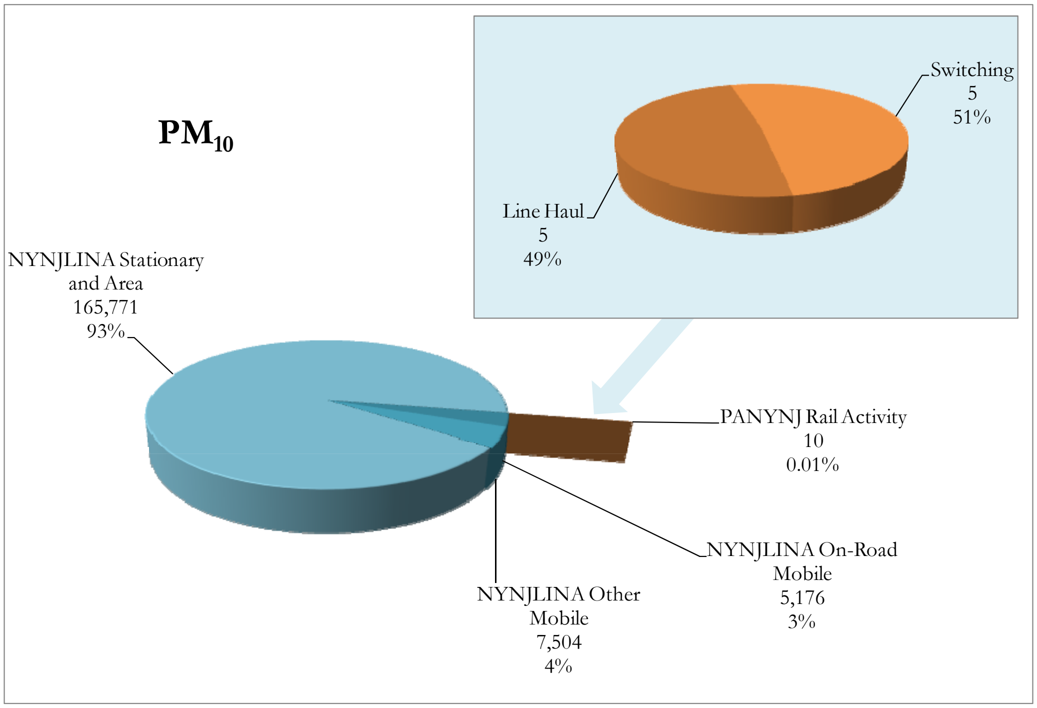


Figure ES4.3: Distribution and Comparison of $PM_{2.5}$ from Locomotives, tpy and percent

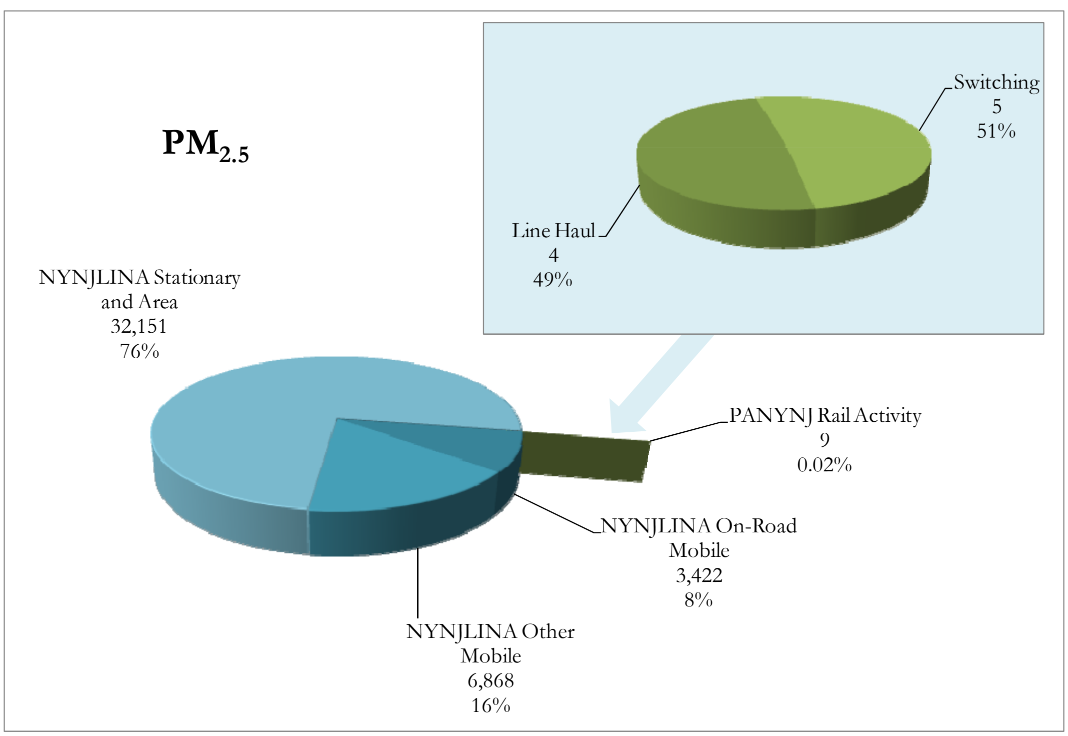


Figure ES4.4: Distribution and Comparison of VOC from Locomotives, tpy and percent

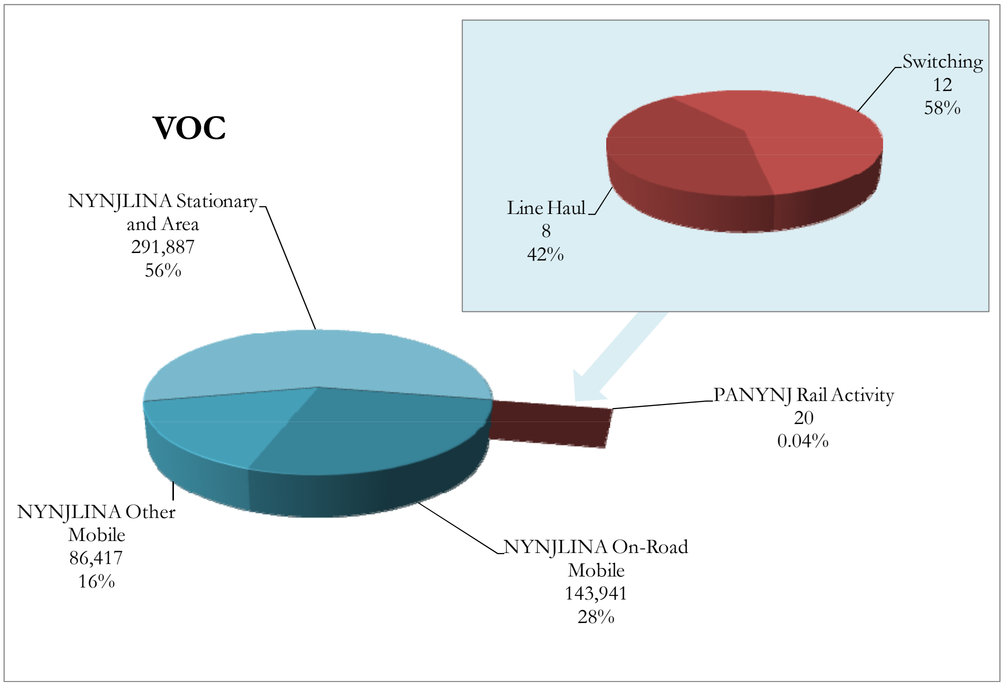


Figure ES4.5: Distribution and Comparison of CO from Locomotives, tpy and percent

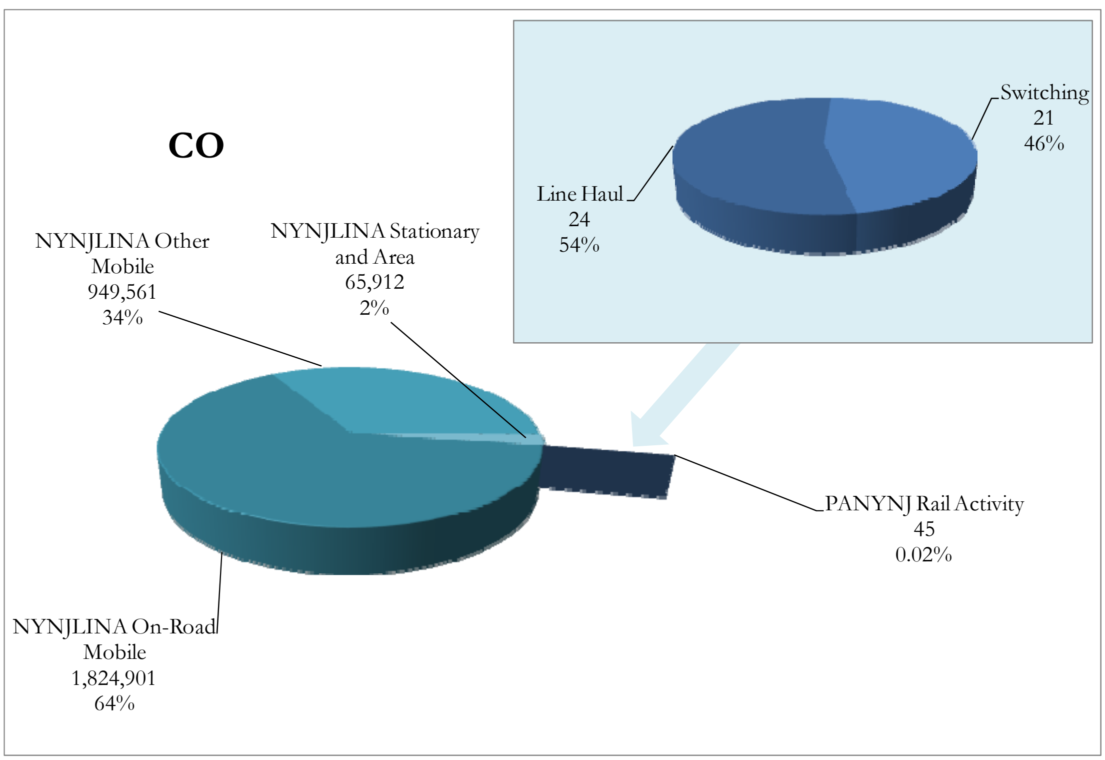


Figure ES4.6: Distribution and Comparison of SO_2 from Locomotives, tpy and percent

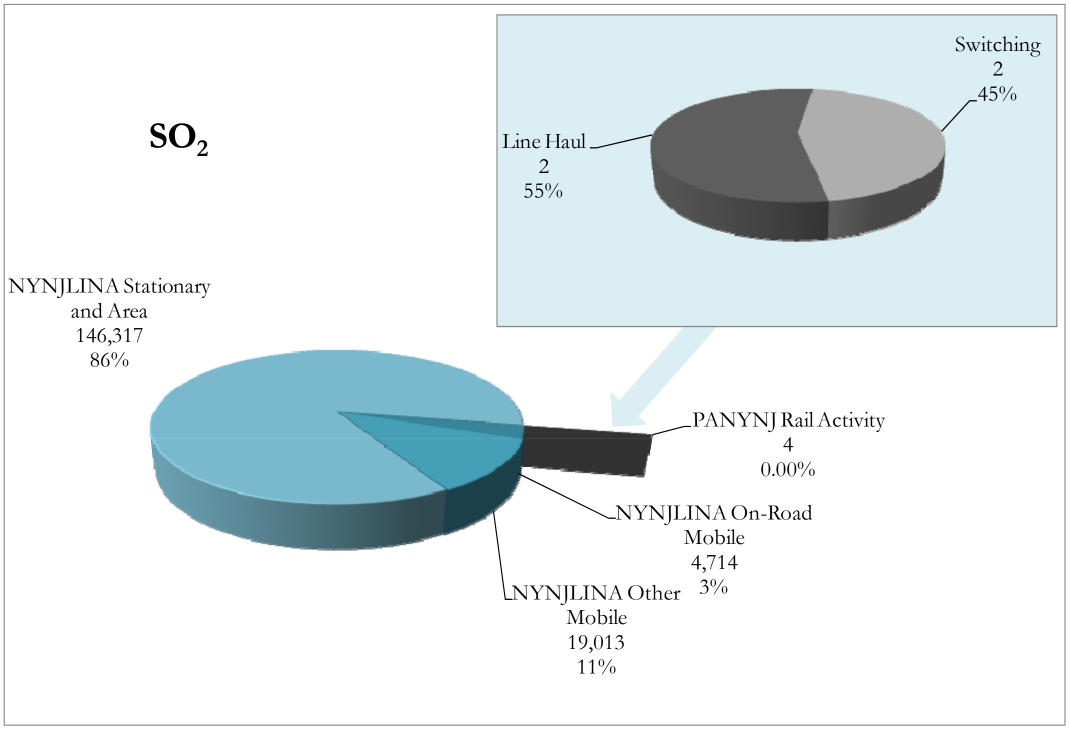
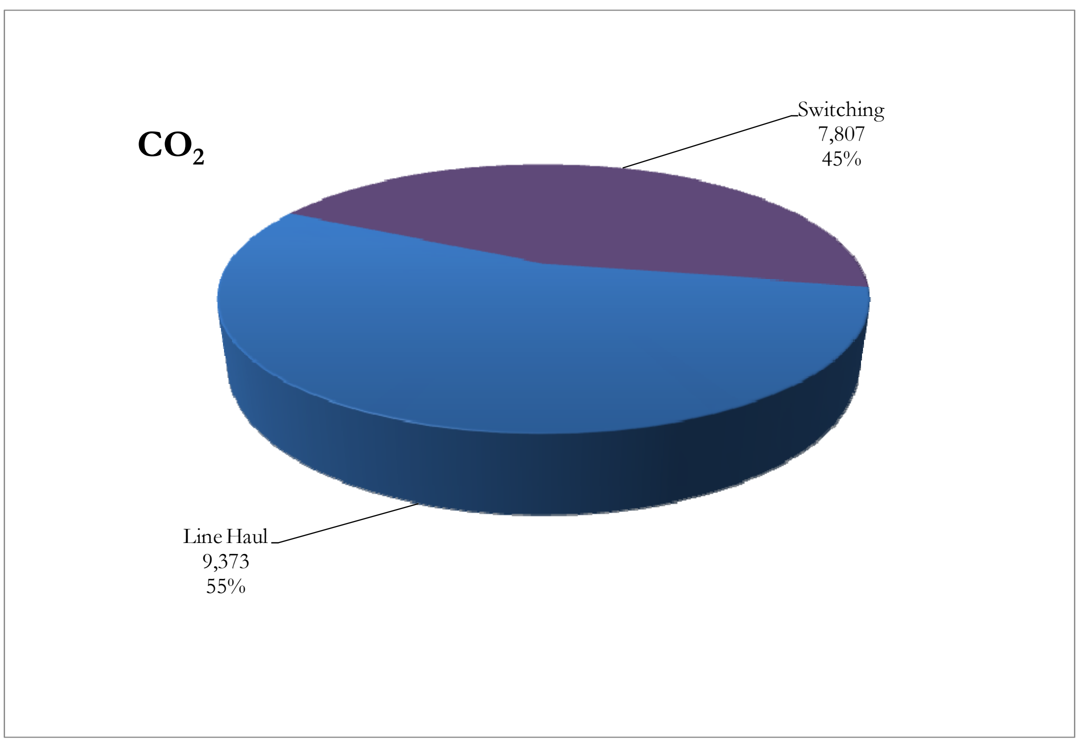


Figure ES4.7: Distribution of CO_2 from Locomotives, tpy and percent



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.

Table 4.1 summarizes the line haul and switching locomotive criteria pollutant emissions, and Table 4.2 summarizes greenhouse gas emissions from these emission sources.

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	154	5	4	8	24	2
Switching	114	5	5	12	21	2
Totals	**268**	**10**	**9**	**20**	**45**	**4**

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

Emission Estimates	CO_2	N_2O	CH_4	CO_2 Equiv.
Line Haul	9,289	0.22	0.73	9,373
Switching	7,735	0.20	0.61	7,807
Totals	**17,024**	**0.42**	**1.34**	**17,180**

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.[14] 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 which were then summed to yield the regional total. A more detailed discussion of the rail emission calculation methodology is presented in Section 4.3.

[14] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008; no update currently available. *http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata*

Table 4.3 examines 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 4.9 present each pollutant individually, comparing Port related locomotive emissions with total county level emissions. Figures 4.1 through 4.6 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
Bergen	NJ	34.7	1.0	1.0	1.8	5.5	0.5
Essex	NJ	94.1	4.0	3.7	9.0	17.1	1.4
Hudson	NJ	30.0	0.9	0.8	1.6	4.7	0.4
Middlesex	NJ	5.4	0.2	0.2	0.3	0.9	0.1
Monmouth	NJ	0.0	0.0	0.0	0.0	0.0	0.0
Union	NJ	29.6	1.1	1.0	2.3	5.1	0.4
New Jersey subtotal		**194**	**7.2**	**6.7**	**15.0**	**33.3**	**2.8**
Bronx	NY	0.0	0.0	0.0	0.0	0.0	0.0
Kings (Brooklyn)	NY	0.0	0.0	0.0	0.0	0.0	0.0
Nassau	NY	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
Orange	NY	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
Richmond (Staten Isld)	NY	19.2	0.8	0.8	1.9	3.5	0.3
Rockland	NY	55.4	1.7	1.5	3.0	8.7	0.7
Suffolk	NY	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
New York subtotal		**75**	**2.5**	**2.3**	**4.9**	**12.2**	**1.0**
TOTAL		**268**	**10**	**9**	**20**	**45**	**4**

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	25,972	35	0.13%
Essex	NJ	23,498	94	0.40%
Hudson	NJ	27,776	30	0.11%
Middlesex	NJ	33,000	5.4	0.02%
Monmouth	NJ	19,177	0.0	0.00%
Union	NJ	21,154	30	0.14%
New Jersey Subtotal		**150,577**	**194**	**0.13%**
Bronx	NY	16,018	0.0	0.00%
Kings (Brooklyn)	NY	29,788	0.0	0.00%
Nassau	NY	36,258	0.0	0.00%
New York	NY	39,082	0.0	0.00%
Orange	NY	19,397	0.0	0.00%
Queens	NY	41,172	0.0	0.00%
Richmond (Staten Isld)	NY	10,085	19.2	0.19%
Rockland	NY	13,645	55	0.41%
Suffolk	NY	61,223	0.0	0.00%
Westchester	NY	28,040	0.0	0.00%
New York Subtotal		**294,708**	**75**	**0.03%**
TOTAL		**445,285**	**268**	**0.06%**

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

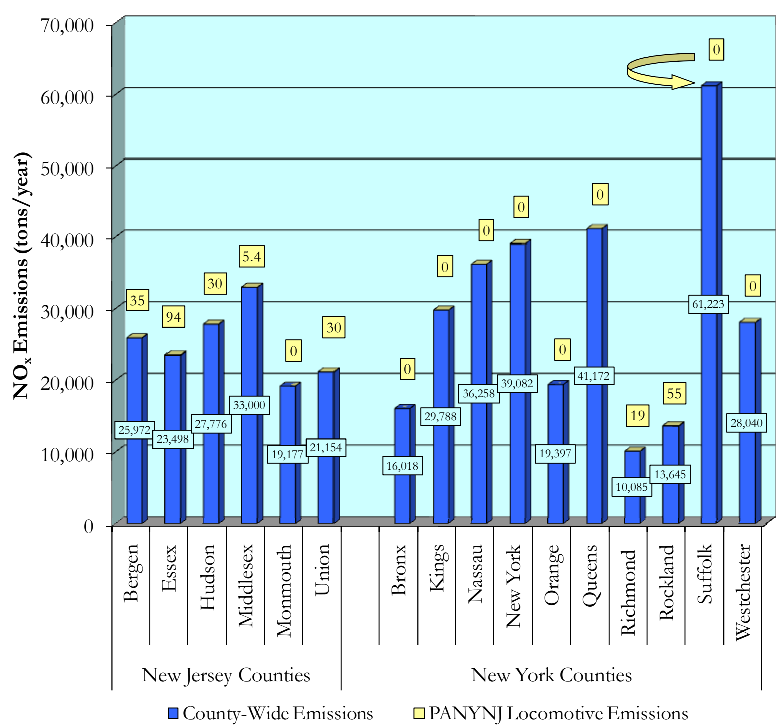


Table 4.5: Comparison of Locomotive PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	1.0	0.02%
Essex	NJ	3,745	4.0	0.11%
Hudson	NJ	6,764	0.9	0.01%
Middlesex	NJ	9,927	0.2	0.002%
Monmouth	NJ	7,935	0	0%
Union	NJ	4,227	1.1	0.03%
New Jersey Subtotal		**38,850**	**7**	**0.02%**
Bronx	NY	5,803	0	0%
Kings (Brooklyn)	NY	8,312	0	0%
Nassau	NY	14,142	0	0%
New York	NY	8,689	0	0%
Orange	NY	27,696	0	0%
Queens	NY	9,615	0	0%
Richmond (Staten Isld)	NY	8,092	1	0%
Rockland	NY	4,880	1.7	0.03%
Suffolk	NY	39,210	0	0%
Westchester	NY	13,162	0	0%
New York Subtotal		**139,601**	**3**	**0.002%**
TOTAL		**178,451**	**10**	**0.01%**

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

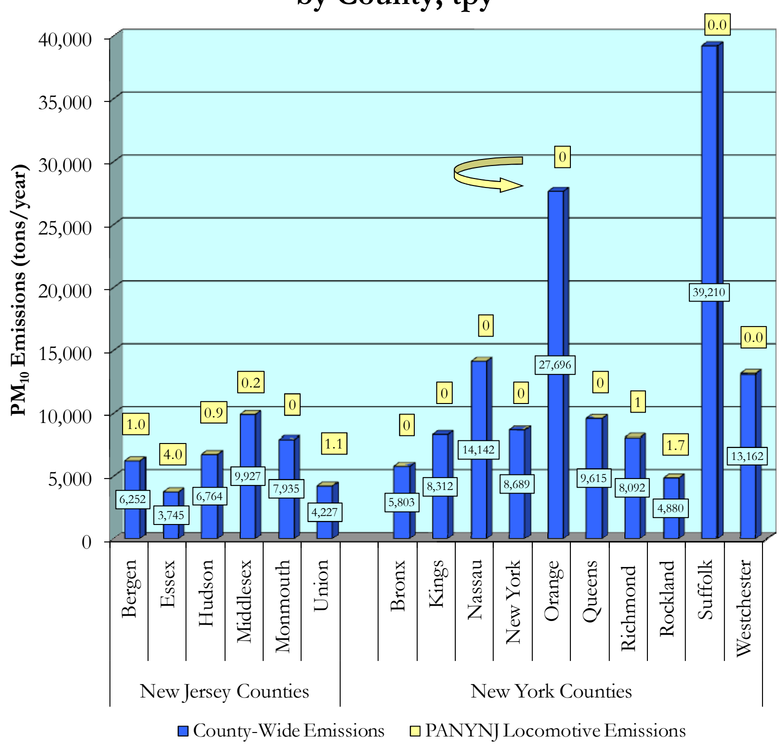


Table 4.6: Comparison of Locomotive $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	1.0	0.07%
Essex	NJ	1,159	3.7	0.32%
Hudson	NJ	3,754	0.8	0.02%
Middlesex	NJ	2,150	0.2	0.01%
Monmouth	NJ	1,623	0	0%
Union	NJ	1,472	1.0	0.07%
New Jersey Subtotal		**11,567**	**7**	**0.1%**
Bronx	NY	1,357	0	0%
Kings (Brooklyn)	NY	2,676	0	0%
Nassau	NY	2,727	0	0%
New York	NY	4,017	0	0%
Orange	NY	4,968	0	0%
Queens	NY	3,655	0	0%
Richmond (Staten Isld)	NY	1,323	1	0%
Rockland	NY	1,638	1.5	0.09%
Suffolk	NY	6,057	0	0%
Westchester	NY	2,456	0	0%
New York Subtotal		**30,874**	**2**	**0.01%**
TOTAL		**42,441**	**9**	**0.02%**

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

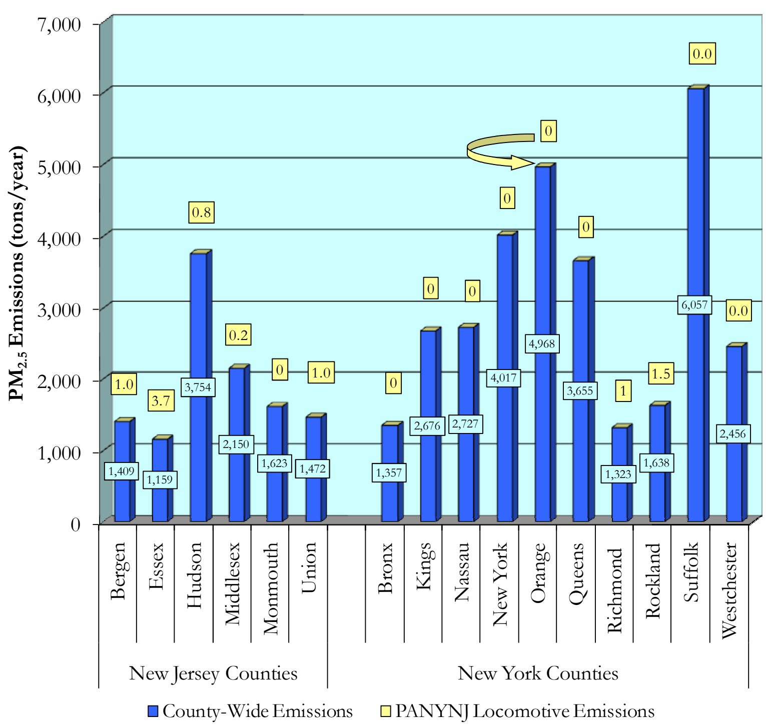


Table 4.7: Comparison of Locomotive VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	1.8	0.005%
Essex	NJ	20,940	9.0	0.043%
Hudson	NJ	14,428	1.6	0.011%
Middlesex	NJ	30,357	0.3	0.001%
Monmouth	NJ	22,727	0	0%
Union	NJ	20,627	2.3	0.01%
New Jersey Subtotal		**142,075**	**15.0**	**0.01%**
Bronx	NY	25,454	0	0%
Kings (Brooklyn)	NY	54,809	0	0%
Nassau	NY	47,865	0	0%
New York	NY	45,292	0	0%
Orange	NY	18,349	0	0%
Queens	NY	47,262	0	0%
Richmond (Staten Isld)	NY	13,542	2	0%
Rockland	NY	13,767	3.0	0.022%
Suffolk	NY	77,071	0	0%
Westchester	NY	36,759	0	0%
New York Subtotal		**380,170**	**4.9**	**0.001%**
TOTAL		**522,245**	**19.9**	**0.004%**

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

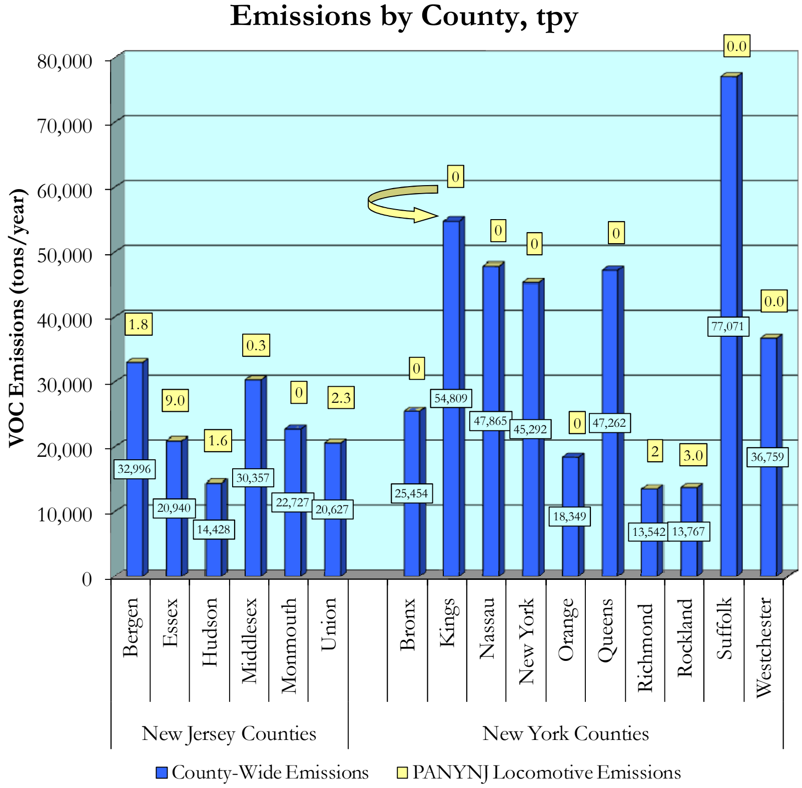


Table 4.8: Comparison of Locomotive CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	5.5	0.002%
Essex	NJ	131,856	17.1	0.013%
Hudson	NJ	69,129	4.7	0.007%
Middlesex	NJ	196,869	0.9	0.0005%
Monmouth	NJ	166,309	0.0	0.00%
Union	NJ	114,302	5.1	0.00%
New Jersey Subtotal		**921,446**	**33**	**0.004%**
Bronx	NY	113,641	0.0	0.000%
Kings (Brooklyn)	NY	158,527	0.0	0.000%
Nassau	NY	282,348	0.0	0.000%
New York	NY	220,345	0.0	0.000%
Orange	NY	114,316	0.0	0.000%
Queens	NY	207,255	0.0	0.000%
Richmond (Staten Isld)	NY	52,149	3.5	0.007%
Rockland	NY	67,761	8.7	0.013%
Suffolk	NY	472,083	0.0	0.000%
Westchester	NY	230,503	0.0	0.000%
New York Subtotal		**1,918,928**	**12**	**0.0006%**
TOTAL		**2,840,374**	**45**	**0.002%**

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

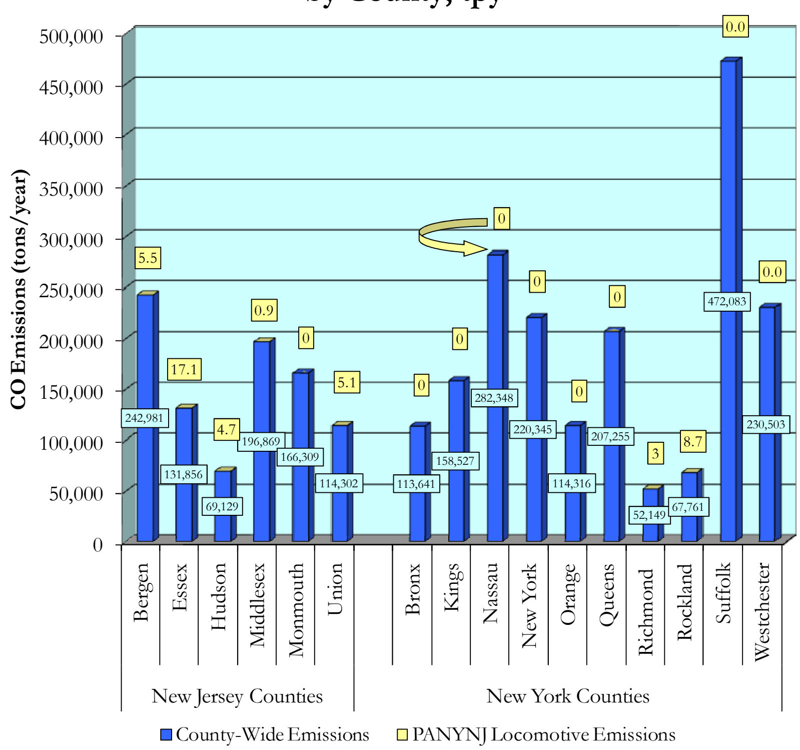
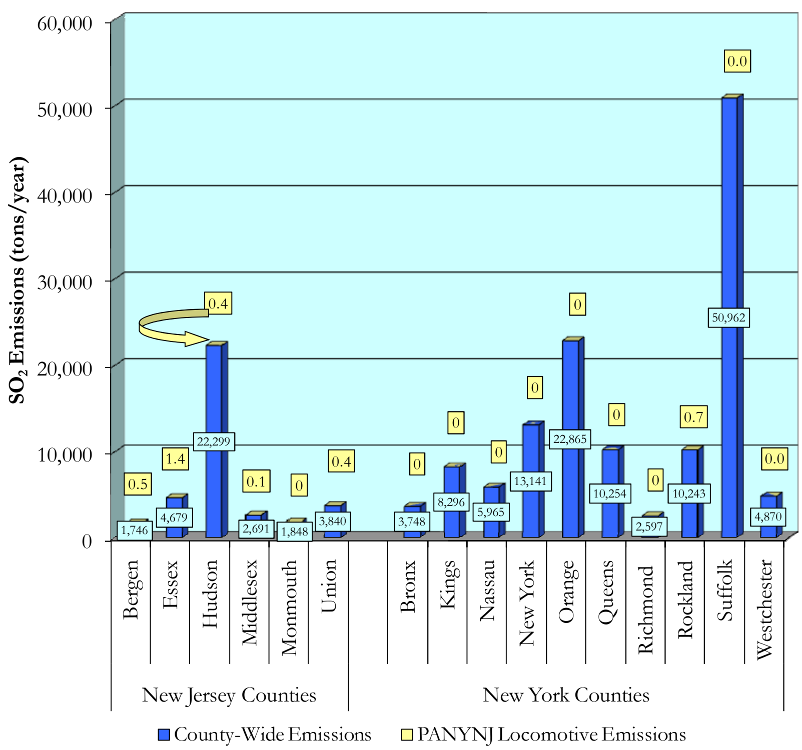


Table 4.9: Comparison of Locomotive SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0.5	0.03%
Essex	NJ	4,679	1.4	0.03%
Hudson	NJ	22,299	0.4	0.00%
Middlesex	NJ	2,691	0.1	0.00%
Monmouth	NJ	1,848	0	0%
Union	NJ	3,840	0.4	0.01%
New Jersey Subtotal		**37,103**	**3**	**0.01%**
Bronx	NY	3,748	0	0%
Kings (Brooklyn)	NY	8,296	0	0%
Nassau	NY	5,965	0	0%
New York	NY	13,141	0	0%
Orange	NY	22,865	0	0%
Queens	NY	10,254	0	0%
Richmond (Staten Isld)	NY	2,597	0	0%
Rockland	NY	10,243	0.7	0.01%
Suffolk	NY	50,962	0	0%
Westchester	NY	4,870	0	0%
New York Subtotal		**132,941**	**1**	**0.00%**
TOTAL		**170,044**	**4**	**0.00%**

Figure 4.6: Comparison of Locomotive SO_2 Emissions with Overall SO_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,[15] 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.

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[16] issued in support of locomotive rulemaking. The EPA factors are published as fuel-based factors, in units of grams per gallon of fuel. 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.[17] The g/gal emission factors for line haul locomotives are presented in Table 4.10.

Table 4.10: 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	169	5.1	4.7	9.0	26.7	2.2	10,186	0.25	0.79

15 "Port of NY/NJ On-Dock Rail 1991-2006," Port of New York/New Jersey Trade Statistics 1991-2006, provided by D. Lotz, PA NY/NJ, 2007.
16 "Emission Factors for Locomotives," EPA-420-F-09-025, Office of Transportation and Air Quality, April 2009
17 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2008; Draft, March 2010; Table A- 93: Emission Factors for CH4 and N2O Emissions from Non-Highway Mobile Combustion (g gas/kg fuel).

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. 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,[18] which has been confirmed as valid for 2006, the study year.[19]

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. 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 4.11 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 4.11: 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**

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 4.12 and 4.13.

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

[18] "New Jersey Marine Terminal Rail Facility 2005 Comparison Study," CH2MHILL, Port Authority of NJ&NJ, February 2006.
[19] Telephone conversation between D. Park, Starcrest, LLC and D. Lotz, PA NY/NJ, March 24, 2008.

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 4.12: 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 4.13 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 4.12). The total estimated number of containers moved by the train configurations described above (and shown below in Table 4.13) corresponds to the reported 2008 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 4.13: 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 containers:	**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 2008 submittals of an annual report known as the "R-1."[20] 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 4.14. In addition to average car weight, Table 4.14 lists the average number of railcars per train, estimated by multiplying the number of 5-platfom cars (shown in Table 4.11) 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 4.14.

Table 4.14: 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	80					
Gross weight of train	**11,260**	**6,434**	**11,260**	**3,217**	**7,239**	**5,630**

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 4.13). These figures total approximately **10.5 million gross tons** for the railroad whose trains are represented by the left three columns in the previous tables, and approximately **4.9 million gross tons** for the railroad whose trains are represented by the three columns to the right.

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 4.15. 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.

[20] *Class I Railroad Annual Report to the Surface Transportation Board for the Year Ending Dec. 31, 2008* (Norfolk Southern Railroad) and *Class I Railroad Annual Report to the Surface Transportation Board for the Year Ending Dec. 31, 2008* (CSX Transportation, Inc.).

Table 4.15: Line Haul Locomotive Ton-Mile and Fuel Use Estimates

County	Track Mileage	Thousand Gross Ton-Miles	Gallons Fuel
North Route			
Essex	3	31,618	37,205
Hudson	13	137,011	161,223
Bergen	15	158,090	186,027
Rockland	24	252,944	297,643
South Route			
Essex	5	24,675	29,036
Union	15	74,026	87,108
Middlesex	5	24,675	29,036
Total	80	703,040	827,279

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 on the activity information developed for the 2002 and 2006 Port Authority inventories of cargo handling equipment and rail emissions, the change in Port Newark and Elizabeth PA Marine Terminal cargo throughputs between 2006 and 2008, and increased throughput due to the operation of ExpressRail Staten Island, which was not operational in 2006. The scaling of activity with container throughput growth 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 estimates were made using the ratio of 2002 to 2006 container throughputs: 2.35 million containers in 2006 divided by 1.84 million containers in 2002. The result, a growth factor of 1.28, was multiplied by the 2002 operating hours estimate for a 2006 estimate of 34,744 hours. Despite an overall reduction in container throughput between 2006 and 2008, rail throughput increased, in part because of ExpressRail Staten Island. There was an overall increase of 12% from 2006 to 2008, which was applied to the 2006 operating hours estimate, resulting in an updated 2008 estimate of 38,914 operating hours.

Emission factors for most pollutants are from the 2009 EPA publication cited above, which provides switching emission factors in units of grams per horsepower-hour. 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 g/hp-hr emission factors are listed in Table 4.16.

Table 4.16: Switching Locomotive Emission Factors

Units	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x	CO_2	N_2O	CH_4	CO_2 Equiv.
g/hp-hr	9.9	0.4	0.4	1.0	1.8	0.2	672.0	0.0	0.1	678.3

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 g/hp-hr emission factors were multiplied by this total to estimate annual switching emissions.

4.4 Description of Locomotives

This subsection describes the rail system as it served the Port Authority marine terminals in 2008 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 five Port Authority marine terminals covered by this 2008 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. Figures 4.7 and Figure 4.8 illustrate common switching locomotives. 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 4.9 shows a typical line haul locomotive.

Figure 4.7: Example Switching Locomotives

Photo courtesy of PANYNJ

Figure 4.8: Example Switching Locomotive

Photo courtesy of PANYNJ

Figure 4.9: Example Line Haul Locomotive

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

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.

SECTION 5: COMMERCIAL MARNE VESSELS

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

- Port Newark
- Elizabeth Port Authority Marine Terminal
- Port Authority Auto Marine Terminal
- Howland Hook Marine Terminal (on Staten Island)
- 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 privately owned and operated Global Marine Terminal and 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 and 2006 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 – Emission Estimating Methodology
- 5.4 - Description of Marine Vessels and Vessel Activity

Commercial Marine Vessel Executive Summary

Table ES5-1 presents the estimated criteria pollutant emissions from ocean-going vessels (OGVs) and harbor craft, collectively known as commercial marine vessels (CMV) 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. It has not been possible to compare PANYNJ greenhouse gas emissions with those from the NYNJLINA as a whole because greenhouse gas emissions have not been estimated on a county or regional level by EPA or the states.

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_2
New York and New Jersey	936,354	917,144	198,076	1,330,674	6,564,103	540,477
NYNJLINA	445,285	178,451	42,441	522,245	2,840,374	170,044
OGVs and Harbor Craft	3,359	311	252	130	302	2,944
Percent of NYNJLINA Emissions	0.75%	0.17%	0.59%	0.02%	0.01%	1.73%

The following figures ES5.1 through ES5.6 illustrate the distribution of emissions of NO_x, PM_{10}, $PM_{2.5}$, VOC, CO, and SO_2 from OGVs and harbor craft 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. Figure ES5.7 illustrates the distribution of CO_2 emissions but does not include the comparison with overall NYNJLINA emissions because these emissions have not been compiled.

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

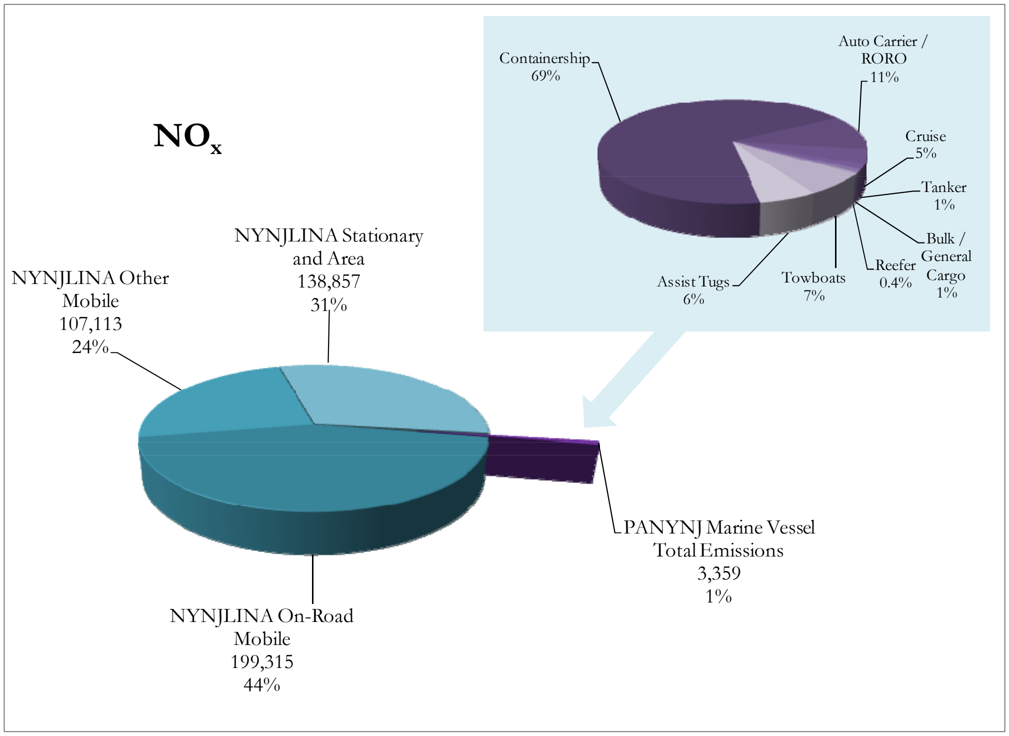


Figure ES5.2: Distribution and Comparison of PM_{10} from CMVs, tpy and percent

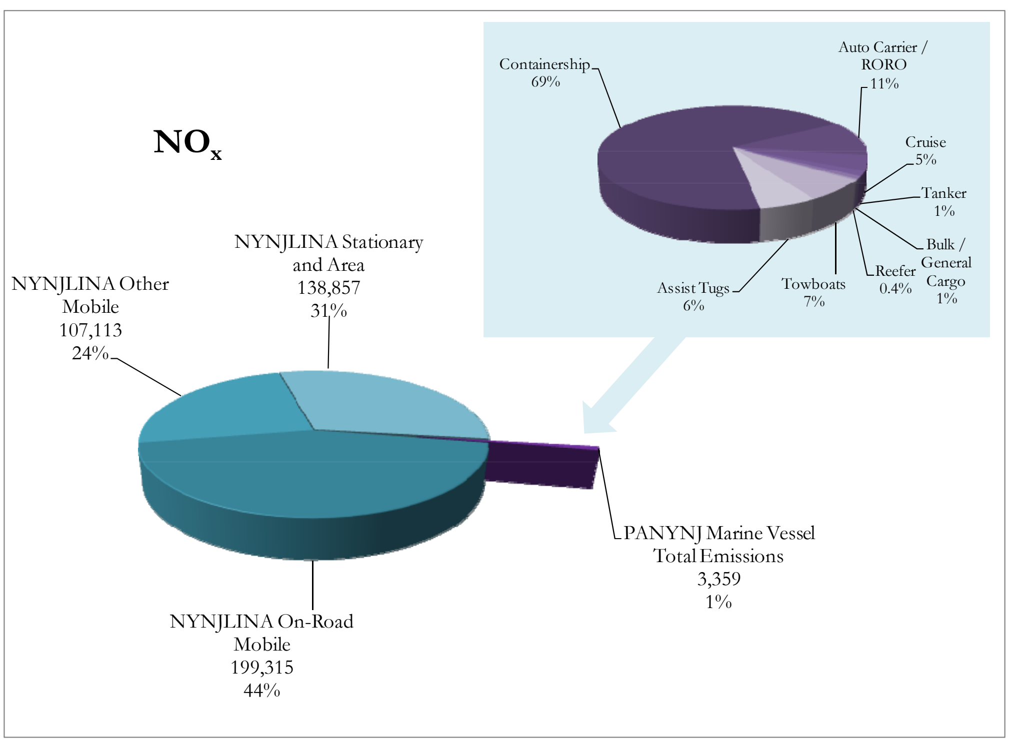


Figure ES5.3: Distribution and Comparison of $PM_{2.5}$ from CMVs, tpy and percent

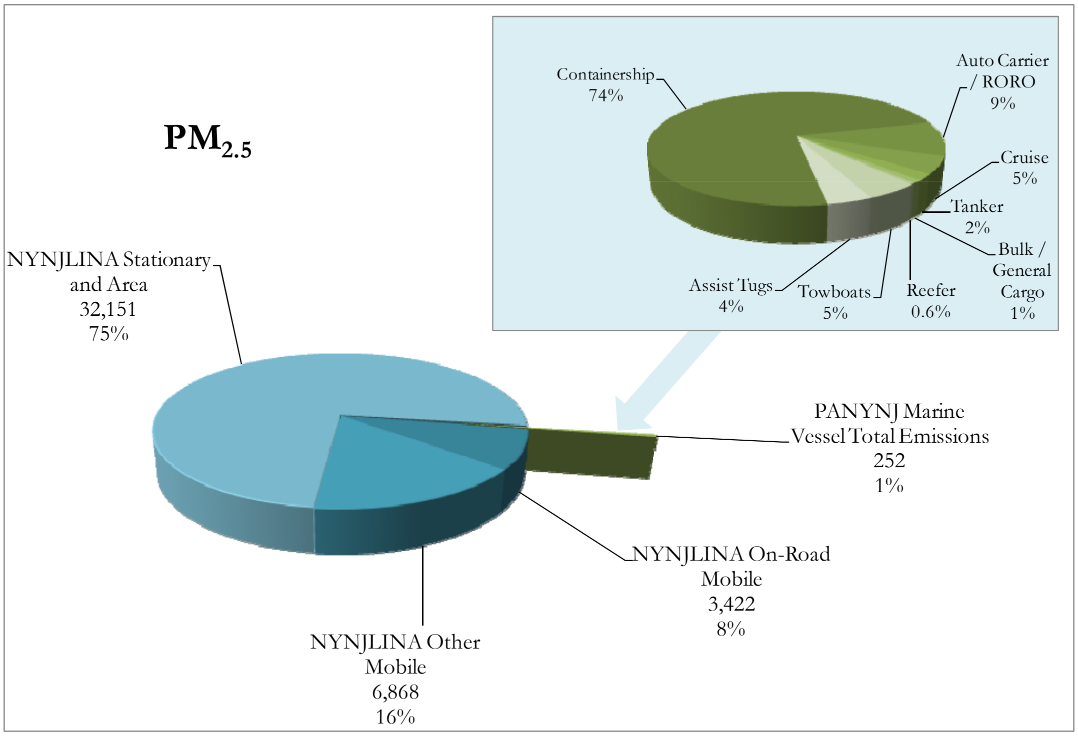


Figure ES5.4: Distribution and Comparison of VOC from CMVs, tpy and percent

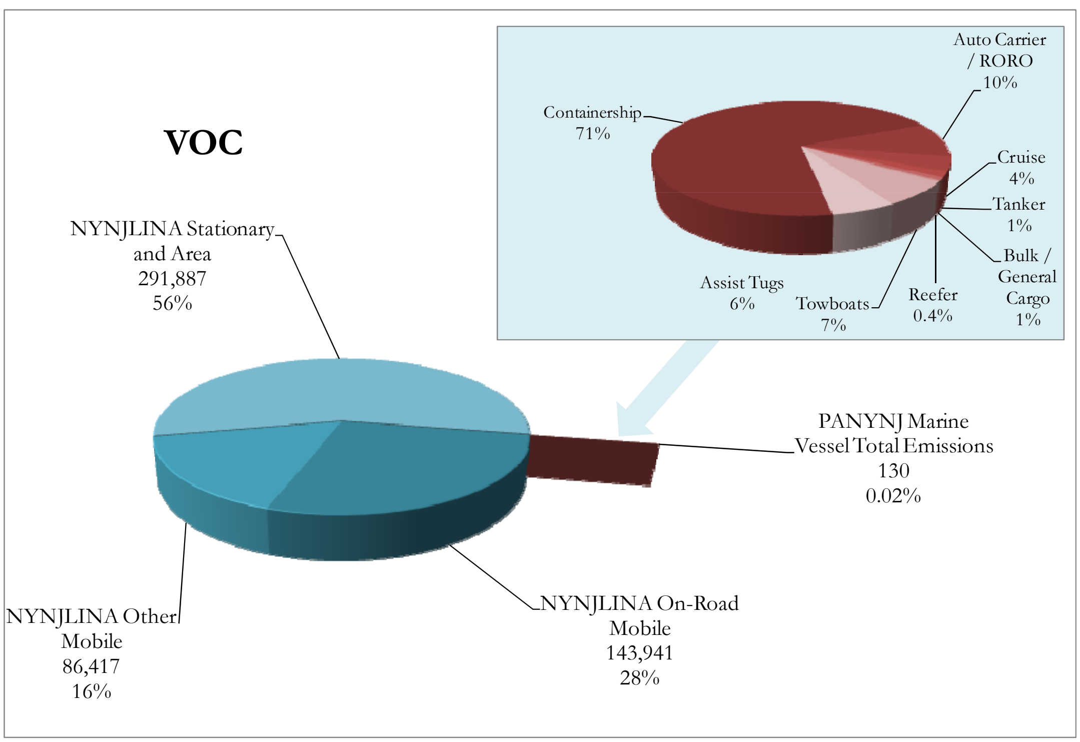


Figure ES5.5: Distribution and Comparison of CO from CMVs, tpy and percent

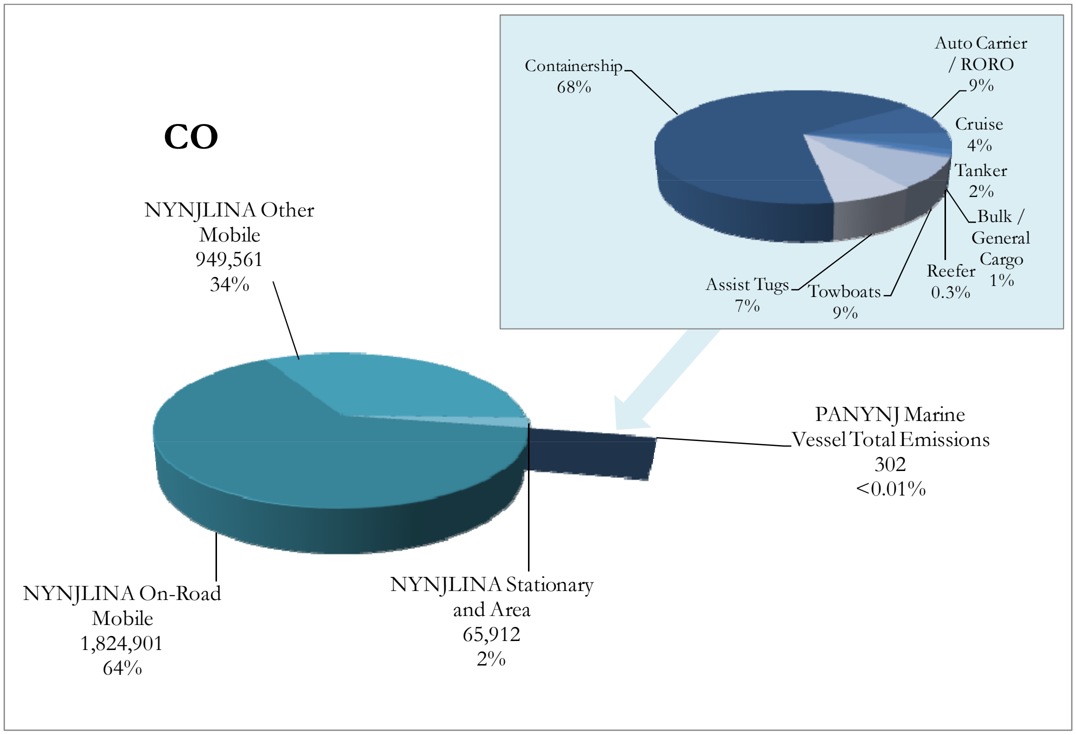


Figure ES5.6: Distribution and Comparison of SO_2 from CMVs, tpy and percent

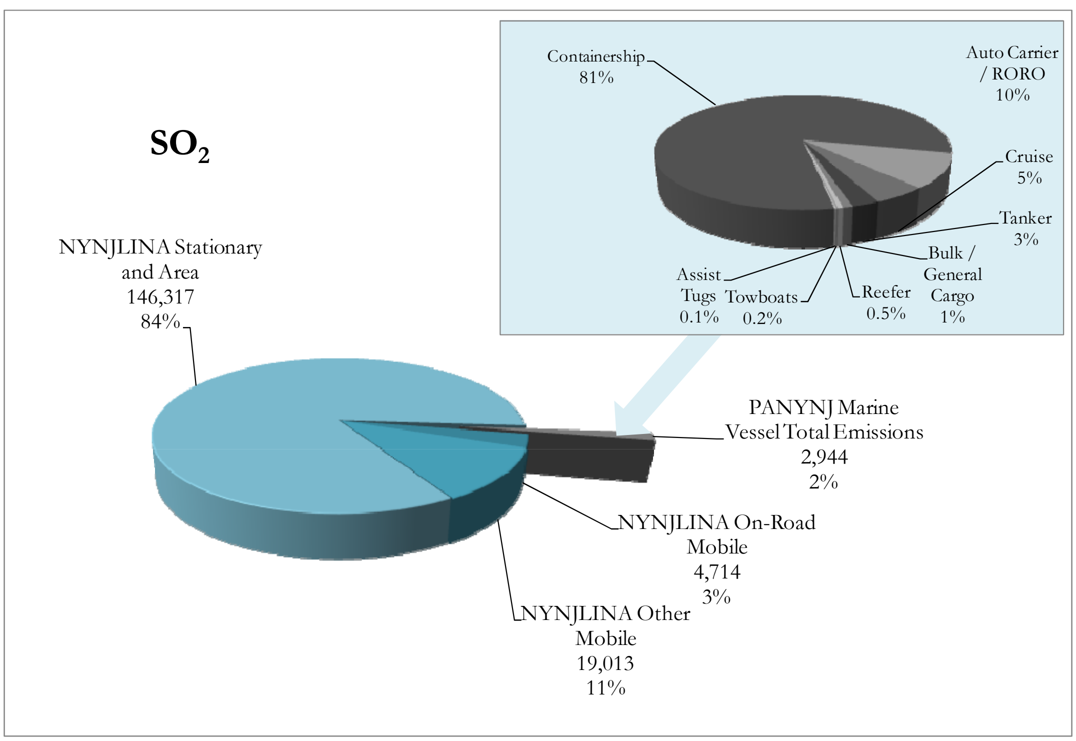
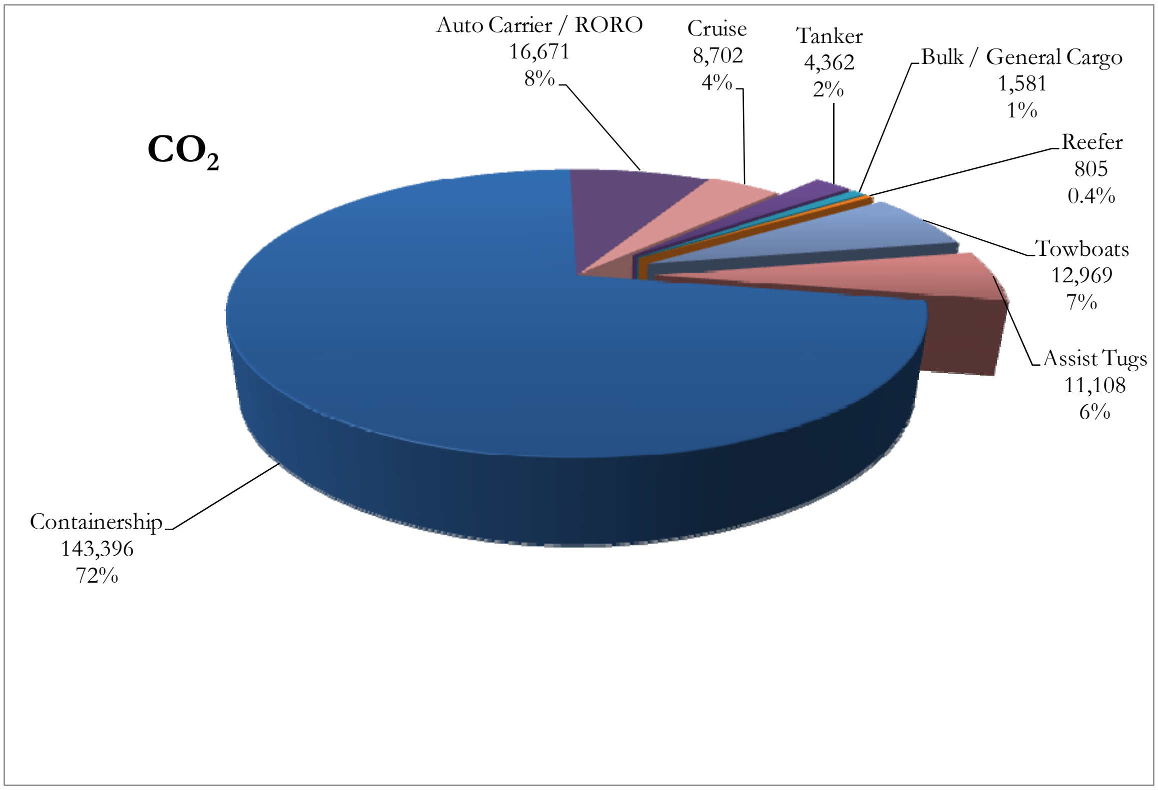


Figure ES5.7: Distribution of CO_2 from OGVs and Harbor Craft, tpy and percent

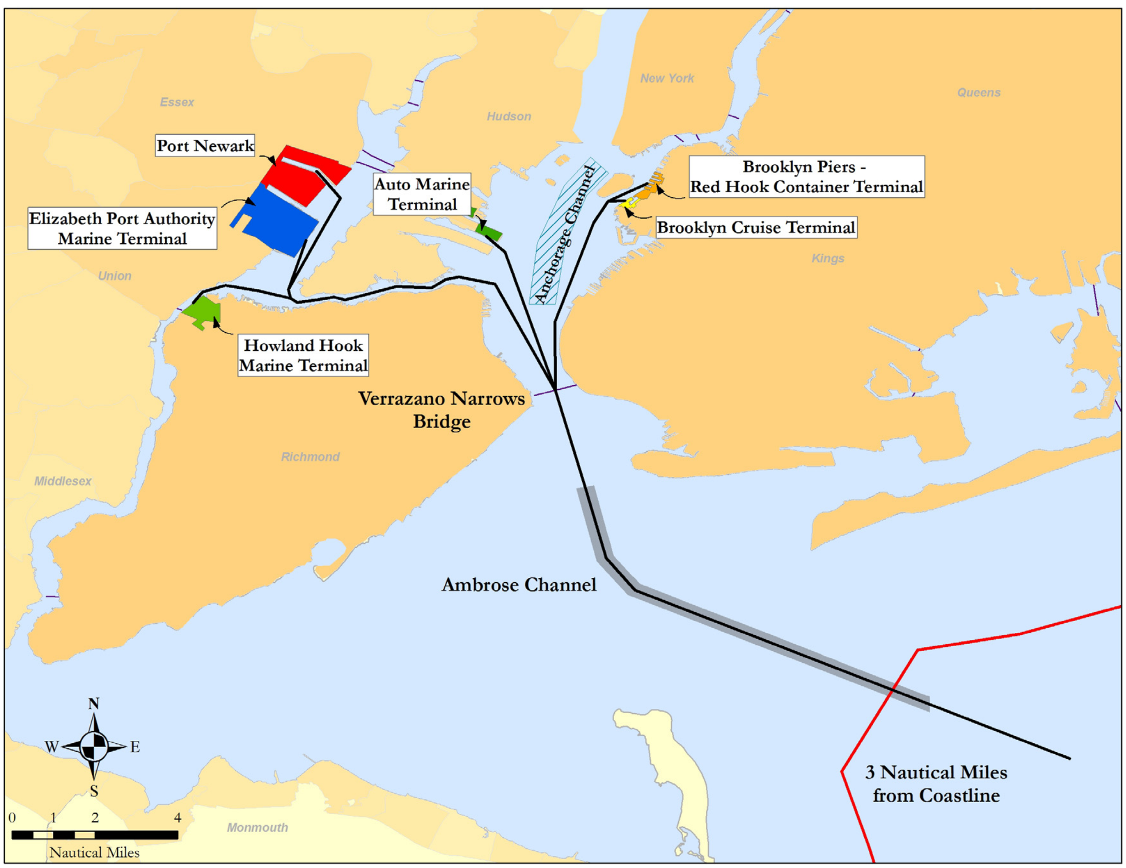


5.1 CMV Emission Estimates

Emission estimates have been developed for OGVs and harbor craft on the basis of vessel type and engine type. The vessel types include the following ocean-going vessels: 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, and the routes taken by OGVs traveling to the terminals covered by this inventory. The outer limit is three nautical miles beyond the eastern coastline 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 harbor craft, consisting of tow boats and assist tugs.

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	2,327	232	186	92	205	2,397
Auto Carrier/RORO	357	30	24	13	28	279
Cruise	155	15	12	5	13	146
Tanker	53	6	5	2	4	73
Bulk	29	3	2	1	2	26
Reefer	12	1	1	0	1	13
General Cargo	1	0	0	0	0	1
Total	**2,934**	**288**	**230**	**113**	**255**	**2,935**

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

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Containership	140,944	8	1	143,396
Auto Carrier/RORO	16,406	1	0	16,671
Cruise	8,583	0	0	8,702
Tanker	4,273	0	0	4,362
Bulk	1,504	0	0	1,531
Reefer	791	0	0	805
General Cargo	50	0	0	50
Total	**172,550**	**9**	**2**	**175,517**

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	1,095	87	70	56	107	629
Auxiliary Engines	1,742	164	131	53	138	1,548
Boilers	96	37	29	5	9	758
Total	**2,934**	**288**	**230**	**113**	**255**	**2,935**

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	37,167	2	1	37,763
Auxiliary Engines	90,838	4	1	92,069
Boilers	44,545	4	0	45,685
Total	**172,550**	**9**	**2**	**175,517**

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	1,519	131	105	69	141	1,107
Dwelling	1,415	156	125	45	114	1,828
Total	**2,934**	**288**	**230**	**113**	**255**	**2,935**

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

Operating Mode	CO_2	N_2O	CH_4	CO_2 Eq
Transit	65,201	3	1	66,260
Dwelling	107,349	6	1	109,258
Total	**172,550**	**9**	**2**	**175,517**

Table 5.7: Harbor Craft Emissions of Criteria Pollutants, tpy

Vessel Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Towboats/Pushboats	230	13	12	9	26	5
Assist Tugs	196	11	10	8	22	4
Totals	**425**	**23**	**22**	**16**	**48**	**9**

Table 5.8: Harbor Craft Emissions of Greenhouse Gases, tpy

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Towboats/Pushboats	12,435	1	4	12,969
Assist Tugs	10,651	1	4	11,108
Totals	**23,086**	**3**	**8**	**24,077**

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 OGV and harbor craft 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 harbor craft 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.[21] EPA is currently developing a 2008 NEI, but it has not yet been released.

These emission comparisons are segregated into OGV and harbor craft categories and are presented in sections 5.2.1 and 5.2.2 respectively. The 2008 PANYNJ 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, 5.10 through 5.15, present each pollutant individually, comparing Port Authority marine terminal related OGV emissions with total county level emissions. Figures 5.2 through 5.7 summarize the same information visually on an individual county basis.

[21] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008, *http://www.epa.gov/ttn/chief/net/2005inventory.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 Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	0	0	0	0	0	0
Essex	NJ	368	38	30	13	31	412
Hudson	NJ	310	27	22	14	28	234
Middlesex	NJ	0	0	0	0	0	0
Monmouth	NJ	218	19	15	10	20	159
Union	NJ	732	78	62	24	60	883
New Jersey subtotal		**1,628**	**162**	**129**	**61**	**139**	**1,689**
Bronx	NY	0	0	0	0	0	0
Kings (Brooklyn)	NY	310	27	22	14	28	240
Nassau	NY	0	0	0	0	0	0
New York	NY	205	19	15	8	18	170
Orange	NY	0	0	0	0	0	0
Queens	NY	0	0	0	0	0	0
Richmond (Staten Isld)	NY	791	80	64	30	69	836
Rockland	NY	0	0	0	0	0	0
Suffolk	NY	0	0	0	0	0	0
Westchester	NY	0	0	0	0	0	0
New York subtotal		**1,306**	**126**	**101**	**52**	**115**	**1,246**
TOTAL		**2,934**	**288**	**230**	**113**	**255**	**2,935**

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	25,972	0	0.0%
Essex	NJ	23,498	368	1.6%
Hudson	NJ	27,776	310	1.1%
Middlesex	NJ	33,000	0	0.0%
Monmouth	NJ	19,177	218	1.1%
Union	NJ	21,154	732	3.5%
New Jersey subtotal		**150,577**	**1,628**	**1.1%**
Bronx	NY	16,018	0	0.0%
Kings (Brooklyn)	NY	29,788	310	1.0%
Nassau	NY	36,258	0	0.0%
New York	NY	39,082	205	0.5%
Orange	NY	19,397	0	0.0%
Queens	NY	41,172	0	0.0%
Richmond (Staten Isld)	NY	10,085	791	7.8%
Rockland	NY	13,645	0	0.0%
Suffolk	NY	61,223	0	0.0%
Westchester	NY	28,040	0	0.0%
New York subtotal		**294,708**	**1,306**	**0.4%**

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

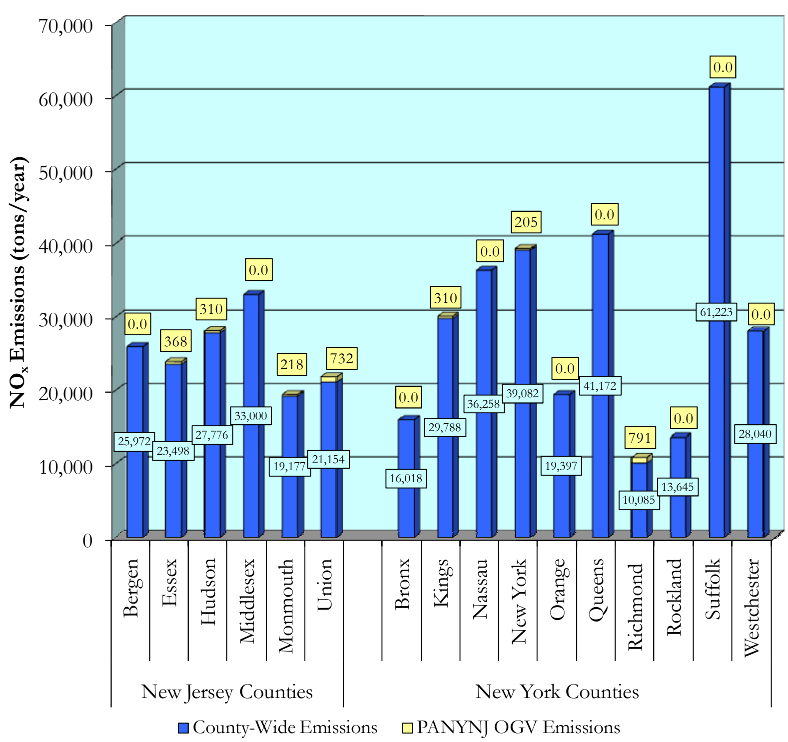


Table 5.11: Comparison of Ocean Going Vessel PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0	0.0%
Essex	NJ	3,745	38	1.0%
Hudson	NJ	6,764	27	0.4%
Middlesex	NJ	9,927	0	0.0%
Monmouth	NJ	7,935	19	0.2%
Union	NJ	4,227	78	1.8%
New Jersey subtotal		**38,850**	**162**	**0.4%**
Bronx	NY	5,803	0	0.0%
Kings (Brooklyn)	NY	8,312	27	0.3%
Nassau	NY	1,412	0	0.0%
New York	NY	8,689	19	0.2%
Orange	NY	27,696	0	0.0%
Queens	NY	9,615	0	0.0%
Richmond (Staten Isld)	NY	8,092	80	1.0%
Rockland	NY	4,880	0	0.0%
Suffolk	NY	39,210	0	0.0%
Westchester	NY	13,162	0	0.0%
New York subtotal		**139,601**	**126**	**0.09%**
TOTAL		**178,451**	**288**	**0.16%**

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

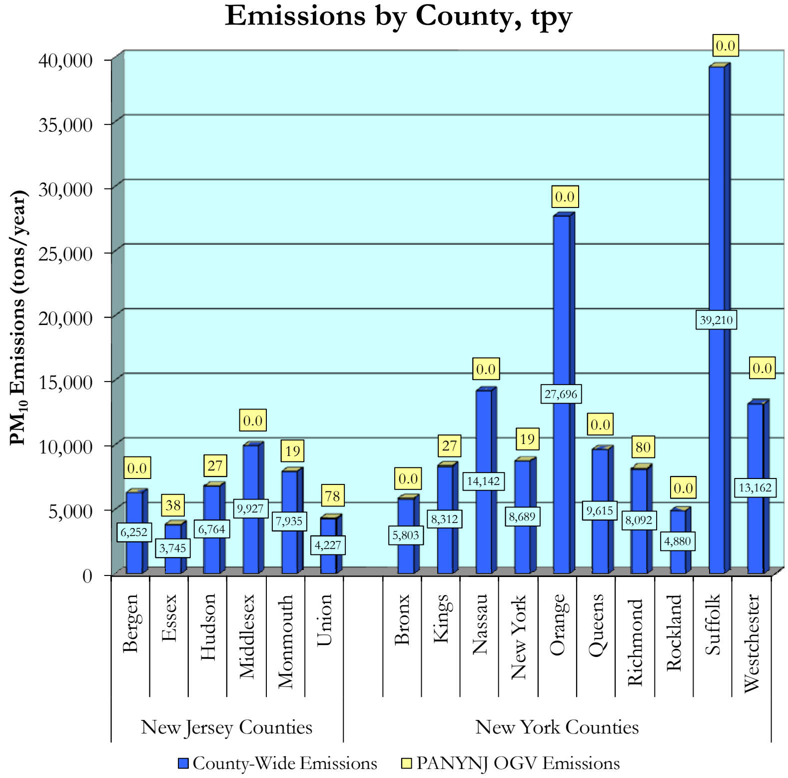


Table 5.12: Comparison of Ocean Going Vessel $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0	0.0%
Essex	NJ	1,159	30	2.6%
Hudson	NJ	3,754	22	0.6%
Middlesex	NJ	2,150	0	0.0%
Monmouth	NJ	1,623	15	0.9%
Union	NJ	1,472	62	4.2%
New Jersey subtotal		**11,567**	**129**	**1.1%**
Bronx	NY	1,357	0	0.0%
Kings (Brooklyn)	NY	2,676	22	0.8%
Nassau	NY	2,727	0	0.0%
New York	NY	4,017	15	0.4%
Orange	NY	4,968	0	0.0%
Queens	NY	3,655	0	0.0%
Richmond (Staten Isld)	NY	1,323	64	4.8%
Rockland	NY	1,638	0	0.0%
Suffolk	NY	6,057	0	0.0%
Westchester	NY	2,456	0	0.0%
New York subtotal		**30,874**	**101**	**0.3%**
TOTAL		**42,441**	**230**	**0.54%**

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

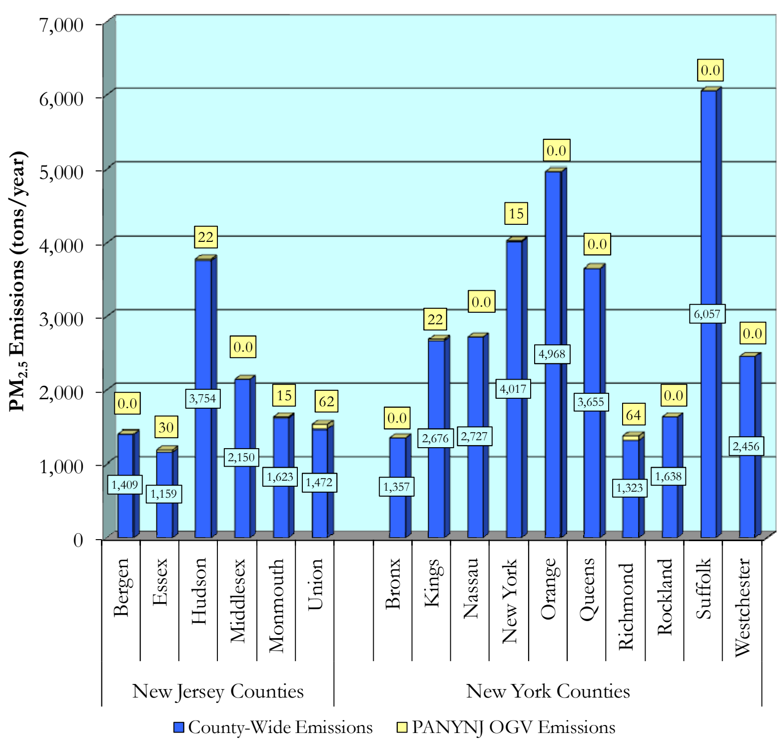


Table 5.13: Comparison of Ocean Going Vessel VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0	0.0%
Essex	NJ	20,940	13	0.1%
Hudson	NJ	14,428	14	0.1%
Middlesex	NJ	30,357	0	0.0%
Monmouth	NJ	22,727	10	0.0%
Union	NJ	20,627	24	0.1%
New Jersey subtotal		**142,075**	**61**	**0.04%**
Bronx	NY	25,454	0	0.0%
Kings (Brooklyn)	NY	54,809	14	0.0%
Nassau	NY	47,865	0	0.0%
New York	NY	45,292	8	0.0%
Orange	NY	18,349	0	0.0%
Queens	NY	47,262	0	0.0%
Richmond (Staten Isld)	NY	13,542	30	0.2%
Rockland	NY	13,767	0	0.0%
Suffolk	NY	77,071	0	0.0%
Westchester	NY	36,759	0	0.0%
New York subtotal		**380,170**	**52**	**0.01%**
TOTAL		**522,245**	**113**	**0.02%**

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

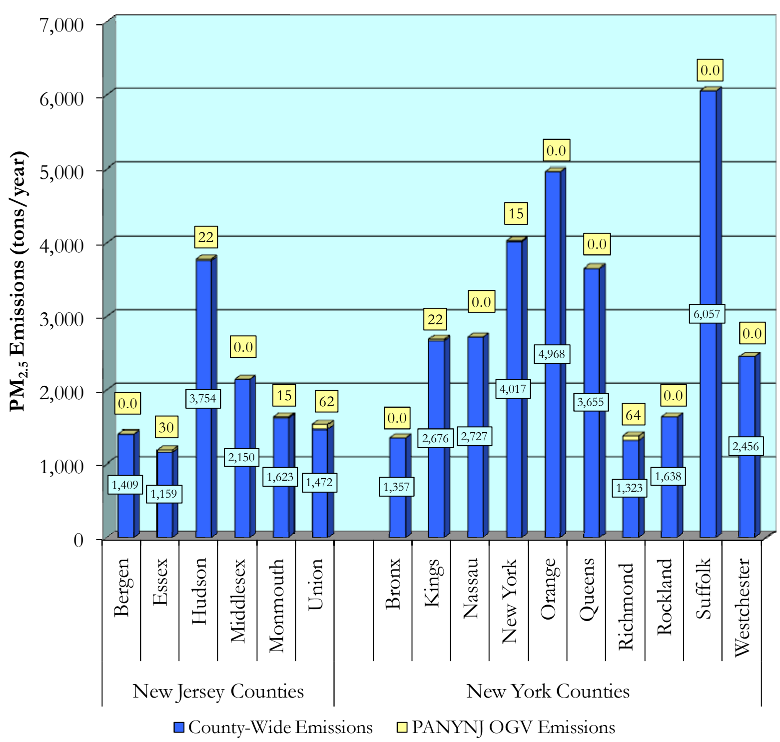


Table 5.14: Comparison of Ocean Going Vessel CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	0	0.0%
Essex	NJ	131,856	31	0.0%
Hudson	NJ	69,129	28	0.0%
Middlesex	NJ	196,869	0	0.0%
Monmouth	NJ	166,309	20	0.0%
Union	NJ	114,302	60	0.1%
New Jersey subtotal		**921,446**	**139**	**0.02%**
Bronx	NY	113,641	0	0.0%
Kings (Brooklyn)	NY	158,527	28	0.0%
Nassau	NY	282,348	0	0.0%
New York	NY	220,345	18	0.0%
Orange	NY	114,316	0	0.0%
Queens	NY	207,255	0	0.0%
Richmond (Staten Isld)	NY	52,149	69	0.1%
Rockland	NY	67,761	0	0.0%
Suffolk	NY	472,083	0	0.0%
Westchester	NY	250,503	0	0.0%
New York subtotal		**1,918,928**	**115**	**0.006%**
TOTAL		**2,840,374**	**255**	**0.01%**

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

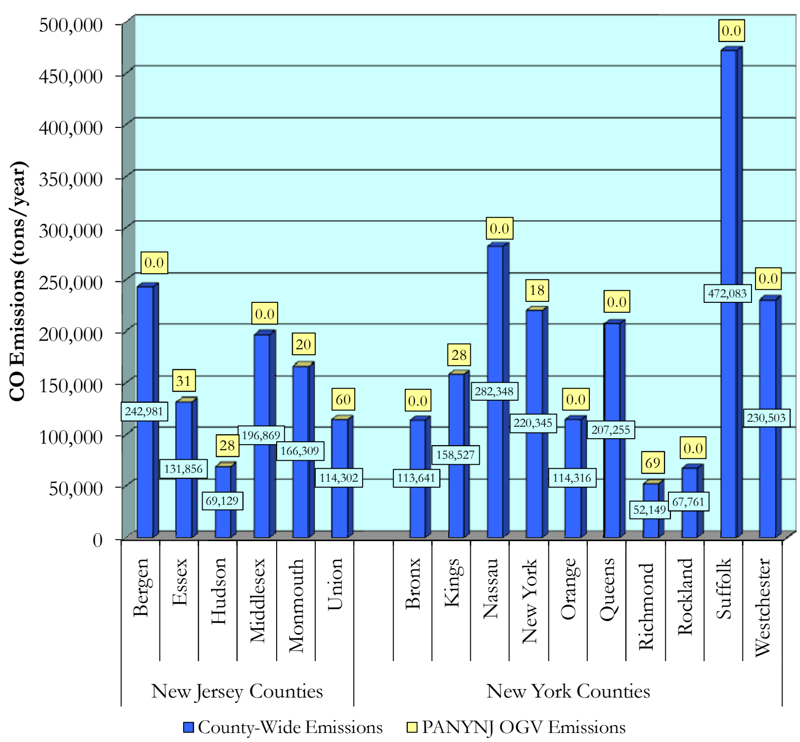
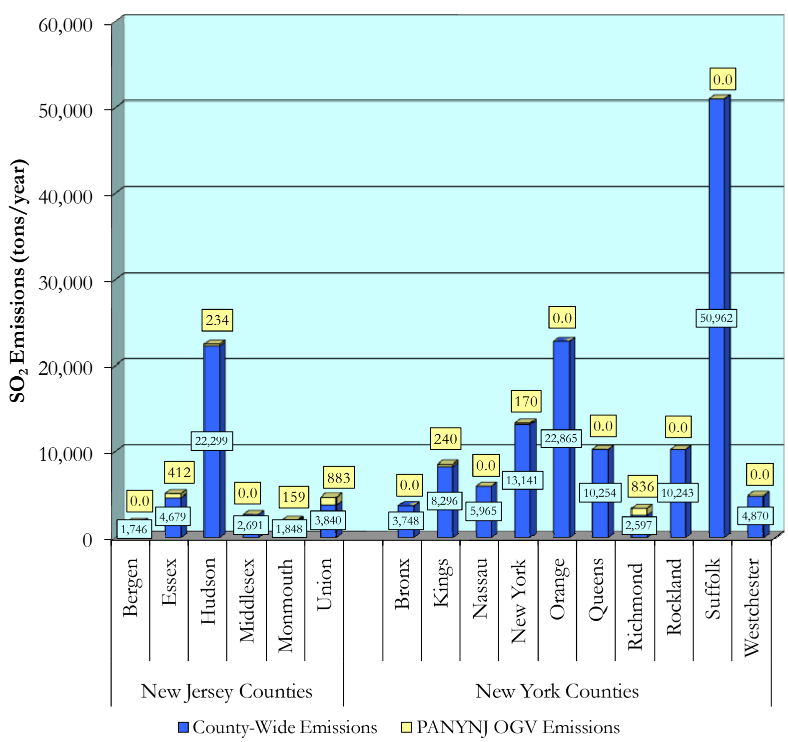


Table 5.15: Comparison of Ocean Going Vessel SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0	0.0%
Essex	NJ	4,679	412	8.8%
Hudson	NJ	22,299	234	1.1%
Middlesex	NJ	2,691	0	0.0%
Monmouth	NJ	1,848	159	8.6%
Union	NJ	3,840	883	23.0%
New Jersey subtotal		**37,103**	**1,689**	**4.6%**
Bronx	NY	3,748	0	0.0%
Kings (Brooklyn)	NY	8,296	240	2.9%
Nassau	NY	5,965	0	0.0%
New York	NY	13,141	170	1.3%
Orange	NY	22,865	0	0.0%
Queens	NY	10,254	0	0.0%
Richmond (Staten Isld)	NY	2,597	836	32.2%
Rockland	NY	10,243	0	0.0%
Suffolk	NY	50,962	0	0.0%
Westchester	NY	4,870	0	0.0%
New York subtotal		**132,941**	**1,246**	**0.9%**
TOTAL		**170,044**	**2,935**	**1.7%**

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



5.2.2 Harbor Craft Emission Comparisons

The following series of tables and charts display the contributions of Port Authority marine terminal related harbor craft (tug and tow boat) emissions to regional emissions. Table 5.16 summarizes estimated criteria pollutant emissions from these vessels at the county level. The subsequent tables, 5.17 through 5.22, present each pollutant individually, comparing Port Authority marine terminal related OGV activity with total county level emissions. Figures 5.8 through 5.13 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 5.16: Summary of Harbor Craft Criteria Pollutant Emissions by County, tpy

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Bergen	NJ	2.22	0.12	0.12	0.09	0.25	0.05
Essex	NJ	72.71	3.95	3.83	2.81	8.19	1.55
Hudson	NJ	61.52	3.35	3.25	2.38	6.88	1.30
Middlesex	NJ	15.62	0.85	0.83	0.61	1.74	0.33
Monmouth	NJ	11.51	0.63	0.61	0.45	1.28	0.24
Union	NJ	113.48	6.17	5.98	4.38	12.78	2.42
New Jersey subtotal		**277**	**15**	**15**	**11**	**31**	**6**
Bronx	NY	0.41	0.02	0.02	0.02	0.05	0.01
Kings	NY	14.53	0.79	0.77	0.56	1.63	0.31
Nassau	NY	2.96	0.16	0.16	0.11	0.33	0.06
New York	NY	4.63	0.25	0.24	0.18	0.52	0.10
Orange	NY	2.55	0.14	0.13	0.10	0.28	0.05
Queens	NY	4.52	0.25	0.24	0.18	0.50	0.10
Richmond	NY	101.49	5.53	5.37	3.93	11.36	2.15
Rockland	NY	3.12	0.17	0.17	0.12	0.35	0.07
Suffolk	NY	10.11	0.55	0.54	0.39	1.13	0.21
Westchester	NY	3.86	0.21	0.20	0.15	0.43	0.08
New York subtotal		**148**	**8**	**8**	**6**	**17**	**3**
TOTAL		**425**	**23**	**22**	**16**	**48**	**9**

Table 5.17: 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	25,972	2	0.01%
Essex	NJ	23,498	73	0.3%
Hudson	NJ	27,776	62	0.2%
Middlesex	NJ	33,000	16	0.05%
Monmouth	NJ	19,177	12	0.1%
Union	NJ	21,154	113	0.5%
New Jersey subtotal		**150,577**	**277**	**0.2%**
Bronx	NY	16,018	0.4	0.003%
Kings	NY	29,788	15	0.05%
Nassau	NY	36,258	3	0.01%
New York	NY	39,082	5	0.01%
Orange	NY	19,397	3	0.01%
Queens	NY	41,172	5	0.01%
Richmond	NY	10,085	101	1.0%
Rockland	NY	13,645	3	0.02%
Suffolk	NY	61,223	10	0.02%
Westchester	NY	28,040	4	0.01%
New York subtotal		**294,708**	**148**	**0.1%**
TOTAL		**445,285**	**425**	**0.10%**

Figure 5.8: Comparison of Harbor Craft NO_x Emissions with Overall NO_x Emissions by County, tpy

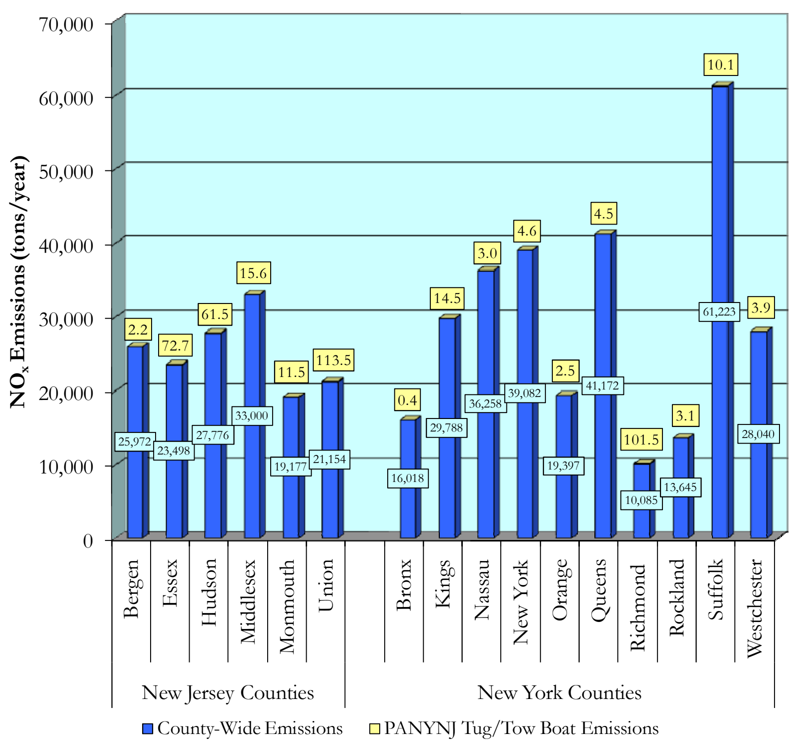


Table 5.18: Comparison of Harbor Craft PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0.1	0.002%
Essex	NJ	3,745	4.0	0.106%
Hudson	NJ	6,764	3.4	0.050%
Middlesex	NJ	9,927	0.9	0.009%
Monmouth	NJ	7,935	0.6	0.008%
Union	NJ	4,227	6.2	0.146%
New Jersey subtotal		**38,850**	**15**	**0.04%**
Bronx	NY	5,803	0.02	0.0004%
Kings	NY	8,312	0.8	0.010%
Nassau	NY	1,412	0.2	0.011%
New York	NY	8,689	0.3	0.003%
Orange	NY	27,696	0.1	0.001%
Queens	NY	9,615	0.2	0.003%
Richmond	NY	8,092	5.5	0.068%
Rockland	NY	4,880	0.2	0.003%
Suffolk	NY	39,210	0.6	0.001%
Westchester	NY	13,162	0.2	0.002%
New York subtotal		**139,601**	**8**	**0.01%**
TOTAL		**178,451**	**23**	**0.01%**

Figure 5.9: Comparison of Harbor Craft PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

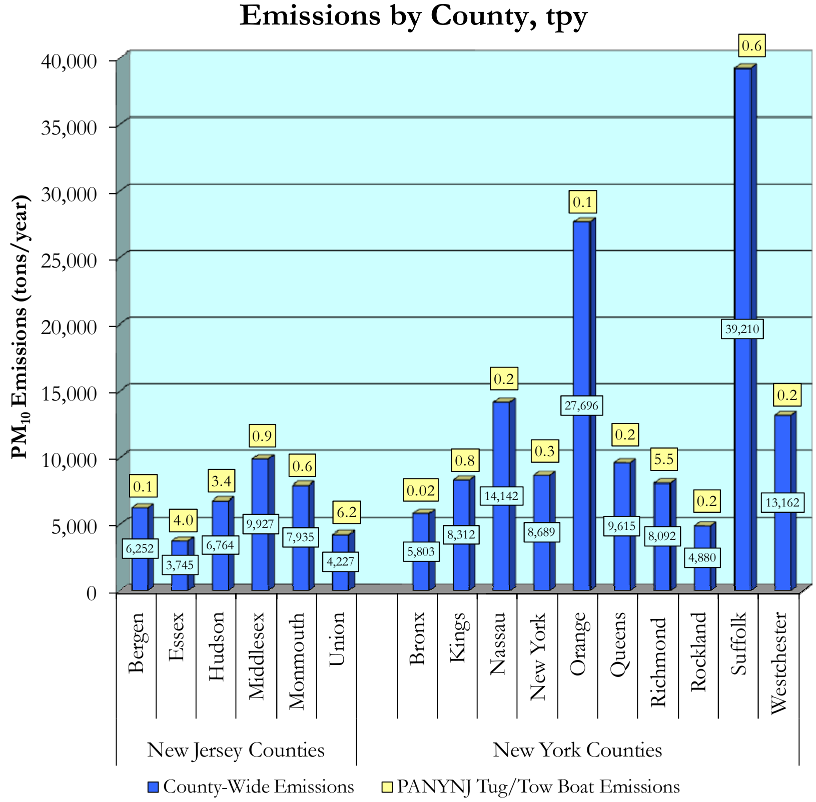


Table 5.19: Comparison of Harbor Craft $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0.1	0.01%
Essex	NJ	1,159	3.8	0.33%
Hudson	NJ	3,754	3.3	0.09%
Middlesex	NJ	2,150	0.8	0.04%
Monmouth	NJ	1,623	0.6	0.04%
Union	NJ	1,472	6.0	0.41%
New Jersey subtotal		**11,567**	**15**	**0.1%**
Bronx	NY	1,357	0.02	0.002%
Kings	NY	2,676	0.8	0.03%
Nassau	NY	2,727	0.2	0.01%
New York	NY	4,017	0.2	0.01%
Orange	NY	4,968	0.1	0.003%
Queens	NY	3,655	0.2	0.01%
Richmond	NY	1,323	5.4	0.41%
Rockland	NY	1,638	0.2	0.01%
Suffolk	NY	6,057	0.5	0.01%
Westchester	NY	2,456	0.2	0.01%
New York subtotal		**30,874**	**8**	**0.03%**
TOTAL		**42,441**	**22**	**0.05%**

Figure 5.10: Comparison of Harbor Craft $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

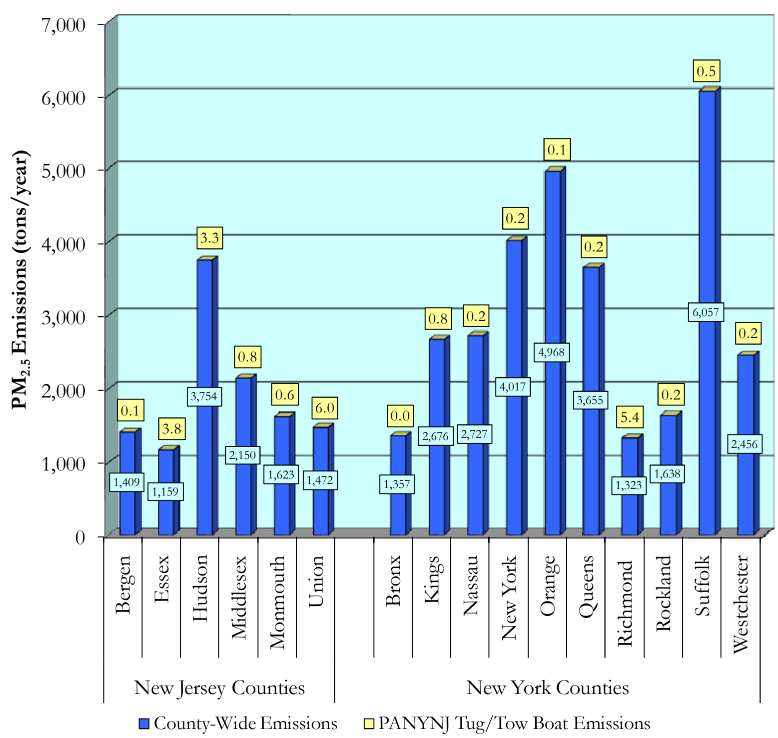


Table 5.20: Comparison of Harbor Craft VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0.1	0.0003%
Essex	NJ	20,940	2.8	0.013%
Hudson	NJ	14,428	2.4	0.017%
Middlesex	NJ	30,357	0.6	0.002%
Monmouth	NJ	22,727	0.4	0.002%
Union	NJ	20,627	4.4	0.021%
New Jersey subtotal		**142,075**	**11**	**0.01%**
Bronx	NY	25,454	0.02	0.0001%
Kings	NY	54,809	0.6	0.0010%
Nassau	NY	47,865	0.1	0.0002%
New York	NY	45,292	0.2	0.0004%
Orange	NY	18,349	0.1	0.0005%
Queens	NY	47,262	0.2	0.0004%
Richmond	NY	13,542	3.9	0.0290%
Rockland	NY	13,767	0.1	0.0009%
Suffolk	NY	77,071	0.4	0.0005%
Westchester	NY	36,759	0.1	0.0004%
New York subtotal		**380,170**	**6**	**0.002%**
TOTAL		**522,245**	**16**	**0.003%**

Figure 5.11: Comparison of Harbor Craft VOC Emissions with Overall VOC Emissions by County, tpy

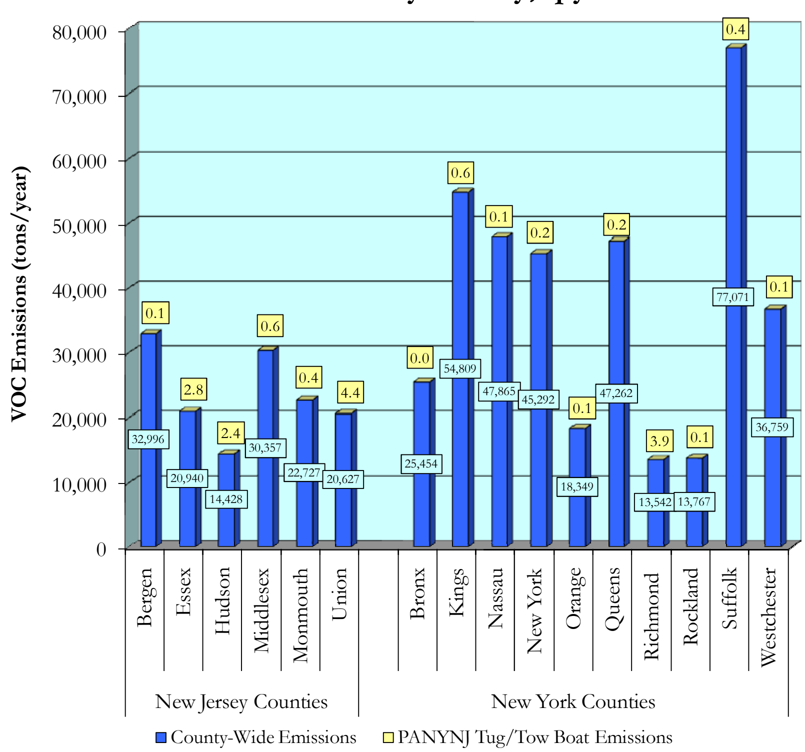


Table 5.21: Comparison of Harbor Craft CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	0.2	0.000%
Essex	NJ	131,856	8.2	0.006%
Hudson	NJ	69,129	6.9	0.010%
Middlesex	NJ	196,869	1.7	0.001%
Monmouth	NJ	166,309	1.3	0.001%
Union	NJ	114,302	12.8	0.011%
New Jersey subtotal		**921,446**	**31**	**0.003%**
Bronx	NY	113,641	0.05	0.00004%
Kings	NY	158,527	1.6	0.0010%
Nassau	NY	282,348	0.3	0.0001%
New York	NY	220,345	0.5	0.0002%
Orange	NY	114,316	0.3	0.0002%
Queens	NY	207,255	0.5	0.0002%
Richmond	NY	52,149	11.4	0.0218%
Rockland	NY	67,761	0.3	0.0005%
Suffolk	NY	472,083	1.1	0.0002%
Westchester	NY	250,503	0.4	0.0002%
New York subtotal		**1,918,928**	**17**	**0.001%**
TOTAL		**2,840,374**	**48**	**0.002%**

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

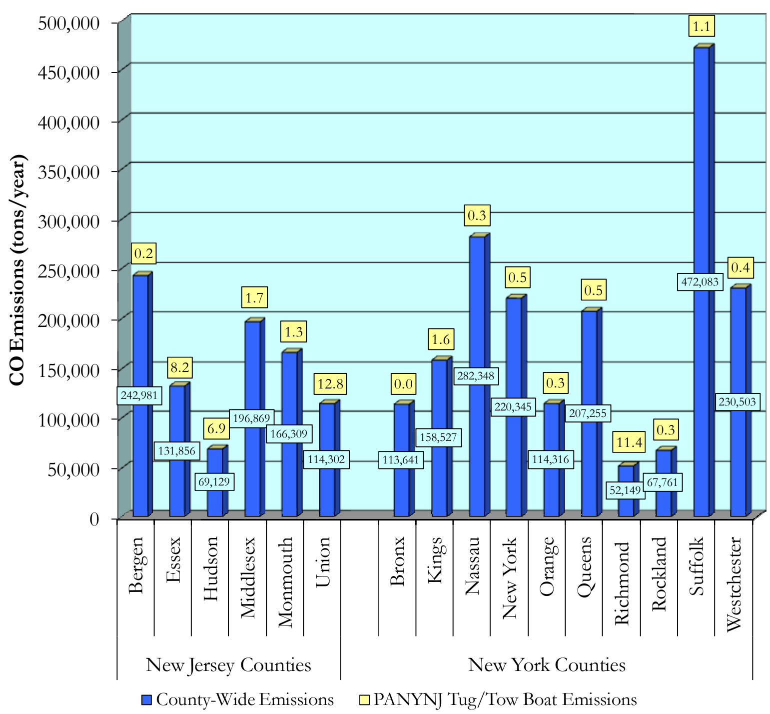
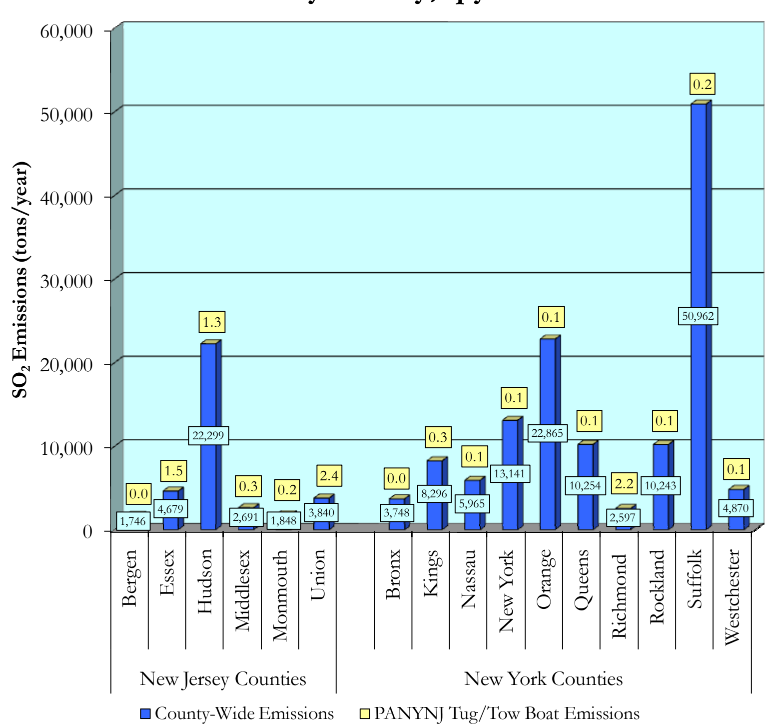


Table 5.22: Comparison of Harbor Craft SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0.05	0.003%
Essex	NJ	4,679	1.5	0.033%
Hudson	NJ	22,299	1.3	0.006%
Middlesex	NJ	2,691	0.3	0.012%
Monmouth	NJ	1,848	0.2	0.013%
Union	NJ	3,840	2.4	0.063%
New Jersey subtotal		**37,103**	**6**	**0.02%**
Bronx	NY	3,748	0.01	0.0002%
Kings	NY	8,296	0.3	0.0037%
Nassau	NY	5,965	0.1	0.0011%
New York	NY	13,141	0.1	0.0007%
Orange	NY	22,865	0.1	0.0002%
Queens	NY	10,254	0.1	0.0009%
Richmond	NY	2,597	2.2	0.0829%
Rockland	NY	10,243	0.1	0.0006%
Suffolk	NY	50,962	0.2	0.0004%
Westchester	NY	4,870	0.1	0.0017%
New York subtotal		**132,941**	**3**	**0.002%**
TOTAL		**170,044**	**9**	**0.01%**

Figure 5.13: Comparison of Harbor Craft SO_2 Emissions with Overall SO_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 information on vessel calls provided by the Port Authority. 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.

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 2008 vessel call data that forms the basis of the emission estimates presented in this report consists of vessel call data provided by the Port Authority for the specific marine terminals noted above. Most of the terminals provided detailed vessel by vessel call data with vessel name and dwelling time for each call. There were other terminals that only provided the number of calls in 2008, but were not able to provide detailed vessel data. The detailed vessel by vessel data set was used to develop vessel type characteristic averages to be used for vessel types that did not have specific data. A second set of data was used, the U.S. Army Corps of Engineer's *Foreign Traffic Vessel Entrances and Clearances*[22], for those vessel types that did not have complete vessel characteristic averages. The actual call data is based on the Port Authority's record of the number of vessel calls at each of its marine terminals.

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 ships made to Port Authority marine terminals in 2008 and speed profiles within the channel based on information developed for the 2000 emissions inventory. 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.

[22] See *http://www.ndc.iwr.usace.army.mil//data/dataclen.htm*

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

As noted above, most of the vessel call data was provided by the marine terminals. The level of detail varied among the terminals and not every terminal provided data with vessel-by-vessel activity levels; defaults were developed to account for unavailable data. 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. The numbers of calls of each vessel type to Port Authority owned marine terminals are listed in Table 5.23.

Table 5.23: Number of Calls to the Port Authority Marine Terminals in 2008

Vessel Type	Calls, 2008
Auto Carrier/RORO	639
Bulk Carrier	76
Containership	2,191
Cruise Ship	60
General Cargo	3
Reefer	30
Tanker	92
Total	**3,091**

Average main engine and auxiliary engine power for each vessel type was derived from the specific vessel-by-vessel terminal data that was matched to the Lloyd's data. 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 a recently released marine vessel emissions inventory.[23] The values of main, auxiliary, and boiler power used in developing the 2008 emission estimates are presented in Table 5.24.

[23] Port of Long Beach 2009 Air Emissions Inventory, June 2010.

Table 5.24: 2008 – Average OGV Engine and Boiler Power (kW)

Vessel Type	Main Power (kW)	Auxiliary Power (kW)	Boiler Power (kW)
Auto Carrier	11,334	4,296	254
Bulk	7,170	1,758	130
Containership 1000	10,290	4,152	298
Containership 2000	20,911	7,134	253
Containership 3000	29,837	5,020	537
Containership 4000	41,069	7,139	578
Containership 5000	44,959	8,582	722
Containership 6000	65,371	12,842	667
Containership 8000	85,549	12,099	705
Cruise	85,549	NA	NA
General Cargo	7,863	2,028	130
Reefer	11,288	3,267	464
Ro-Ro	15,023	3,473	248
Tanker	9,488	3,158	3,000

A second set of data was used for auto carriers, bulk carriers, and tankers. The *Foreign Traffic Vessel Entrances and Clearances* report was used for average main engine power and average dwell times for specific berths that did not provide detailed data, but only the number of calls by vessel type. See section 5.3.2.2 for the average dwelling times.

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 for 2008 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 5.25 lists the number of vessel assists and the average number of assist tugs per arrival or departure for the various vessel types and Port Authority owned berth locations.

Table 5.25: Assist Tug Operating Data and Assumptions

Vessel Type	Destination	2008 Calls	2008 Trips (In + Out)	Assist Tugs Per Trip
Conaintership	APM (EPAMT)	533	1,066	2
Conaintership	Red Hook (Brooklyn)	100	200	2
Cruise Ship	New York Passenger Ship Terminal	60	120	1
Conaintership	Maher (EPAMT)	916	1,832	2
Auto Carrier	Auto Terminal (NEAT)	174	348	2
Conaintership	New York Container Terminal	380	760	2
Conaintership	Port Newark Container Terminal	341	682	2
Varies	Port Newark	587	1,174	2
Total		**3,091**	**6,182**	

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 2008. 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 emissions inventory. The same emission factors were used for these vessels as for assist tugs, because the vessels share many of the same characteristics. Table 5.26 lists the towboat trip counts by terminal.

Table 5.26: Towboat/Pushboat Trips by Terminal

Terminal	Towboat Trips
APM (EPAMT)	0
Red Hook (Brooklyn)	300
New York Passenger Ship Terminal	0
Maher (EPAMT)	54
Auto Terminal (NEAT)	0
New York Container Terminal	0
Port Newark Container Terminal	10
Port Newark	2,698
Total	**3,062**

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

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

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 $(actual\ speed/sea\ speed)^3$

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[24] 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.[25] The SO_2 emission factor is based on fuel with an average 2.7% sulfur content. The emission factors

[24] 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.

[25] 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)

used for main and auxiliary engines and for auxiliary boilers are listed in Tables 5.27 (criteria pollutants) and 5.28 (greenhouse gases).

Table 5.27: OGV Criteria Pollutant Emission Factors (g/kW-hr)

Engine Category	Model Year	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 5.28: OGV Greenhouse Gas Emission Factors (g/kW-hr)

Engine Category	Model Year	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

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.

Table 5.29 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 5.29: 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

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

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 5.30 lists the load factors, by vessel type, used for auxiliary engines during transiting, maneuvering, and dwelling.

Table 5.30: 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 5.31. Most cruise ships that called the cruise terminal were diesel electric, with the exception of two small cruise ships.

Table 5.31: Diesel Electric Cruise Ship Auxiliary Engine Load, kW

Vessel Type	Auxiliary Engine Load Defaults (kW) 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. In 2008, the container terminals and cruise ship terminal provided dwell times by vessel and although the specific dwell time per vessel was used, below is a summary of the average dwell times for these vessel types.

Table 5.32: Summary of Average Dwell Time, hours

Vessel Type	Average Dwell Time (hours)
Auto Carrier	18
Bulk	31
Containership 1000	21
Containership 2000	15
Containership 3000	25
Containership 4000	29
Containership 5000	37
Containership 6000	51
Containership 8000	17
Cruise	10
General Cargo	12
Reefer	13
Ro-Ro	12
Tanker	7

A different average dwell time was used for specific berths that did not provide dwell time data. For these berths, for auto carriers, bulk and tankers, the Foreign Traffic Vessel Entrances and Clearances data was used to calculate the following average dwell times: 8 hours for auto carriers, 14 hours for bulk carriers and 7 hours for tankers.

5.3.2.3 OGV Auxiliary Boilers

The same basic equation is used to estimate auxiliary boiler emissions. 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 5.24 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. All OGV auxiliary engine and boiler load factor assumptions are presented below in Table 5.33.

Table 5.33: OGV Engine and 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 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)

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,[26] and which has been used widely since that time. The 43% factor for auxiliary engines is based on the EPA NONROAD model guidance[27] and has also been used in this effort for the towboat/pushboat emission estimates. The main engine load factor for towboats/ pushboats is 68% and is based on a California survey findings report[28] 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 2008. 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 where time was estimated by dividing trip length by speed in mode. Since detailed origination-destination data was not available for 2008 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 2008.

The emission factors used for assist tug, towboat, and pushboat main and auxiliary engines are listed in Table 5.34.

Table 5.34: 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

[26] 2001 POLA Baseline Emissions Inventory
[27] EPA, *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*, December 2002, EPA 420-P-02-014.
[28] California Air Resources Board, *Statewide Commercial Harbor Craft Survey*, Final Report, March 2004.

The base emission factors[29] 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.

The SO_2 emission factor was calculated using a mass-balance method with an assumed diesel fuel sulfur content of 500 ppm. This lower sulfur content diesel fuel was required by EPA for marine engines and was burned in assist tug engines and towboat/pushboat engines in 2008. It should be noted that in 2006, these same vessels used the required diesel fuel with less than 5,000 ppm sulfur, so there has been a substantial decrease in sulfur dioxide emissions due to the lower sulfur fuel used in 2008.

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. An example bulk carrier is shown in Figure 5.14.

[29] *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.

Figure 5.14: 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. An example containership is shown in Figure 5.15.

Figure 5.15: 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. An example cruise ship is shown in Figure 5.16.

Figure 5.16: 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. An example car carrier is shown in Figure 5.17.

Figure 5.17: 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. An example tanker is shown in Figure 5.18.

Figure 5.18: 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. An example tug boat is shown in Figure 5.19.

Figure 5.19: Tugboat