THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

PORT COMMERCE DEPARTMENT

2006 BASELINE MULTI-FACILITY EMISSIONS INVENTORY
OF
CARGO HANDLING EQUIPMENT,
HEAVY-DUTY DIESEL VEHICLES,
RAILROAD LOCOMOTIVES AND
COMMERCIAL MARINE VESSELS

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The Port Authority of New York and New Jersey

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TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

LIST OF ACRONYMS

CHE	Cargo handling equipment
CMV	Commercial marine vessels
HDDV	Heavy duty diesel vehicles
NYNJLINA	New York/New Jersey Non-Attainment Area
RAT	Regional Air Team
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 horse power 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
LRF	Lloyds Register–Fairplay
USCG	United States Coast Guard
VTS	Vessel Tracking Service
AIS	Automatic Identification System
DWT	Deadweight tonnage
kW	Kilowatt
LPG	Liquefied petroleum gas

EXECUTIVE SUMMARY

The purpose of this inventory is to estimate air emissions generated in 2006 by mobile sources associated with port activity linked to facilities maintained by the Port Authority of New York and New Jersey (Port Authority) and leased to private terminal operators.

By surveying emissions in 2006 from the vessels, vehicles, and equipment used at or traveling to and from these facilities, this inventory establishes a baseline year against which the Port Authority may compare future port emissions, evaluate port emissions against regional and industry trends, and, as warranted, develop programs to enhance air quality.

KEY FINDINGS

Although the primary purpose of this emissions inventory is to provide a baseline year against which to measure future emissions, there were also some immediate findings:

- Port Authority maritime emissions of oxides of nitrogen (NO_x) constitute less than two percent (1.8%) of the overall NYNJLINA NO_x emissions.
- Port Authority maritime emissions of particulate matter less than 10 microns (PM_{10}) constitute well under one percent (0.3%) of the overall NYNJLINA PM_{10} emissions.
- Port Authority maritime emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) constitute just over one percent (1.1%) of the overall NYNJLINA $PM_{2.5}$ emissions.
- Port Authority maritime emissions of volatile organic compounds (VOCs) constitute only one-tenth of one percent (0.1%) of the overall NYNJLINA VOC emissions.
- Port Authority maritime emissions of carbon monoxide (CO) constitute less than one-tenth of one percent (0.05%) of the overall NYNJLINA CO emissions.
- Port Authority maritime emissions of sulfur dioxide (SO_2) constitute just over two percent (2.1%) of the overall NYNJLINA SO_2 emissions.

SCOPE

This inventory includes emissions generated in 2006 that are linked to five Port Authority-associated marine terminals. Three of these terminals are in New Jersey:

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

The remaining two marine terminals are in New York:

- Howland Hook Marine Terminal (on Staten Island), and
- 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 the many oil and fuel depots 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 the emissions inventory, make up the Port of New York and New Jersey.

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 generated by earlier-year fleets: ocean-going vessels/harbor craft (2000), on-dock railroad locomotives (2002), heavy-duty diesel vehicles, also known as on-road trucks (2005), and cargo handling equipment (2002 and 2004). This inventory is the first to look at all of these emission source categories within a given year.

EMISSIONS SURVEYED

This inventory estimates the quantity of emissions of various pollutants from mobile sources tied to maritime facilities maintained by the Port Authority. Most of these pollutants 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 these pollutants or 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 pollutants:

- 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 pollutants are referred to as greenhouse gases (GHGs) because of their contribution to climate change. The greenhouse gas emissions included in this inventory are:

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

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

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 2006, 5.1 million TEUs passed through the Port, and the value of all cargo moved through the Port reached almost $150 billion.

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 make up 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.

Table ES.1: Criteria Pollutant Emission Summary by Source Category, tpy - 2006

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	1,402	93	86	124	465	219
Heavy-Duty Diesel Vehicles	1,935	59	54	87	564	26
Railroad Locomotives	286	10	9	20	44	32
Ocean-Going Vessels	3,691	348	279	165	319	3,270
Harbor Craft	486	26	24	18	41	50
Total PANYNJ Emissions	**7,800**	**537**	**452**	**413**	**1,434**	**3,597**
NYNJLINA Emissions	**445,285**	**178,451**	**42,441**	**522,245**	**2,840,374**	**170,044**
PANYNJ Percentage	**1.8%**	**0.3%**	**1.1%**	**0.1%**	**0.05%**	**2.1%**

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

Table ES.2: Criteria Pollutant Emission Summary by Source Category, % - 2006

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Cargo Handling Equipment	18%	17%	19%	30%	32%	6%
Heavy-Duty Diesel Vehicles	25%	11%	12%	21%	39%	1%
Railroad Locomotives	4%	2%	2%	5%	3%	1%
Ocean-Going Vessels	47%	65%	62%	40%	22%	91%
Harbor Craft	6%	5%	5%	4%	3%	1%

(Columns do not all add to 100% due to rounding)

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	142,253	4	8	143,542
Heavy-Duty Diesel Vehicles	208,403	1	1	208,446
Railroad Locomotives	14,567	0.4	1	14,710
Ocean-Going Vessels	195,763	5	18	197,664
Harbor Craft	25,597	3	9	26,691
Totals	**586,583**	**13**	**36**	**591,053**

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

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	24%	29%	23%	24%
Heavy-Duty Diesel Vehicles	36%	5%	2%	35%
Railroad Locomotives	2%	3%	3%	2%
Ocean-Going Vessels	33%	40%	49%	33%
Harbor Craft	4%	24%	24%	5%

(Columns do not all add to 100% due to rounding)

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

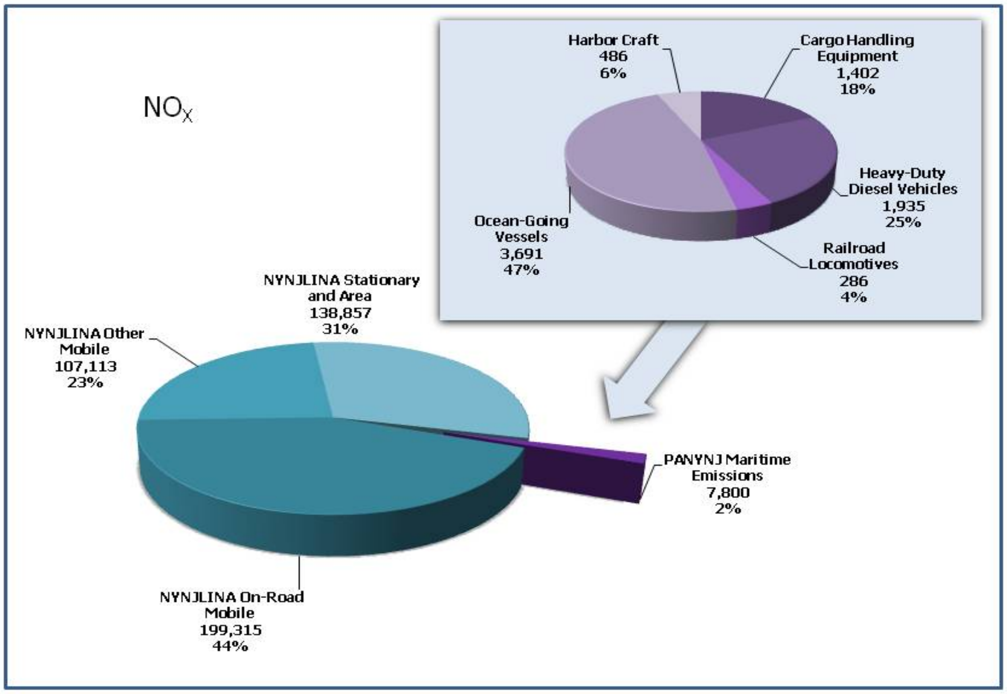


Figure ES.2: Distribution of PM_{10} Emissions by Source Category, tpy & percent

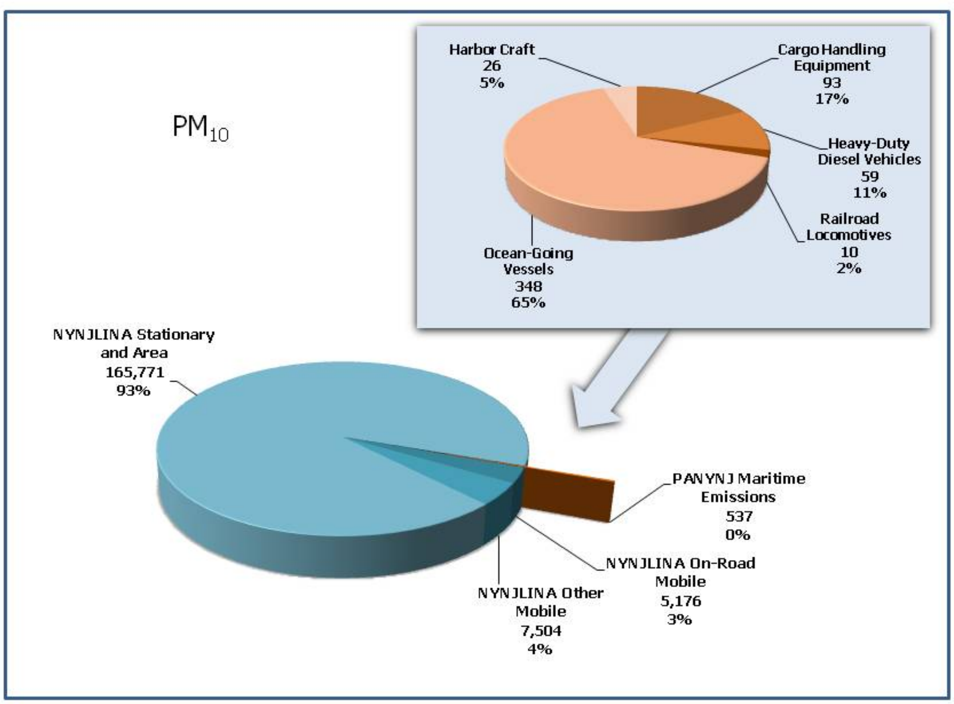


Figure ES.3: Distribution of $PM_{2.5}$ Emissions by Source Category, tpy & percent

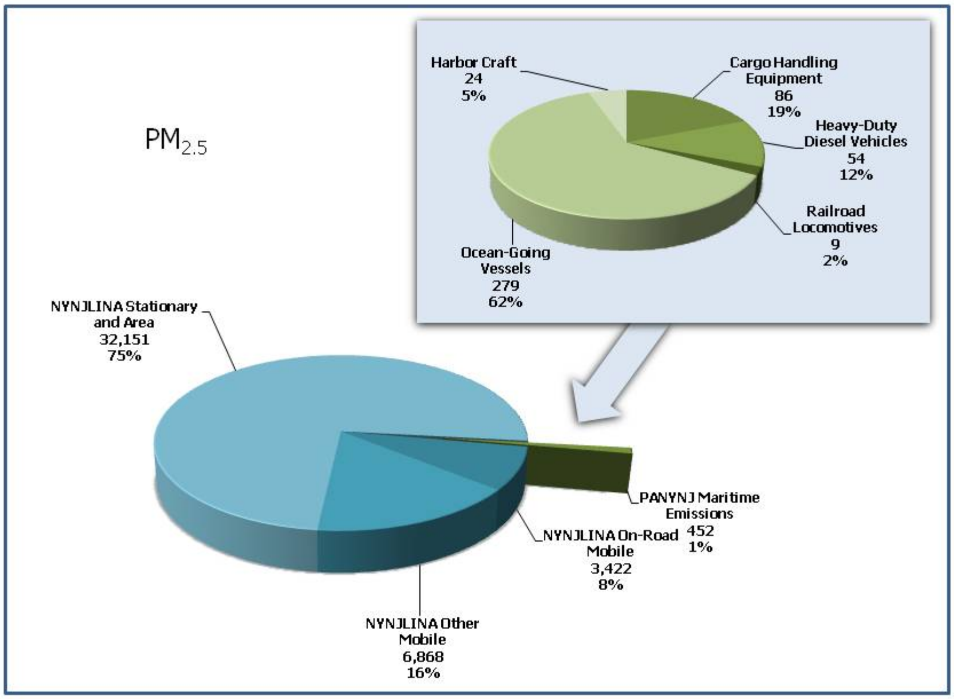


Figure ES.4: Distribution of VOC Emissions by Source Category, tpy & percent

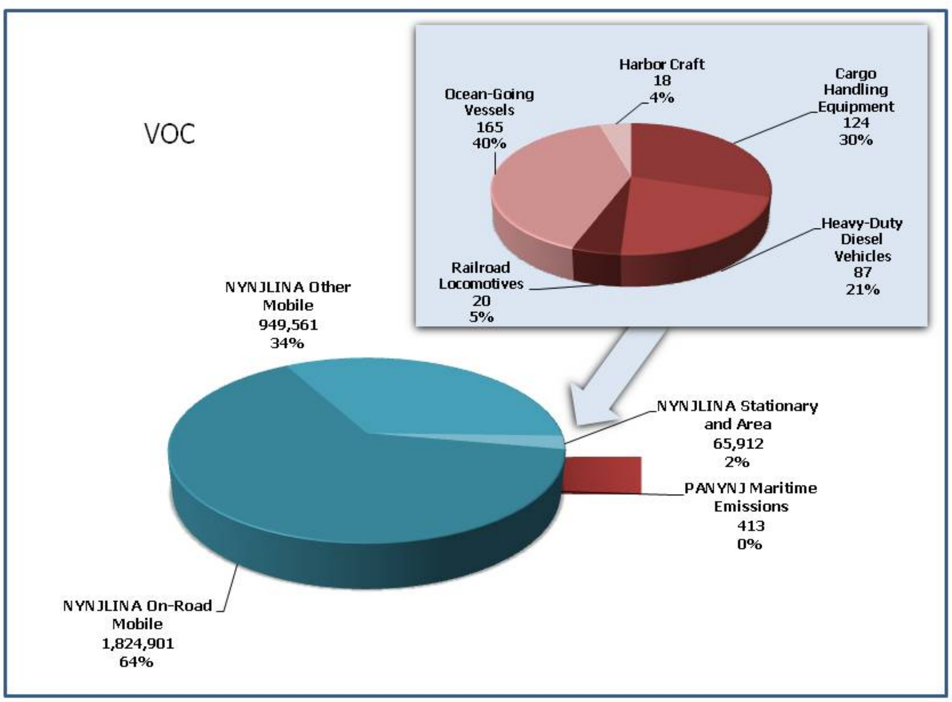


Figure ES.5: Distribution of CO Emissions by Source Category, tpy & percent

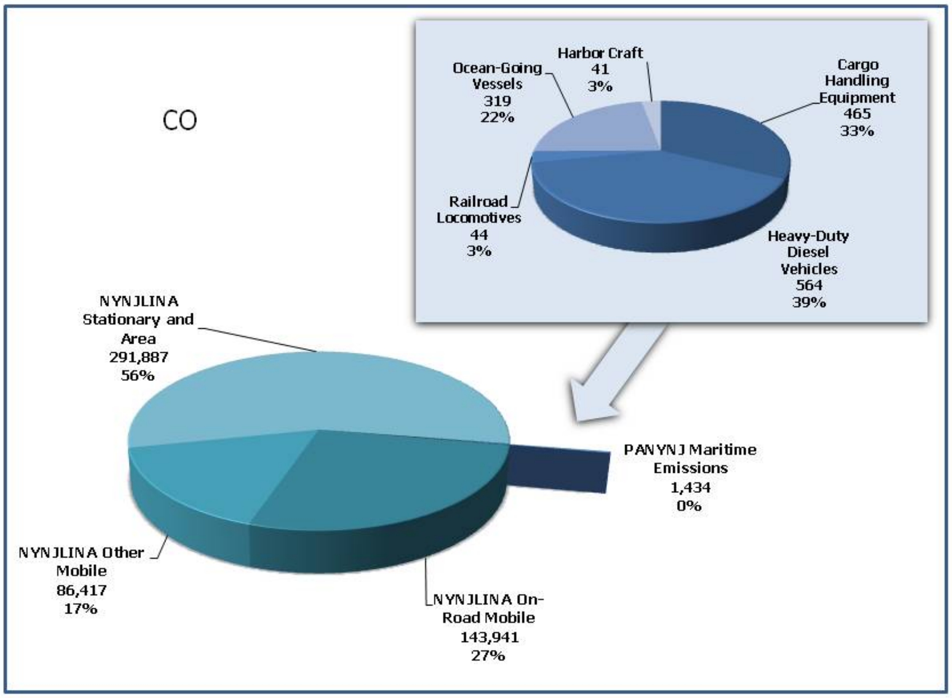
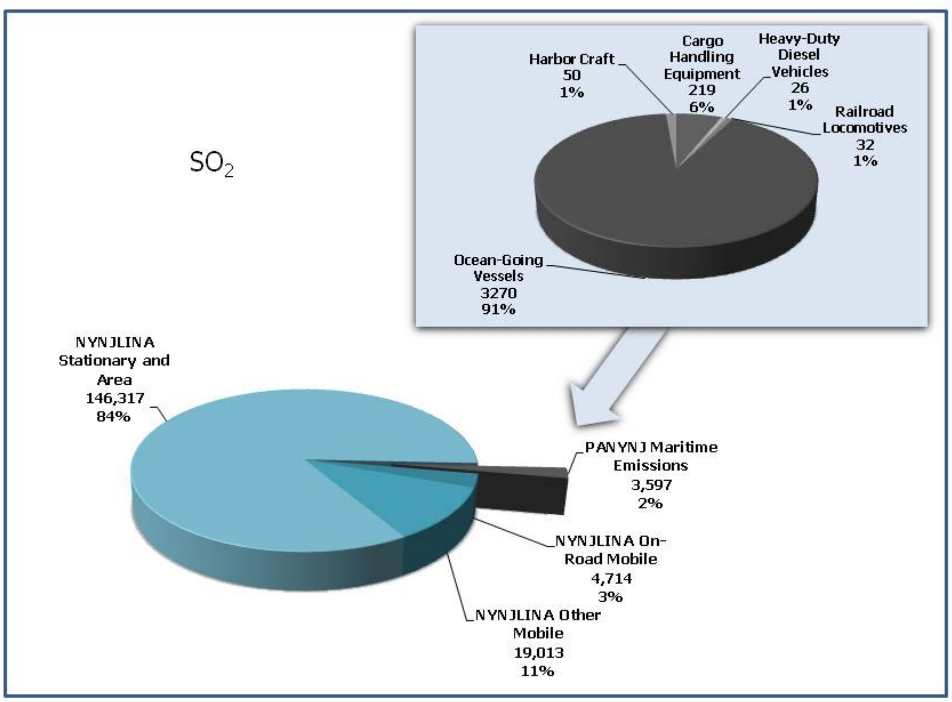
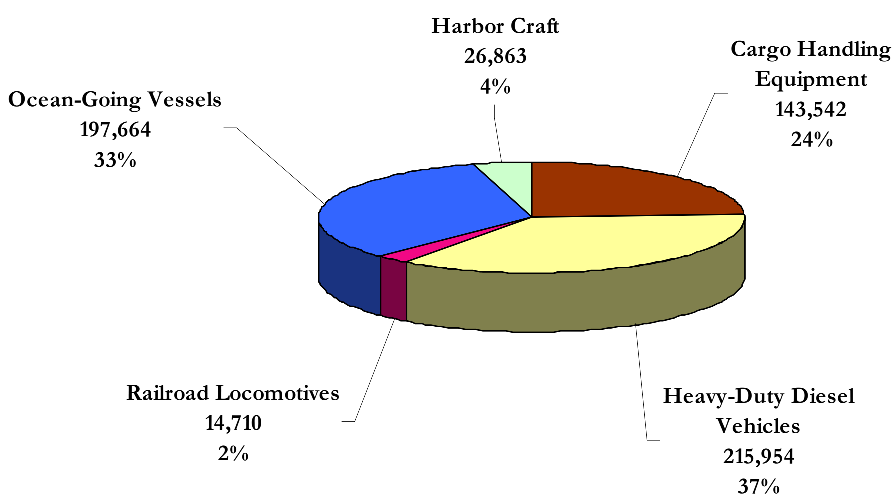


Figure ES.6: Distribution of SO_2 Emissions by Source Category, tpy & percent



Due to rounding in the figures presented above, the percentage of Port Authority maritime emissions compared with overall NYNJLINA emissions is displayed as zero (0) in some of the figures. In those figures, the actual percentage of Port Authority maritime emissions is displayed in Table ES1. The following figure shows only the breakdown of greenhouse gas emissions from Port Authority 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 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 the many oil and fuel depots 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 the emissions inventory, make up the Port of New York and New Jersey.

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), commercial marine vessels (CMV), heavy duty diesel vehicles (HDDV, i.e., trucks), and locomotives that visit these facilities from 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 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 purpose of this emissions inventory is to update the emission estimates presented in these previous emissions inventories, and to focus on the five Port Authority marine terminals. This study has evaluated the CHE, HDDV, railroad locomotive and marine vessel source categories for the year 2006, which will allow for emission comparisons when future inventories are conducted. 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; and
- 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 operations at five Port Authority marine terminals, including cargo handling equipment, visiting vessels, 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 on interviews and conversations with tenants who own, operate, maintain, and/or lease equipment, and on vessel activity data specific to the Port Authority marine terminals collected through Port Commerce staff. In addition, surveys on HDDV activity were developed (in conjunction with facility operators) and distributed to terminal and facility operators. The activity and operational data collected was then used to estimate emissions for each of the source categories in a manner consistent with the latest estimating methods. The information that was gathered, analyzed and presented in this report improves the understanding of the nature and magnitude of emission sources tied to the five Port Authority marine terminals.

1.1.1 Pollutants

his inventory estimates and reports the quantity of emissions of various pollutants from mobile emission sources tied to maritime facilities maintained by the Port Authority. The estimates are based on activities that occurred during calendar year 2006. Most of the pollutants 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 these pollutants or 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 pollutants:

- Oxides of nitrogen (NO_X),
- 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), and
- Sulfur dioxide (SO_2).

The remaining pollutants are referred to as greenhouse gases (GHGs) because of their contribution to climate change. The greenhouse gas emissions included in this inventory are:

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

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

The Port Authority's New York marine facilities are:

- Howland Hook Marine Terminal (which includes container operations),
- Brooklyn Port Authority Marine Terminal (which includes container operations)

Figure 1.1: Major Port of New York and New Jersey Marine Terminals

1.2 Report Organization by Section

The sections that follow are organized by source category detailing 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). Section 6 details the estimated emissions from all source categories by county and state and presents the emissions in comparison with area emissions by county and state.

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, and the total emissions in the NYNJLINA[3] in tons per year, and the percentage that the PANYNJ emissions make up of the total NYNJLINA emissions. Table 1.2 illustrates the percentage contribution of each source category to the total PANYNJ emissions of each pollutant. Tables 1.3 and 1.4 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. Following these tables,

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

Figures 1.2 through 1.8 illustrate the contribution of emissions from Port Authority emission source categories to overall emissions in the NYNJLINA

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

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
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Heavy-Duty Diesel Vehicles	1,935	59	54	87	564	26
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PANYNJ Percentage	**1.8%**	**0.3%**	**1.1%**	**0.1%**	**0.05%**	**2.1%**

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

Source Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
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Railroad Locomotives	4%	2%	2%	5%	3%	1%
Ocean-Going Vessels	47%	65%	62%	40%	22%	91%
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(Columns do not all add to 100% due to rounding)

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

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
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Harbor Craft	25,597	3	9	26,691
Totals	**586,583**	**13**	**36**	**591,053**

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

Source Category	CO_2	N_2O	CH_4	CO_2 Eq
Cargo Handling Equipment	24%	29%	23%	24%
Heavy-Duty Diesel Vehicles	36%	5%	2%	35%
Railroad Locomotives	2%	3%	3%	2%
Ocean-Going Vessels	33%	40%	49%	33%
Harbor Craft	4%	24%	24%	5%

(Columns do not all add to 100% due to rounding)

Figure 1.2: Distribution and Comparison of NO_x by Source Category, tpy and percent

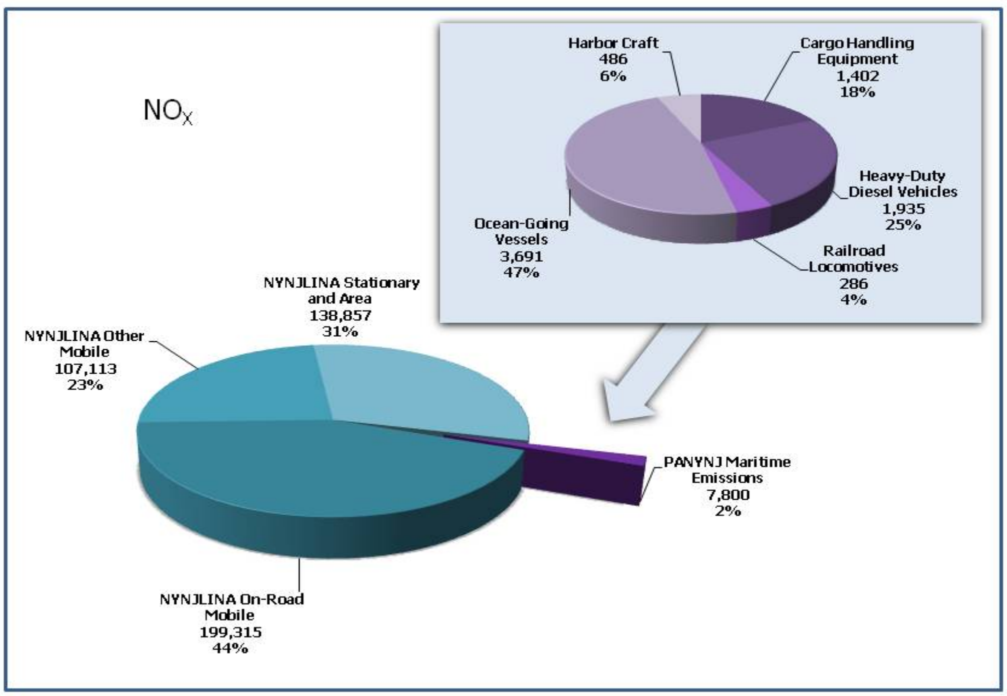


Figure 1.3: Distribution and Comparison of PM_{10} by Source Category, tpy & percent

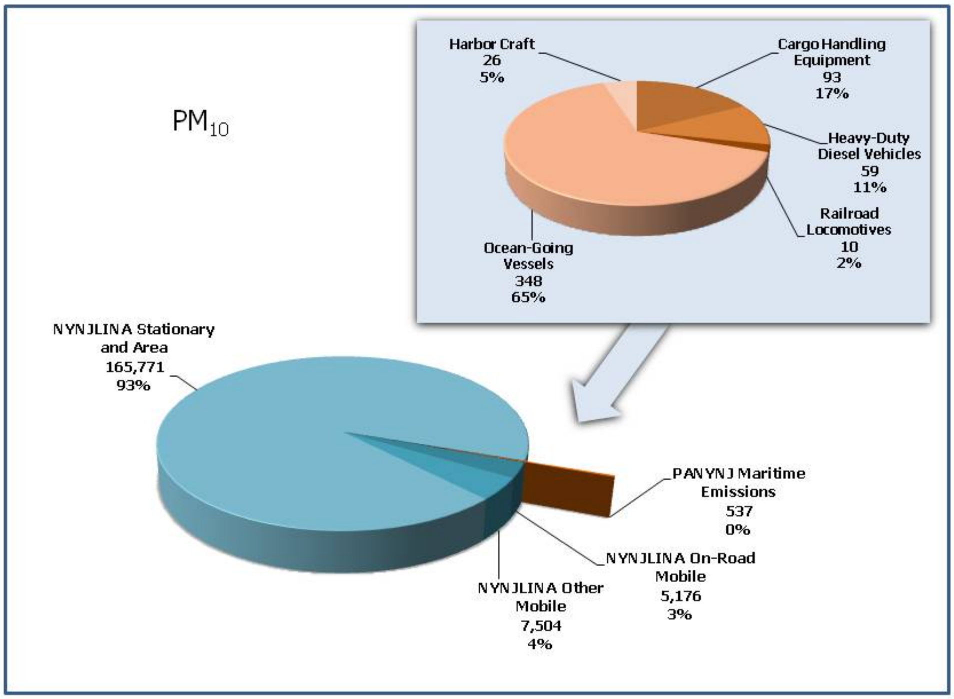


Figure 1.4: Distribution and Comparison of $PM_{2.5}$ by Source Category, tpy & percent

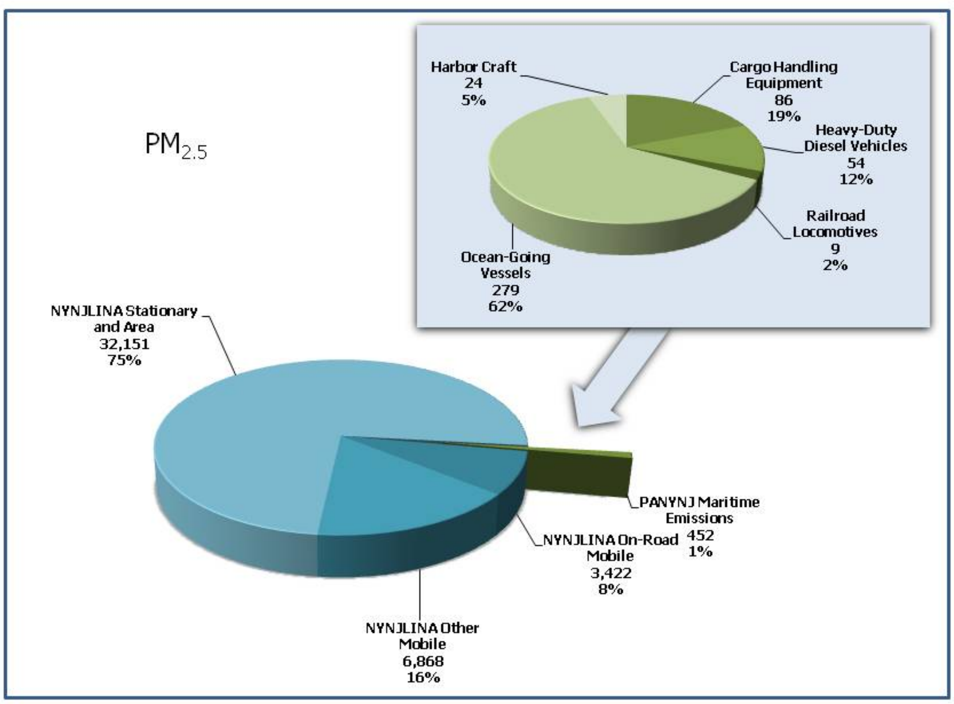


Figure 1.5: Distribution and Comparison of VOC by Source Category, tpy & percent

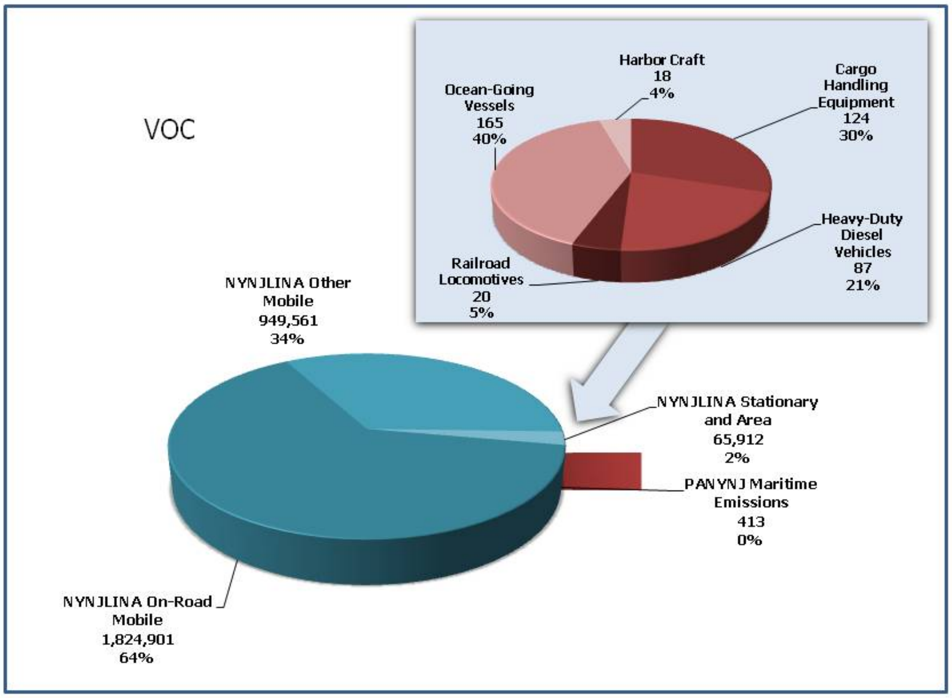


Figure 1.6: Distribution and Comparison of CO by Source Category, tpy & percent

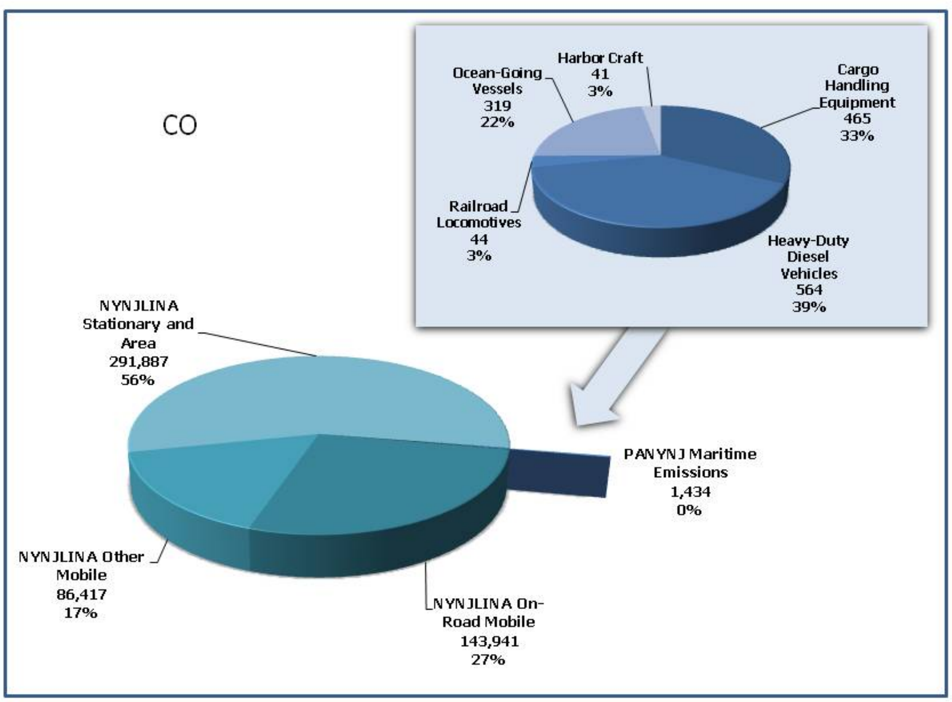
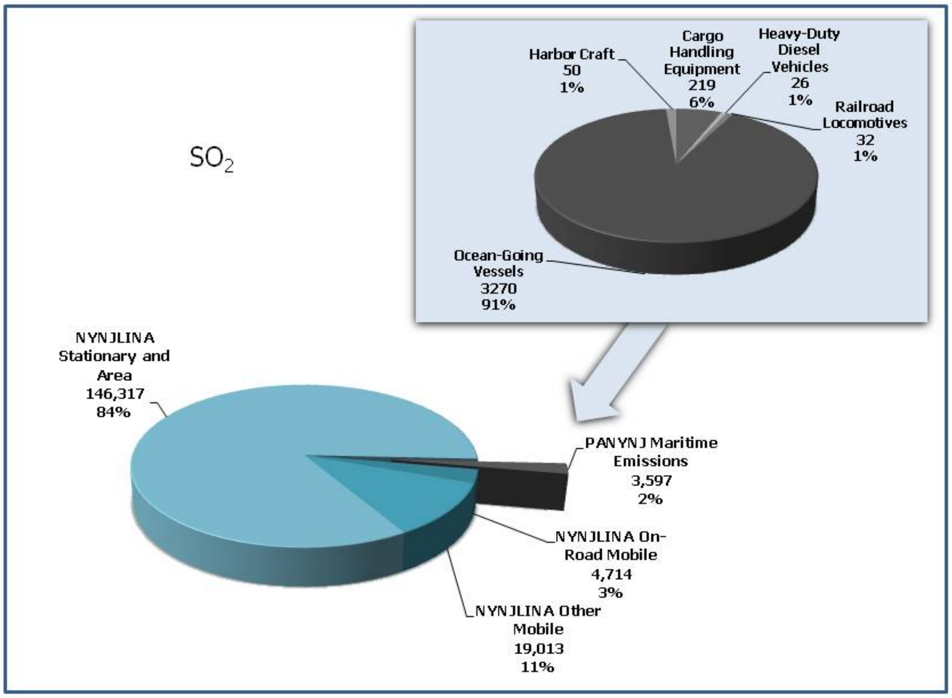
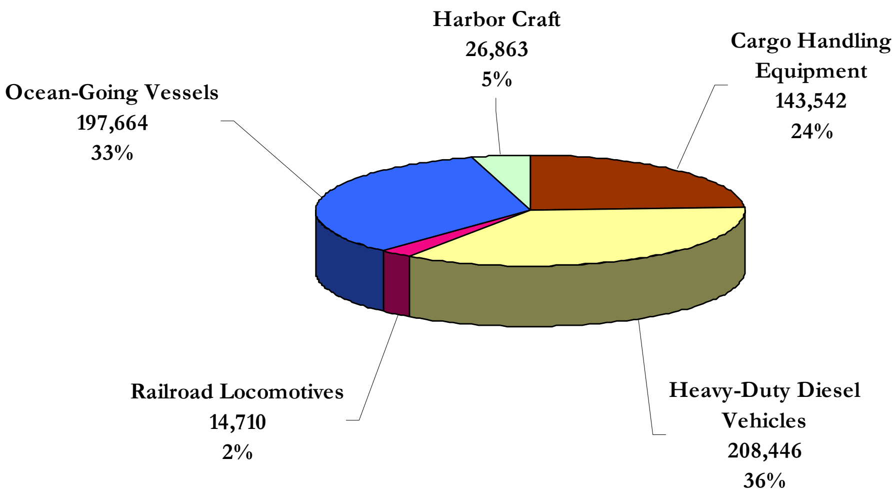


Figure 1.7: Distribution and Comparison of SO_2 by Source Category, tpy & percent



Due to rounding in the figures presented above, the percentage of Port Authority maritime emissions compared with overall NYNJLINA emissions is displayed as zero (0) in some of the figures. In those figures, the actual percentage of Port Authority maritime emissions is displayed in Table 1.1. The following figure shows only the breakdown of greenhouse gas emissions from Port Authority 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 Port Authority Maritime Emissions Comparison

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

Table 1.5 summarizes by county the estimated emissions from the Port Authority maritime related activities covered by this report, and Table 1.6 lists total emissions of each criteria pollutant by county and state, as reported in the most recent National Emissions Inventory database. Greenhouse gases are not included in these tables because at the present time county-level estimates of overall greenhouse gas emissions are not available.

[4] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008, http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata

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

County	State	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	122	4	4	6	29	7
Essex	NJ	1,642	116	96	79	305	901
Hudson	NJ	859	62	50	43	113	412
Middlesex	NJ	293	10	9	14	77	7
Monmouth	NJ	244	19	16	13	26	128
Union	NJ	2,600	186	160	155	561	1,261
New Jersey subtotal		**5,760**	**397**	**335**	**312**	**1,112**	**2,716**
Bronx	NY	28	1	1	1	8	1
Kings (Brooklyn)	NY	564	43	35	30	80	270
Nassau	NY	45	2	1	2	12	1
New York	NY	97	8	6	4	10	65
Orange	NY	25	1	1	1	6	1
Queens	NY	30	1	1	1	7	1
Richmond (Staten Island)	NY	1,125	80	67	54	174	533
Rockland	NY	66	2	2	4	11	8
Suffolk	NY	32	1	1	1	7	2
Westchester	NY	29	1	1	1	7	1
New York subtotal		**2,040**	**140**	**117**	**102**	**322**	**881**
PANYNJ Total		**7,800**	**537**	**452**	**413**	**1,434**	**3,597**

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 Port Authority maritime emissions on a county level with overall county-wide emissions. Each table (one for each criteria pollutant) shows the county-wide emissions, Port Authority maritime emissions, and the percentage Port Authority emissions make up 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	122	0.47%
Essex	NJ	23,498	1,642	6.99%
Hudson	NJ	27,776	859	3.09%
Middlesex	NJ	33,000	293	0.89%
Monmouth	NJ	19,177	244	1.27%
Union	NJ	21,154	2,600	12.29%
New Jersey subtotal		**150,577**	**5,760**	**3.83%**
Bronx	NY	16,018	28	0.175%
Kings (Brooklyn)	NY	29,788	564	1.892%
Nassau	NY	36,258	45	0.124%
New York	NY	39,082	97	0.248%
Orange	NY	19,397	25	0.130%
Queens	NY	41,172	30	0.073%
Richmond (Staten Island)	NY	10,085	1,125	11.152%
Rockland	NY	13,645	66	0.486%
Suffolk	NY	61,223	32	0.052%
Westchester	NY	28,040	29	0.102%
New York subtotal		**294,708**	**2,040**	**0.69%**
NYNJLINA and PANYNJ Totals		**445,285**	**7,800**	**1.75%**

Figure 1.9: Comparison of NO_x Emissions by County, tpy

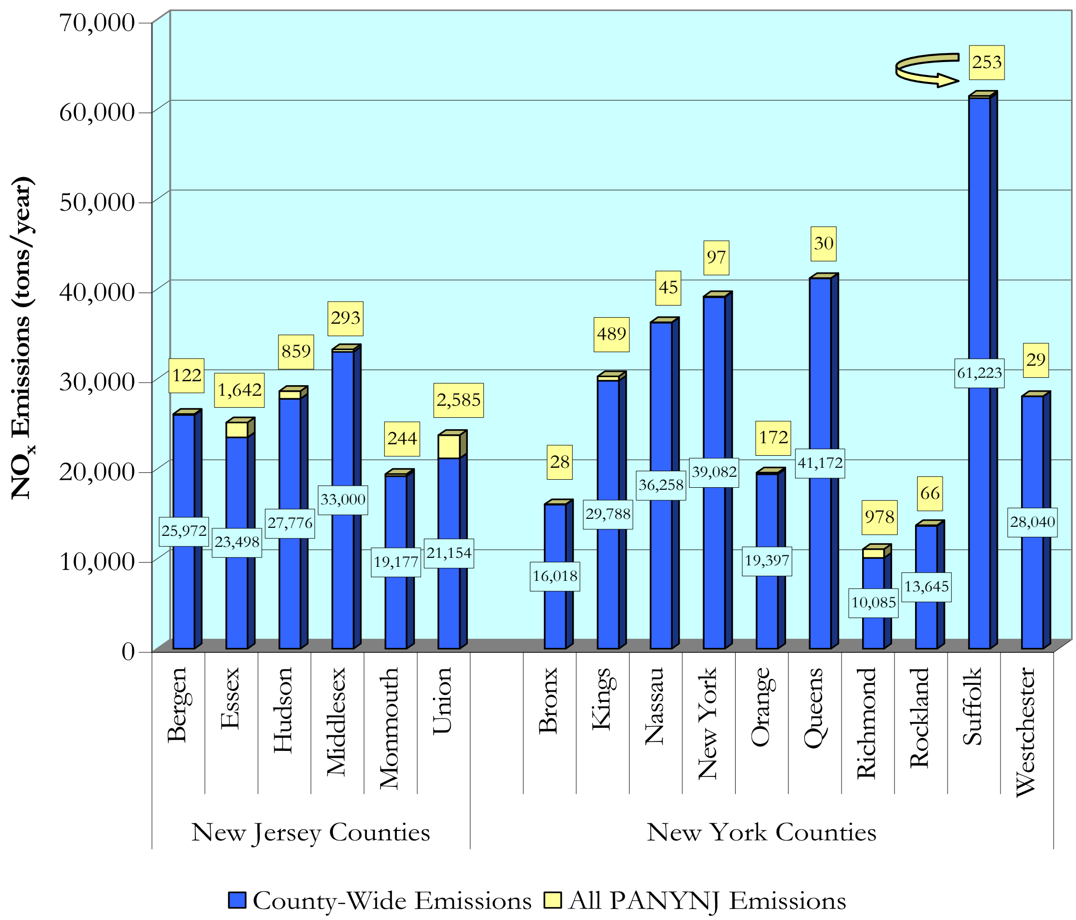


Table 1.8: Comparison of PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	4	0.07%
Essex	NJ	3,745	116	3.09%
Hudson	NJ	6,764	62	0.91%
Middlesex	NJ	9,927	10	0.10%
Monmouth	NJ	7,935	19	0.24%
Union	NJ	4,227	186	4.40%
New Jersey subtotal		**38,850**	**397**	**1.02%**
Bronx	NY	5,803	1	0.02%
Kings (Brooklyn)	NY	8,312	43	0.51%
Nassau	NY	14,142	2	0.01%
New York	NY	8,689	8	0.09%
Orange	NY	27,696	1	0.00%
Queens	NY	9,615	1	0.01%
Richmond (Staten Island)	NY	8,092	80	0.99%
Rockland	NY	4,880	2	0.05%
Suffolk	NY	39,210	1	0.00%
Westchester	NY	13,162	1	0.01%
New York subtotal		**139,601**	**140**	**0.10%**
NYNJLINA and PANYNJ Totals		**178,451**	**537**	**0.30%**

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

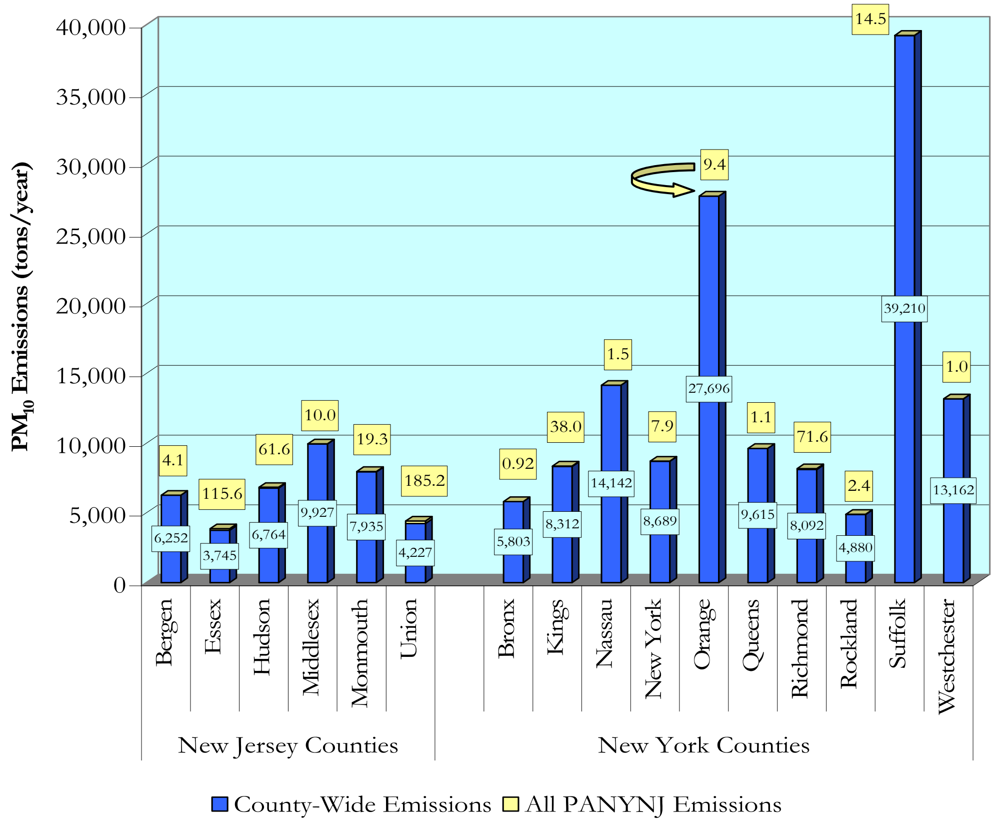


Table 1.9: Comparison of $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	3.8	0.3%
Essex	NJ	1,159	96.1	8.3%
Hudson	NJ	3,754	50.4	1.3%
Middlesex	NJ	2,150	9.2	0.4%
Monmouth	NJ	1,623	15.7	1.0%
Union	NJ	1,472	160.1	10.9%
New Jersey subtotal		**11,567**	**335**	**2.9%**
Bronx	NY	1,357	0.8	0.06%
Kings (Brooklyn)	NY	2,676	35.4	1.32%
Nassau	NY	2,727	1.4	0.05%
New York	NY	4,017	6.3	0.16%
Orange	NY	4,968	0.8	0.02%
Queens	NY	3,655	1.0	0.03%
Richmond (Staten Island)	NY	1,323	66.9	5.05%
Rockland	NY	1,638	2.3	0.14%
Suffolk	NY	6,057	1.2	0.02%
Westchester	NY	2,456	0.9	0.04%
New York subtotal		**30,874**	**117**	**0.38%**
NYNJLINA and PANYNJ Totals		**42,441**	**452**	**1.07%**

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

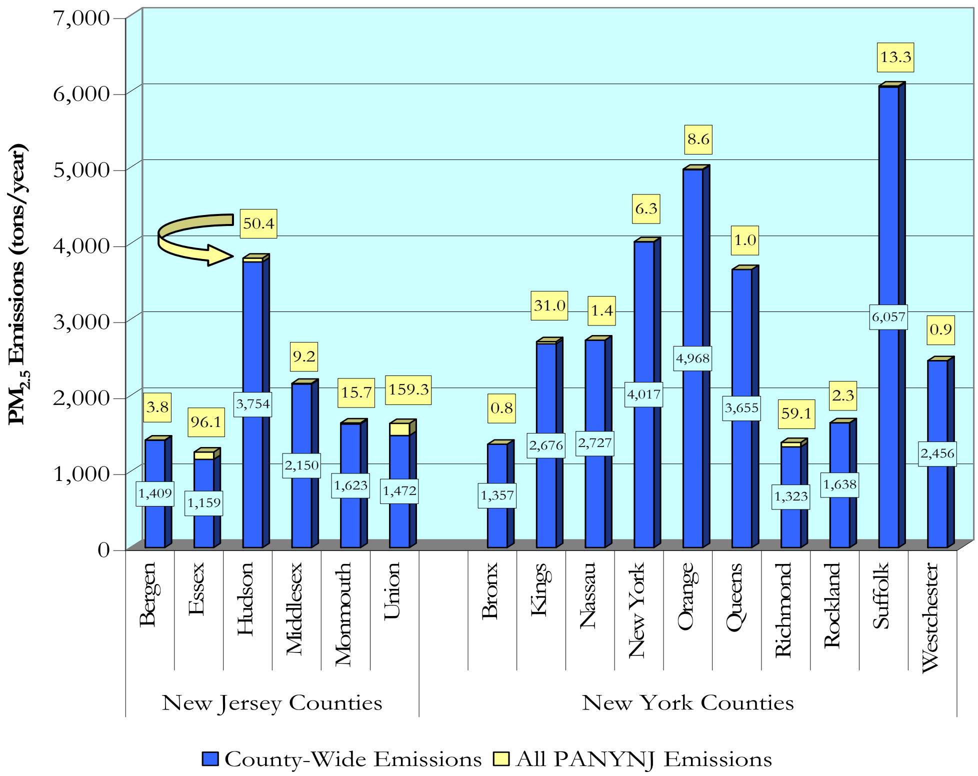


Table 1.10: Comparison of VOC Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	6	0.02%
Essex	NJ	20,940	79	0.38%
Hudson	NJ	14,428	43	0.30%
Middlesex	NJ	30,357	14	0.05%
Monmouth	NJ	22,727	13	0.06%
Union	NJ	20,627	155	0.75%
New Jersey subtotal		**142,075**	**312**	**0.22%**
Bronx	NY	25,454	1.4	0.01%
Kings (Brooklyn)	NY	54,809	30	0.06%
Nassau	NY	47,865	2.2	0.005%
New York	NY	45,292	4.0	0.01%
Orange	NY	18,349	1.2	0.01%
Queens	NY	47,262	1.4	0.003%
Richmond (Staten Island)	NY	13,542	54	0.40%
Rockland	NY	13,767	3.7	0.03%
Suffolk	NY	77,071	1.4	0.00%
Westchester	NY	36,759	1.4	0.004%
New York subtotal		**380,170**	**102**	**0.03%**
NYNJLINA and PANYNJ Totals		**522,245**	**413**	**0.08%**

Figure 1.12: Comparison of VOC Emissions by County, tpy

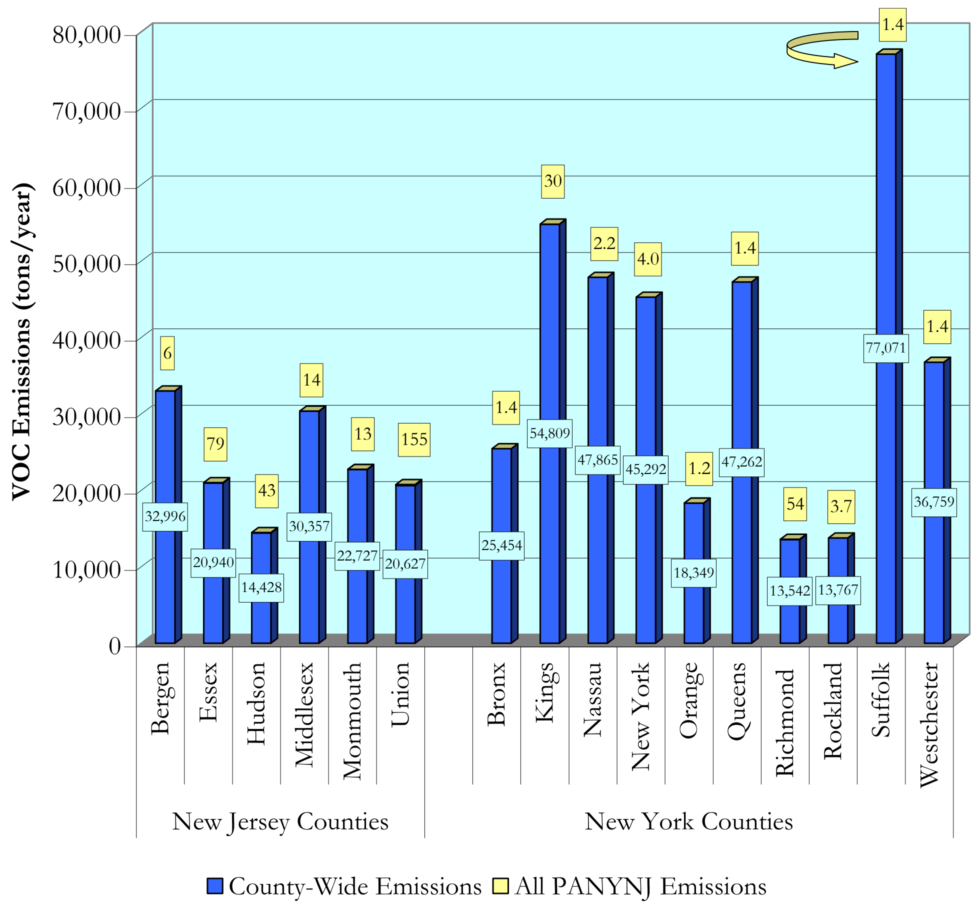


Table 1.11: Comparison of CO Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	29	0.01%
Essex	NJ	131,856	305	0.23%
Hudson	NJ	69,129	113	0.16%
Middlesex	NJ	196,869	77	0.04%
Monmouth	NJ	166,309	26	0.02%
Union	NJ	114,302	561	0.49%
New Jersey subtotal		**921,446**	**1,112**	**0.12%**
Bronx	NY	113,641	8	0.007%
Kings (Brooklyn)	NY	158,527	80	0.05%
Nassau	NY	282,348	12	0.004%
New York	NY	220,345	10	0.004%
Orange	NY	114,316	6.4	0.01%
Queens	NY	207,255	7.2	0.003%
Richmond (Staten Island)	NY	52,149	174	0.33%
Rockland	NY	67,761	11	0.02%
Suffolk	NY	472,083	6.5	0.00%
Westchester	NY	230,503	7.0	0.003%
New York subtotal		**1,918,928**	**322**	**0.02%**
NYNJLINA and PANYNJ Totals		**2,840,374**	**1,434**	**0.05%**

Figure 1.13: Comparison of CO Emissions by County, tpy

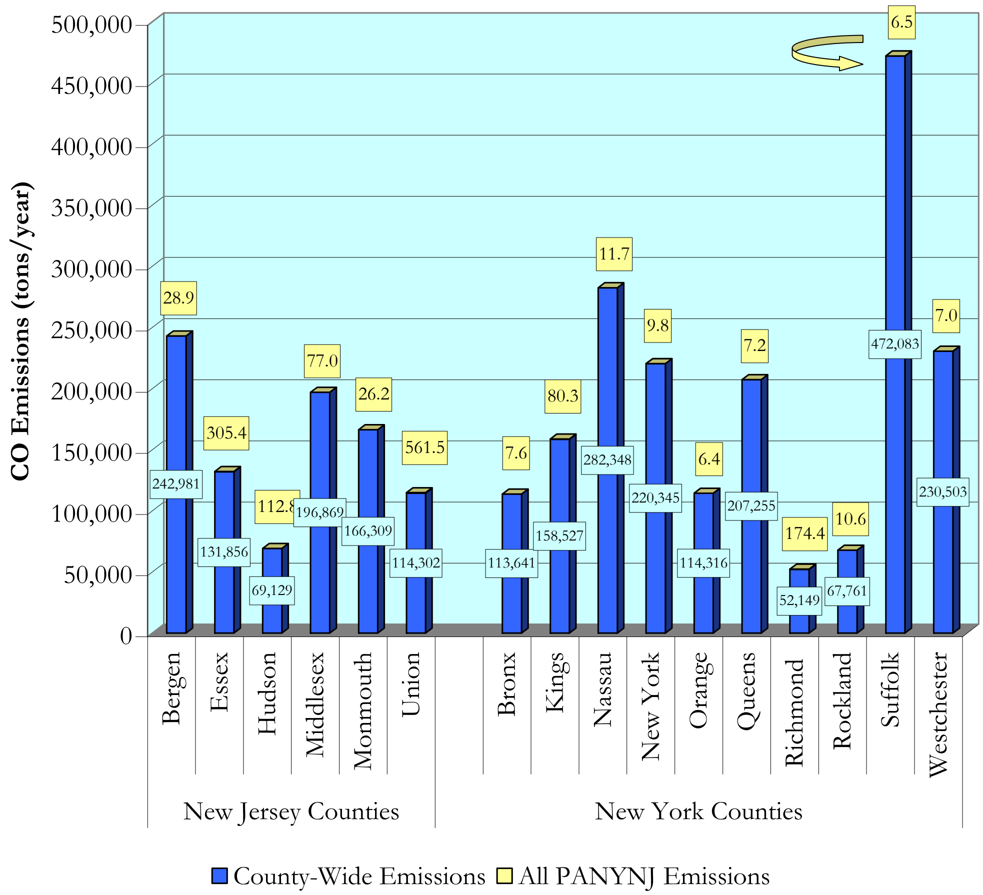
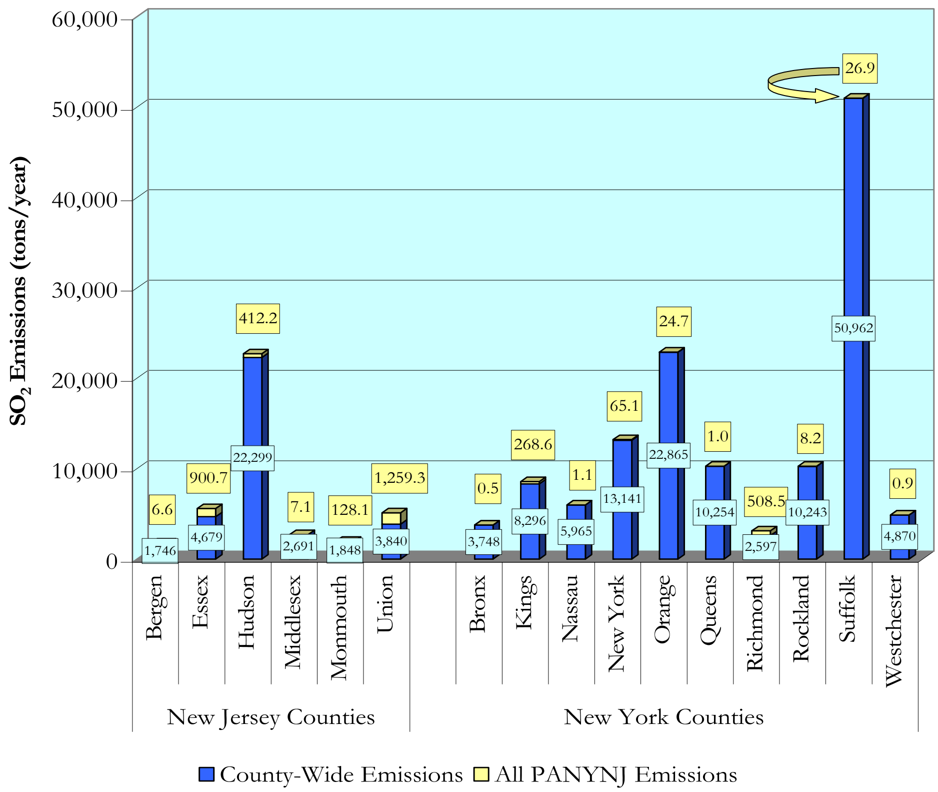


Table 1.12: Comparison of SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	All PANYNJ Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	7	0.4%
Essex	NJ	4,679	901	19.2%
Hudson	NJ	22,299	412	1.8%
Middlesex	NJ	2,691	7	0.3%
Monmouth	NJ	1,848	128	6.9%
Union	NJ	3,840	1,261	32.8%
New Jersey subtotal		**37,103**	**2,716**	**7.32%**
Bronx	NY	3,748	0.5	0.01%
Kings (Brooklyn)	NY	8,296	270	3.3%
Nassau	NY	5,965	1	0.02%
New York	NY	13,141	65	0.50%
Orange	NY	22,865	1	0.00%
Queens	NY	10,254	1	0.01%
Richmond (Staten Island)	NY	2,597	533	20.5%
Rockland	NY	10,243	8	0.08%
Suffolk	NY	50,962	2	0.00%
Westchester	NY	4,870	0.9	0.02%
New York subtotal		**132,941**	**881**	**0.66%**
NYNJLINA and PANYNJ Totals		**170,044**	**3,597**	**2.12%**

Figure 1.14: Comparison of SO_2 Emissions by County, tpy



SECTION 2: CARGO HANDLING EQUIPMENT

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

The following five Port Authority 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.

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

- 2.1 - Emission Estimates
- 2.2 - Emission Comparisons
- 2.3 - Methodology
- 2.4 - Description of 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. 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	1,402	93	86	124	465	219
Percent of NYNJLINA Emissions	0.31%	0.05%	0.20%	0.02%	0.02%	0.13%

The following figures illustrate the distribution of PANYNJ CHE emissions by type of equipment in terms of tons per year and percent of total CHE emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Due to rounding in these figures, the percentage of Port Authority CHE emissions compared with overall NYNJLINA emissions is displayed as zero (0) in the figures. The actual percentage of Port Authority CHE emissions is displayed above in Table ES2.1.

Figure ES2.2: Distribution and Comparison of NO_x from CHE, tpy and percent

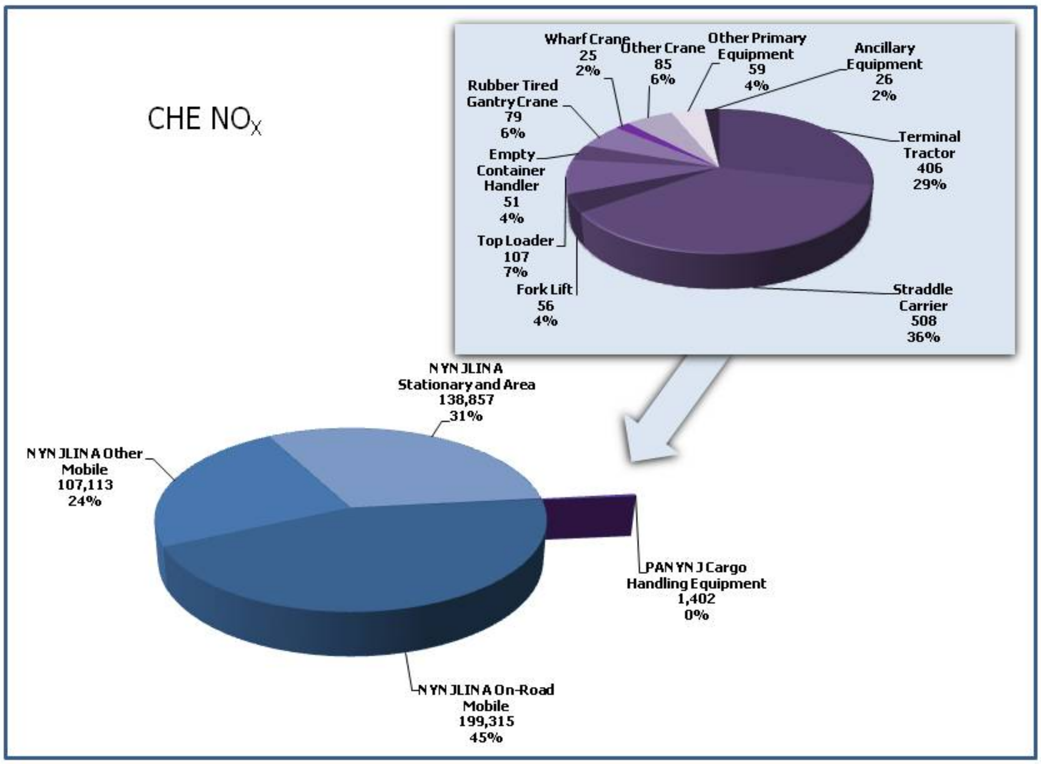


Figure ES2.3: Distribution and Comparison of PM_{10} from CHE, tpy and percent

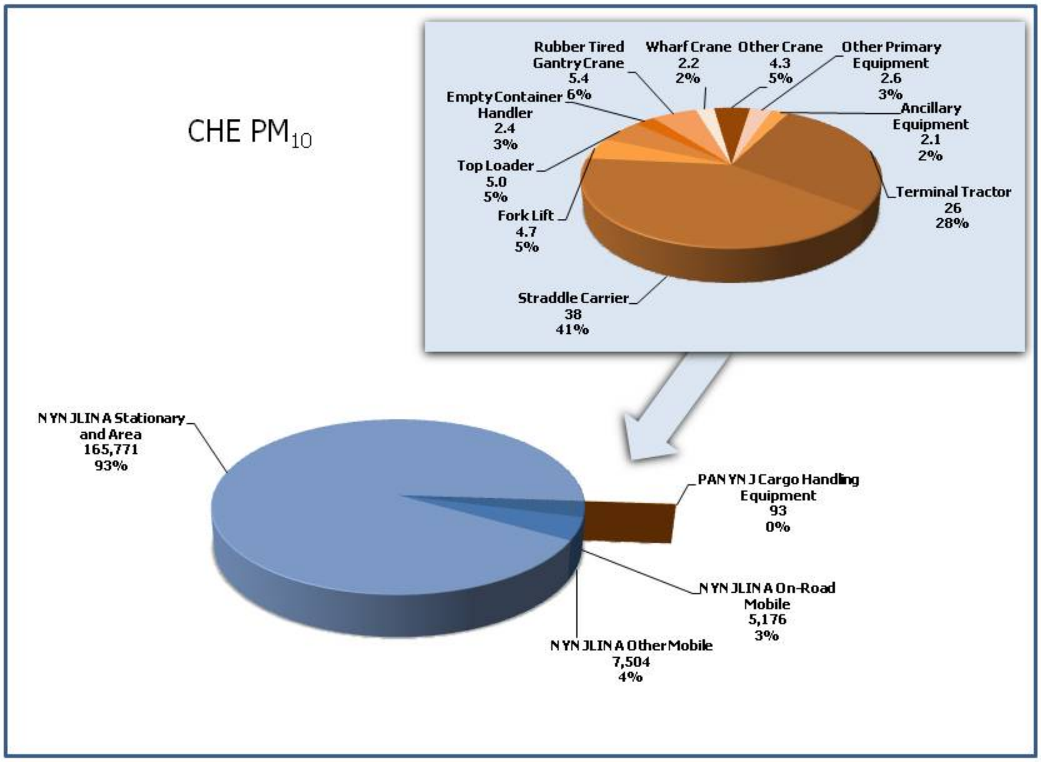


Figure ES2.4: Distribution and Comparison of $PM_{2.5}$ from CHE, tpy and percent

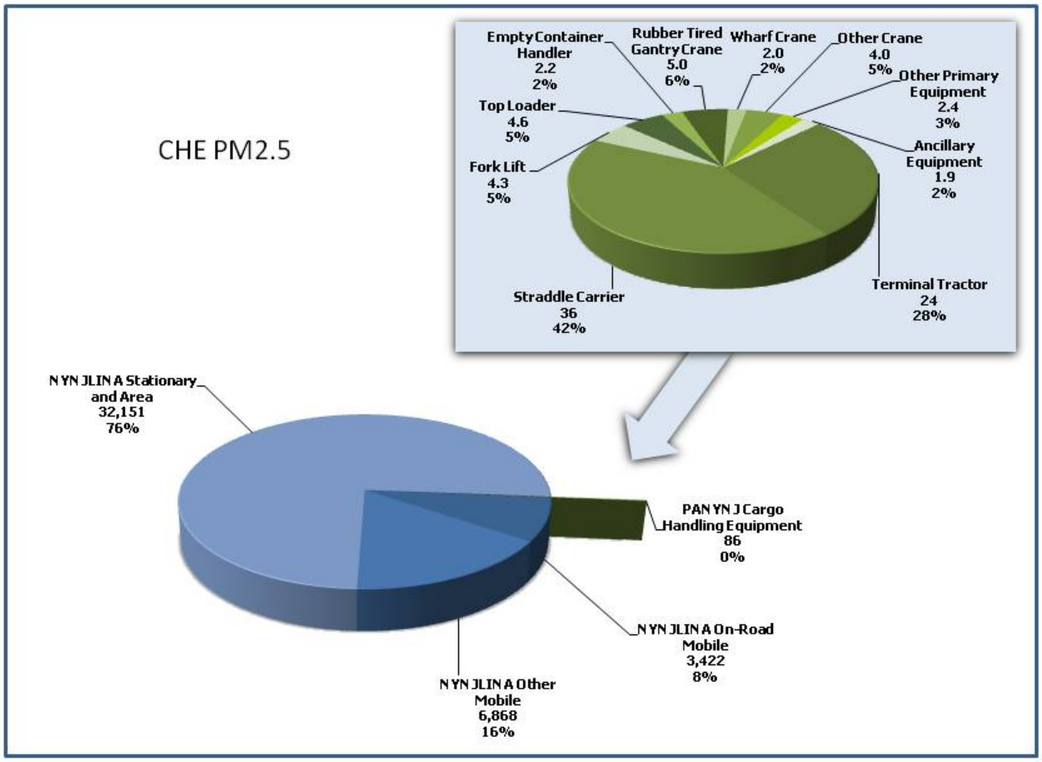


Figure ES2.5: Distribution and Comparison of VOC from CHE, tpy and percent

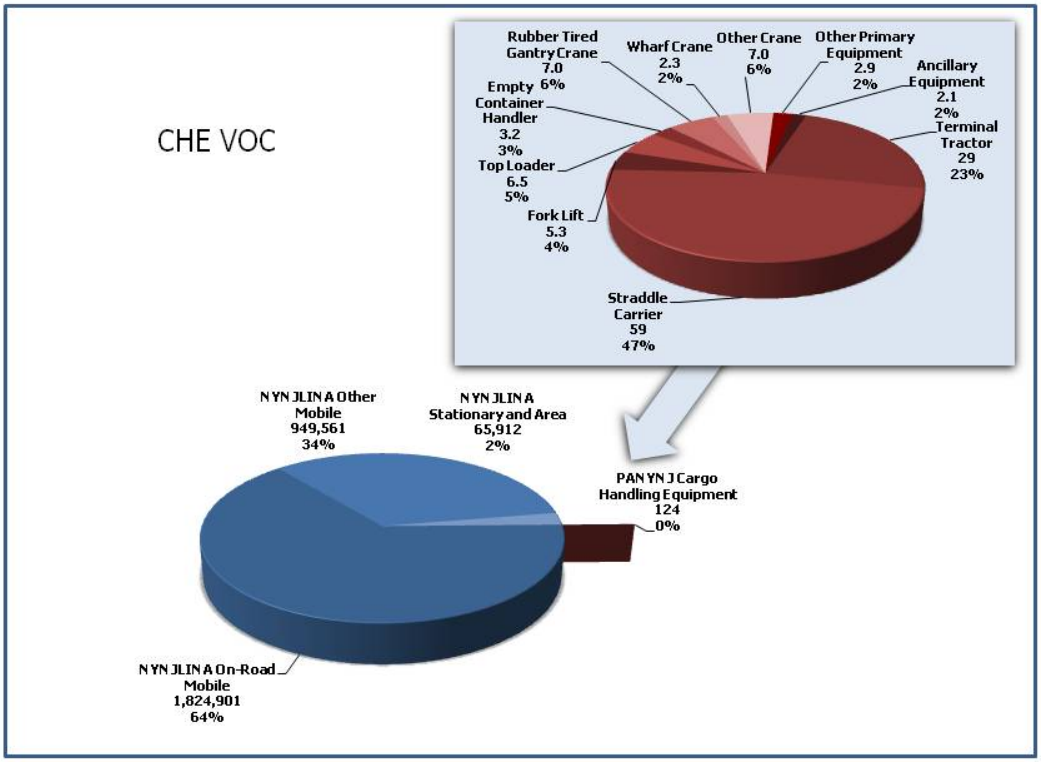


Figure ES2.6: Distribution and Comparison of CO from CHE, tpy and percent

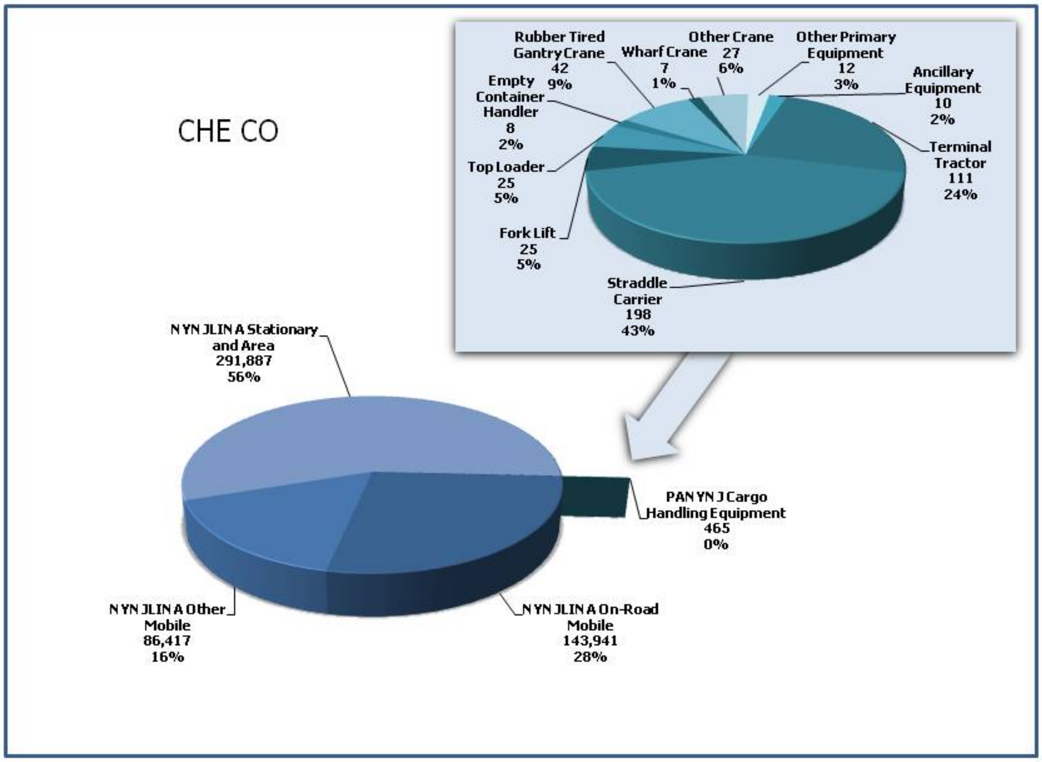
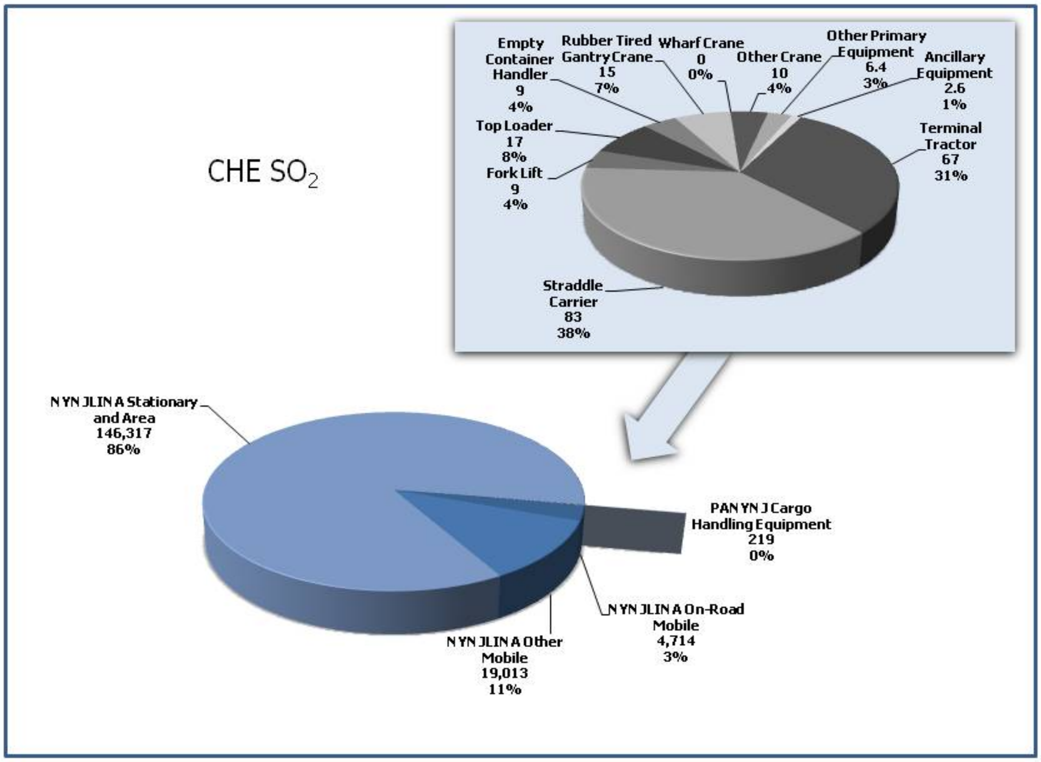


Figure ES2.7: Distribution and Comparison of SO_2 from CHE, tpy and percent



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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.

Table 2.1: 2006 Criteria Pollutant Emissions from CHE by Equipment Type, tpy

Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Terminal Tractor	406	26	24	29	111	67
Straddle Carrier	508	38	36	59	198	83
Fork Lift	56	4.7	4.3	5.3	25	9
Top Loader	107	5.0	4.6	6.5	25	17
Empty Container Handler	51	2.4	2.2	3.2	8	9
Rubber Tired Gantry Crane	79	5.4	5.0	7.0	42	15
Wharf Crane	25	2.2	2.0	2.3	7	0
Other Crane	85	4.3	4.0	7.0	27	10
Other Primary Equipment	59	2.6	2.4	2.9	12	6.4
Ancillary Equipment	26	2.1	1.9	2.1	10	2.6
Totals	**1,402**	**93**	**86**	**124**	**465**	**219**

Figure 2.1: 2006 Emissions of NO_x from CHE by Equipment Type, tpy and percent

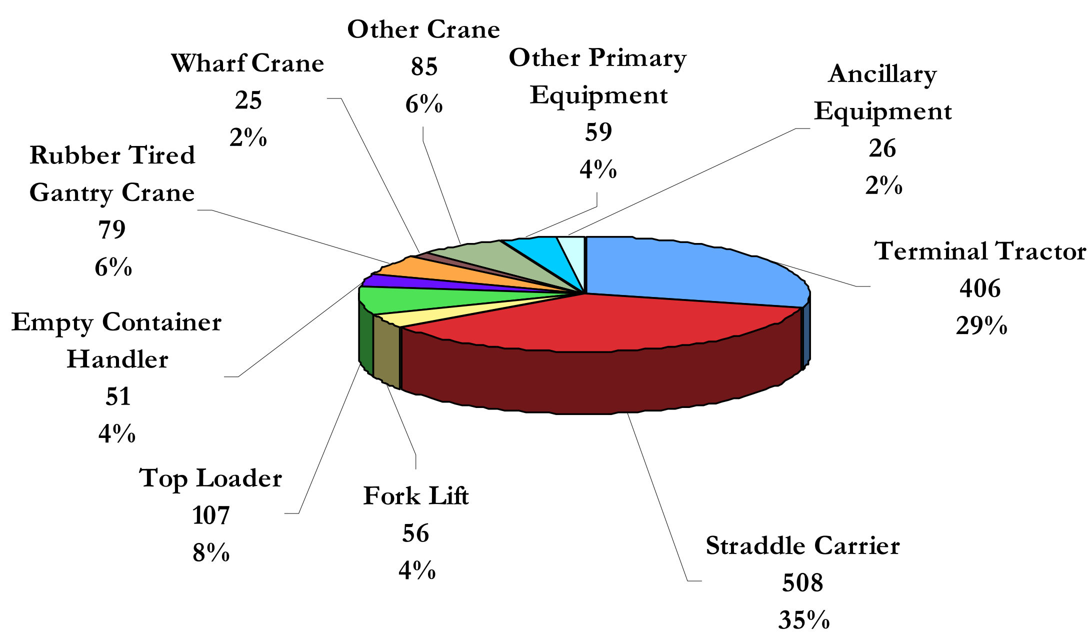
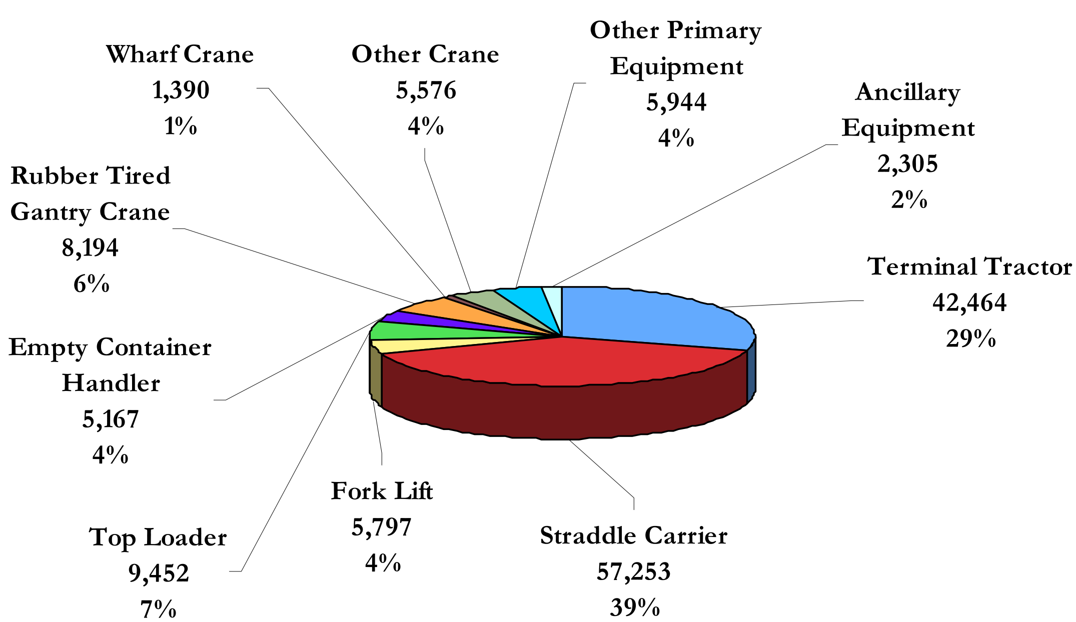


Table 2.2: 2006 GHG Emissions from CHE by Equipment Type, tpy

Equipment Type	CO_2	N_2O	CH_4	CO_2 Equivalent
Terminal Tractor	42,083	1.07	2.40	42,464
Straddle Carrier	56,740	1.44	3.24	57,253
Fork Lift	5,745	0.15	0.33	5,797
Top Loader	9,366	0.24	0.53	9,452
Empty Container Handler	5,121	0.13	0.29	5,167
Rubber Tired Gantry Crane	8,119	0.21	0.46	8,194
Wharf Crane	1,379	0.03	0.08	1,390
Other Crane	5,526	0.14	0.32	5,576
Other Primary Equipment	5,890	0.15	0.34	5,944
Ancillary Equipment	2,284	0.06	0.13	2,305
Totals	**142,253**	**4**	**8**	**143,542**

Figure 2.2: 2006 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 maritime cargo handling equipment emissions with county-level emission totals. Table 2.3 summarizes criteria pollutant emissions from cargo handling equipment operating at Port Authority facilities, 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 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	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Bergen	NJ	0	0	0	0	0	0
Essex	NJ	227	12	11	17	91	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	955	68	63	92	305	190
New Jersey subtotal		**1,181**	**80**	**74**	**109**	**397**	**194**
Bronx	NY	0	0	0	0	0	0
Kings (Brooklyn)	NY	75	5	4	5	21	1
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 Isld)	NY	146	8	8	10	47	24
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		**221**	**13**	**12**	**15**	**69**	**25**
TOTAL		**1,402**	**93**	**86**	**124**	**465**	**219**

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	227	1.0%
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	955	4.5%
New Jersey Subtotal		**150,577**	**1,181**	**0.78%**
Bronx	NY	16,018	0	0.0%
Kings (Brooklyn)	NY	29,788	75	0.3%
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 Isld)	NY	10,085	146	1.5%
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**	**221**	**0.1%**
TOTAL		**445,285**	**1,402**	**0.31%**

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

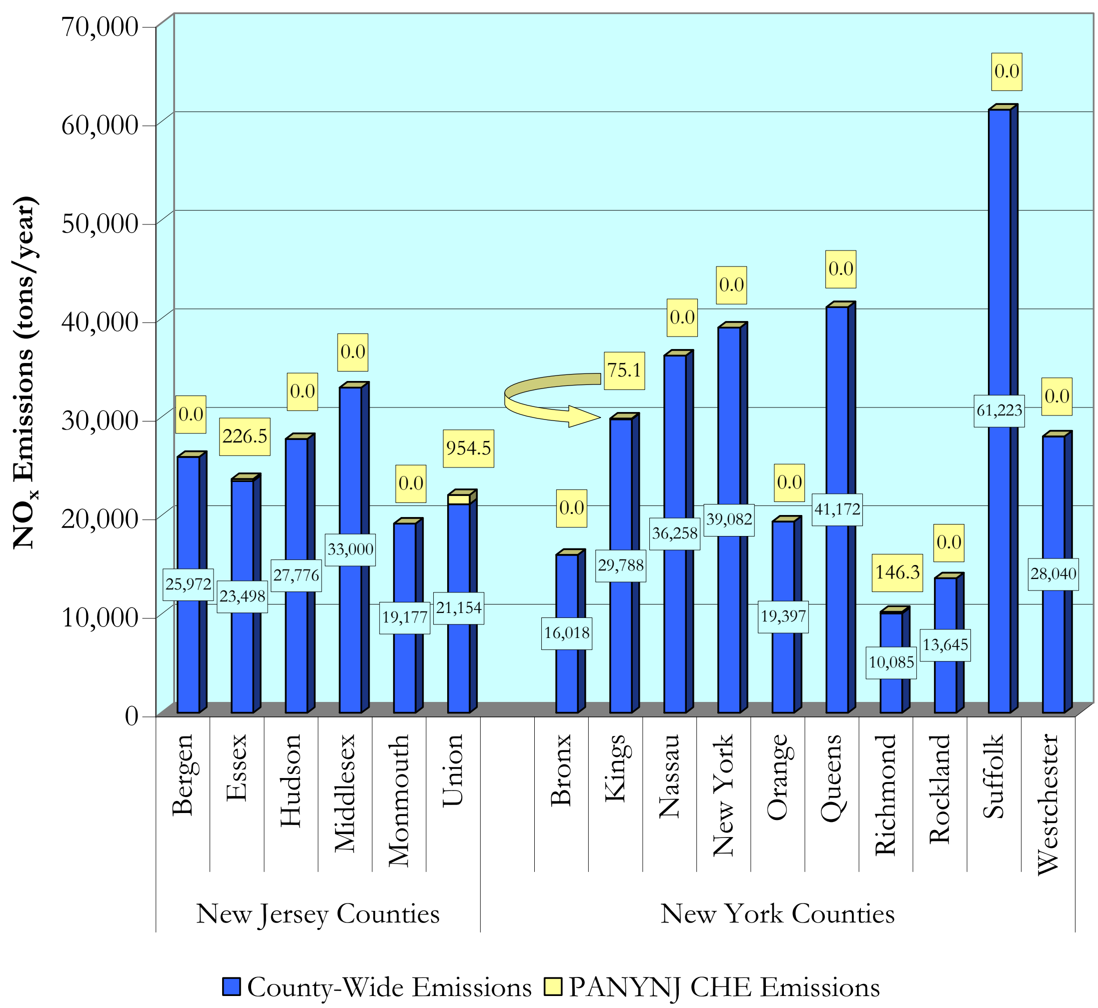


Table 2.5: Comparison of CHE PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0.0	0.0%
Essex	NJ	3,745	12.2	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	68.0	1.6%
New Jersey Subtotal		**38,850**	**80**	**0.21%**
Bronx	NY	5,803	0.0	0.0%
Kings (Brooklyn)	NY	8,312	4.7	0.1%
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 Isld)	NY	8,092	8.5	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**	**13**	**0.01%**
TOTAL		**178,451**	**93**	**0.05%**

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

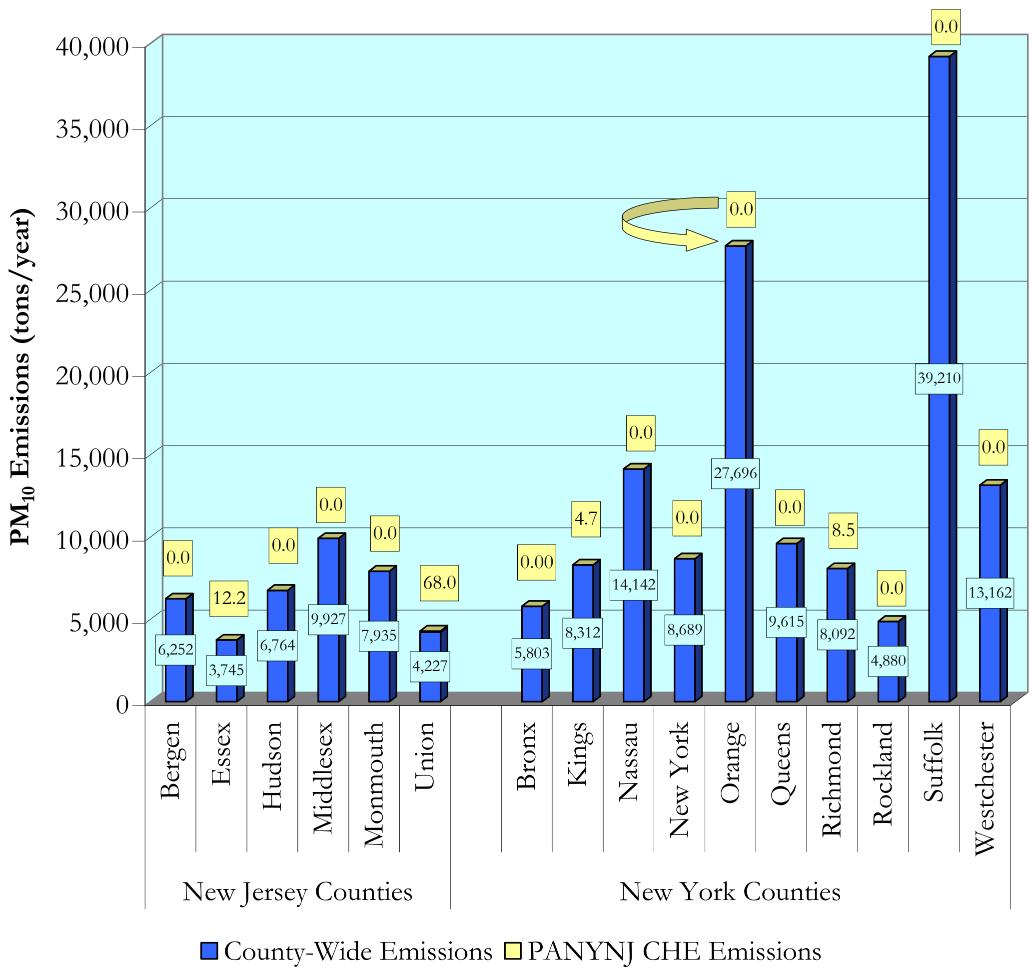


Table 2.6: Comparison of CHE $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0.0	0.0%
Essex	NJ	1,159	11.3	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	62.5	4.2%
New Jersey Subtotal		**11,567**	**74**	**0.6%**
Bronx	NY	1,357	0.0	0.0%
Kings (Brooklyn)	NY	2,676	4.4	0.2%
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 Isld)	NY	1,323	7.8	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**	**86**	**0.20%**

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

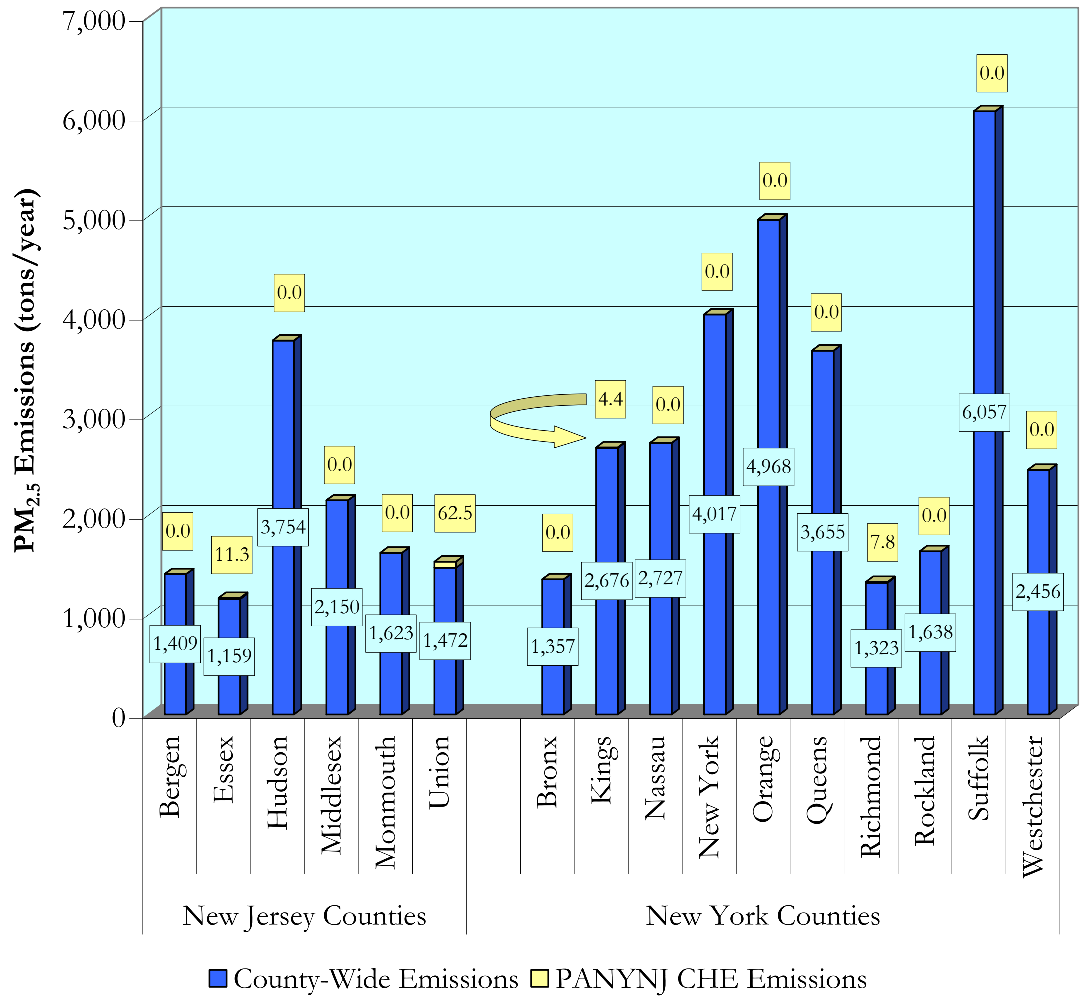


Table 2.7: Comparison of CHE VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0.0	0.0%
Essex	NJ	20,940	16.6	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	92.0	0.4%
New Jersey Subtotal		**142,075**	**109**	**0.1%**
Bronx	NY	25,454	0.0	0.0%
Kings (Brooklyn)	NY	54,809	5.3	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 Isld)	NY	13,542	10.0	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**	**15**	**0.004%**
TOTAL		**522,245**	**124**	**0.02%**

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

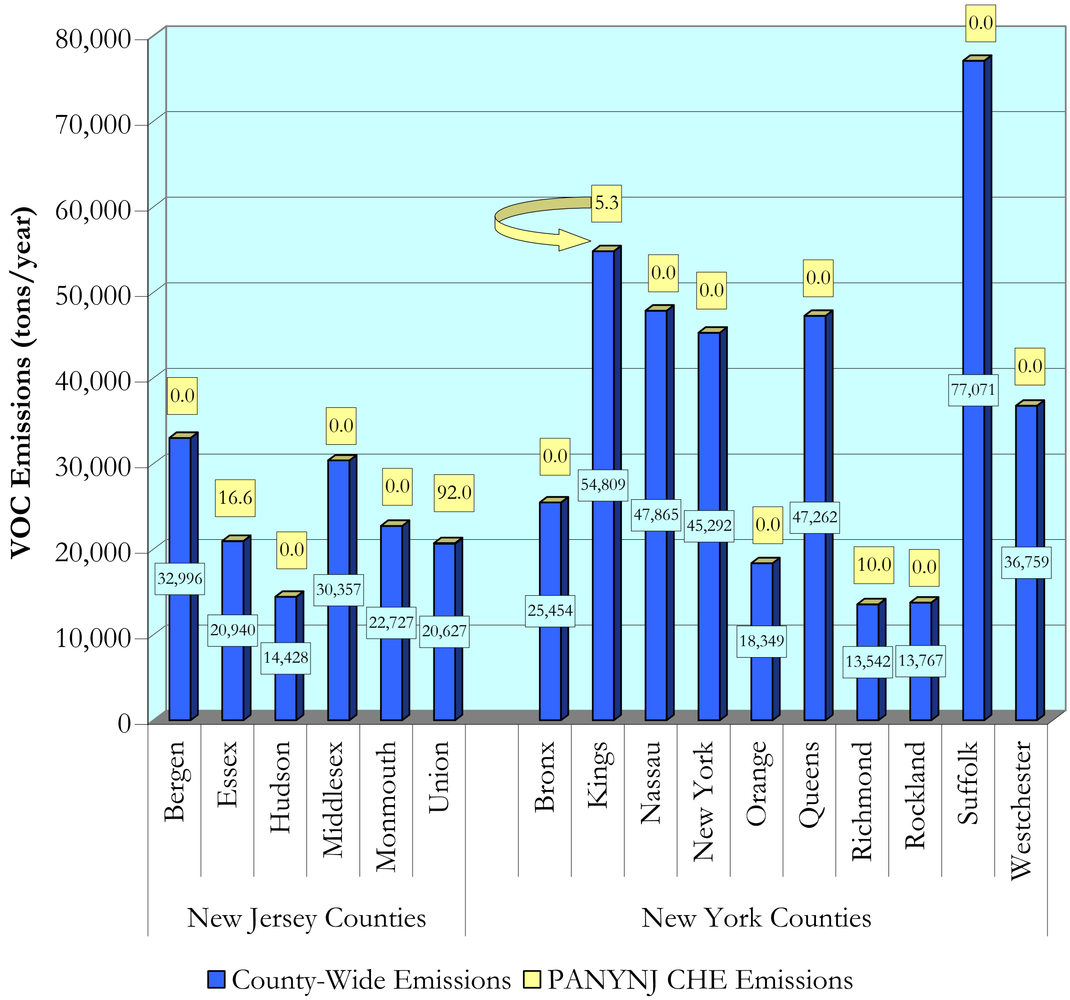


Table 2.8: Comparison of CHE CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	0.0	0.0%
Essex	NJ	131,856	91.4	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	305.3	0.3%
New Jersey Subtotal		**921,446**	**397**	**0.04%**
Bronx	NY	113,641	0.0	0.0%
Kings (Brooklyn)	NY	158,527	21.3	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 Isld)	NY	52,149	47.2	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**	**69**	**0.004%**
TOTAL		**2,840,374**	**465**	**0.02%**

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

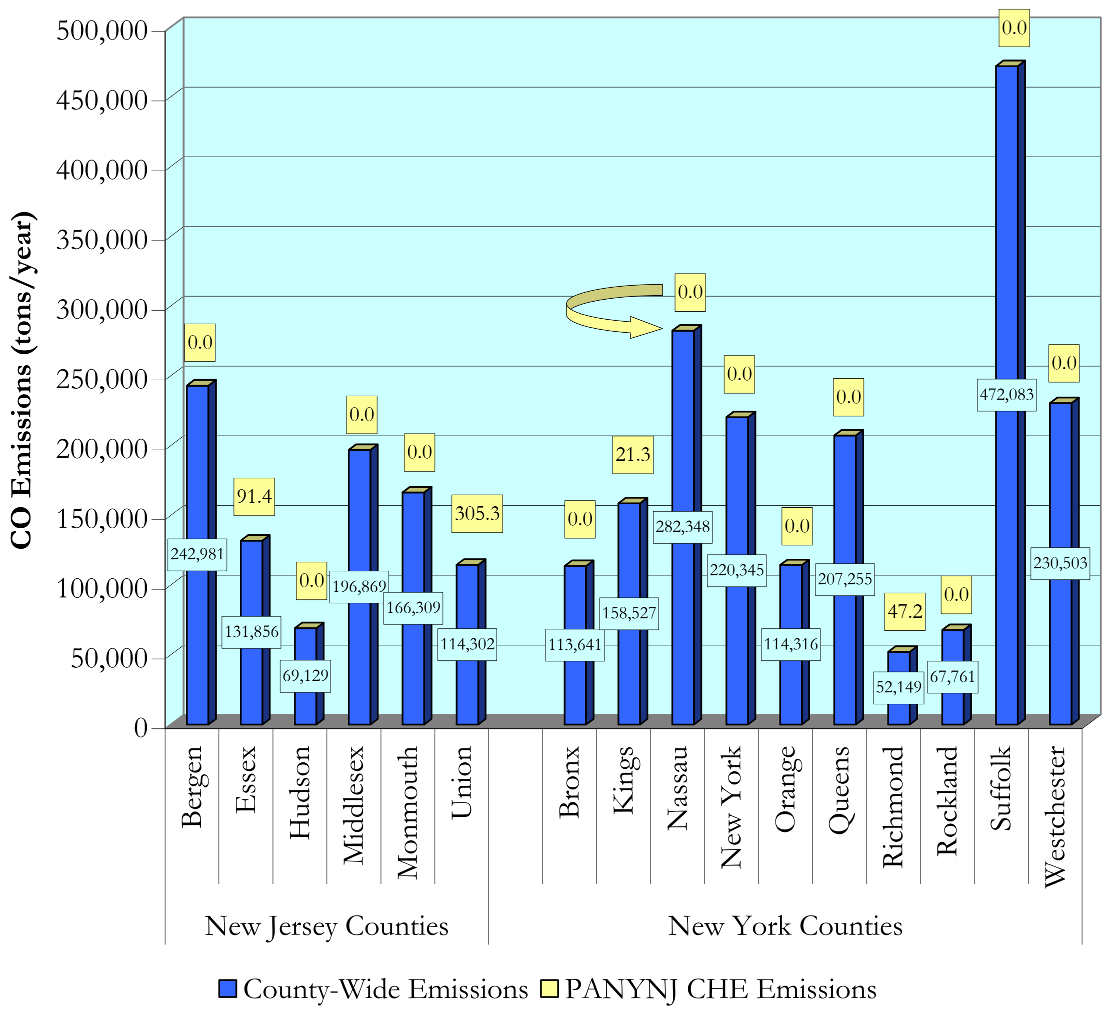
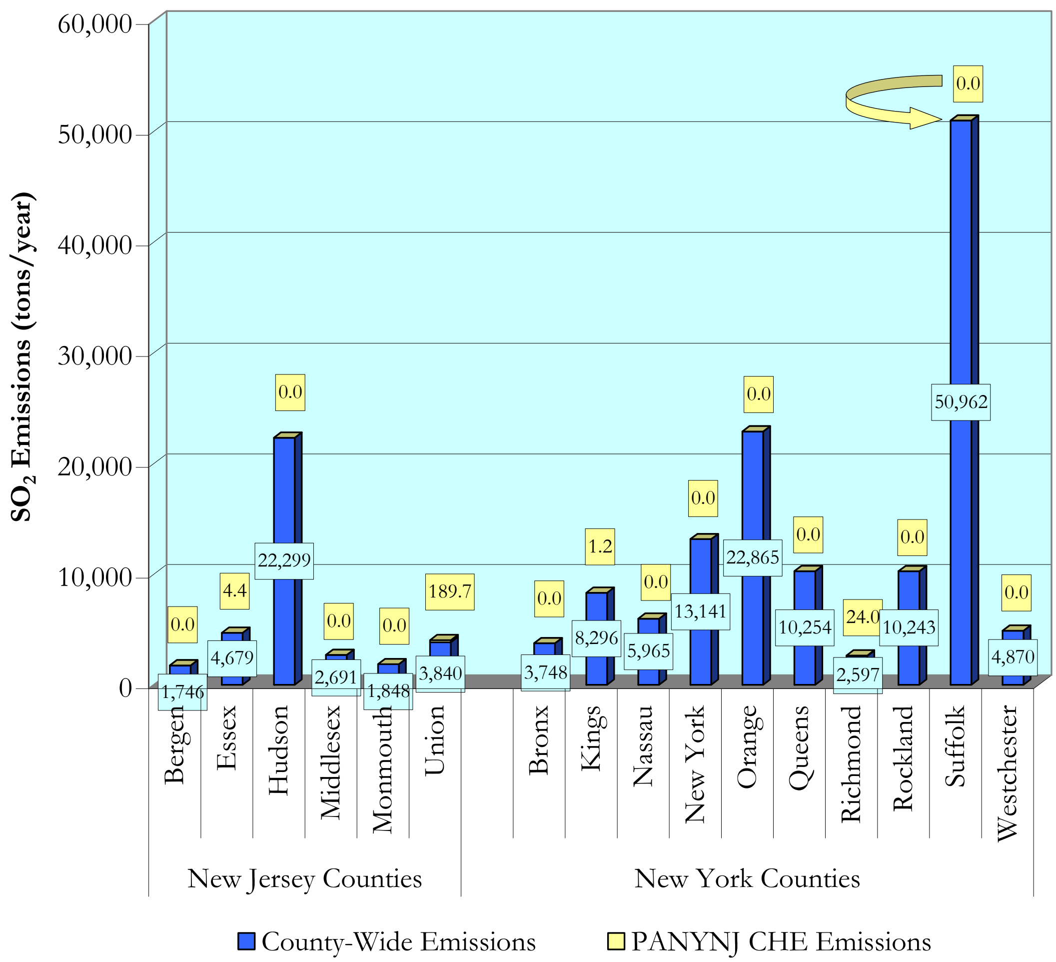


Table 2.9: Comparison of CHE SO_2. Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	CHE Emissions in Inventory	Percent of Total
Bergen	NJ	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	189.7	4.9%
New Jersey Subtotal		**37,103**	**194**	**0.5%**
Bronx	NY	3,748	0.0	0.0%
Kings (Brooklyn)	NY	8,296	1.2	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 Isld)	NY	2,597	24.0	0.9%
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**	**25**	**0.02%**
TOTAL		**170,044**	**219**	**0.13%**

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



2.3: Methodology

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

2.3.1 Data Collection

Data was collected through queries to the terminal operators requesting updates to the information they had provided for the previous emissions inventories, which had been conducted on the year 2002 and year 2004 fleets. Two terminal operators were unable to provide equipment hours of activity for use in developing the emission estimates. The activity hours for this equipment were based on previously submitted information and similar equipment types reported by the other terminals. As in the previous inventories, 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 NONROAD2005 emission estimating model.[5] 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 models or methods. 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 2004 categorizations were replicated for purposes of this 2006 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 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 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.

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

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 diesel sulfur content of 3,300 parts per million (ppm) was used. Estimated emissions of SO_2 from equipment that was reported to use on-highway fuel were adjusted using a control factor of 0.1 (assuming a 90% reduction in SO_2 compared with the use of off-road fuel), and likewise 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[6]. 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[7] 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%.[8]

[6] 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
[7] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006; April 15, 2008
[8] Derived from EPA: Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel; see: http://www.epa.gov/oms/climate/420f05001.htm

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	Count
Aerial Lift - Manlift	2270003010	11
Crane	2270002045	13
Forklift	2270003020	87
Front End Loader	2270002060	13
General Industrial Equip	2270003040	130
Generator	2270006005	1
Material Handling Equip	2270003050	260
Offroad Truck	2270002051	9
Portable Light Set or Sign	2270002027	12
Sweeper	2270003030	2
Terminal Tractor	2270003070	350
Total		**888**

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 2006 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 10% 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	342	39%	2001	204	1,783
Straddle Carrier	232	26%	2003	357	3,578
Fork Lift	87	10%	2000	107	1,481
Top Loader	51	6%	1999	274	2,829
Empty Container Handler	40	5%	2001	196	2,205
Other Primary Equipment					
Rubber Tired Gantry Crane	28	3%	2002	466	4,596
Reach Stacker	23	3%	2003	330	1,589
Stacker	11	1.2%	2000	161	2,298
RORO Hustler	7	0.8%	2000	215	1,759
Crane	7	0.8%	1990	1,750	1,799
Wharf Crane	6	0.7%	1985	812	1,102
Chassis Flipper	5	0.6%	2002	156	2,298
RORO Stacker	1	0%	1998	215	1,759
Subtotal "Other Primary Equipment"	88	10%	2000	478	2,674
Ancillary Equipment					
Portable Light Set	12	1.4%	2001	50	1,200
Aerial Platform	11	1.2%	2001	75	1,000
Bucket Loader	11	1.2%	1981	129	536
Nonroad Vehicle	6	0.7%	1998	243	1,800
Diesel Fuel Truck	3	0.3%	2004	240	1,800
Payloader	2	0.2%	2004	38	250
Sweeper	2	0.2%	2005	51	1,000
Portable Gen Set	1	0%	2003	610	1,200
Subtotal "Ancillary Equipment"	48	5%	1996	121	1,067
Total Population	888				

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

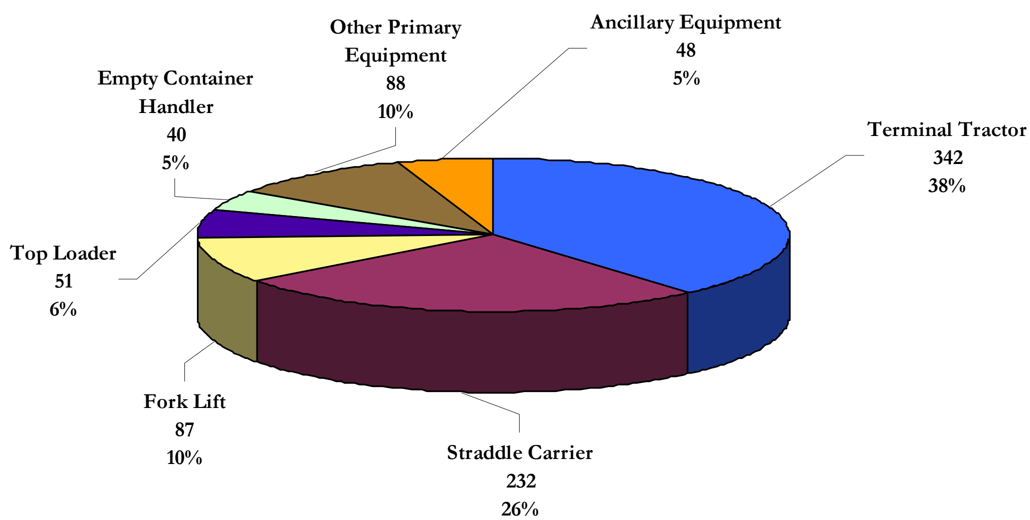
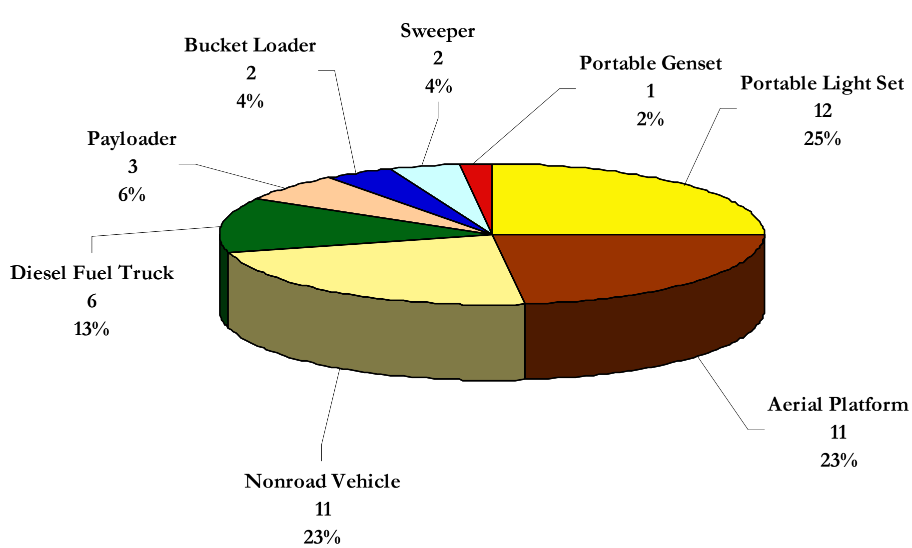


Figure 2.10: Population Distribution of Ancillary Equipment, by Number and Percent



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	2001	1995	2006
Straddle Carrier	2003	1998	2006
Fork Lift	2000	1970	2006
Top Loader	1999	1991	2005
Empty Container Handler	2001	1989	2006
Reach Stacker	2003	1999	2006
Rubber Tired Gantry Crane	2002	1992	2006
Stacker	2000	1999	2004
Crane	1990	1988	2000
RORO Hustler	2000	1999	2000
RORO Stacker	1998	1998	1998
Wharf Crane	1985	1968	1998
Chassis Flipper	2002	1998	2006

Figure 2.11: Model Year Distribution of Terminal Tractors

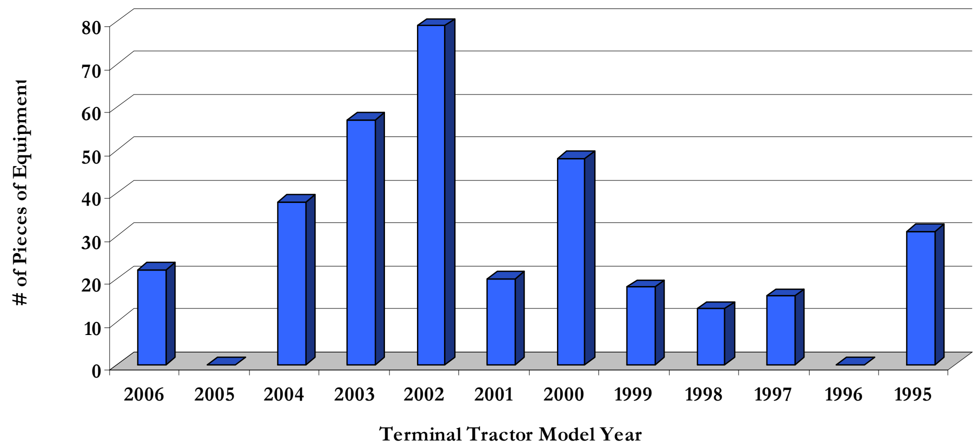


Figure 2.12: Model Year Distribution of Straddle Carriers

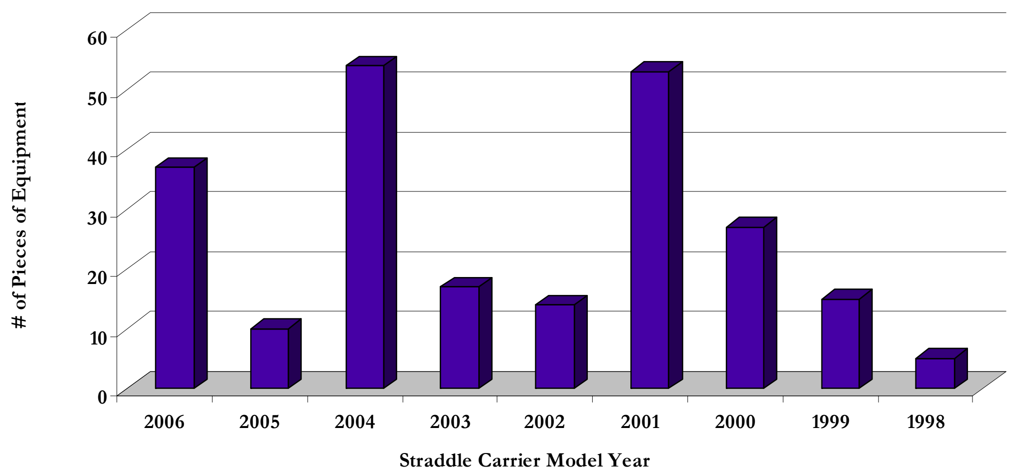


Table 2.14 presents information on the horsepower ratings of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.13 and 2.14 illustrate the number of terminal tractors and straddle carriers in each horsepower group. The straddle carriers in the 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	357	320	386
Fork Lift	107	40	226
Top Loader	274	200	330
Empty Container Handler	196	160	240
Rubber Tired Gantry Crane	466	450	475
Reach Stacker	330	330	330
Stacker	161	152	200
Roro Hustler	215	215	215
Crane	1,750	1,750	1,750
Wharf Crane	812	500	950
Chassis Flipper	156	152	160
Roro Stacker	215	215	215

Figure 2.13: Horsepower Distribution of Terminal Tractors

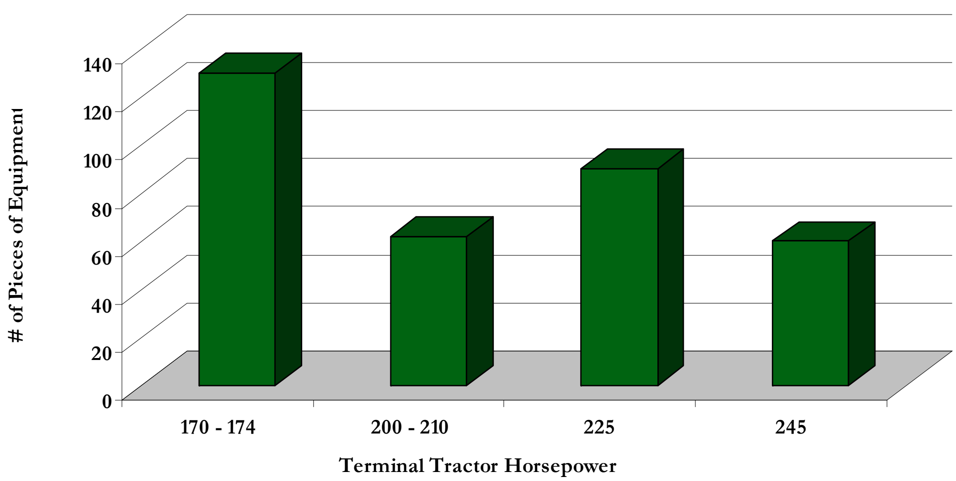


Figure 2.14: Horsepower Distribution of Straddle Carriers

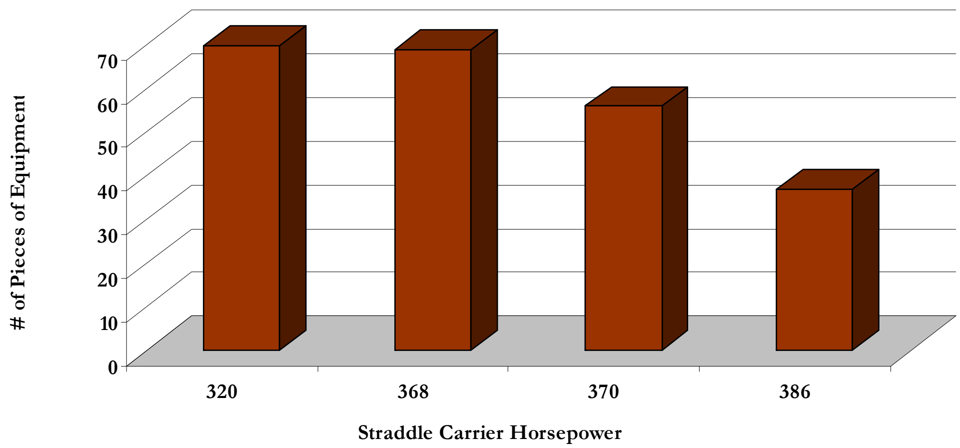


Table 2.15 presents information on the reported annual operating hours of the various types of primary cargo handling equipment – the average, the lowest, and the highest. Figures 2.15 and 2.16 illustrate the variation in reported terminal tractor and straddle carrier operating hours, respectively. The straddle carrier operating hours did not vary significantly, as shown by the very close minimum and maximum hourly operating rates shown in Table 2.15. The two terminal operators with straddle carriers in their equipment fleets each reported a single average operating time for all straddle carriers at their terminals, most likely due to a lack of equipment specific operating data.

Table 2.15: Reported Operating Hours of Primary CHE

Equipment Type	Average hrs/year	Min hrs/year	Max hrs/year
Terminal Tractor	1,783	35	2,300
Straddle Carrier	3,578	3,357	3,673
Fork Lift	1,481	150	4,700
Top Loader	2,829	800	3,800
Empty Container Handler	2,205	1,932	2,548
Reach Stacker	1,589	1,000	2,298
Rubber Tired Gantry Crane	4,596	3,510	4,680
Stacker	2,298	2,298	2,298
Crane	1,799	1,799	1,799
RORO Hustler	1,759	1,759	1,759
RORO Stacker	1,759	1,759	1,759
Wharf Crane	1,102	500	1,800
Chassis Flipper	2,298	2,298	2,298

Figure 2.15: Distribution of Annual Operating Hours for Terminal Tractors

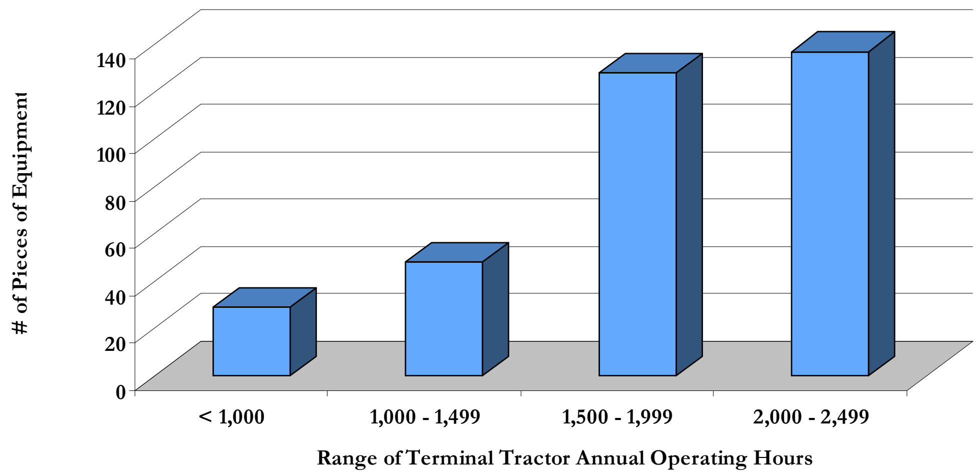
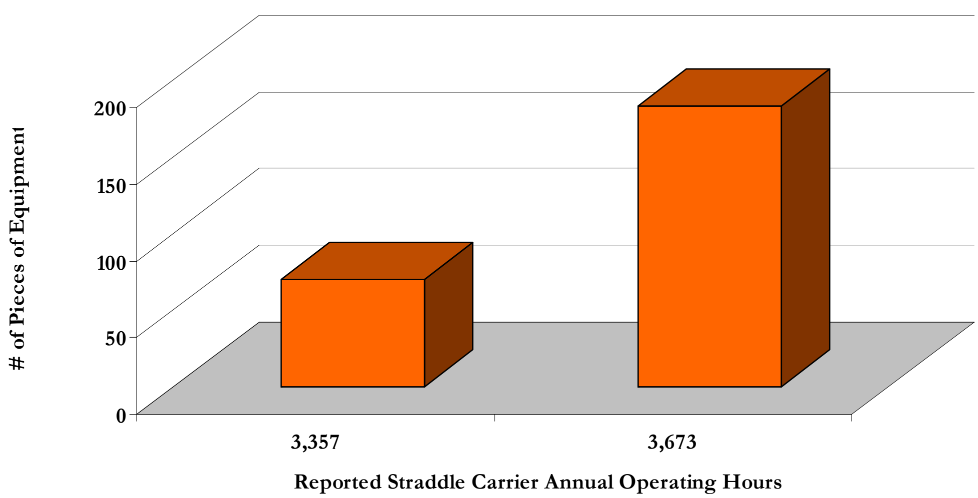


Figure 2.16: Distribution of Annual Operating Hours for Straddle Carriers



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
Nonroad Vehicle	1998	1985	2006
Diesel Fuel Truck	2004	2002	2006
Payloader	2004	2004	2004
Bucket Loader	1981	1974	1997
Sweeper	2005	2005	2005
Portable Genset	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
Nonroad Vehicle	243	210	325
Diesel Fuel Truck	240	240	240
Payloader	38	38	38
Bucket Loader	129	125	140
Sweeper	51	38	63
Portable Genset	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	1,200	1,200	1,200
Aerial Platform	1,000	1,000	1,000
Nonroad Vehicle	1,800	1,800	1,800
Diesel Fuel Truck	1,800	1,800	1,800
Payloader	250	250	250
Bucket Loader	536	100	700
Sweeper	1,000	1,000	1,000
Portable Genset	1,200	1,200	1,200

The following figures2.17 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

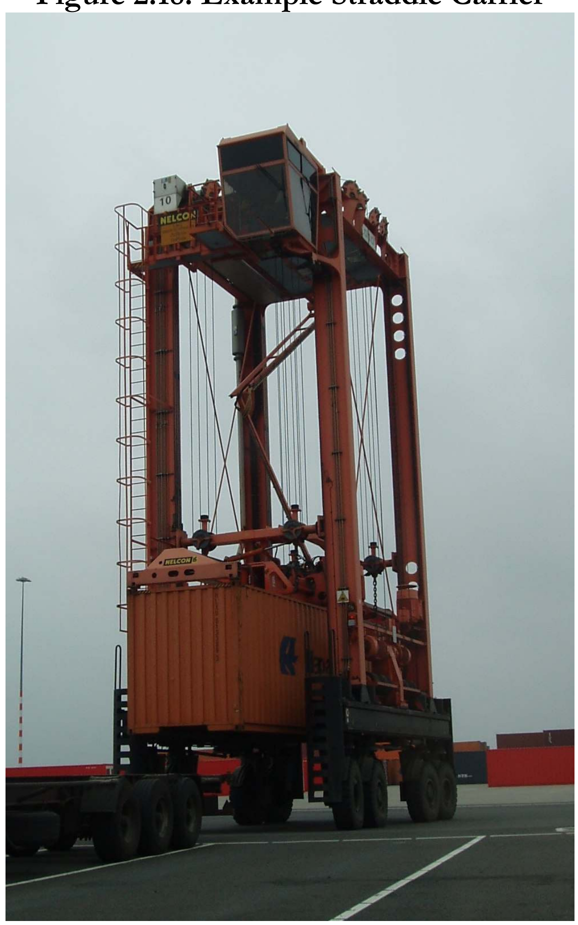


Figure 2.19: Example Fork Lift

Figure 2.17: Example Top Loader

Figure 2.17: 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 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.

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

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

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	1,935	59	54	87	564	26
Percent of NYNJLINA Emissions	0.43%	0.03%	0.13%	0.02%	0.02%	0.02%

The following figures illustrate the distribution of PANYNJ HDDV emissions by activity and location (on-road driving, on-terminal driving and idling) in terms of tons per year and percent of total HDDV emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Due to rounding in these figures, the percentage of Port Authority HDDV emissions compared with overall NYNJLINA emissions is displayed as zero (0) in the figures. The actual percentage of Port Authority HDDV emissions is displayed above in Table ES3.1.

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

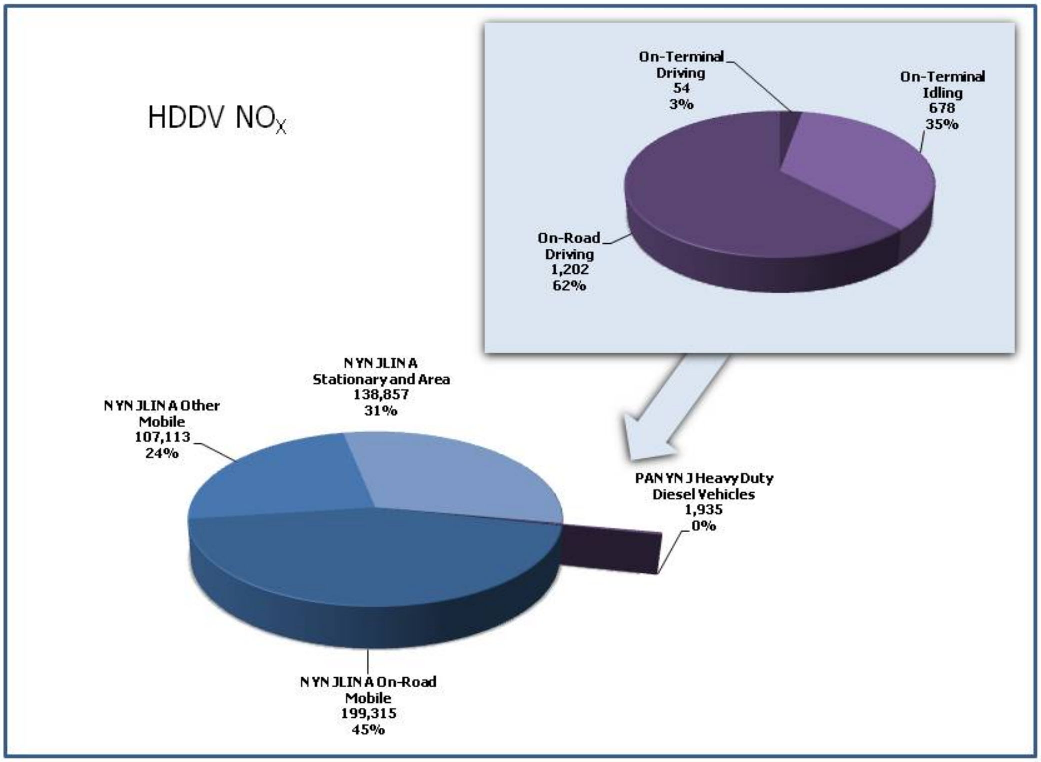


Figure ES3.3: Distribution and Comparison of PM_{10} from HDDVs, tpy and percent

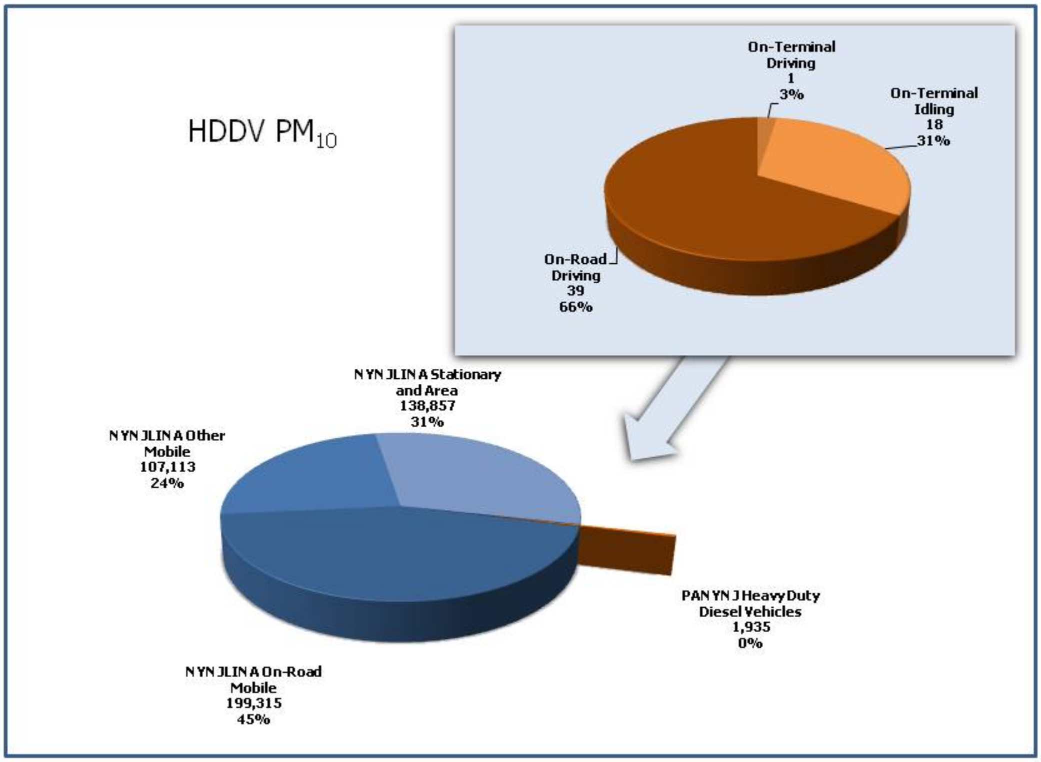


Figure ES3.4: Distribution and Comparison of $PM_{2.5}$ from HDDVs, tpy and percent

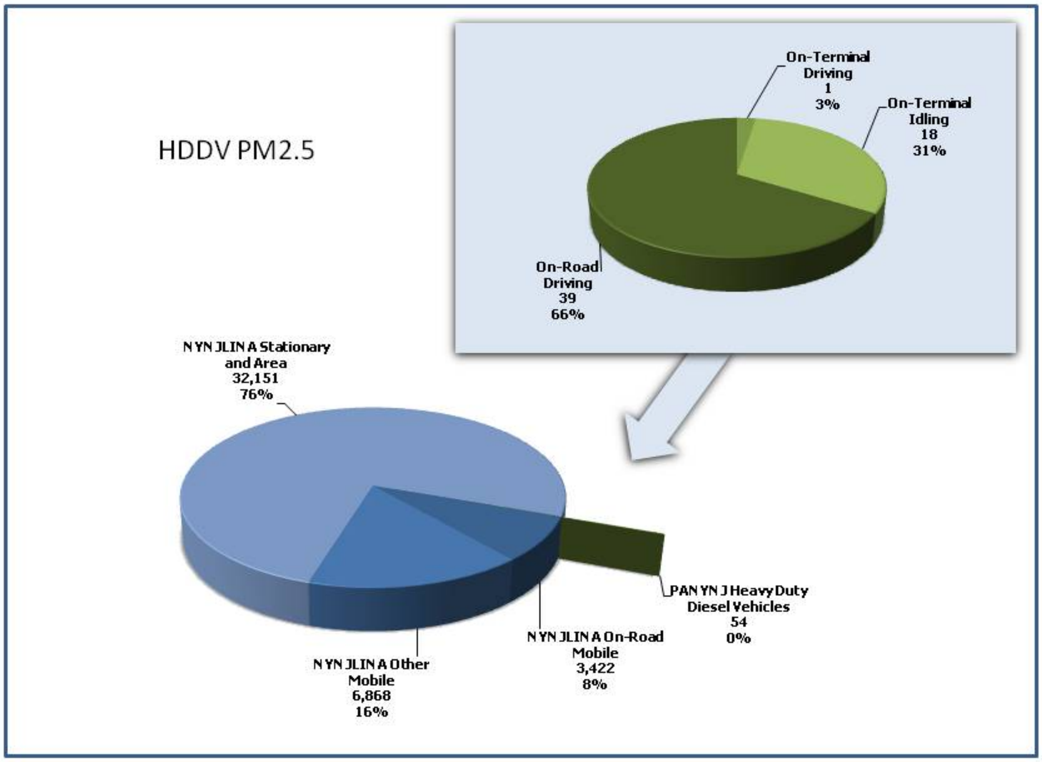


Figure ES3.5: Distribution and Comparison of VOC from HDDVs, tpy and percent

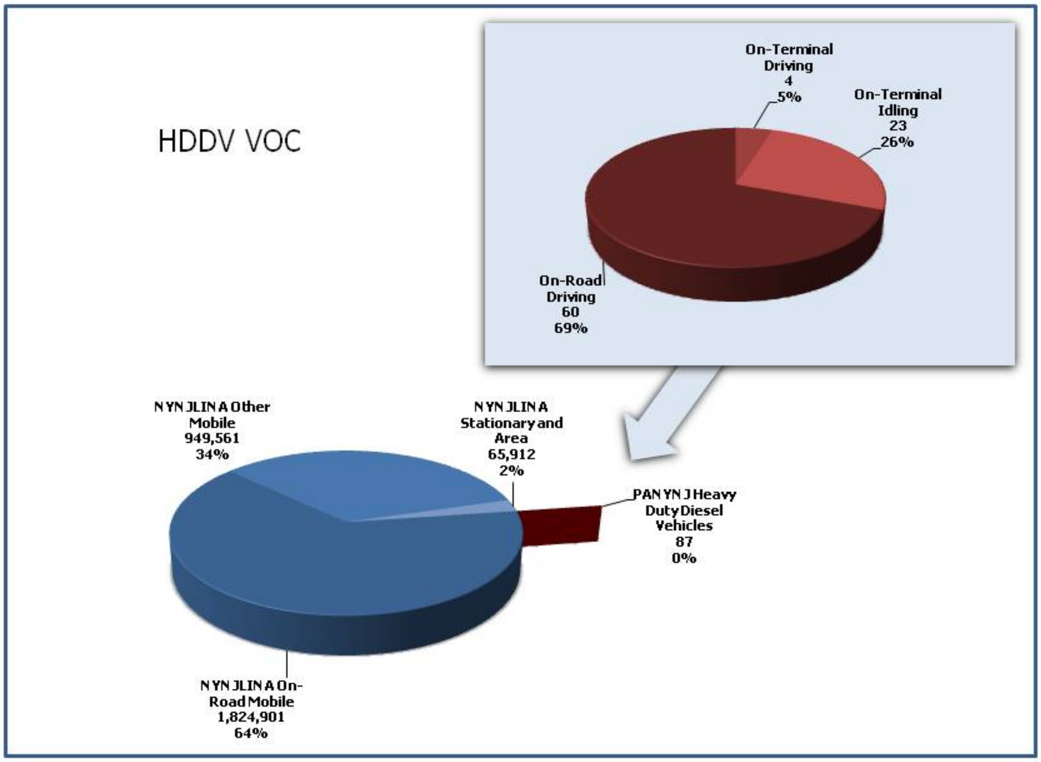


Figure ES3.6: Distribution and Comparison of CO from HDDVs, tpy and percent

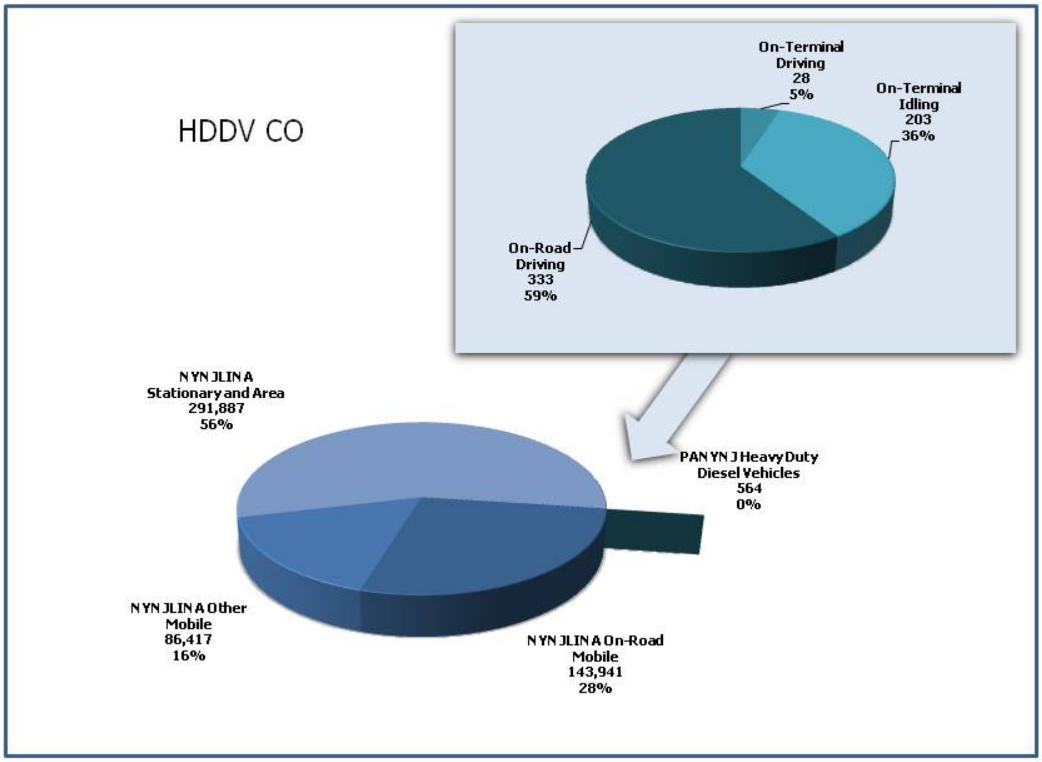
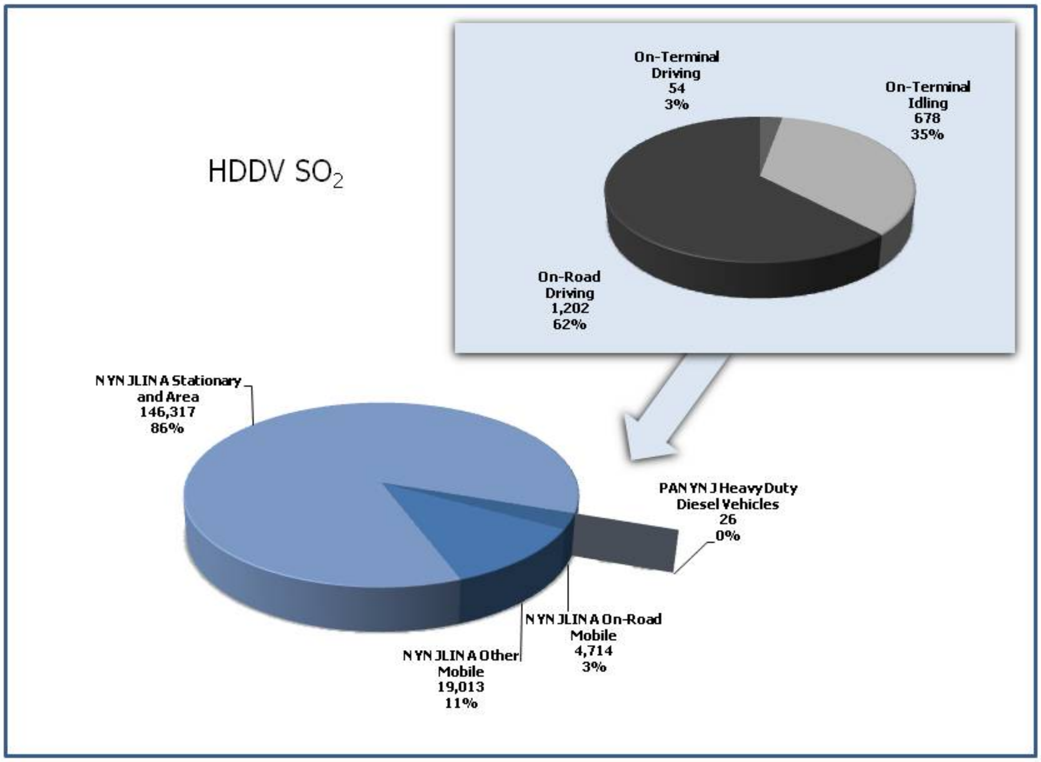


Figure ES3.7: Distribution and Comparison of SO_2 from HDDVs, tpy and percent



3.1 Heavy Duty Diesel Vehicle Emission Estimates

On-terminal and on-road emissions have been estimated for HDDV maritime operations. 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 Tables 3.2, and of greenhouse gas emissions in Table 3.3. Tables 3.4 and 3.5 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 3.6 and 3.7.

Table 3.2: 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	31,880	0.4	0.01	0.01	0.03	0.2	0.01
Container Terms	3,444,234	51.9	1.38	1.27	3.99	26.7	1.28
Warehouses	138,759	2.0	0.05	0.05	0.16	1.0	0.05
Overall Total	**3,614,873**	**54.3**	**1.44**	**1.33**	**4.18**	**27.9**	**1.34**

Table 3.3: Summary of HDDV On-Terminal Driving Greenhouse Gas Emissions (tpy)

Facility Type	VMT	CO_2	N_2O	CH_4	CO_2 Equivalent
Auto Terminals	31,880	55	0.0002	0.0002	55
Container Terms	3,444,234	6,228	0.018	0.019	6,234
Warehouses	138,759	248	0.001	0.001	248
Overall Total	**3,614,873**	**6,531**	**0.02**	**0.02**	**6,537**

Table 3.4: 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	138,590	20.6	0.56	0.52	0.80	7.1	0.12
Container Terms	4,283,948	637.5	17.38	15.99	21.03	189.6	3.96
Warehouses	137,002	20.2	0.55	0.51	0.70	6.3	0.13
Overall Total	**4,559,539**	**678.3**	**18.49**	**17.02**	**22.53**	**203.0**	**4.21**

Table 3.5: 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	138,590	608	0.002	0.002	609
Container Terms	4,283,948	19,310	0.068	0.063	19,333
Warehouses	137,002	614	0.002	0.002	614
Overall Total	**4,559,539**	**20,532**	**0.07**	**0.07**	**20,556**

Table 3.6: 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	31,880	138,590	21.0	0.57	0.53	0.83	7.3	0.14
Container Terms	3,444,234	4,283,948	689.4	18.76	17.26	25.01	216.4	5.24
Warehouses	138,759	137,002	22.2	0.60	0.56	0.85	7.3	0.18
Overall Total	**3,614,873**	**4,559,539**	**732.6**	**19.93**	**18.35**	**26.69**	**231.0**	**5.56**

Table 3.7: 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	31,880	138,590	663	0.002	0.002	664
Container Terms	3,444,234	4,283,948	25,538	0.086	0.083	25,566
Warehouses	138,759	137,002	862	0.003	0.003	863
Overall Total	**3,614,873**	**4,559,539**	**27,063**	**0.09**	**0.09**	**27,093**

3.1.2 On-Road Emissions

Table 3.8 presents estimates of on-road, off-terminal criteria pollutant emissions by state (tpy) for the container terminal truck calls, and Table 3.9 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 3.8: 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	80,761,152	968	31.5	28.9	48.3	268.0	16.3
New York	19,526,580	234	7.6	7.0	11.7	64.8	3.9
Total	**100,287,733**	**1,202**	**39.1**	**35.9**	**60.0**	**332.8**	**20.2**

Table 3.9: Summary of HDDV On-Road Greenhouse Gas Emissions by State (tpy)

State	VMT	CO_2	N_2O	CH_4	CO_2 Eq
New Jersey	80,761,152	146,032	0.43	0.45	146,044
New York	19,526,580	35,308	0.10	0.11	35,308
Total	**100,287,733**	**181,340**	**0.53**	**0.56**	**181,352**

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 3.10 (criteria pollutants) and Table 3.11 (greenhouse gases).

Table 3.10: Total Marine Terminal Criteria Pollutant Emission Estimates, tpy

Activity Component	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
On-Terminal Driving	54.3	1.44	1.33	4.18	27.9	1.3
On-Terminal Idling	678.3	18.49	17.02	22.53	203.0	4.21
On-Road Driving	1,202	39.1	35.9	60.0	332.8	20.2
Totals	**1,935**	**59**	**54**	**87**	**564**	**26**

Table 3.11: Total Marine Terminal Greenhouse Gas Emission Estimates, tpy

Activity Component	CO2	N2O	CH4	CO2 Equivalent
On-Terminal Driving	6,531	0.019	0.020	6,537
On-Terminal Idling	20,532	0.072	0.067	20,556
On-Road Driving	181,340	0.53	0.56	181,352
Totals	**208,403**	**0.62**	**0.65**	**208,446**

3.2: Heavy Duty Diesel Vehicle Emission Comparisons

This section presents the heavy duty truck emission estimates detailed in the section 3.1 in the context of county-wide and non-attainment area-wide emissions. Port Authority maritime 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. [9]

Table 3.12 summarizes estimated criteria pollutant emissions from the Port Authority maritime heavy duty truck related activities reported in this current inventory, at the county level. Subsequent Tables 3.13 through 3.18 examine each pollutant individually, comparing Port Authority 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 truck contribution to total emissions is stacked on top of the countywide column.

[9] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008, http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata

Table 3.12: 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	82	2.7	2.5	4.1	22.8	1.4
Essex	NJ	434	13.5	12.4	20.5	126.8	6.4
Hudson	NJ	173	5.6	5.1	8.5	48.3	2.8
Middlesex	NJ	270	8.8	8.1	13.5	74.7	4.5
Monmouth	NJ	19	0.6	0.6	1.0	5.3	0.3
Union	NJ	523	14.8	13.7	20.8	161.2	5.1
New Jersey subtotal		**1,501**	**45.9**	**42.3**	**68.3**	**439.0**	**20.6**
Bronx	NY	27	0.9	0.8	1.4	7.6	0.5
Kings (Brooklyn)	NY	73	2.3	2.1	3.4	20.8	1.1
Nassau	NY	41	1.3	1.2	2.1	11.4	0.7
New York	NY	9	0.3	0.3	0.5	2.6	0.2
Orange	NY	22	0.7	0.7	1.1	6.1	0.4
Queens	NY	24	0.8	0.7	1.2	6.7	0.4
Richmond (Staten Isla	NY	190	5.2	4.8	6.4	56.5	1.3
Rockland	NY	3	0.1	0.1	0.2	0.9	0.1
Suffolk	NY	20	0.6	0.6	1.0	5.5	0.3
Westchester	NY	24	0.8	0.7	1.2	6.6	0.4
New York subtotal		**435**	**13.1**	**12.0**	**18.4**	**124.8**	**5.2**
TOTAL		**1,935**	**59**	**54**	**87**	**564**	**26**

Table 3.13: 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	82	0.32%
Essex	NJ	23,498	434	1.85%
Hudson	NJ	27,776	173	0.62%
Middlesex	NJ	33,000	270	0.82%
Monmouth	NJ	19,177	19	0.10%
Union	NJ	21,154	523	2.47%
New Jersey Subtotal		**150,577**	**1,501**	**1.0%**
Bronx	NY	16,018	27	0.17%
Kings (Brooklyn)	NY	29,788	73	0.25%
Nassau	NY	36,258	41	0.11%
New York	NY	39,082	9	0.02%
Orange	NY	19,397	22	0.11%
Queens	NY	41,172	24	0.06%
Richmond (Staten Isla	NY	10,085	190	1.88%
Rockland	NY	13,645	3	0.02%
Suffolk	NY	61,223	20	0.03%
Westchester	NY	28,040	24	0.09%
New York Subtotal		**294,708**	**435**	**0.1%**
TOTAL		**445,285**	**1,935**	**0.43%**

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

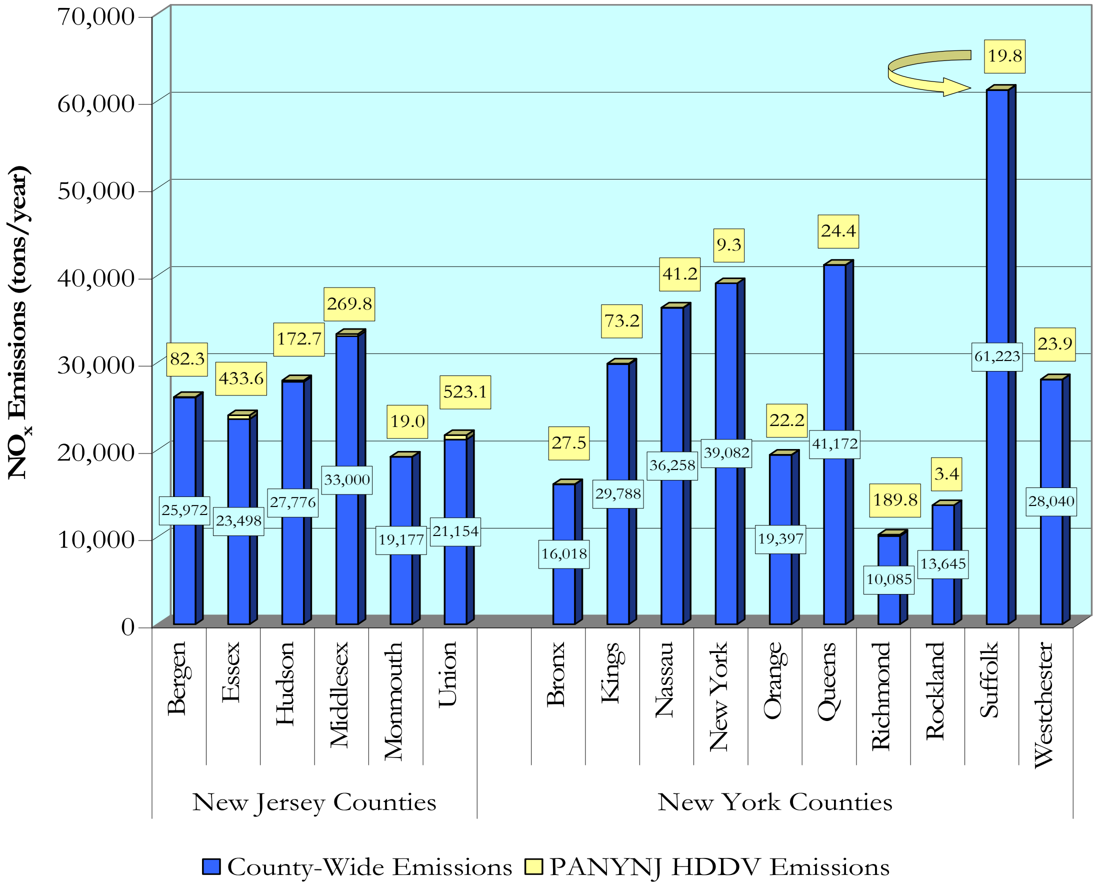


Table 3.14: Comparison of Heavy-duty Diesel Vehicle PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	2.7	0.04%
Essex	NJ	3,745	13.5	0.36%
Hudson	NJ	6,764	5.6	0.08%
Middlesex	NJ	9,927	8.8	0.09%
Monmouth	NJ	7,935	0.6	0.008%
Union	NJ	4,227	14.8	0.4%
New Jersey Subtotal		**38,850**	**46**	**0.1%**
Bronx	NY	5,803	0.9	0.02%
Kings (Brooklyn)	NY	8,312	2.3	0.03%
Nassau	NY	14,142	1.3	0.009%
New York	NY	8,689	0.3	0.003%
Orange	NY	27,696	0.7	0.003%
Queens	NY	9,615	0.8	0.008%
Richmond (Staten Isla	NY	8,092	5.2	0.06%
Rockland	NY	4,880	0.1	0.002%
Suffolk	NY	39,210	0.6	0.002%
Westchester	NY	13,162	0.8	0.006%
New York Subtotal		**139,601**	**13**	**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

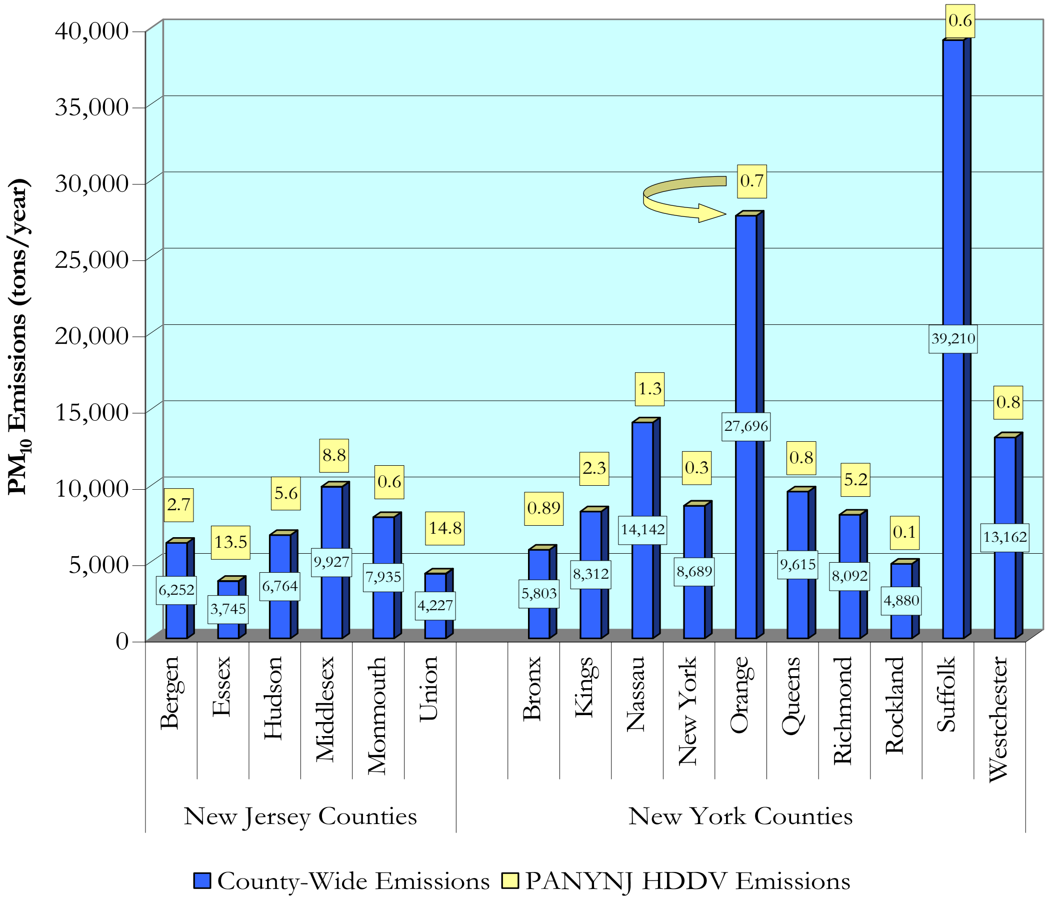


Table 3.15 : Comparison of Heavy-duty Diesel Vehicle $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	2.5	0.17%
Essex	NJ	1,159	12.4	1.07%
Hudson	NJ	3,754	5.1	0.14%
Middlesex	NJ	2,150	8.1	0.37%
Monmouth	NJ	1,623	0.6	0.04%
Union	NJ	1,472	13.7	0.93%
New Jersey Subtotal		**11,567**	**42**	**0.4%**
Bronx	NY	1,357	0.8	0.06%
Kings (Brooklyn)	NY	2,676	2.1	0.08%
Nassau	NY	2,727	1.2	0.05%
New York	NY	4,017	0.3	0.007%
Orange	NY	4,968	0.7	0.01%
Queens	NY	3,655	0.7	0.02%
Richmond (Staten Isla	NY	1,323	4.8	0.36%
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**	**12**	**0.04%**
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

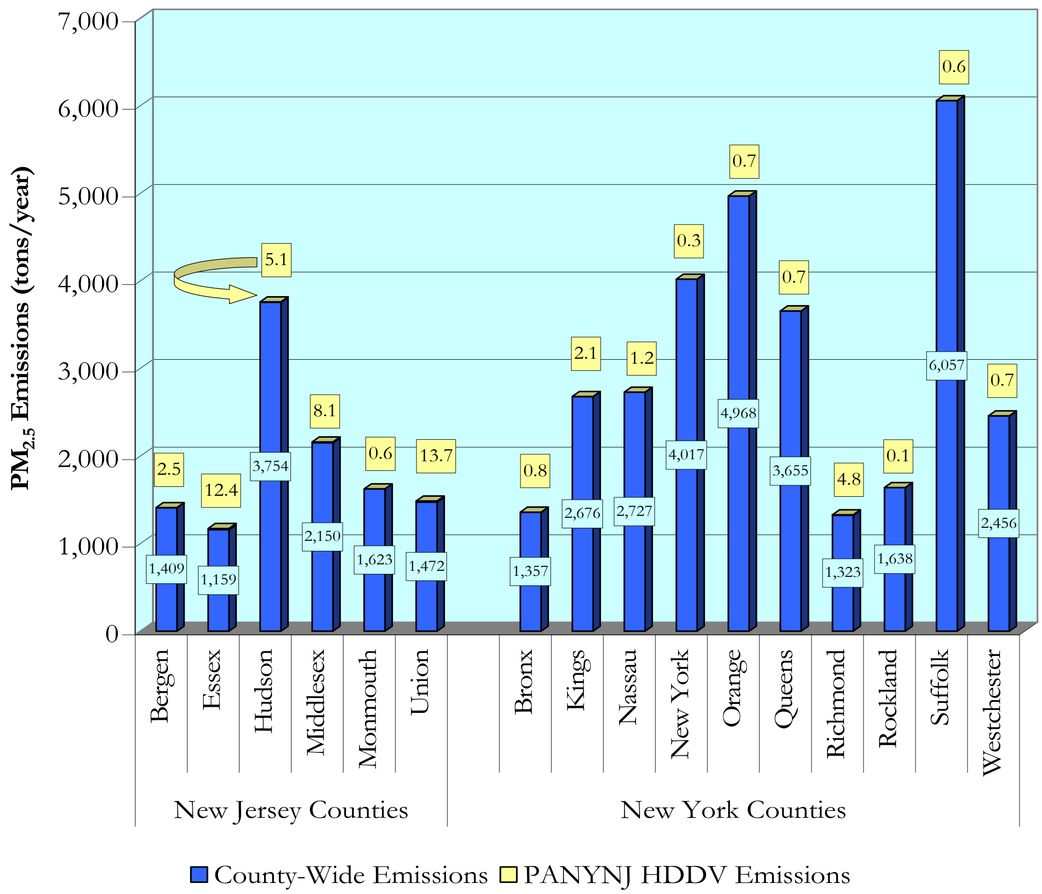


Table 3.16: Comparison of Heavy-duty Diesel Vehicle VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	4	0.01%
Essex	NJ	20,940	21	0.10%
Hudson	NJ	14,428	9	0.06%
Middlesex	NJ	30,357	13	0.04%
Monmouth	NJ	22,727	1	0.004%
Union	NJ	20,627	21	0.10%
New Jersey Subtotal		**142,075**	**68**	**0.05%**
Bronx	NY	25,454	1.4	0.005%
Kings (Brooklyn)	NY	54,809	3.4	0.006%
Nassau	NY	47,865	2.1	0.004%
New York	NY	45,292	0.5	0.001%
Orange	NY	18,349	1.1	0.006%
Queens	NY	47,262	1.2	0.003%
Richmond (Staten Isla	NY	13,542	6.4	0.047%
Rockland	NY	13,767	0.2	0.001%
Suffolk	NY	77,071	1.0	0.001%
Westchester	NY	36,759	1.2	0.003%
New York Subtotal		**380,170**	**18**	**0.005%**
TOTAL		**522,245**	**87**	**0.02%**

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

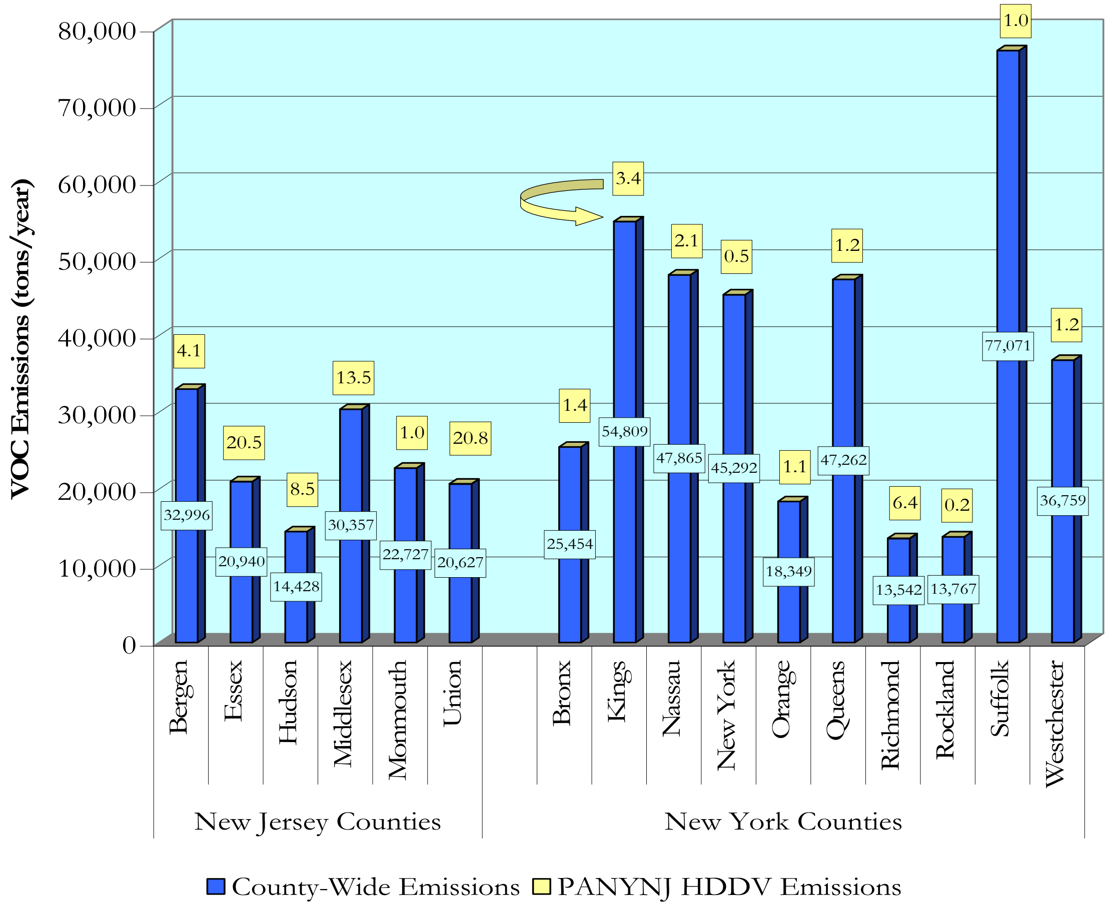


Table 3.17: Comparison of Heavy-duty Diesel Vehicle CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	23	0.009%
Essex	NJ	131,856	127	0.096%
Hudson	NJ	69,129	48	0.070%
Middlesex	NJ	196,869	75	0.038%
Monmouth	NJ	166,309	5	0.003%
Union	NJ	114,302	161	0.141%
New Jersey Subtotal		**921,446**	**439**	**0.05%**
Bronx	NY	113,641	8	0.007%
Kings (Brooklyn)	NY	158,527	21	0.013%
Nassau	NY	282,348	11	0.004%
New York	NY	220,345	3	0.001%
Orange	NY	114,316	6	0.005%
Queens	NY	207,255	7	0.003%
Richmond (Staten Isla	NY	52,149	56	0.108%
Rockland	NY	67,761	0.9	0.001%
Suffolk	NY	472,083	5	0.001%
Westchester	NY	230,503	7	0.003%
New York Subtotal		**1,918,928**	**125**	**0.007%**
TOTAL		**2,840,374**	**564**	**0.02%**

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

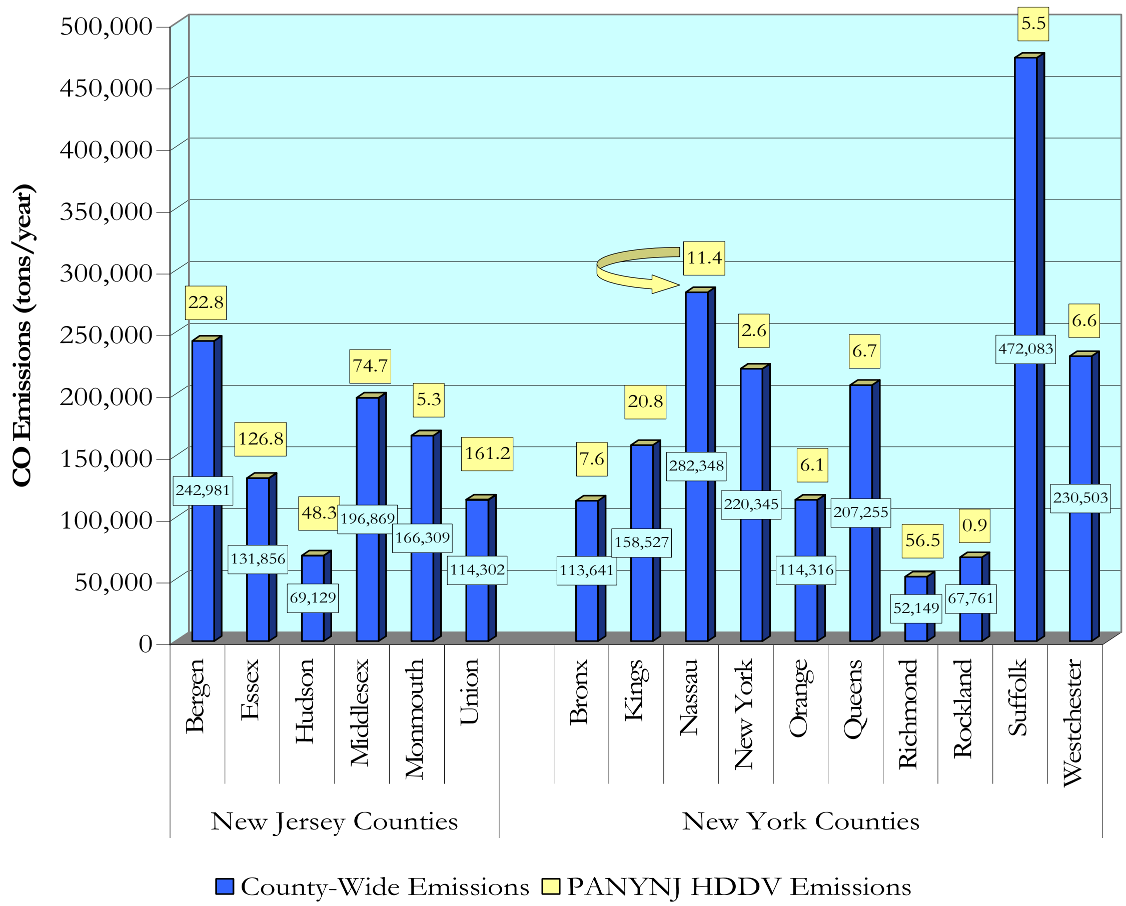
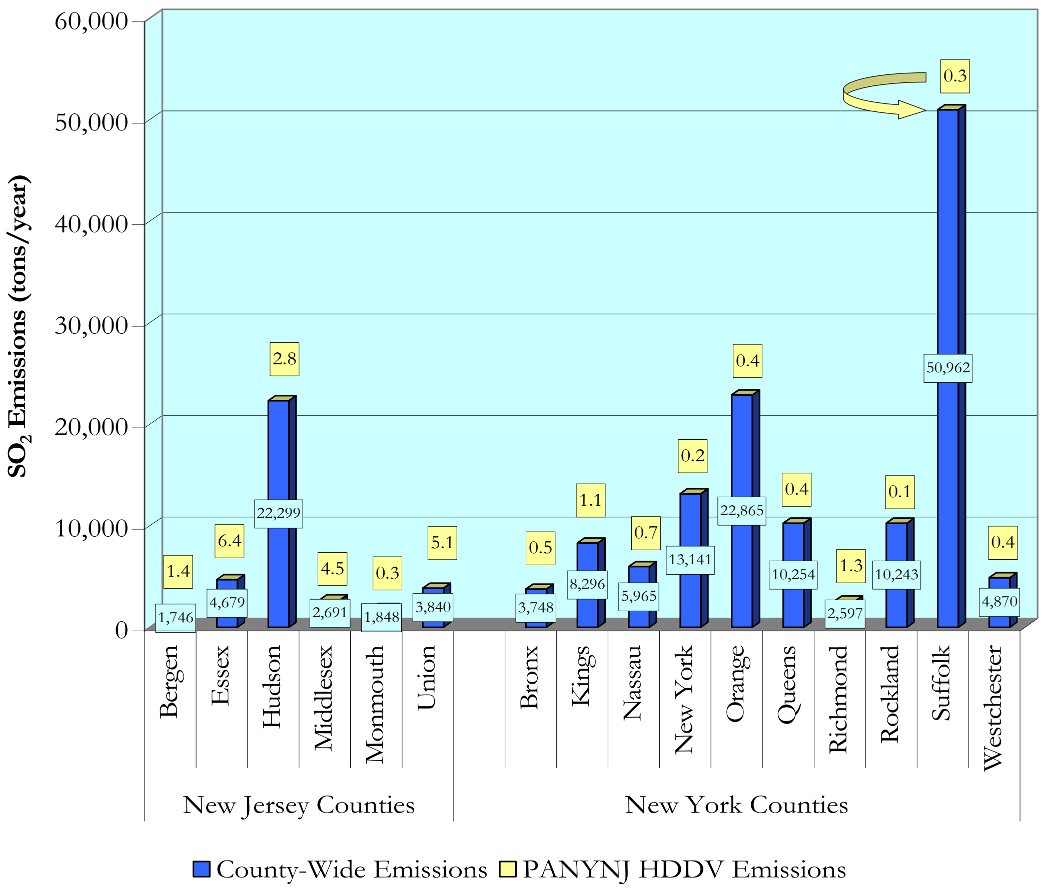


Table 3.18: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	HDDV Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	1.4	0.08%
Essex	NJ	4,679	6.4	0.14%
Hudson	NJ	22,299	2.8	0.01%
Middlesex	NJ	2,691	4.5	0.17%
Monmouth	NJ	1,848	0.3	0.02%
Union	NJ	3,840	5.1	0.13%
New Jersey Subtotal		**37,103**	**21**	**0.1%**
Bronx	NY	3,748	0.5	0.01%
Kings (Brooklyn)	NY	8,296	1.1	0.01%
Nassau	NY	5,965	0.7	0.01%
New York	NY	13,141	0.2	0.001%
Orange	NY	22,865	0.4	0.002%
Queens	NY	10,254	0.4	0.004%
Richmond (Staten Isla	NY	2,597	1.3	0.05%
Rockland	NY	10,243	0.1	0.001%
Suffolk	NY	50,962	0.3	0.001%
Westchester	NY	4,870	0.4	0.008%
New York Subtotal		**132,941**	**5**	**0.004%**
TOTAL		**170,044**	**26**	**0.02%**

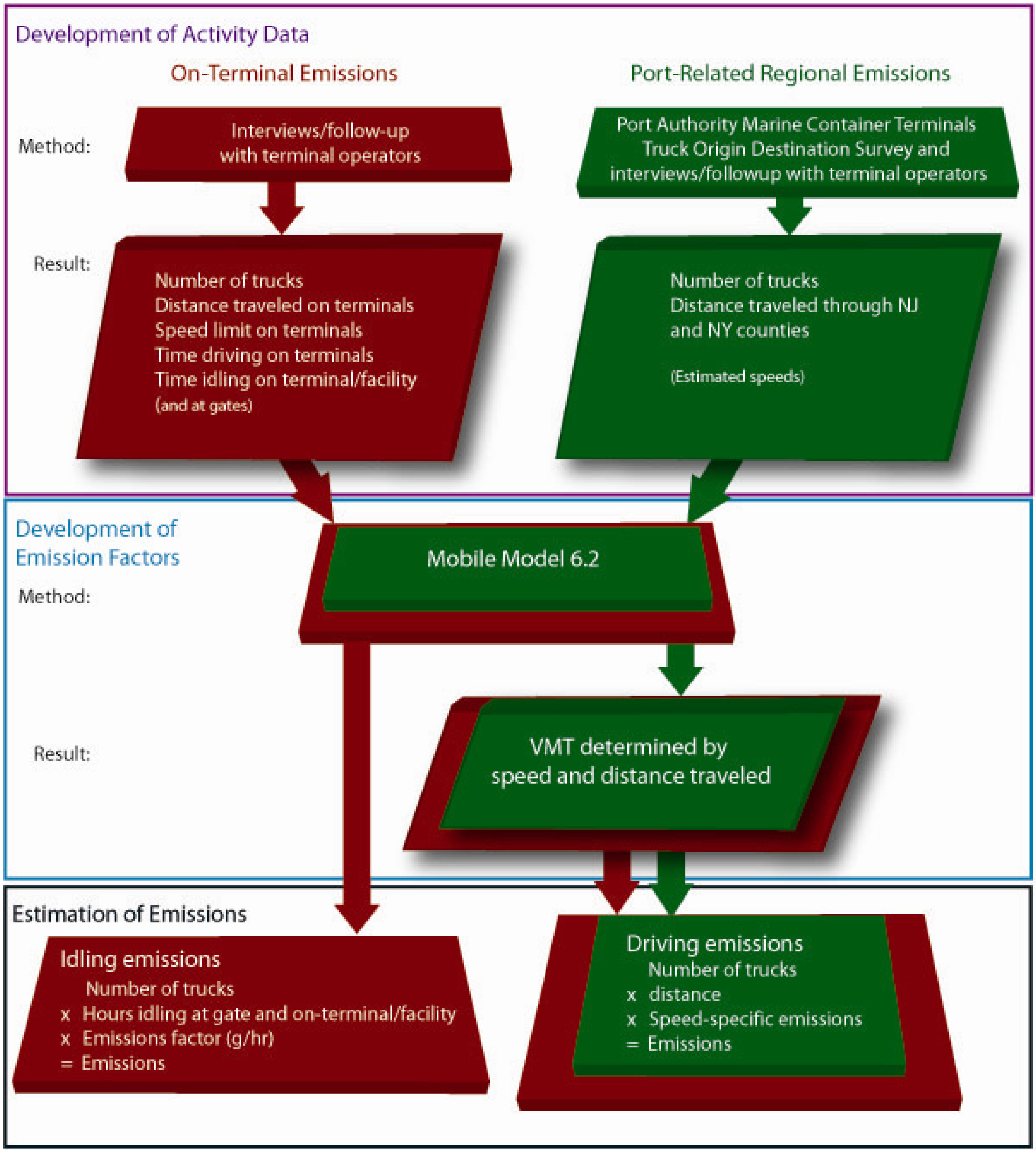
Figure 3.6: Comparison of Heavy-duty Diesel Vehicle SO_2 Emissions with Overall SO_2 Emissions by County, tpy



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 a truck survey developed for each type of operation; container terminals, warehouse, and auto – handling facilities. The following describes how the surveys were developed, distributed and collected. This section also includes the type of questions that were asked on the surveys.

Outreach Meeting and On-Terminal Truck Survey Development

On 3 December 2007, the Port Authority organized a meeting with terminal/facility operators, truckers, and fleet owners that move cargo into and out of container terminals, warehouses and auto-handling facilities, which are located within Port Newark/EPAMT, the Auto Marine Terminal, the Howland Hook Marine Terminal and the Brooklyn Port Authority Marine Terminal. During the meeting, the participants were presented with an overview of the results from the 2005 HDDV Emissions Inventory in addition to the Port Authority's goals to continue evaluating HDDV emissions with a port-wide 2006 emissions inventory. Depending on the type of maritime operation (container, warehouse or auto-handling), participants were provided a survey that relates to their specific operation type. To encourage accurate and complete reporting, all information was promised to be kept confidential. Participants were asked to return the surveys to Starcrest. For tenants who were unable to participate in the face to face meeting, telephone follow-up e-mail contact was made with the appropriate survey attached. In addition to receiving surveys through email, Starcrest conducted interviews over the telephone. Information collected from the surveys and followup communications was used to develop the estimates of times on terminal, idling duration, and other aspects of the operating parameters used in developing the emission estimates.

In order to strengthen the level of information required to better understand each maritime operation, the Port Authority and Starcrest organized individual meetings with a terminal operator that represented each operation type. Each meeting served as an opportunity to gain insight on the specific operation type and the correct approach to ask questions that would provide a better understanding on HDDV activity at each type of facility. The tailored surveys covered specific information on HDDV activity on and off terminal. Questions included annual gate count, distance traveled on and off the terminal, speed traveled, average idling time at the facility, trip origins and destinations, and typical HDDV characteristics. In addition, the surveys covered questions on the transaction process, which was a missing element from the 2005 HDDV Emissions Inventory. Appendix C includes a copy of the three HDDV survey types.

Table 3.19 illustrates the range and average of reported characteristics of on-terminal HDDV activities at Port Authority owned auto handling, container terminal, and warehouse facilities.

Table 3.19: Summary of Reported On-Terminal Operating Characteristics

Maritime Operation	Annual Trips	Vehicle Miles Traveled	Average Speed (mph)	Average Idling Time (hours)
Auto-Handling Facilities	82,474	31,880	17.5	1.7
Container Terminals	3,062,660	3,444,234	15.0	1.4
Warehouses	198,848	138,759	13.0	0.7

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). The average idling time for an individual truck that does idle is 2 hours, according to survey responses.

On-Road

As used previously in the 2005 HDDV Emissions Inventory, Vollmer's origin/destination study[10] was used for the 2006 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 auto marine terminals, 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

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

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

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

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 3.20.

[11] 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.

Table 3.20: 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	55.290	1.2995	1.1955	5.4475	48.420	0.8093	3,947.5	0.0144	0.0134
	HDDV8b	50.935	0.8473	0.7795	4.4525	40.155	0.8383	4,089.3	0.0144	0.0134
Extended Idle (g/hr)	HDDV8a	135	3.68	3.3856	5.4475	48.420	0.8093	3,947.5	0.0144	0.0134
	HDDV8b	135	3.68	3.3856	4.4525	40.155	0.8383	4,089.3	0.0144	0.0134
On-Terminal (g/mi)	HDDV8a	11.621	0.3340	0.3073	0.8830	5.533	0.3193	1,557.5	0.0048	0.0051
(15 mph avg. speed)	HDDV8b	13.660	0.3640	0.3349	1.0500	7.045	0.3363	1,640.4	0.0048	0.0051
Off-Port Roads (g/mi)	HDDV8a	9.200	0.3238	0.2979	0.4560	2.365	0.1742	1,557.5	0.0048	0.0051
(35 mph avg. speed)	HDDV8b	10.878	0.3533	0.3250	0.5430	3.011	0.1834	1,640.4	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 3.21 summarizes the terminal operating characteristics by terminal/facility type for 2006.

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 281,322, less than 10% of the total number of container truck visits, 3,062,660.

Table 3.21: 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	44,400	0.25	1.48	HDDV8A	11,100	65,712	Yes
Automobile	18,143	0.10	1.74	HDDV8B	1,814	31,569	Yes
Automobile	13,931	0.50	1.90	HDDV8A	6,966	26,469	Yes
Automobile	6,000	2.00	2.47	HDDV8A	12,000	14,840	Yes
Container	1,085,616	1.50	1.49	HDDV8B	1,628,424	1,613,949	Yes
Container	669,940	1.00	1.25	HDDV8B	669,940	837,425	Yes
Container	643,440	1.60	0.77	HDDV8B	1,029,504	497,594	Yes
Container	538,664	0.10	2.27	HDDV8B	53,866	1,224,564	Yes
Container	125,000	0.50	0.88	HDDV8B	62,500	110,417	Yes
Warehouse	55,000	0.50	0.41	HDDV8A	27,500	22,733	Yes
Warehouse	40,000	0.25	1.01	HDDV8B	10,000	40,533	Yes
Warehouse	39,000	1.50	1.30	HDDV8B	58,500	50,570	Yes
Warehouse	30,000	0.20	0.34	HDDV8B	6,000	10,200	Yes
Warehouse	7,750	1.50	0.08	HDDV8B	11,625	620	No
Warehouse	5,408	0.10	0.16	HDDV8B	541	865	No
Warehouse	3,120	2.00	0.54	HDDV8B	6,240	1,685	Yes
Warehouse	3,120	0.90	0.55	HDDV8B	2,808	1,716	Yes
Warehouse	3,000	2.00	0.13	HDDV8B	6,000	390	No
Warehouse	2,860	2.00	1.17	HDDV8B	5,720	3,346	Yes
Warehouse	2,700	0.10	0.34	HDDV8A	270	918	Yes
Warehouse	2,400	0.50	0.47	HDDV8B	1,200	1,128	Yes
Warehouse	2,350	0.10	0.50	HDDV8B	235	1,175	Yes
Warehouse	1,440	0.50	0.39	HDDV8B	720	562	Yes
Warehouse	700	2.00	0.80	HDDV8A	1,400	560	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:

Table 3.1: 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 Auto Marine Terminal 5. BMW at the Auto Marine Terminal
On-Terminal Warehouses at Port Newark/EPAMT	1. Mid States Packaging & Distribution 2. Pittston Warehouse Corporation 3. Phoenix Beverage 4. Linon Home Décor Products 5. Harbor Freight Transport 6. Port Newark Refrigerated Warehouse 7. Eastern Warehouse 8. Export Transport Co. 9. ASA Apple Inc. 10. Van Brunt Port Jersey Warehouse Inc. 11. Port Warehouse & Distribution Corp. 12. TRT International Ltd. 13. Tyler Distribution Centers Inc. 14. East Coast Warehouse & Distribution Corp. 15. P. Judge and Sons

3.4.1 Operational Modes

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

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

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

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

3.4.2 Vehicle Types

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

Figure 3.8: HDDV with Container

Figure 3.8: HDDV - Bobtail

SECTION 4: RAIL LOCOMOTVES

This section presents estimated emissions from the locomotives that visit and serve the Port Authority' 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 Auto Marine Terminal

Line haul activity refers to the import and export of cargo from these Port Authority facilities 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.

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

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

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	286	10	9	20	44	32
Percent of NYNJLINA Emissions	0.06%	0.01%	0.02%	0.004%	0.002%	0.02%

The following figures illustrate the distribution of PANYNJ switching and line haul locomotive emissions in terms of tons per year and percent of total locomotive emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Due to rounding in these figures, the percentage of Port Authority locomotive emissions compared with overall NYNJLINA emissions is displayed as zero (0) in the figures. The actual percentage of Port Authority locomotive emissions is displayed above in Table ES4.1.

Figure ES4.2: Distribution and Comparison of NO_x from Locomotives, tpy and percent

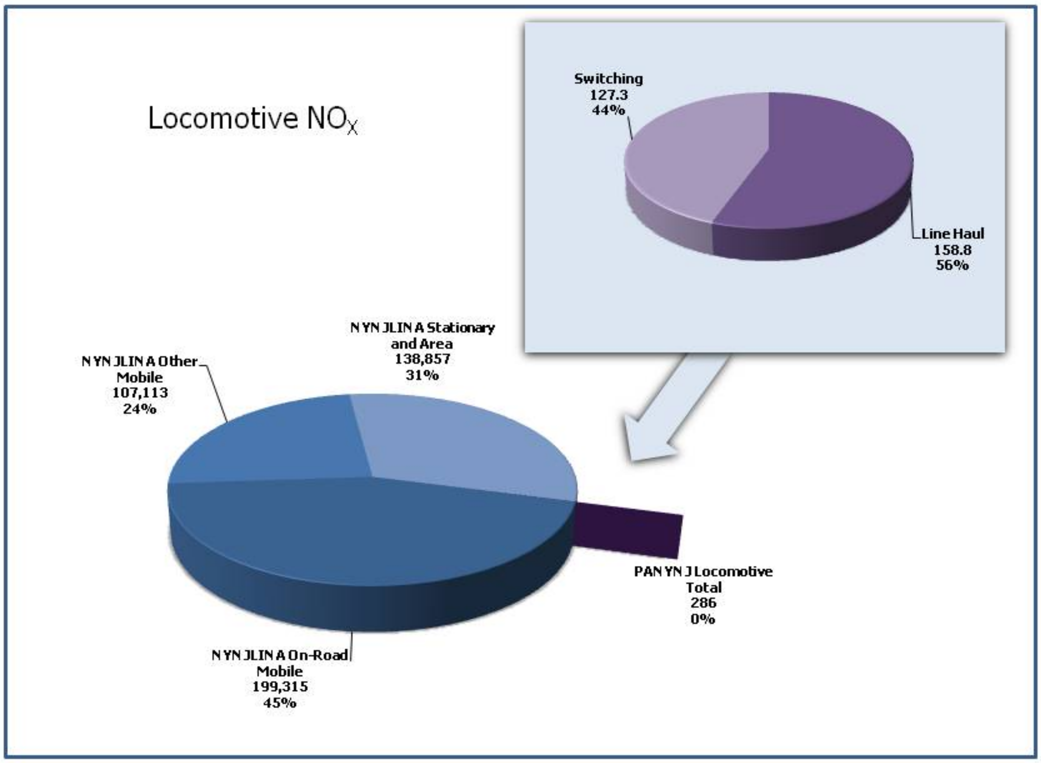


Figure ES4.3: Distribution and Comparison of PM_{10} from Locomotives, tpy and percent

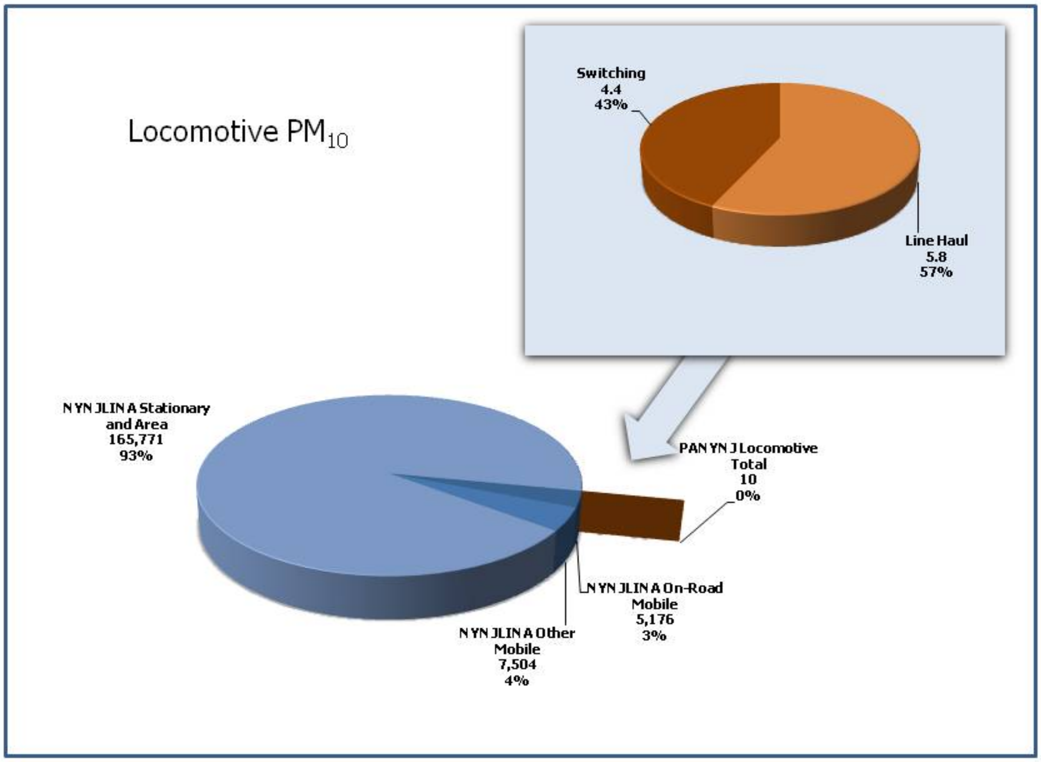


Figure ES4.4: Distribution and Comparison of $PM_{2.5}$ from Locomotives, tpy and percent

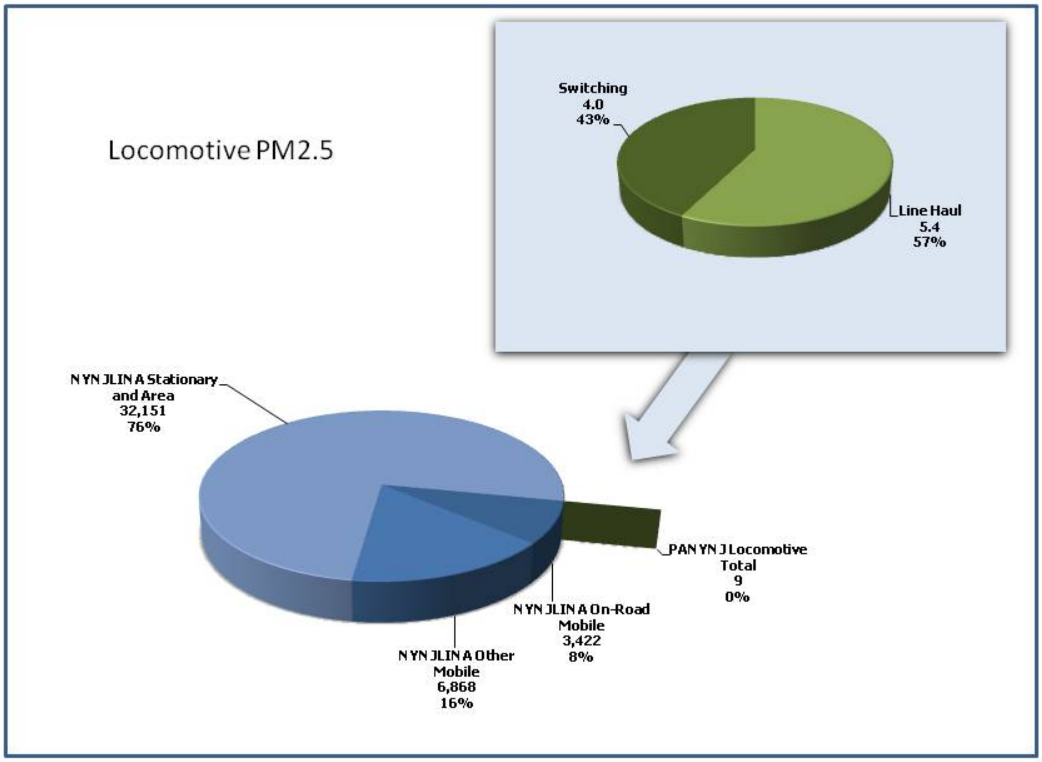


Figure ES4.5: Distribution and Comparison of VOC from Locomotives, tpy and percent

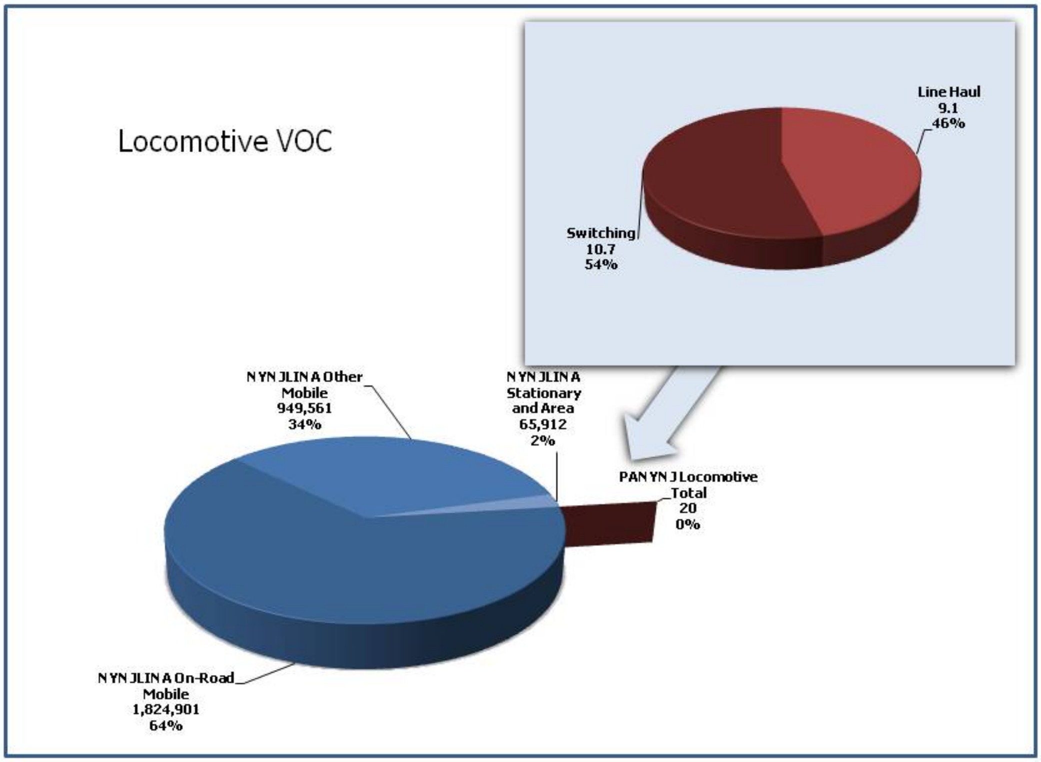


Figure ES4.6: Distribution and Comparison of CO from Locomotives, tpy and percent

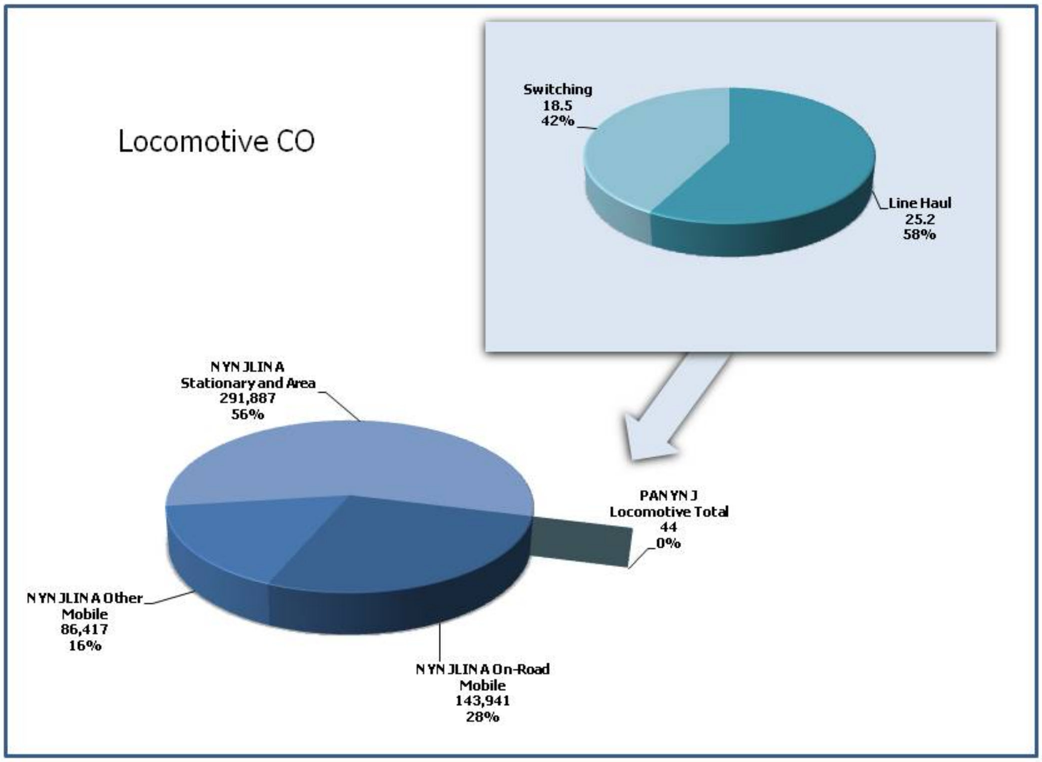
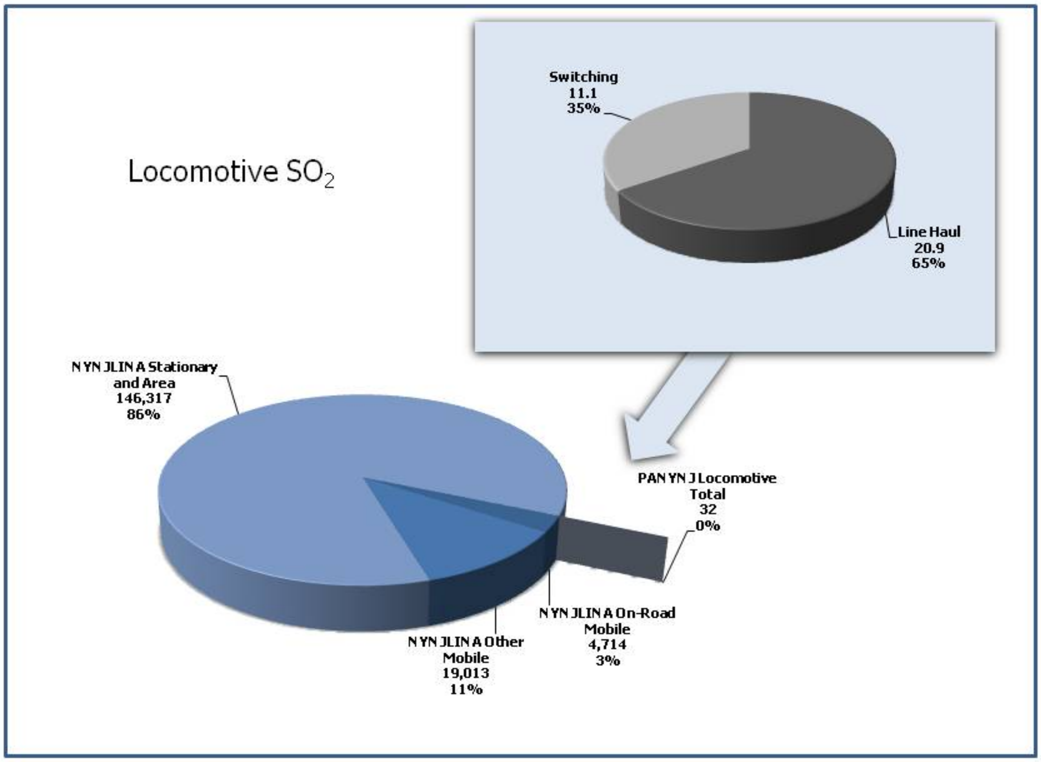


Figure ES4.7: Distribution and Comparison of SO_2 from Locomotives, tpy and percent



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 criteria pollutant emissions, and Table 4.2 summarizes greenhouse gas emissions.

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

Emission Estimates	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Line Haul	159	5.8	5.4	9.1	25.2	20.9
Switching	127	4.4	4.0	10.7	18.5	11.1
Totals	**286**	**10.2**	**9.4**	**19.8**	**43.7**	**32**

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

Emission Estimates	CO_2	N_2O	CH_4	CO_2 Equiv.
Line Haul	9,626	0.25	0.76	9,721
Switching	4,941	0.13	0.39	4,989
Totals	**14,567**	**0.38**	**1.15**	**14,710**

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 maritime 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.[12] 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.

Table 4.3 examines estimated criteria pollutant emissions from the Port Authority maritime 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 locomotive contribution to total emissions.

[12] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008, http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata

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	36.9	1.3	1.2	2.1	5.9	4.9
Essex	NJ	75.8	2.7	2.4	6.1	11.2	7.2
Hudson	NJ	32.0	1.2	1.1	1.8	5.1	4.2
Middlesex	NJ	4.7	0.2	0.2	0.3	0.7	0.6
Monmouth	NJ	0.0	0.0	0.0	0.0	0.0	0.0
Union	NJ	77.7	2.7	2.5	6.2	11.5	7.4
New Jersey subtotal		**227**	**8.1**	**7.4**	**16.4**	**34.3**	**24.2**
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	0.0	0.0	0.0	0.0	0.0	0.0
Rockland	NY	59.1	2.1	2.0	3.4	9.4	7.8
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		**59**	**2.1**	**2.0**	**3.4**	**9.4**	**7.8**
TOTAL		**286**	**10**	**9**	**20**	**44**	**32**

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	37	0.14%
Essex	NJ	23,498	76	0.32%
Hudson	NJ	27,776	32	0.12%
Middlesex	NJ	33,000	4.7	0.01%
Monmouth	NJ	19,177	0.0	0.00%
Union	NJ	21,154	78	0.37%
New Jersey Subtotal		**150,577**	**227**	**0.15%**
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	0.0	0.00%
Rockland	NY	13,645	59	0.43%
Suffolk	NY	61,223	0.0	0.00%
Westchester	NY	28,040	0.0	0.00%
New York Subtotal		**294,708**	**59**	**0.02%**
TOTAL		**445,285**	**286**	**0.06%**

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

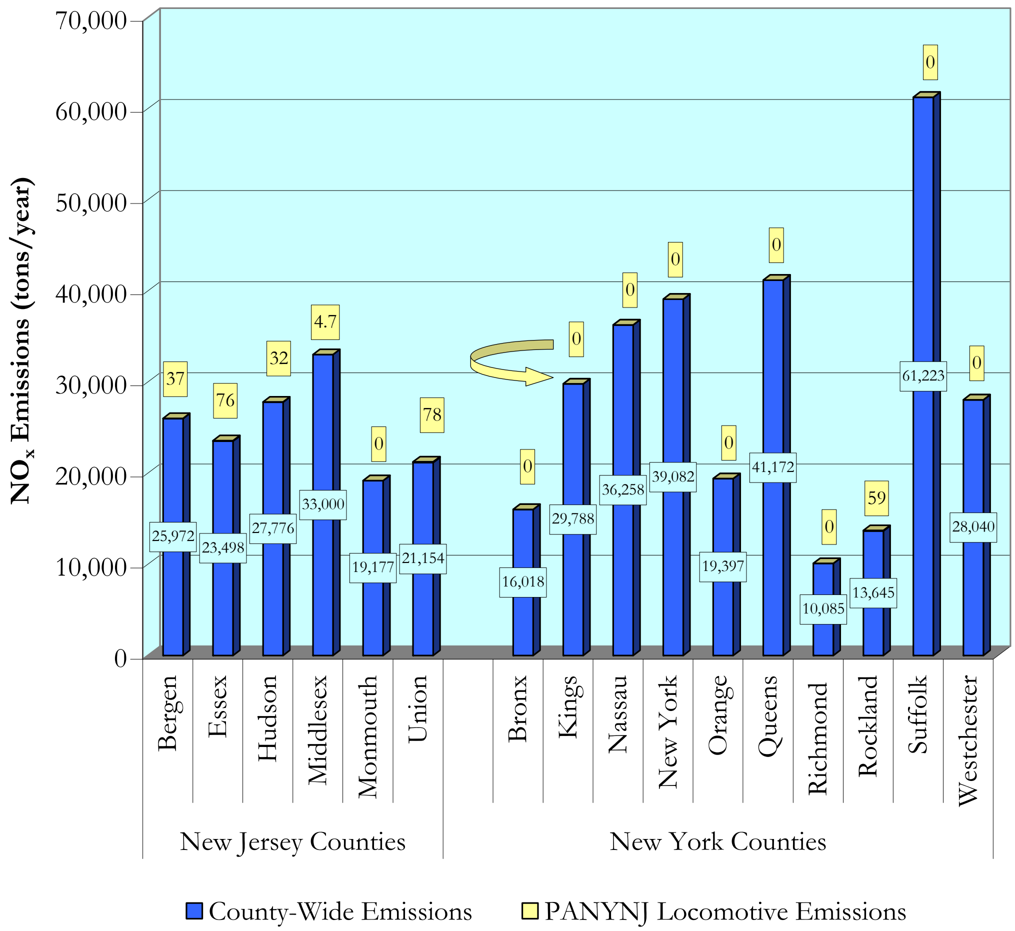


Table 4.5: Comparison of Locomotive PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	1.3	0.02%
Essex	NJ	3,745	2.7	0.07%
Hudson	NJ	6,764	1.2	0.02%
Middlesex	NJ	9,927	0.2	0.00%
Monmouth	NJ	7,935	0.0	0.00%
Union	NJ	4,227	2.7	0.06%
New Jersey Subtotal		**38,850**	**8**	**0.02%**
Bronx	NY	5,803	0.0	0.00%
Kings (Brooklyn)	NY	8,312	0.0	0.00%
Nassau	NY	14,142	0.0	0.00%
New York	NY	8,689	0.0	0.00%
Orange	NY	27,696	0.0	0.00%
Queens	NY	9,615	0.0	0.00%
Richmond (Staten Isld)	NY	8,092	0.0	0.00%
Rockland	NY	4,880	2.1	0.04%
Suffolk	NY	39,210	0.0	0.00%
Westchester	NY	13,162	0.0	0.00%
New York Subtotal		**139,601**	**2**	**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

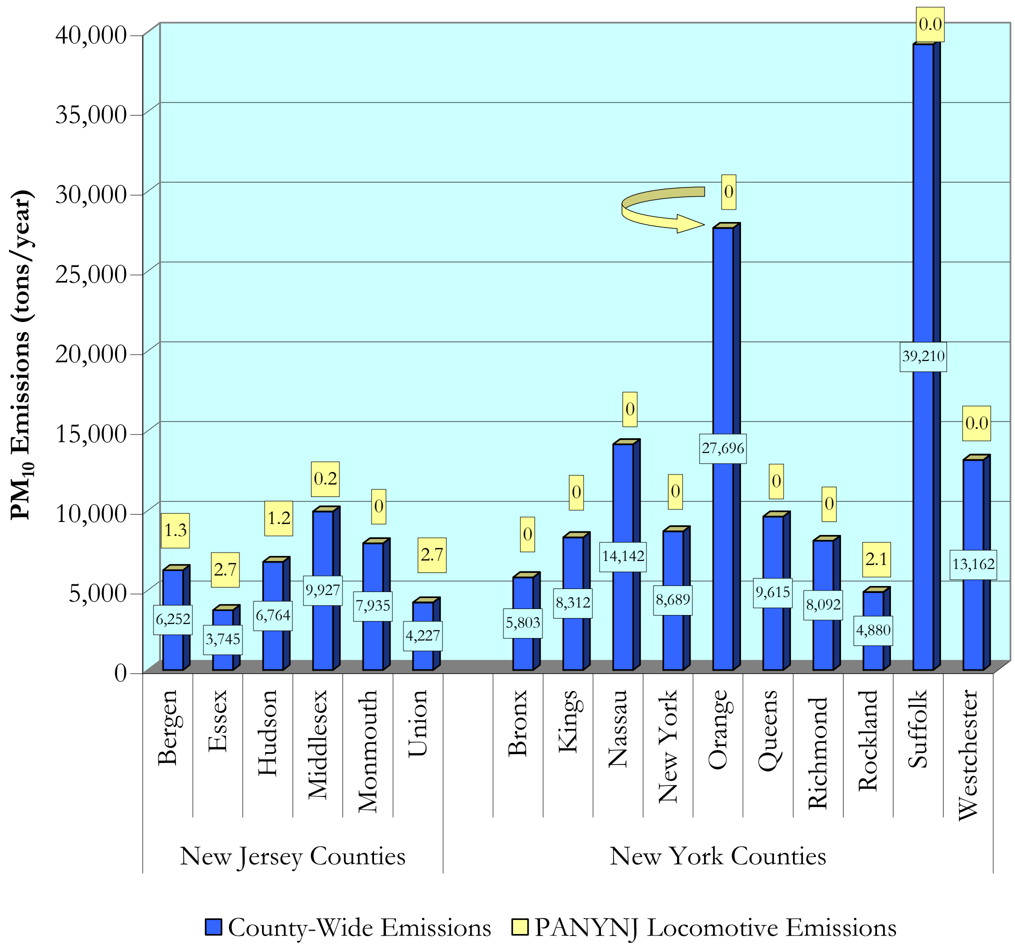


Table 4.6: Comparison of Locomotive $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	1.2	0.09%
Essex	NJ	1,159	2.4	0.21%
Hudson	NJ	3,754	1.1	0.03%
Middlesex	NJ	2,150	0.2	0.01%
Monmouth	NJ	1,623	0.0	0.00%
Union	NJ	1,472	2.5	0.17%
New Jersey Subtotal		**11,567**	**7**	**0.1%**
Bronx	NY	1,357	0.0	0.00%
Kings (Brooklyn)	NY	2,676	0.0	0.00%
Nassau	NY	2,727	0.0	0.00%
New York	NY	4,017	0.0	0.00%
Orange	NY	4,968	0.0	0.00%
Queens	NY	3,655	0.0	0.00%
Richmond (Staten Isld)	NY	1,323	0.0	0.00%
Rockland	NY	1,638	2.0	0.12%
Suffolk	NY	6,057	0.0	0.00%
Westchester	NY	2,456	0.0	0.00%
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

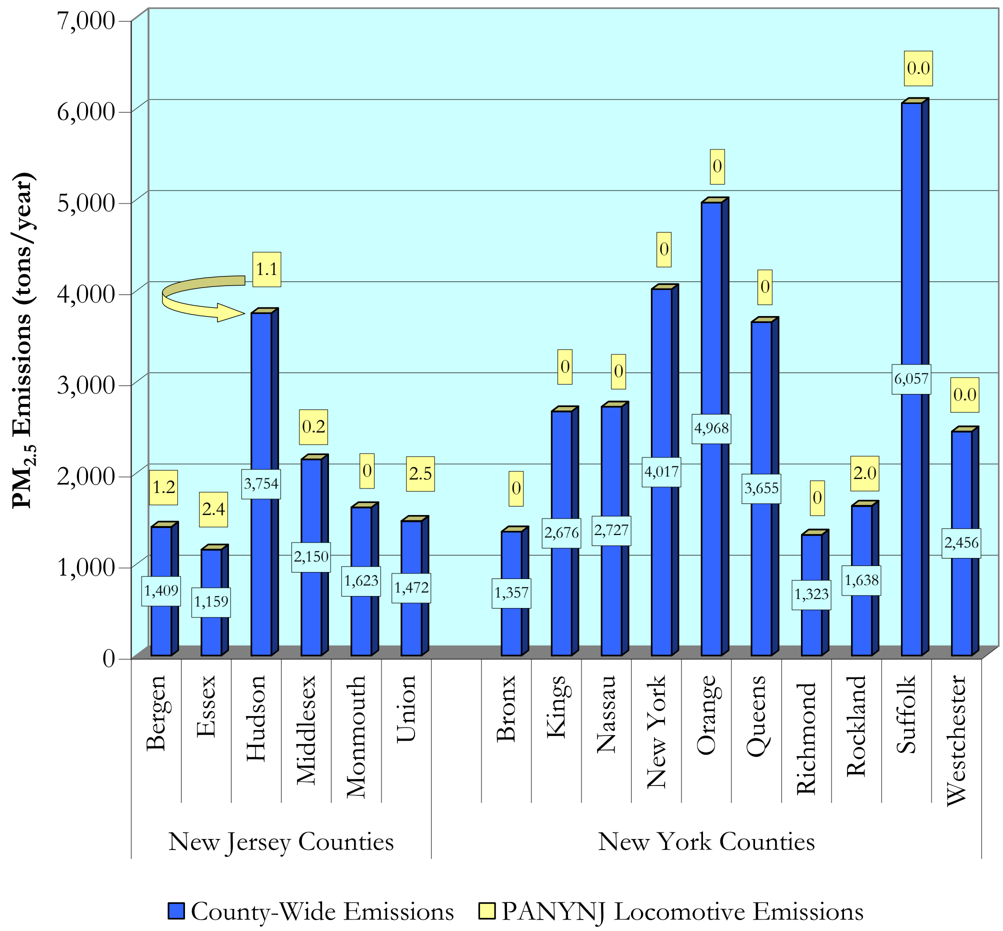


Table 4.7: Comparison of Locomotive VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	2.1	0.006%
Essex	NJ	20,940	6.1	0.029%
Hudson	NJ	14,428	1.8	0.012%
Middlesex	NJ	30,357	0.3	0.001%
Monmouth	NJ	22,727	0.0	0.00%
Union	NJ	20,627	6.2	0.03%
New Jersey Subtotal		**142,075**	**16**	**0.01%**
Bronx	NY	25,454	0.0	0.000%
Kings (Brooklyn)	NY	54,809	0.0	0.000%
Nassau	NY	47,865	0.0	0.000%
New York	NY	45,292	0.0	0.000%
Orange	NY	18,349	0.0	0.000%
Queens	NY	47,262	0.0	0.000%
Richmond (Staten Isld)	NY	13,542	0.0	0.000%
Rockland	NY	13,767	3.4	0.025%
Suffolk	NY	77,071	0.0	0.000%
Westchester	NY	36,759	0.0	0.000%
New York Subtotal		**380,170**	**3**	**0.001%**
TOTAL		**522,245**	**20**	**0.004%**

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

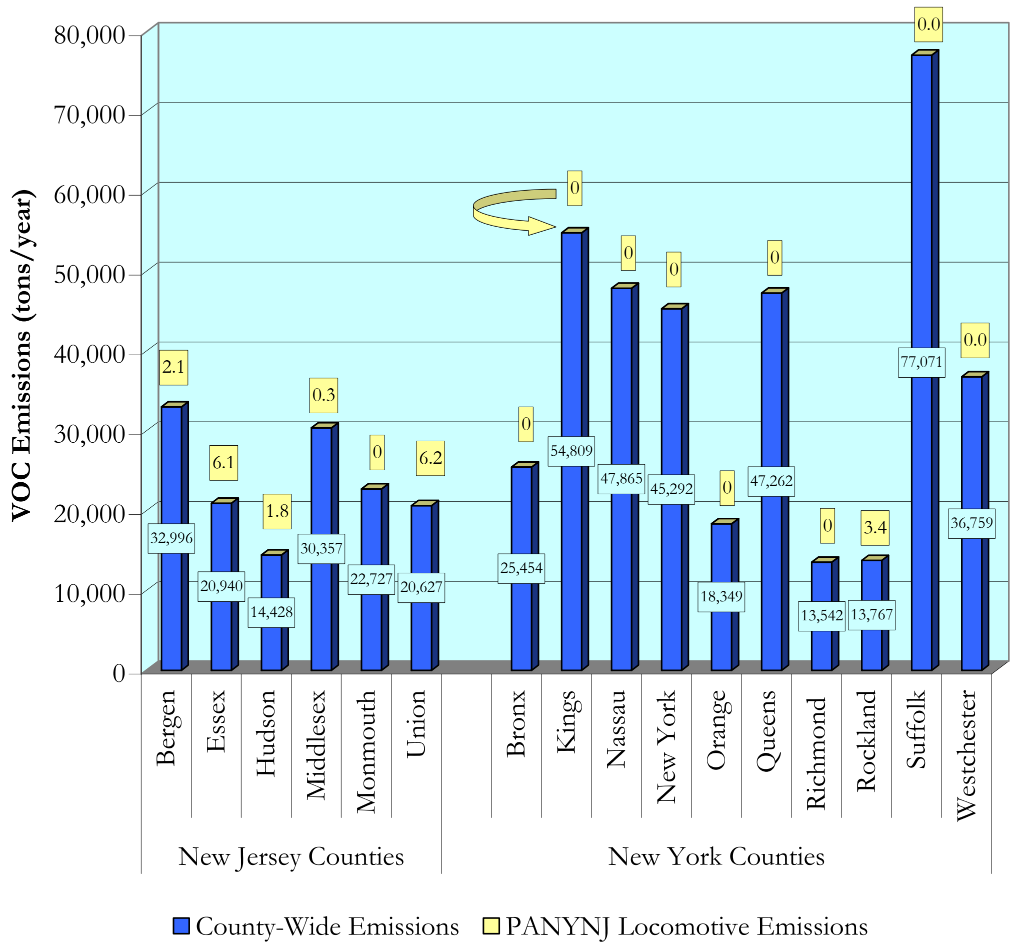


Table 4.8: Comparison of Locomotive CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	5.9	0.002%
Essex	NJ	131,856	11.2	0.008%
Hudson	NJ	69,129	5.1	0.007%
Middlesex	NJ	196,869	0.7	0.0004%
Monmouth	NJ	166,309	0.0	0.00%
Union	NJ	114,302	11.5	0.01%
New Jersey Subtotal		**921,446**	**34**	**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	0.0	0.000%
Rockland	NY	67,761	9.4	0.014%
Suffolk	NY	472,083	0.0	0.000%
Westchester	NY	230,503	0.0	0.000%
New York Subtotal		**1,918,928**	**9**	**0.0005%**
TOTAL		**2,840,374**	**44**	**0.002%**

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

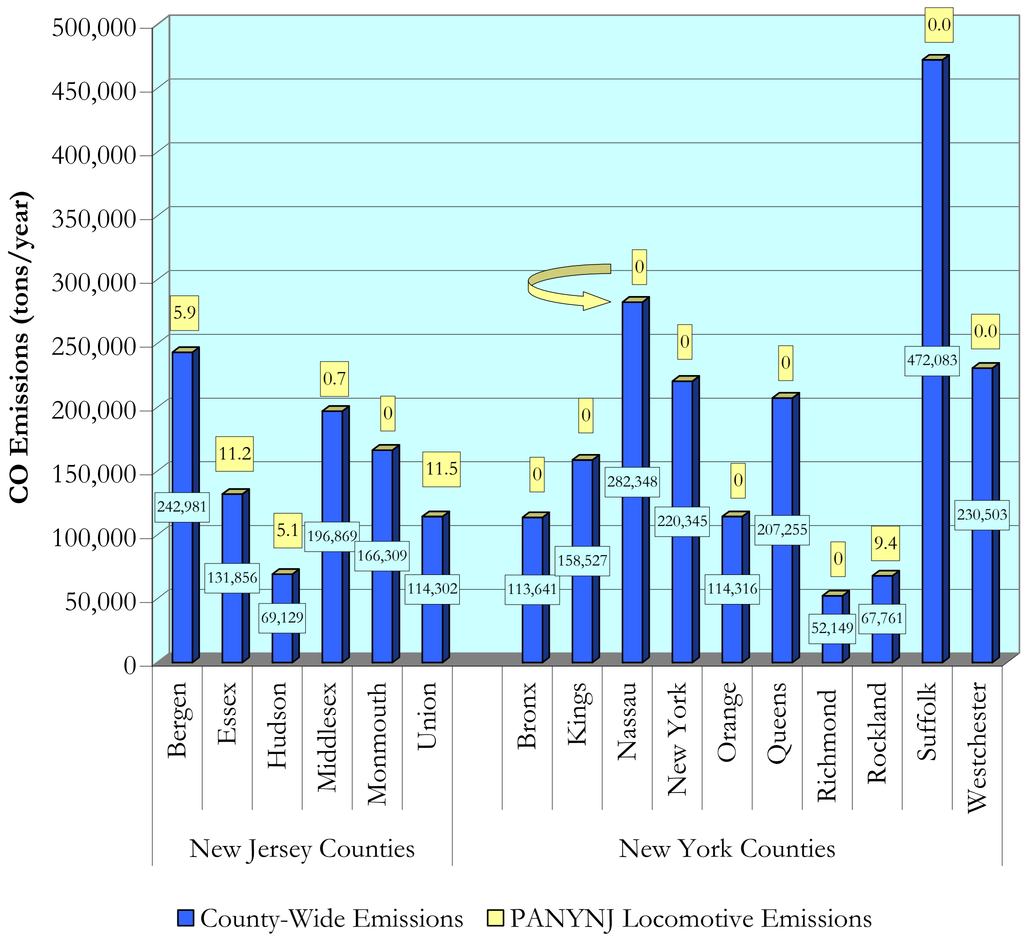
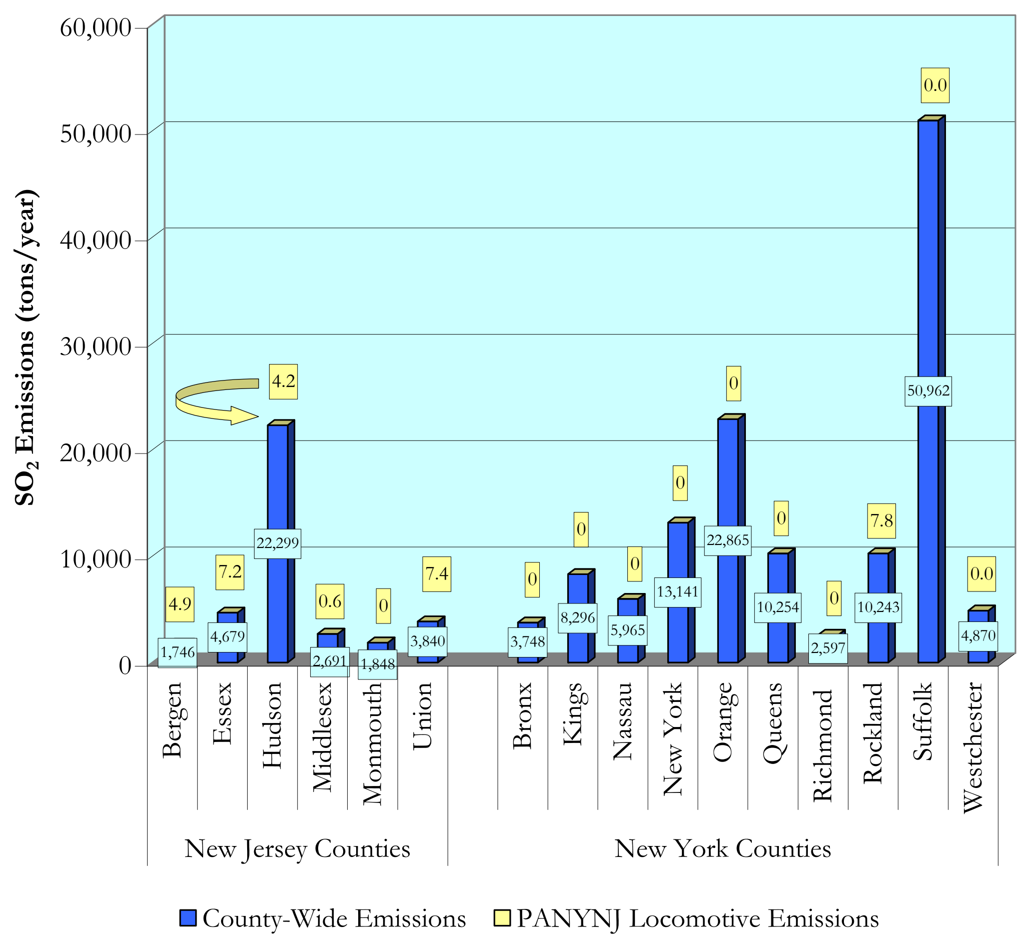


Table 4.9: Comparison of Locomotive SO_2. Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Locomotive Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	4.9	0.28%
Essex	NJ	4,679	7.2	0.15%
Hudson	NJ	22,299	4.2	0.02%
Middlesex	NJ	2,691	0.6	0.02%
Monmouth	NJ	1,848	0.0	0.00%
Union	NJ	3,840	7.4	0.19%
New Jersey Subtotal		**37,103**	**24**	**0.07%**
Bronx	NY	3,748	0.0	0.00%
Kings (Brooklyn)	NY	8,296	0.0	0.00%
Nassau	NY	5,965	0.0	0.00%
New York	NY	13,141	0.0	0.00%
Orange	NY	22,865	0.0	0.00%
Queens	NY	10,254	0.0	0.00%
Richmond (Staten Isld)	NY	2,597	0.0	0.00%
Rockland	NY	10,243	7.8	0.08%
Suffolk	NY	50,962	0.0	0.00%
Westchester	NY	4,870	0.0	0.00%
New York Subtotal		**132,941**	**8**	**0.01%**
TOTAL		**170,044**	**32**	**0.02%**

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,[13] the rail line routes used to transport these goods, an approximate schedule for these trains, and the average length of primary scheduled trains. This data has been used to estimate the total amount of fuel used by the locomotives and hence the associated emissions. Calculations were developed in three general stages, outlined in Figures 4.1, 4.2, and 4.3 in flowchart form and defined in equation form in the following discussion.

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

The emission factors for most pollutants (NO_x, PM, HC, CO) come from an EPA publication[14] issued in support of locomotive rulemaking. The EPA factors are published as energy-based factors, in units of grams per horsepower-hour. These factors have been converted to fuel-based factors using a conversion factor of 20.8 horsepower-hours per gallon of fuel.[15] Emission factors for SO_2 and CO_2 have been developed using a mass balance approach (based on the typical amounts of sulfur and carbon in diesel fuel) and emission factors for N_2O and CH_4 were obtained from an EPA publication on greenhouse gases.[16] The emission factors for line haul locomotives are presented in Table 4.10.

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/hp-hr	8.065	0.295	0.271	0.468	1.280	1.1	489	0.012	0.0384
g/gal	168.0	6.1	5.6	9.70	26.7	22.2	10,186	0.26	0.80

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

[13] "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.

[14] Locomotive Emission Standards, Regulatory Support Document. U.S. EPA, Office of Mobile Sources, April 1998.

[15] EPA, Technical Highlights, Emission Factors for Locomotives, EPA420-F-97-051. December 1997.

[16] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2006; Draft, 22 Feb 2008; Table A- 90: Emission Factors for CH4 and N2O Emissions from Non-Highway Mobile Combustion (g gas/kg fuel).

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

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	14	28	6	16	12	
Length of 5-platform car	300	300	300	300	300	300	feet
Length of cargo	8,400	4,200	8,400	1,800	4,800	3,600	feet
Length of locomotive	70	70	70	70	70	70	feet
# of locomotives per train	2	2	2	1	2	2	
Total locomotive length	140	140	140	140	140	140	feet
Total train length	**8,540**	**4,340**	**8,540**	**1,940**	**4,940**	**3,740**	**feet**

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 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 he typical train, and dividing by the average number of TEUs per container (most, but not all,

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

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	280	560	120	320	240	
Average "density"	85%	85%	85%	75%	75%	75%	
TEUs per train (adjusted)	476	238	476	90	240	180	TEUs
Average TEUs per container:	1.7	1.7	1.7	1.7	1.7	1.7	TEUs
Containers per train (average)	**280**	**140**	**280**	**53**	**141**	**106**	

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). As shown in the table, the estimated number of containers moved by the train configurations described above matches the reported 2006 throughput for one railroad to within less than three percent, and for the other railroad to within less than two 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	101,920	50,960	101,920	13,780	51,324	27,560	containers
Total estimated containers:	**254,800**			**92,664**			
Reported throughput:	247,774			91,110			
Variance:	2.8%			1.7%			

The next step in estimating fuel usage is estimating the gross weight of each of the train sizes described by the previous tables. Table 4.14 presents the assumptions on the weight of train components, including the locomotives and the combined weight of an average container and railcar. [19] The average gross weight of each train type is the sum of the weight of each component times the number of components in each train (e.g., two locomotives, Table 4.11, and 280 containers, Table 4.12).

[19] Email correspondence, D.Lotz, Port Authority of NY & NJ to D. Park of Starcrest, LLC. March 27, 2008.

Table 4.14: Line-Haul Train Gross Weight

Parameters	Q159 Outbound	Q162 Outbound	Q112 Inbound	25V Outbound	23M Outbound	24V Inbound
Weight of locomotive	210	210	210	210	210	210
Gross wgt of container & railcar	37.5	37.5	37.5	37.5	37.5	37.5
Gross weight of train	**10,920**	**5,670**	**10,920**	**2,198**	**5,708**	**4,395**

Overall annual gross tonnage for each railroad is the gross weight of each train multiplied by the number of trains per year. These figures total approximately **10 million gross tons** for the railroad whose trains are represented by the left three columns in the previous tables, and approximately **3.8 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 1.328 gallons of fuel per thousand gross ton-miles.[20] The result of this calculation step is also shown in the table.

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	30,041	39,894
Hudson	13	130,177	172,875
Bergen	15	150,205	199,472
Rockland	24	240,327	319,155
South Route			
Essex	5	18,958	25,176
Union	15	56,874	75,528
Middlesex	5	18,958	25,176
Total	80	645,540	857,277

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

[20] Port of Los Angeles, Inventory of Air Emissions - 2006, Volume 1 Technical Report ADP#050520-525. July, 2008

4.3.2 Switching Emissions

Switching emission estimates have been based on the activity information developed for the 2002 Port Authority inventory of cargo handling equipment and rail emissions, which is the latest year for which this information is available, and the increase in Port Newark and Elizabeth PA Marine Terminal cargo throughputs over that period. While development of the ExpressRail system serving Port Newark and the Elizabeth PA Marine Terminal may have affected the relationship between the volume of cargo movement and switching activity, specific information on the effect of the ExpressRail development on switching activities was not available during the data collection phase of this project. The scaling of activity with container throughput growth may provide an overestimate of activity growth because if anything the changes should be expected to reduce switching activity with respect to throughput.

The 2002 emission estimates were based on the number and duration of daily shift operations. A total of 27,144 locomotive hours was derived from 11 daily operating shifts. The adjustment to 2006 levels of cargo throughput was 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.

Emission factors for most pollutants are from an EPA publication on locomotive emission factors, and apply to locomotives in switching service that were built between 1973 and 2001.[21] There may be newer locomotives operating in Port-related rail service (which may have lower emissions than reflected in the emission factors) but information on them was not made available by the railroad. Emission factors for SO_2 and CO_2 have been developed using a mass balance approach (based on the typical amounts of sulfur and carbon in diesel fuel) and emission factors for N_2O and CH_4 were obtained from the EPA publication on greenhouse gases cited previously. The emission factors are listed in Table 4.16.

Table 4.16: Switching Locomotive Emission Factors

Emission Factors	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x	CO_2	N_2O	CH_4	CO_2 Equiv.
Units: g/hp-hr	12.6	0.44	0.40	1.06	1.83	1.1	489	0.01248	0.0384	NA

The emission factors are in units of grams per horsepower-hour. An estimate of annual horsepower-hours was developed from the adjusted operating hour estimate discussed above using data contained in an EPA dataset the lists average switching duty in-use horsepower for 20 locomotive models rated between 1,500 and 4,100 horsepower, averaging 3,030 horsepower. The in-use horsepower varies from 159 to 349 horsepower, with an average of 264 horsepower. Multiplying the estimate of 34,744 hours by the average in-use horsepower of 264 results in a horsepower-hour estimate of 9,165,552 for the year. The emission factors were multiplied by this total to estimate annual switching emissions, presented in the following subsection.

21 EPA420-F-97-051 - Technical Highlights - Emission Factors for Locomotives. Dec. 1997

4.4 Description of Locomotives

This subsection describes the rail system as it served the Port Authority marine terminals in 2006 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 2006 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). Switching takes place adjacent to the Port Newark Container Terminal (an operation known as ExpressRail Port Newark) and at a rail facility between the APM and Maher Terminals (known as ExpressRail Elizabeth). 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. Lastly, ExpressRail Staten Island, which serves New York Container Terminal at the Howland Hook Marine Terminal, is not covered in this inventory because it became fully operational after the time period of this study.

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

4.4.2 Locomotives

The locomotives used in these activities are essentially similar, although switching locomotives are usually smaller than the locomotives used in line haul service. Locomotives in switching service are often older line haul locomotives that are no longer suitable for the longer and heavier trains that are common in present-day train transport. Figure 4.7 illustrates a typical older switching locomotive, while Figure 4.8 presents a newer model switcher. These specific switch engines do not necessarily work on Port Authority marine terminals – the illustrations are provided as examples. Line haul locomotives, especially those in intermodal service (used in transporting containerized cargo) are typically in the range of 4,000 horsepower, while locomotives in switching use are smaller, typically under 3,000 horsepower. Figure 4.9 shows a typical line haul locomotive.

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

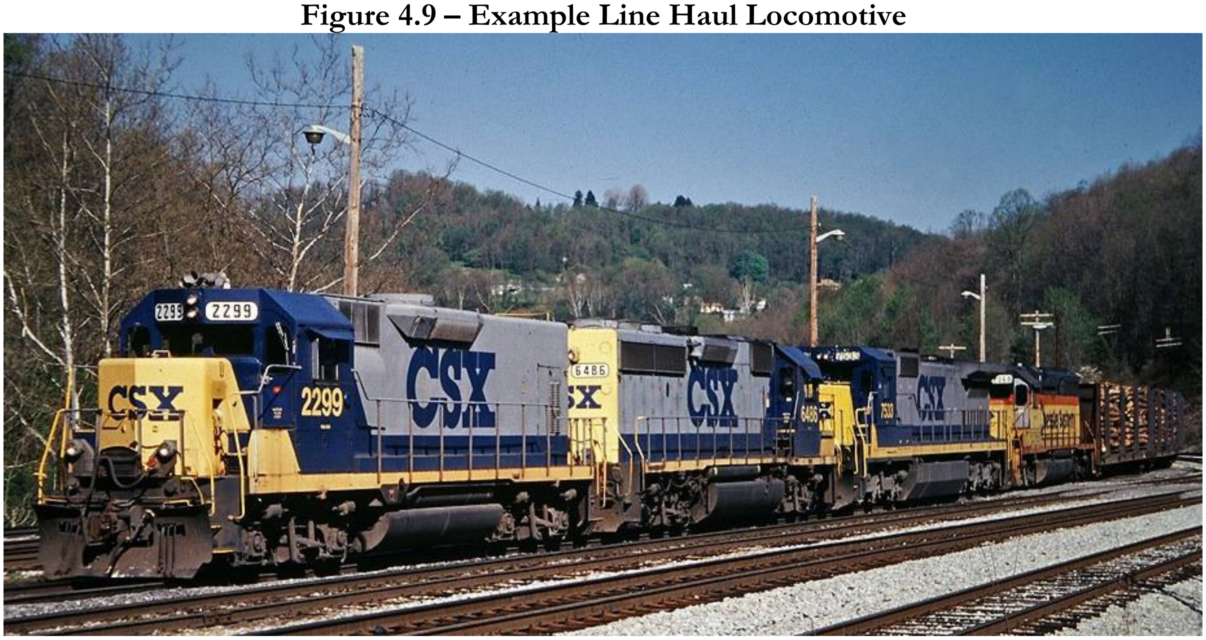
Because line haul locomotives are used to transport cargo across large areas of the country, they are dispatched by the railroads that own and operate them on the basis of where they are needed and not on the basis of any discrete operating area. Therefore, there are no "local fleets" of line haul locomotives.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

Figure 4.7 – Example Switching Locomotive - Old

Figure 4.8 – Example Switching Locomotive - New

Photograph courtesy of Railpower Hybrid Technologies Corp., Erie, Pennsylvania.

Figure 4.9 – Example Line Haul Locomotive



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

SECTION 5: COMMERCIAL MARINE VESSELS

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

- Port Newark
- The Elizabeth Port Authority Marine Terminal
- The Auto Marine Terminal
- The Howland Hook Marine Terminal
- The 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, and 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 commercial marine vessel emissions inventory. It includes the counties within the New York New Jersey Long Island Non-Attainment Area (NYNJLINA) in which Port Authority 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 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 locomotive emissions from PANYNJ activity compared with overall emissions in the NYNJLINA and New York/New Jersey statewide emissions, the following four subsections focus on:

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

Executive Summary

Table ES5-1 presents the estimated CMV 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 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
Commercial Marine Vessels	4,177	374	303	183	361	3,320
Percent of NYNJLINA Emissions	0.94%	0.21%	0.71%	0.03%	0.01%	1.95%

The following figures illustrate the distribution of PANYNJ CMV emissions by vessel type in terms of tons per year and percent of total CMV emissions, and in the context of overall NYNJLINA emissions. The NYNJLINA emissions are broken down into on-road mobile sources, other (non-road) mobile sources, and stationary and area sources. Due to rounding in these figures, the percentage of Port Authority CMV emissions compared with overall NYNJLINA emissions is displayed as zero (0) in some of the figures. The actual percentage of Port Authority CMV emissions is displayed above in Table ES5.1.

Figure ES5.2: Distribution and Comparison of NO_x from CMVs, tpy and percent

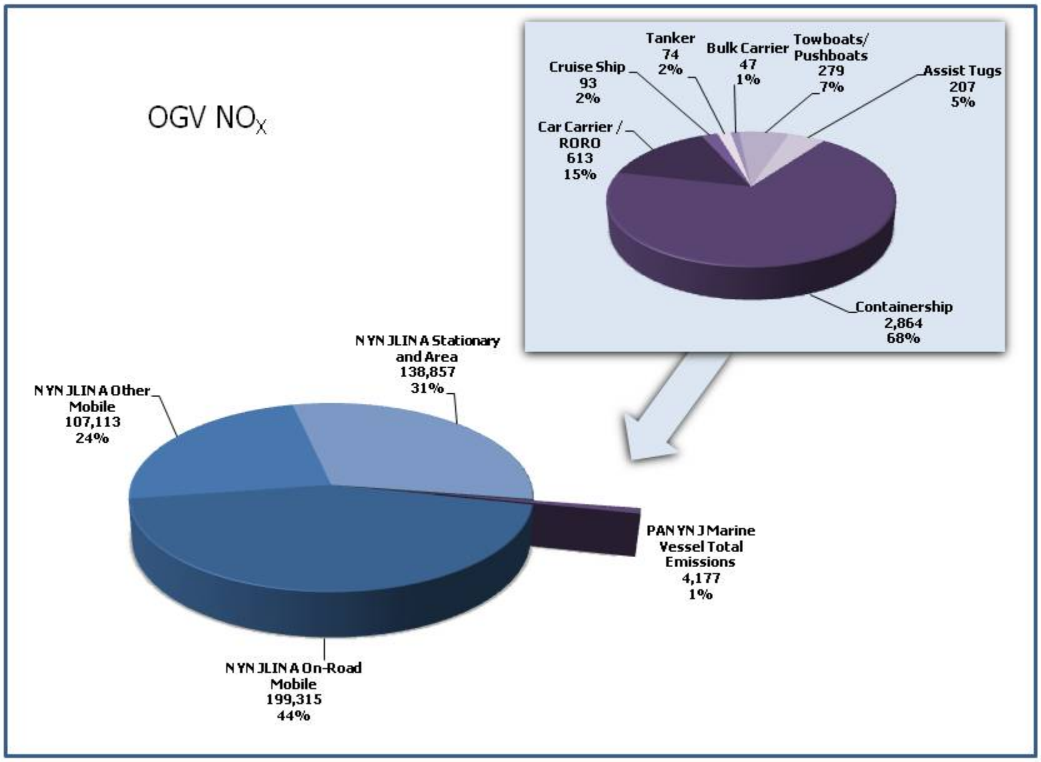


Figure ES5.3: Distribution and Comparison of PM_{10} from CMVs, tpy and percent

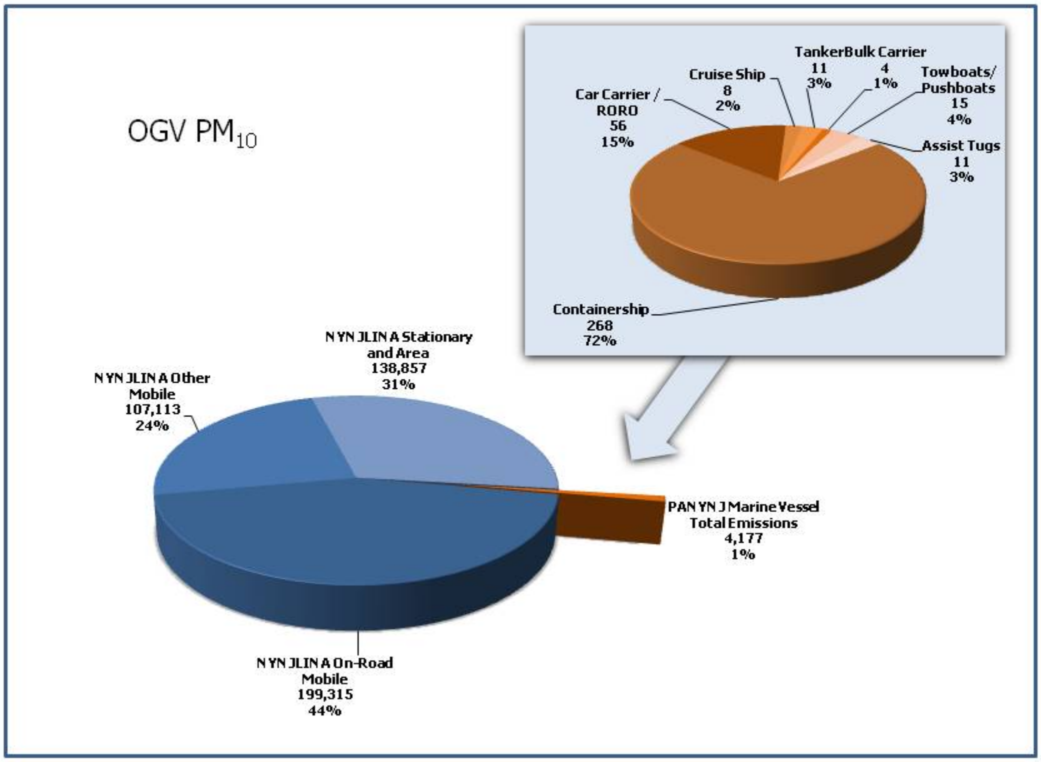


Figure ES5.4: Distribution and Comparison of $PM_{2.5}$ from CMVs, tpy and percent

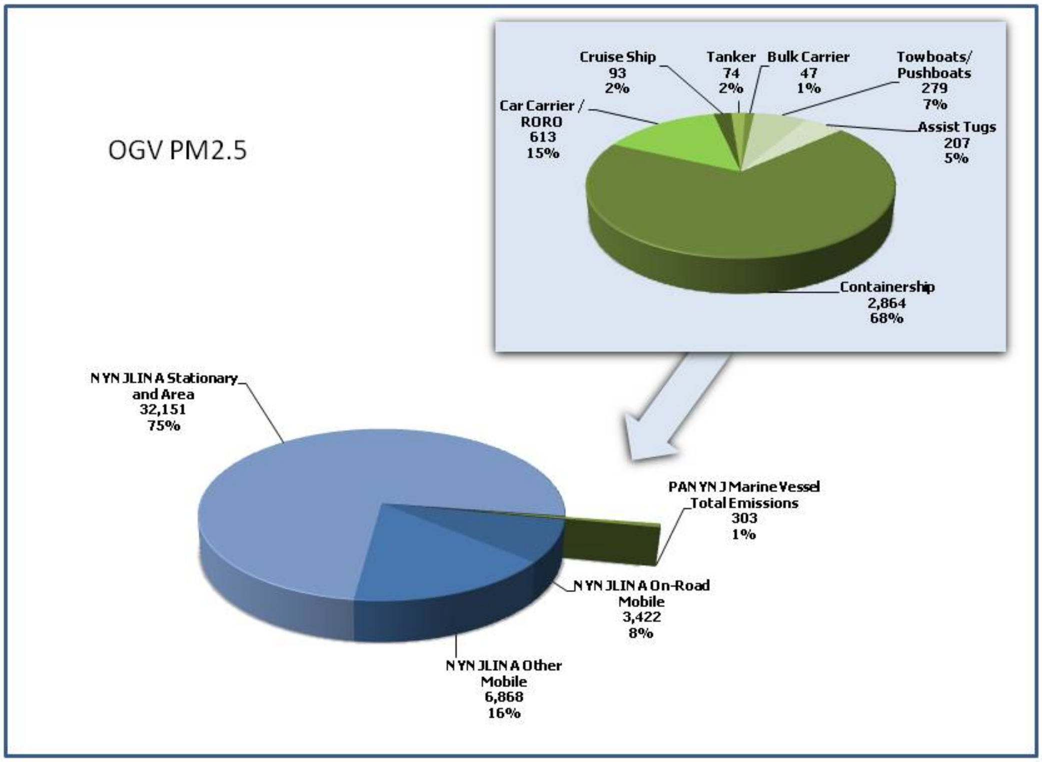


Figure ES5.5: Distribution and Comparison of VOC from CMVs, tpy and percent

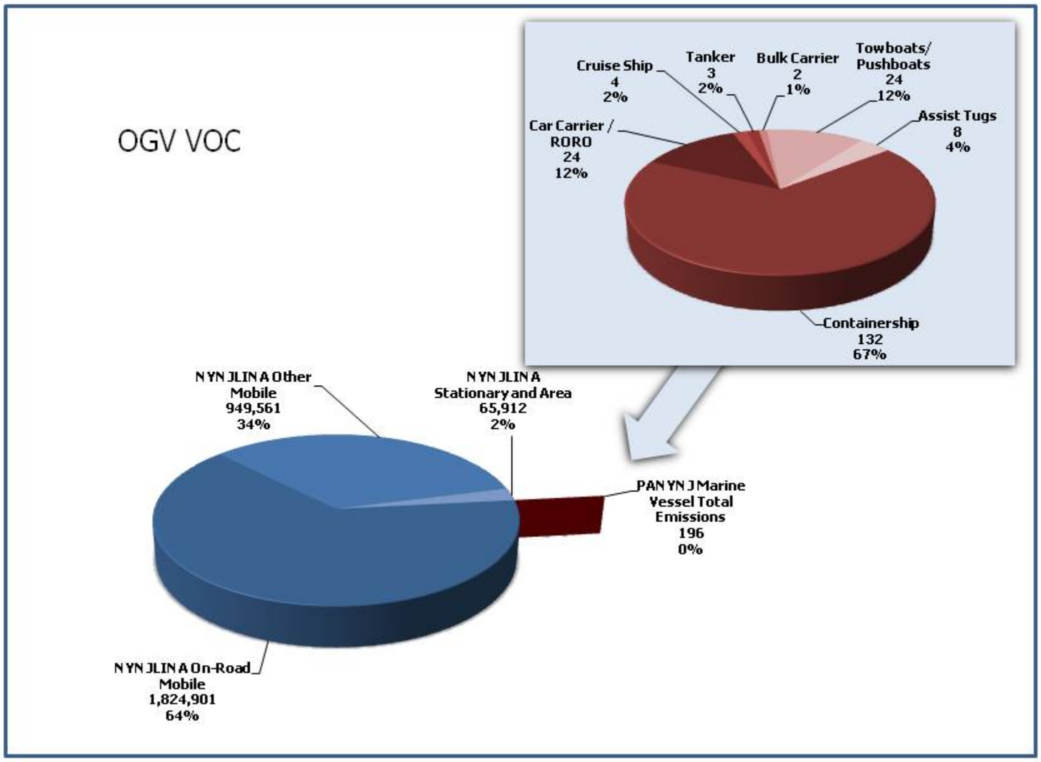


Figure ES5.6: Distribution and Comparison of CO from CMVs, tpy and percent

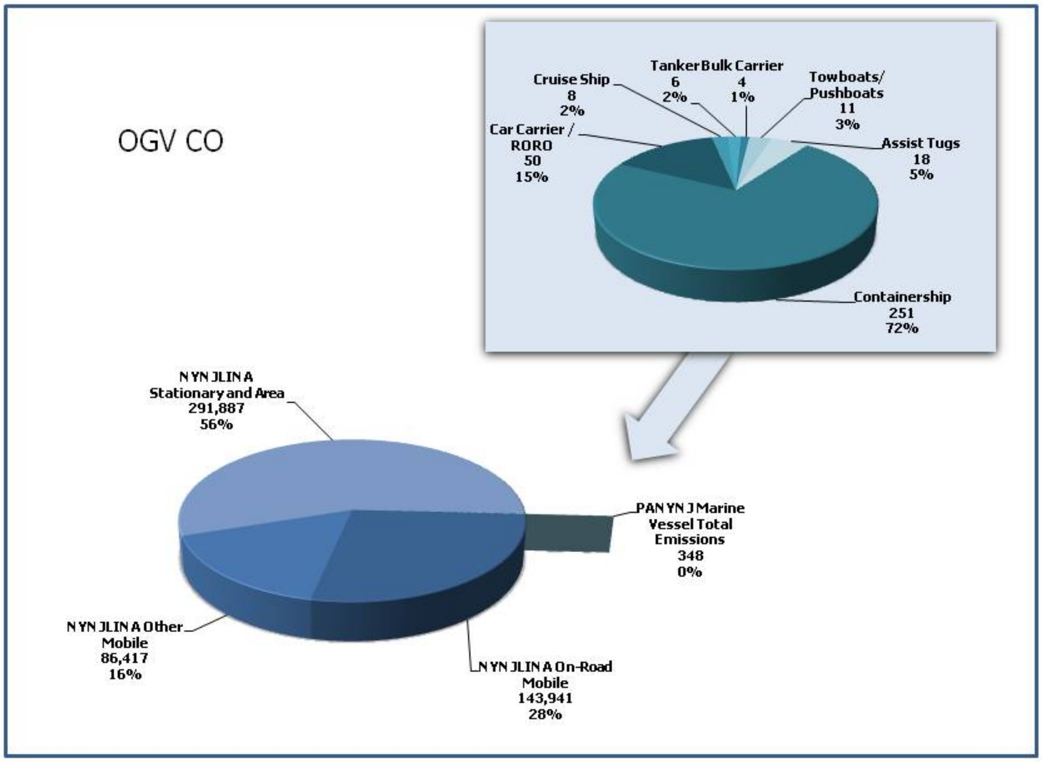
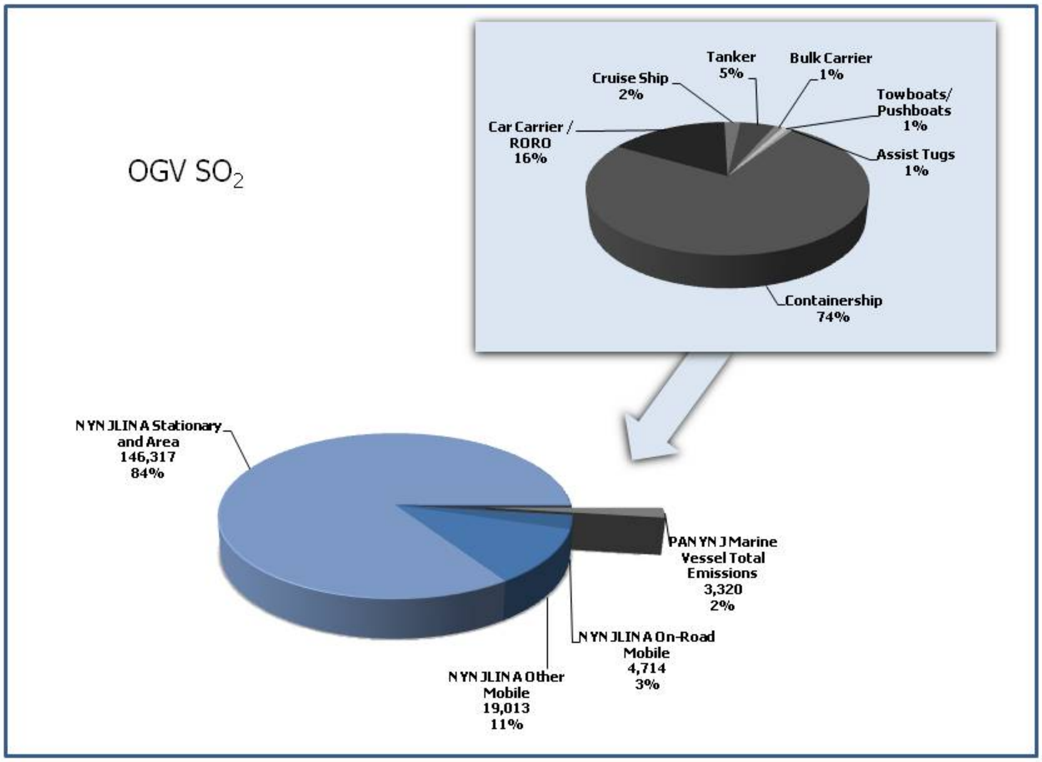


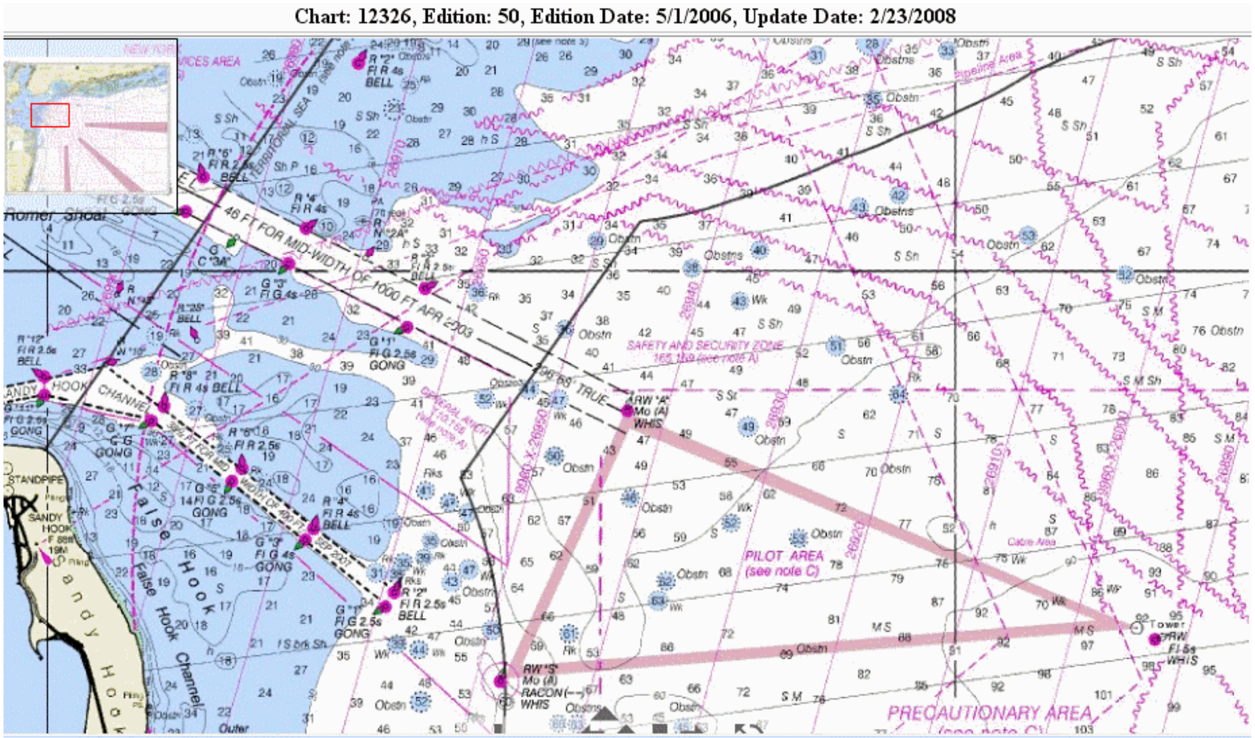
Figure ES5.7: Distribution and Comparison of SO_2 from CMVs, tpy and percent



5.1 CMV Emission Estimates

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

Figure 5.1 – Outer Limit of Study Area



(The dark line running approximately diagonally across the center of the map is the three-mile territorial limit and boundary of the non-attainment area.)

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

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

Vessel Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Containership	2,864	268	215	132	251	2,464
Car Carrier / RORO	613	56	46	24	50	537
Cruise Ship	93	8	6	4	8	72
Tanker	74	11	8	3	6	158
Bulk Carrier	47	4	3	2	4	39
Totals	**3,691**	**348**	**279**	**165**	**319**	**3,270**

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

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Containership	147,760	3.76	13.66	149,212
Car Carrier / RORO	32,038	0.79	2.60	32,338
Cruise Ship	4,292	0.11	0.35	4,332
Tanker	9,336	0.23	0.70	9,422
Bulk Carrier	2,337	0.06	0.21	2,359
Totals	**195,763**	**4.95**	**17.52**	**197,664**

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

Emission Source	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Main Engines	1,559	128	102	101	158	735
Auxiliary Engines	2,025	179	143	58	152	1,694
Boilers	107	41	33	5	10	841
Totals	**3,691**	**348**	**279**	**165**	**319**	**3,270**

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

Emission Source	CO_2	N_2O	CH_4	CO_2 Eq
Main Engines	46,878	1.38	7.20	47,457
Auxiliary Engines	99,444	2.34	6.75	100,311
Boilers	49,441	1.23	3.57	49,896
Totals	**195,763**	**4.95**	**17.52**	**197,664**

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

Mode	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_x
Transit	2,096	178	143	117	198	1,253
Dwelling	1,594	169	136	48	121	2,017
Totals	**3,691**	**348**	**279**	**165**	**319**	**3,270**

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

Mode	CO_2	N_2O	CH_4	CO_2 Eq
Transit	77,306	2.10	9.28	78,152
Dwelling	118,457	2.84	8.24	119,512
Totals	**195,763**	**4.95**	**17.52**	**197,664**

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

Vessel Type	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Towboats/Pushboats	279	15	14	11	24	29
Assist Tugs	207	11	10	8	18	21
Totals	**486**	**26**	**24**	**18**	**41**	**50**

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

Vessel Type	CO_2	N_2O	CH_4	CO_2 Eq
Towboats/Pushboats	14,685	1.69	4.89	15,311
Assist Tugs	10,912	1.26	3.61	11,380
Totals	**25,597**	**2.95**	**8.50**	**26,691**

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

5.2 CMV Emission Comparisons

This subsection presents the marine vessel emission estimates detailed in Section 5.1 in the context of overall county-wide and area-wide emissions. Port Authority maritime related OGV and tug/tow boat emissions are compared with all emissions in the NYNJLINA on a county-by-county basis. Overall county-level emissions were excerpted from the most recent National Emissions Inventory database. [22]

These emission comparisons are segregated into ocean going and assist vessel categories and are presented in sections 5.2.1 and 5.2.2 respectively. County level emissions have been estimated by determining the time and distance marine vessels spend plying waterways within each county

[22] 2005 National Emission Inventory Database, US EPA, 2008, downloaded May, 2008, http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata

and multiplying these by the appropriate load and emission factors. A detailed discussion of calculation methods is presented in section 4.3.

5.2.1 Ocean Going Vessel Emission Comparisons

The following series of tables and charts display the contribution that Port Authority 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 related OGV emissions with total county level emissions. Figures 5.2 through 5.7 summarize the same information visually on an individual county basis. Each column displays the county-wide emissions and on top of each column is the Port Authority 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	834	83	66	34	70	875
Hudson	NJ	588	51	41	30	54	398
Middlesex	NJ	0	0	0	0	0	0
Monmouth	NJ	211	18	14	12	20	126
Union	NJ	909	93	75	31	72	1,045
New Jersey subtotal		**2,542**	**246**	**196**	**107**	**215**	**2,445**
Bronx	NY	0	0	0	0	0	0
Kings (Brooklyn)	NY	397	35	28	21	37	266
Nassau	NY	0	0	0	0	0	0
New York	NY	83	7	6	3	7	64
Orange	NY	0	0	0	0	0	0
Queens	NY	0	0	0	0	0	0
Richmond (Staten Isld)	NY	669	60	48	34	61	495
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		**1,148**	**102**	**82**	**58**	**104**	**825**
TOTAL		**3,691**	**348**	**279**	**165**	**319**	**3,270**

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	834	3.5%
Hudson	NJ	27,776	588	2.1%
Middlesex	NJ	33,000	0	0.0%
Monmouth	NJ	19,177	211	1.1%
Union	NJ	21,154	909	4.3%
New Jersey subtotal		**150,577**	**2,542**	**1.7%**
Bronx	NY	16,018	0	0.0%
Kings (Brooklyn)	NY	29,788	397	1.3%
Nassau	NY	36,258	0	0.0%
New York	NY	39,082	83	0.2%
Orange	NY	19,397	0	0.0%
Queens	NY	41,172	0	0.0%
Richmond (Staten Isld)	NY	10,085	669	6.6%
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**	**1,148**	**0.4%**
TOTAL		**445,285**	**3,691**	**0.83%**

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

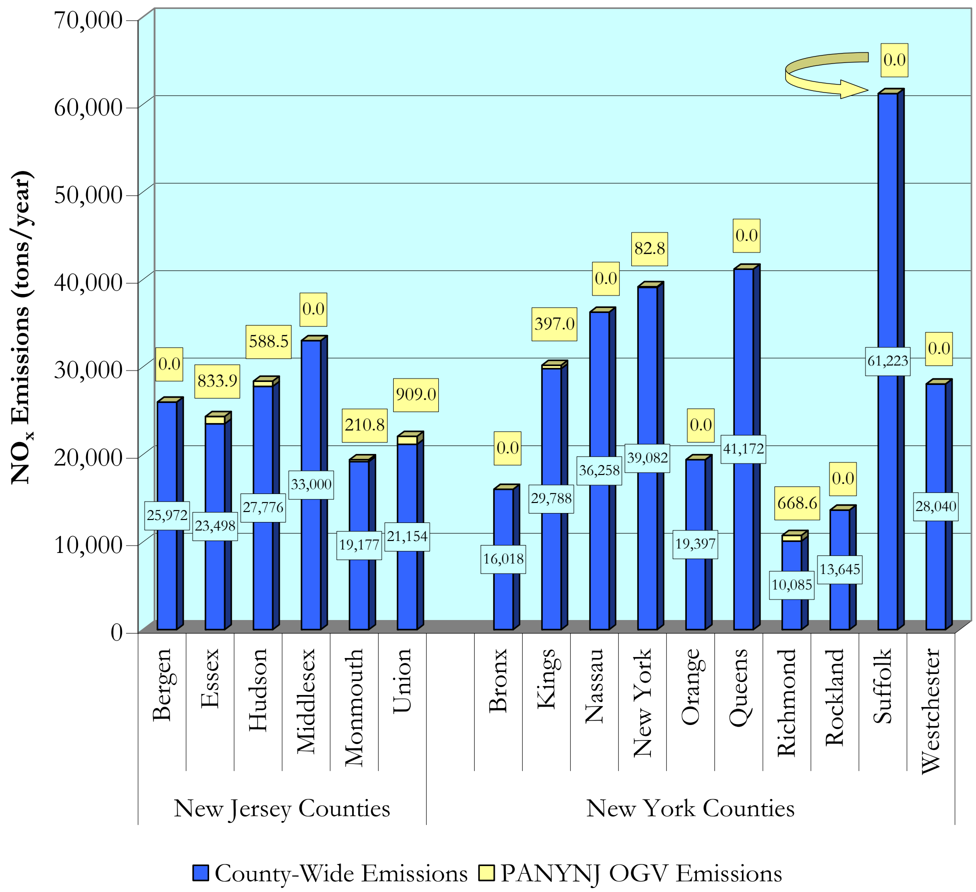


Table 5.11: Comparison of Ocean Going Vessel PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0	0.0%
Essex	NJ	3,745	83	2.2%
Hudson	NJ	6,764	51	0.8%
Middlesex	NJ	9,927	0	0.0%
Monmouth	NJ	7,935	18	0.2%
Union	NJ	4,227	93	2.2%
New Jersey subtotal		**38,850**	**246**	**0.6%**
Bronx	NY	5,803	0	0.0%
Kings (Brooklyn)	NY	8,312	35	0.4%
Nassau	NY	14,142	0	0.0%
New York	NY	8,689	7	0.1%
Orange	NY	27,696	0	0.0%
Queens	NY	9,615	0	0.0%
Richmond (Staten Isld)	NY	8,092	60	0.7%
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**	**102**	**0.07%**
TOTAL		**178,451**	**348**	**0.19%**

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

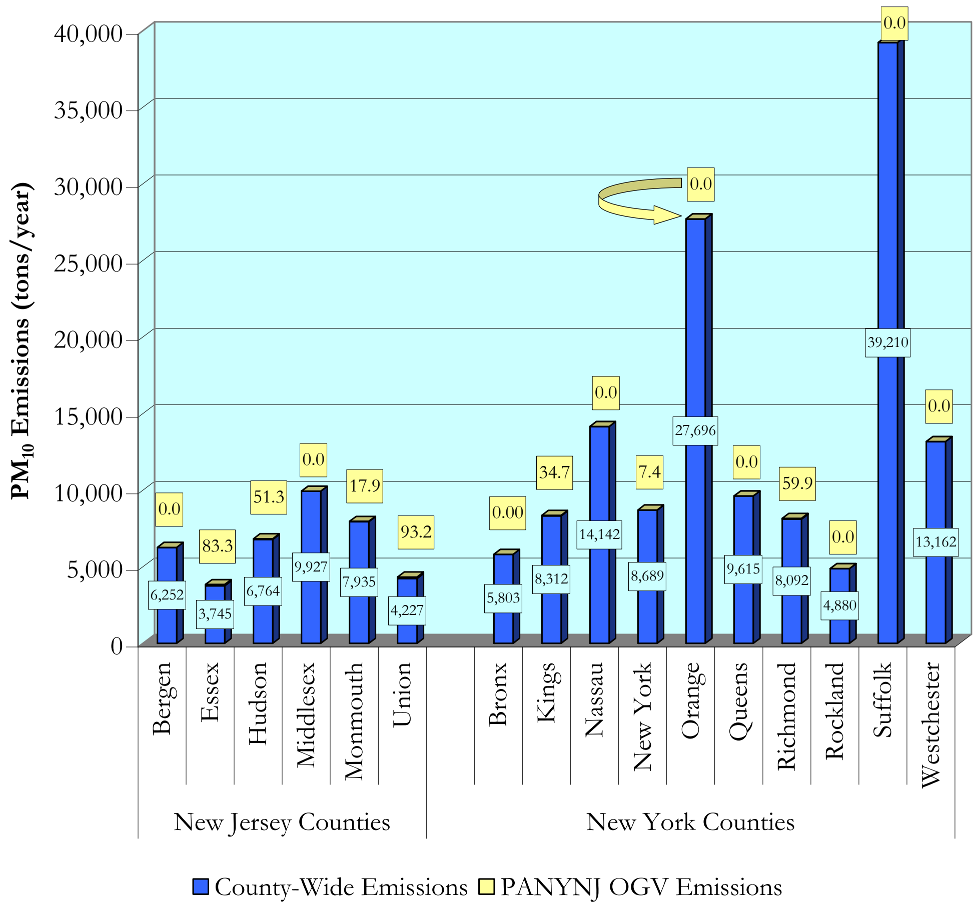


Table 5.12: Comparison of Ocean Going Vessel $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0	0.0%
Essex	NJ	1,159	66	5.7%
Hudson	NJ	3,754	41	1.1%
Middlesex	NJ	2,150	0	0.0%
Monmouth	NJ	1,623	14	0.9%
Union	NJ	1,472	75	5.1%
New Jersey subtotal		**11,567**	**196**	**1.7%**
Bronx	NY	1,357	0	0.0%
Kings (Brooklyn)	NY	2,676	28	1.0%
Nassau	NY	2,727	0	0.0%
New York	NY	4,017	6	0.1%
Orange	NY	4,968	0	0.0%
Queens	NY	3,655	0	0.0%
Richmond (Staten Isld)	NY	1,323	48	3.7%
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**	**82**	**0.3%**
TOTAL		**42,441**	**279**	**0.7%**

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

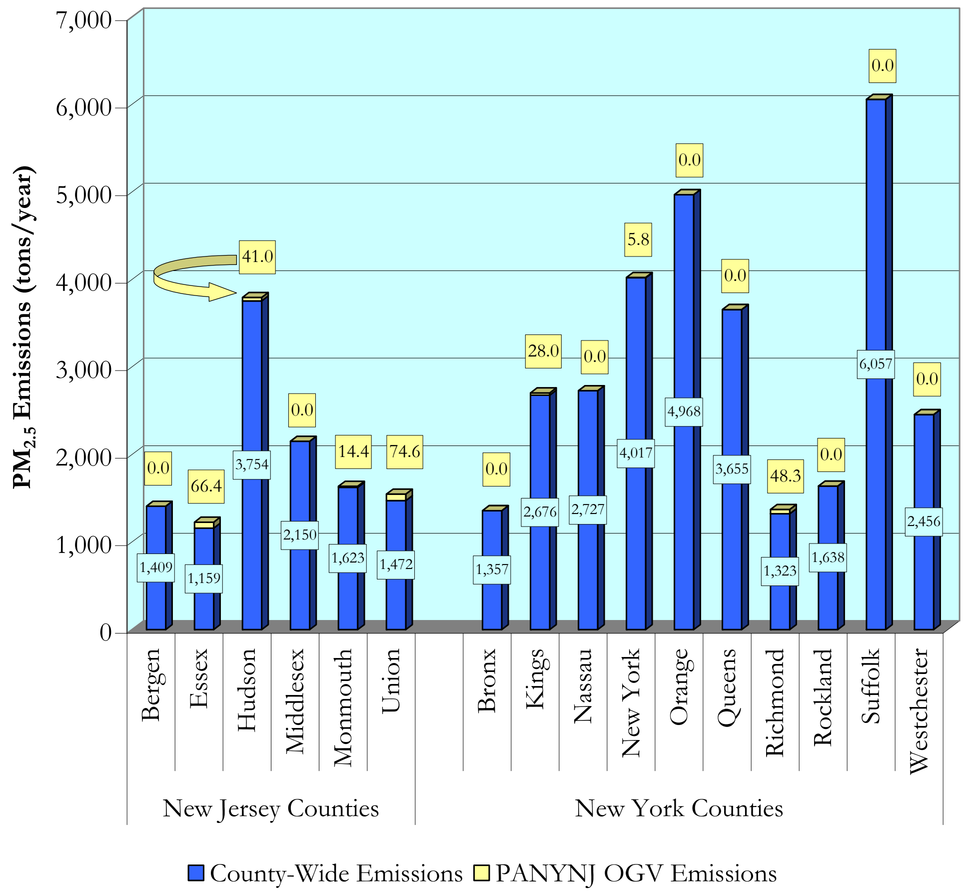


Table 5.13: Comparison of Ocean Going Vessel VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0	0.00%
Essex	NJ	20,940	34	0.16%
Hudson	NJ	14,428	30	0.21%
Middlesex	NJ	30,357	0	0.00%
Monmouth	NJ	22,727	12	0.05%
Union	NJ	20,627	31	0.15%
New Jersey subtotal		**142,075**	**107**	**0.08%**
Bronx	NY	25,454	0	0.00%
Kings (Brooklyn)	NY	54,809	21	0.04%
Nassau	NY	47,865	0	0.00%
New York	NY	45,292	3	0.007%
Orange	NY	18,349	0	0.00%
Queens	NY	47,262	0	0.00%
Richmond (Staten Isld)	NY	13,542	34	0.25%
Rockland	NY	13,767	0	0.00%
Suffolk	NY	77,071	0	0.00%
Westchester	NY	36,759	0	0.00%
New York Subtotal		**380,170**	**58**	**0.015%**
TOTAL		**522,245**	**165**	**0.03%**

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

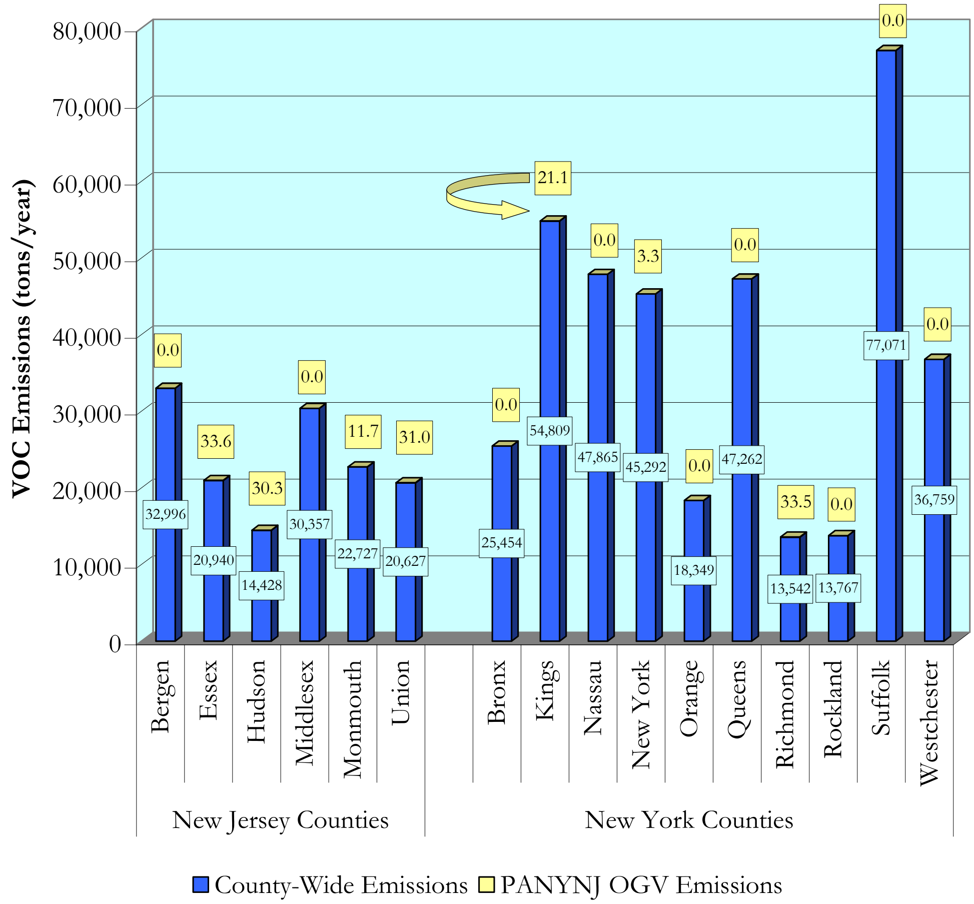


Table 5.14: Comparison of Ocean Going Vessel CO Emissions with Overall CO Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	242,981	0	0.00%
Essex	NJ	131,856	70	0.05%
Hudson	NJ	69,129	54	0.08%
Middlesex	NJ	196,869	0	0.00%
Monmouth	NJ	166,309	20	0.01%
Union	NJ	114,302	72	0.06%
New Jersey subtotal		**921,446**	**215**	**0.02%**
Bronx	NY	113,641	0	0.00%
Kings (Brooklyn)	NY	158,527	37	0.02%
Nassau	NY	282,348	0	0.00%
New York	NY	220,345	7	0.003%
Orange	NY	114,316	0	0.00%
Queens	NY	207,255	0	0.00%
Richmond (Staten Isld)	NY	52,149	61	0.12%
Rockland	NY	67,761	0	0.00%
Suffolk	NY	472,083	0	0.00%
Westchester	NY	230,503	0	0.00%
New York Subtotal		**1,918,928**	**104**	**0.005%**
TOTAL		**2,840,374**	**319**	**0.01%**

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

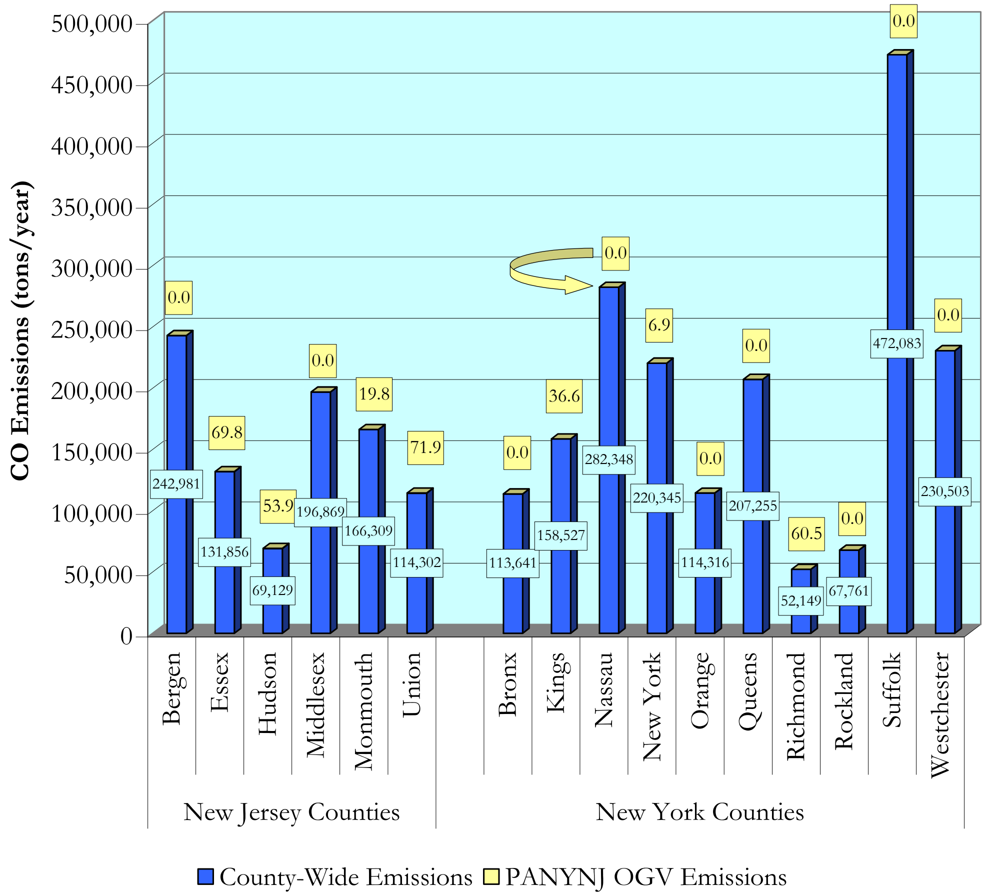
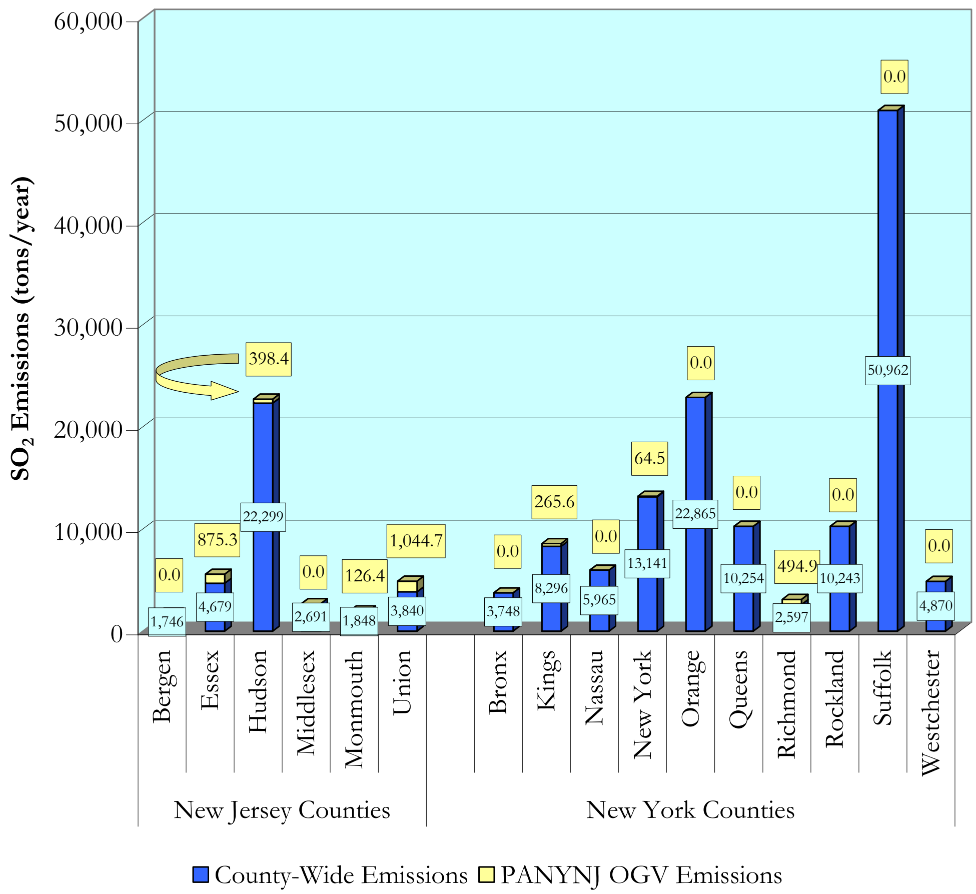


Table 5.15: Comparison of Ocean Going Vessel SO_2 Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	OGV Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0	0.0%
Essex	NJ	4,679	875	19%
Hudson	NJ	22,299	398	1.8%
Middlesex	NJ	2,691	0	0.0%
Monmouth	NJ	1,848	126	6.8%
Union	NJ	3,840	1,045	27%
New Jersey subtotal		**37,103**	**2,445**	**6.6%**
Bronx	NY	3,748	0	0.0%
Kings (Brooklyn)	NY	8,296	266	3.2%
Nassau	NY	5,965	0	0.0%
New York	NY	13,141	64	0.5%
Orange	NY	22,865	0	0.0%
Queens	NY	10,254	0	0.0%
Richmond (Staten Isld)	NY	2,597	495	19%
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**	**825**	**0.6%**
TOTAL		**170,044**	**3,270**	**1.9%**

Figure 5.7: Comparison of Ocean Going Vessel SO_2 Emissions with Overall SO2 Emissions by County, tpy



5.2.2 Tug and Tow Boat Emission Comparisons

The following series of tables and charts display the contribution of Port Authority related tug and tow boat emissions on 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 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 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_2
Bergen	NJ	3	0.2	0.1	0.1	0.2	0.3
Essex	NJ	72	3.9	3.6	2.7	6.2	7.5
Hudson	NJ	65	3.5	3.3	2.5	5.6	6.7
Middlesex	NJ	19	1.0	1.0	0.7	1.6	2.0
Monmouth	NJ	14	0.8	0.7	0.5	1.2	1.4
Union	NJ	136	7.4	6.8	5.1	11.7	14.0
New Jersey subtotal		**309**	**16.7**	**15.4**	**11.6**	**26.4**	**31.9**
Bronx	NY	1	0.0	0.0	0.0	0.0	0.1
Kings (Brooklyn)	NY	18	1.0	0.9	0.7	1.6	1.9
Nassau	NY	4	0.2	0.2	0.1	0.3	0.4
New York	NY	5	0.3	0.2	0.2	0.4	0.5
Orange	NY	3	0.2	0.2	0.1	0.3	0.3
Queens	NY	6	0.3	0.3	0.2	0.5	0.6
Richmond (Staten Isld)	NY	120	6.5	6.0	4.5	10.2	12.4
Rockland	NY	4	0.2	0.2	0.1	0.3	0.4
Suffolk	NY	12	0.7	0.6	0.5	1.0	1.3
Westchester	NY	5	0.3	0.2	0.2	0.4	0.5
New York subtotal		**177**	**9.6**	**8.8**	**6.7**	**15.0**	**18.2**
TOTAL		**486**	**26**	**24**	**18**	**41**	**50**

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	2.7	0.01%
Essex	NJ	23,498	72.5	0.31%
Hudson	NJ	27,776	65.4	0.24%
Middlesex	NJ	33,000	19.0	0.06%
Monmouth	NJ	19,177	14.0	0.07%
Union	NJ	21,154	135.9	0.64%
New Jersey Subtotal		**150,577**	**309**	**0.21%**
Bronx	NY	16,018	0.5	0.003%
Kings (Brooklyn)	NY	29,788	18.4	0.06%
Nassau	NY	36,258	3.6	0.01%
New York	NY	39,082	4.7	0.01%
Orange	NY	19,397	3.1	0.02%
Queens	NY	41,172	5.5	0.01%
Richmond (Staten Isld)	NY	10,085	120.1	1.19%
Rockland	NY	13,645	3.8	0.03%
Suffolk	NY	61,223	12.3	0.02%
Westchester	NY	28,040	4.7	0.02%
New York Subtotal		**294,708**	**177**	**0.1%**
TOTAL		**445,285**	**486**	**0.11%**

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

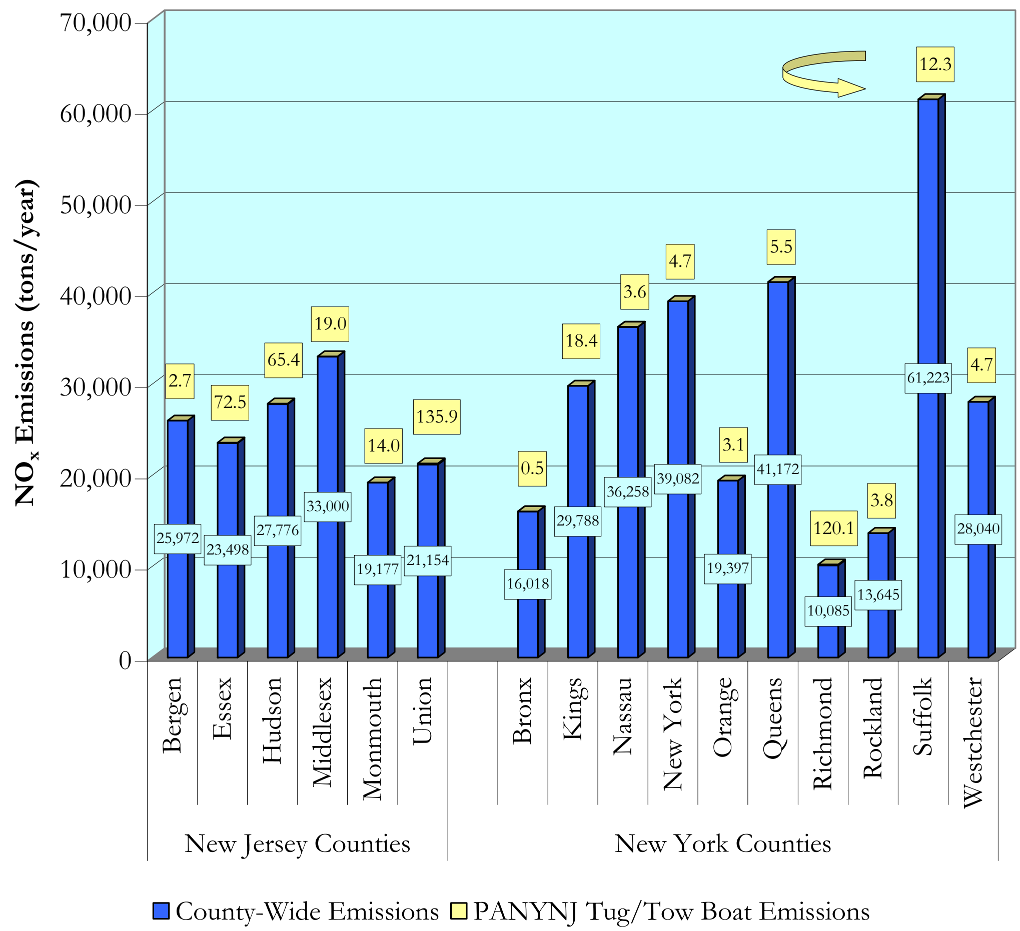


Table 5.18: Comparison of Harbor Craft PM_{10} Emissions with Overall PM_{10} Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	6,252	0.2	0.002%
Essex	NJ	3,745	3.9	0.104%
Hudson	NJ	6,764	3.5	0.052%
Middlesex	NJ	9,927	1.0	0.010%
Monmouth	NJ	7,935	0.8	0.010%
Union	NJ	4,227	7.4	0.174%
New Jersey Subtotal		**38,850**	**17**	**0.04%**
Bronx	NY	5,803	0.03	0.001%
Kings (Brooklyn)	NY	8,312	1.0	0.012%
Nassau	NY	14,142	0.2	0.001%
New York	NY	8,689	0.3	0.003%
Orange	NY	27,696	0.2	0.001%
Queens	NY	9,615	0.3	0.003%
Richmond (Staten Isld)	NY	8,092	6.5	0.080%
Rockland	NY	4,880	0.2	0.004%
Suffolk	NY	39,210	0.7	0.002%
Westchester	NY	13,162	0.3	0.002%
New York Subtotal		**139,601**	**10**	**0.01%**
TOTAL		**178,451**	**26**	**0.01%**

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

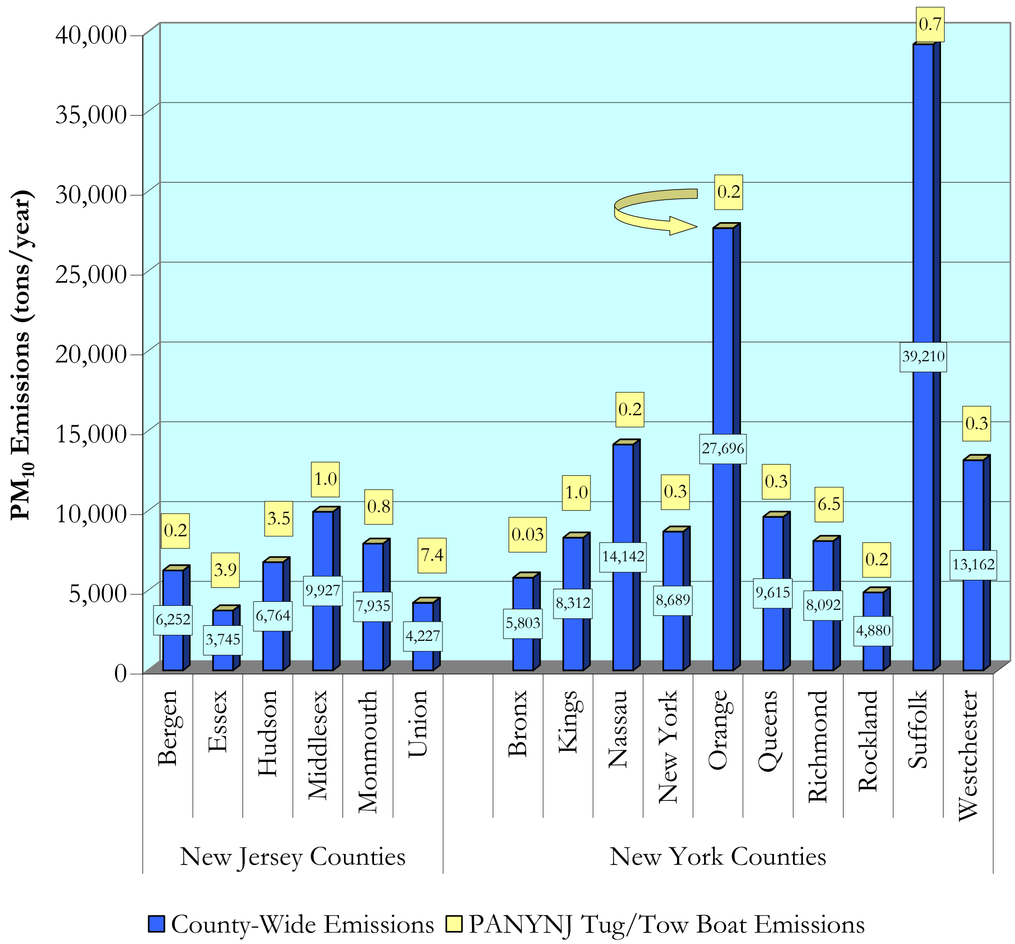


Table 5.19: Comparison of Harbor Craft $PM_{2.5}$ Emissions with Overall $PM_{2.5}$ Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	1,409	0.1	0.010%
Essex	NJ	1,159	3.6	0.310%
Hudson	NJ	3,754	3.3	0.087%
Middlesex	NJ	2,150	1.0	0.044%
Monmouth	NJ	1,623	0.7	0.043%
Union	NJ	1,472	6.8	0.459%
New Jersey Subtotal		**11,567**	**15**	**0.1%**
Bronx	NY	1,357	0.0	0.001%
Kings (Brooklyn)	NY	2,676	0.9	0.034%
Nassau	NY	2,727	0.2	0.007%
New York	NY	4,017	0.2	0.006%
Orange	NY	4,968	0.2	0.003%
Queens	NY	3,655	0.3	0.008%
Richmond (Staten Isld)	NY	1,323	6.0	0.453%
Rockland	NY	1,638	0.2	0.012%
Suffolk	NY	6,057	0.6	0.010%
Westchester	NY	2,456	0.2	0.009%
New York Subtotal		**30,874**	**9**	**0.03%**
TOTAL		**42,441**	**24**	**0.06%**

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

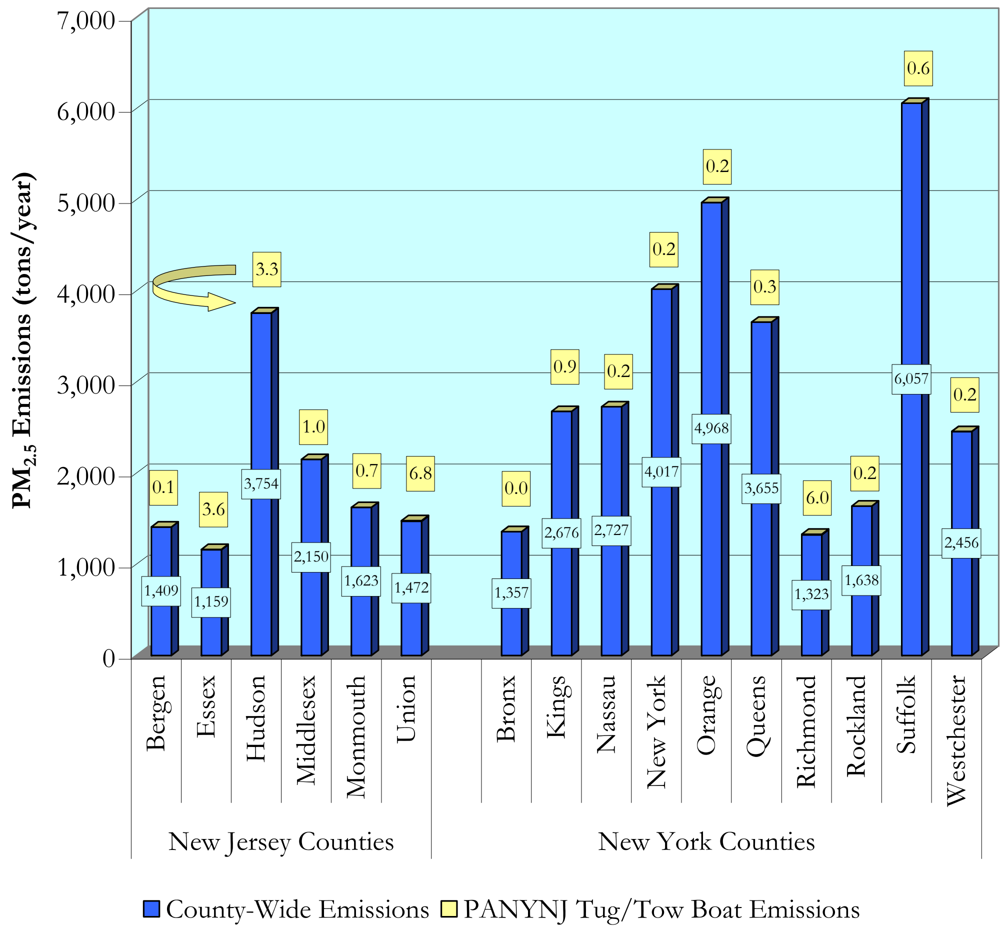


Table 5.20: Comparison of Harbor Craft VOC Emissions with Overall VOC Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	32,996	0.1	0.000%
Essex	NJ	20,940	2.7	0.013%
Hudson	NJ	14,428	2.5	0.017%
Middlesex	NJ	30,357	0.7	0.002%
Monmouth	NJ	22,727	0.5	0.002%
Union	NJ	20,627	5.1	0.025%
Bronx	NY	25,454	0.0	0.000%
Kings (Brooklyn)	NY	54,809	0.7	0.001%
Nassau	NY	47,865	0.1	0.000%
New York	NY	45,292	0.2	0.000%
Orange	NY	18,349	0.1	0.001%
Queens	NY	47,262	0.2	0.000%
Richmond (Staten Islc	NY	13,542	4.5	0.033%
Rockland	NY	13,767	0.1	0.001%
Suffolk	NY	77,071	0.5	0.001%
Westchester	NY	36,759	0.2	0.000%
New York Subtotal		**380,170**	**7**	**0.002%**
TOTAL		**380,170**	**18**	**0.00%**

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

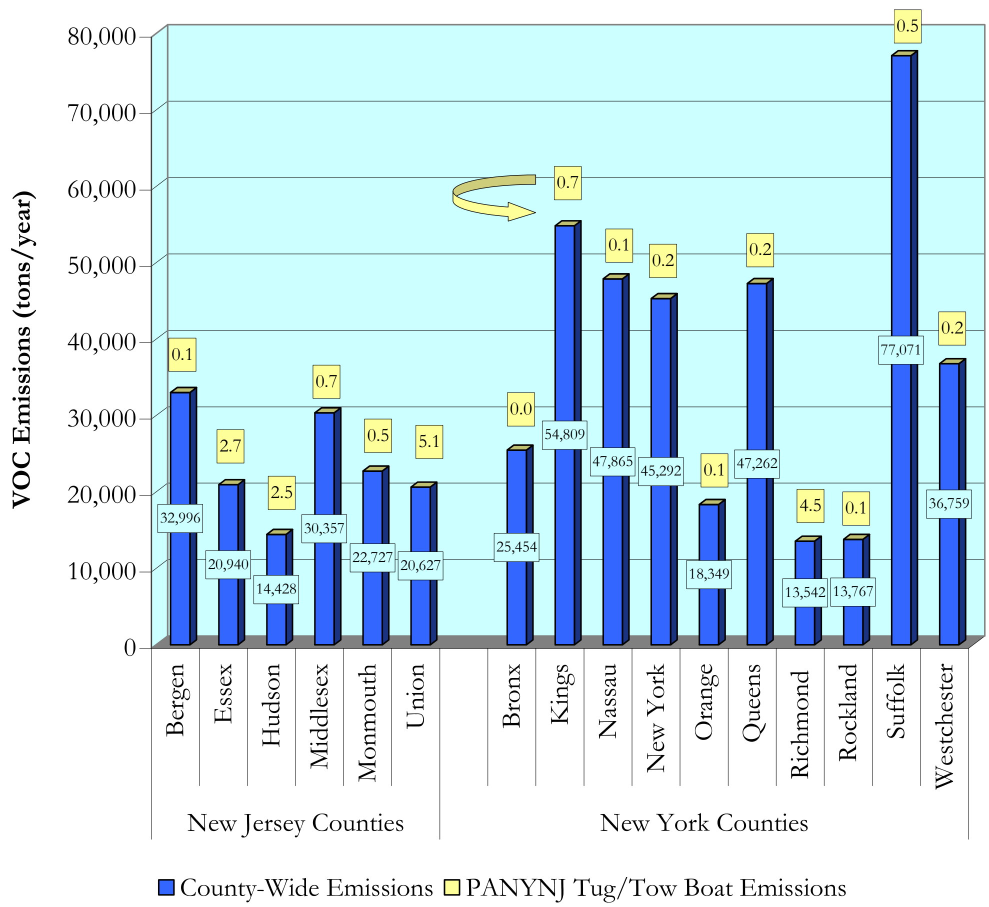


Table 5.21: Comparison of Harbor Craft CO Emissions with Overall CO Emissions by County, tpy

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	6.2	0.005%
Hudson	NJ	69,129	5.6	0.008%
Middlesex	NJ	196,869	1.6	0.001%
Monmouth	NJ	166,309	1.2	0.001%
Union	NJ	114,302	11.7	0.010%
Bronx	NY	113,641	0.0	0.0000%
Kings (Brooklyn)	NY	158,527	1.6	0.0010%
Nassau	NY	282,348	0.3	0.0001%
New York	NY	220,345	0.4	0.0002%
Orange	NY	114,316	0.3	0.0002%
Queens	NY	207,255	0.5	0.0002%
Richmond (Staten Islc	NY	52,149	10.2	0.0196%
Rockland	NY	67,761	0.3	0.0005%
Suffolk	NY	472,083	1.0	0.0002%
Westchester	NY	230,503	0.4	0.0002%
New York Subtotal		**1,918,928**	**15**	**0.001%**
TOTAL		**1,918,928**	**41**	**0.00%**

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

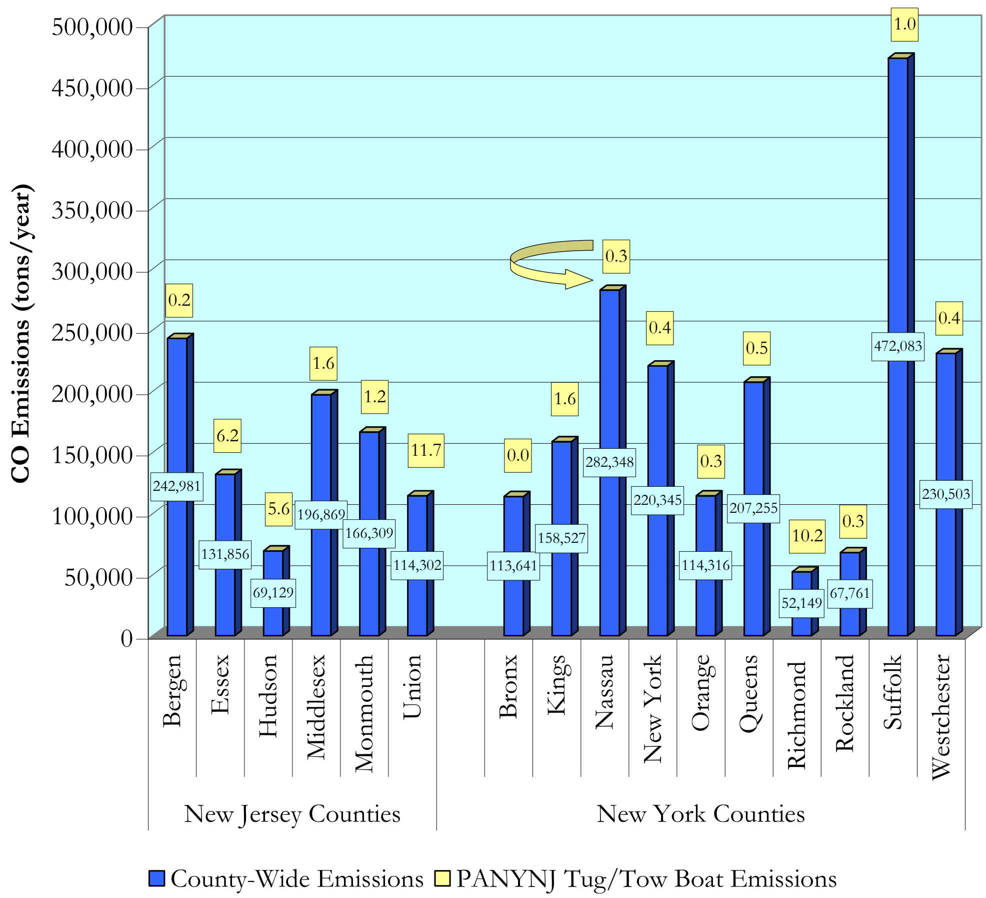
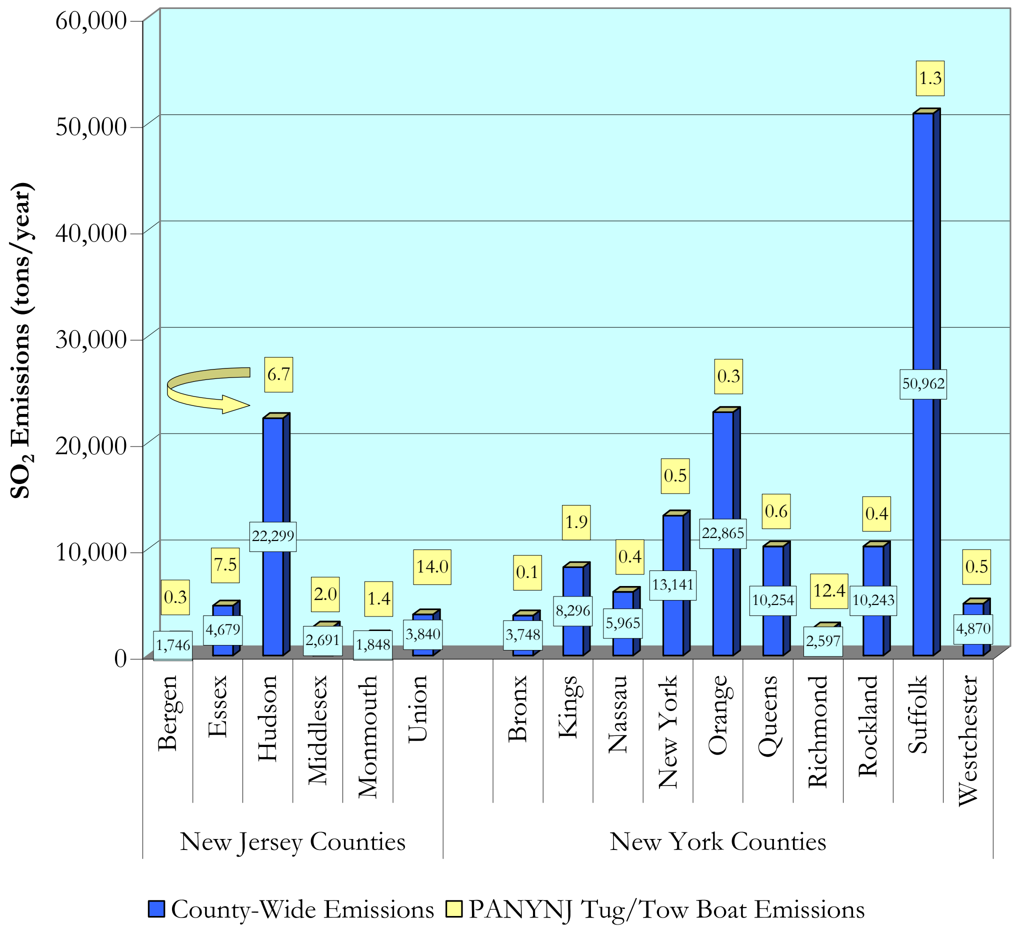


Table 5.22: Comparison of Harbor Craft SO_2. Emissions with Overall SO_2 Emissions by County, tpy

County	State	County-Wide Emissions	Tug/Tow Boat Emissions in Inventory	Percent of Total
Bergen	NJ	1,746	0.3	0.016%
Essex	NJ	4,679	7.5	0.160%
Hudson	NJ	22,299	6.7	0.030%
Middlesex	NJ	2,691	2.0	0.073%
Monmouth	NJ	1,848	1.4	0.078%
Union	NJ	3,840	14.0	0.365%
New Jersey Subtotal		**37,103**	**32**	**0.09%**
Bronx	NY	3,748	0.1	0.001%
Kings (Brooklyn)	NY	8,296	1.9	0.023%
Nassau	NY	5,965	0.4	0.006%
New York	NY	13,141	0.5	0.004%
Orange	NY	22,865	0.3	0.001%
Queens	NY	10,254	0.6	0.006%
Richmond (Staten Isld)	NY	2,597	12.4	0.476%
Rockland	NY	10,243	0.4	0.004%
Suffolk	NY	50,962	1.3	0.002%
Westchester	NY	4,870	0.5	0.010%
New York Subtotal		**132,941**	**18**	**0.01%**
TOTAL		**170,044**	**50**	**0.03%**

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 Lloyds Register–Fairplay (LRF) 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 previous marine vessel emission estimates were based on vessel call information tracked by the U.S. Coast Guard (USCG) using their Vessel Tracking Service (VTS), which supports a Coast Guard function to provide vessel monitoring and navigational advice to vessels operating in the area of U.S. ports[23]. At the time that inventory was developed, VTS monitoring was by radio contact between OGVs and the Coast Guard, and records were available from the Coast Guard as spreadsheets that listed vessel arrivals and departures by vessel name and by berth. In the intervening years the recordkeeping system that produced the arrival/departure record has been supplanted by a more comprehensive system, called the Automatic Identification System (AIS)[24] based on transponders carried by all OGVs and monitored by the Coast Guard on a continual basis. Because of this shift in monitoring methodology, the type of record that was available for year 2000 OGV activity is not available for year 2006 activity. Records that are available are currently not suitable for emissions inventory purposes because the Coast Guard's main interest in the AIS system is to provide real-time assistance to marine traffic, and records were not kept in a suitable format. However, future data should be available based on discussions between the Port Authority and the Coast Guard in preparation for the possible implementation of a harbor speed reduction zone to reduce OGV emissions in the NYNJHS.

The year 2006 vessel call data that forms the basis of the emission estimates presented in this report consists of a record of the number of vessel calls of each type to the Port Authority marine terminals noted above, and a record of all OGV calls to points within the NYNJHS. This second record is limited in that, while it specifies the vessel and date of call, it does not specify the terminal called at within the harbor system. For that reason, this data set has been used to develop vessel characteristic profiles but 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

[23] http://www.navcen.uscg.gov/mwv/vts/vts_home.htm
[24] http://www.navcen.uscg.gov/enav/ais/default.htm

berth. Activity levels have been evaluated based on the number of calls the ships made to Port Authority marine terminals in 2006 and speed profiles within the channel based on information developed for the 2000 emissions inventory. Data from LRF has been 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 the LRF-derived 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.

The 2000 marine vessel emissions inventory was a landmark study that evaluated and described in depth the operation of commercial marine vessels in the NYNJHS. Many of the findings and methods reported in that document have been used in developing the 2006 emission estimates, with updates as appropriate to reflect improvements to emission estimating methodologies, the level of marine vessel activity in 2006, and the somewhat different scope of evaluation (the 2000 study was concerned with commercial marine vessel activity over the entire harbor system, whereas the current study is focused on marine vessel activity directly related to the marine terminals owned by the Port Authority and leased to private tenants).

The 2006 NYNJHS-wide ship call data was evaluated with respect to the distribution of engine type, size category, and main engine power. These parameters can be compared with the corresponding statistics reported in the 2000 emissions inventory as a measure of changes that have taken place in the vessel fleet calling at NYNJHS-wide facilities during the intervening years. The 2006 harbor-wide characteristics have been used as surrogates for the actual vessels that called at the Port Authority marine terminals, since the data specific to the Port Authority terminals is not detailed to the vessel level.

OGVs are designed with various types of propulsion configuration, listed in Table 5.23. These configurations affect emissions because different engine designs are used in the different configuration, and the different engine designs have different emission characteristics. Most vessels are of the direct drive configuration, in which a single large main engine turns a shaft that is directly connected to the vessel's propeller – when the main engine is running, the propeller turns. The next most common drive configuration is the category of gear & electric drive, in which the engines either drive the propeller through a reduction gear system or they run electric generators that turn the propeller through an electric motor. In both cases the engines typically operate at higher speeds than direct drive engines. The remaining drive types, steam ships, gas turbines, and other drive types (which are listed in Lloyd's as either a combination of the types described above, as a sailing vessel, or as "unknown" propulsion type) were insignificant in 2006.

Table 5.23 presents the harbor-wide distribution of propulsion configurations by number of ships and by number of calls in 2006, while Table 5.24 presents the distribution of propulsion configurations by number of ships in 2000 for comparison. The difference between "number of ships" and "number of calls" is that the "number of ships" distribution counts each calling vessel once, whereas the "number of calls" distribution counts each call, such that vessels calling more often have a greater effect on the overall distribution. The 2000 report listed only the "number of ships" distribution. The most notable difference between the two years is the decline in the number and percentage of steamships among the vessels that called.

Table 5.23: 2006 Harbor-Wide Propulsion Configuration by Number of Ships and by Number of Calls

Propulsion Engine Configuration	Number of Ships	Percent of Ships	Number of Calls	Percent of Calls
Direct Drive	1,492	90%	5,169	88%
Gear & Electric Drive	146	9%	551	9%
Steam	7	0.4%	66	1.1%
Gas Turbine	3	0.2%	20	0.3%
Other	6	0.4%	51	0.9%
Totals	1,654	100%	5,857	100%

Table 5.24: 2000 Harbor-Wide Propulsion Configuration by Number of Ships

Propulsion Engine Configuration	Number of Ships	Percent of Ships
Direct Drive	1,232	86%
Gear & Electric Drive	153	11%
Steam	39	3%
Gas Turbine	1	0.1%
Other	0	0%
Totals	1,425	100%

The percentages of vessel visits by vessel type and size group were also evaluated. Table 5.25 lists the harbor-wide percentages of vessel calls by type in 2006, while Table 5.26 presents the data on the basis of unique vessels (each ship counted once regardless of how many times it visited the area) for comparison with the corresponding 2000 data shown in Table 5.27. These tables indicate a trend toward larger vessels. For example, 25% of the containerships calling on harbor berths were 50,000 DWT or larger in 2000, while in 2006 that percentage had increased to 50%. (The values in these tables do not add to 100% in all cases because of rounding.)

Table 5.25: 2006 Harbor-Wide OGV Calls by Type and Weight Group – All Calls

	Percentage of Calls by Dead-Weight Tonnage Groups				
Vessel Type	<10,000	10,000 - 49,999	50,000 - 99,999	100,000 - 149,999	150,000+
Containership	2%	46%	52%	0%	0%
Car Carrier / RORO	6%	94%	0%	0%	0%
Cruise Ship	62%	38%	0%	0%	0%
Tanker	1%	69%	22%	7%	1%
Bulk Carrier	0%	83%	17%	0%	0%
Miscellaneous	43%	43%	14%	0%	0%

Table 5.26: 2006 OGV Harbor-Wide Calls by Type and Weight Group – Unique Vessels

	Percentage of Calls by Dead-Weight Tonnage Groups				
Vessel Type	<10,000	10,000 - 49,999	50,000 - 99,999	100,000 - 149,999	150,000+
Containership	0%	49%	50%	0%	0%
Car Carrier / RORO	14%	86%	0%	0%	0%
Cruise Ship	70%	30%	0%	0%	0%
Tanker	2%	69%	20%	8%	1%
Bulk Carrier	0%	58%	42%	0%	0%
Miscellaneous	50%	33%	17%	0%	0%

Table 5.27: 2000 OGV Calls by Size Group – Unique Vessels

	Percentage of Calls by Dead-Weight Tonnage Groups				
Vessel Type	<10,000	10,000 - 49,999	50,000 - 99,999	100,000 - 149,999	150,000+
Containership	1%	75%	25%	0%	0%
Car Carrier / RORO	6%	91%	3%	0%	0%
Cruise Ship	75%	25%	0%	0%	0%
Tanker	3%	66%	26%	4%	2%
Bulk Carrier	13%	82%	4%	0%	0%
Miscellaneous	13%	21%	60%	2%	4%

The preceding tables presented data related to all vessel calls to the NYNJHS in 2006. 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 5.28.

Table 5.28: 2006 – Number of Calls to the Port Authority Marine Terminals

Vessel Type	No. of Calls
Bulk Carrier	119
Car Carrier / RORO	769
Containership	2,552
Cruise Ship	41
Tanker	81
Total	**3,562**

The main engine power characteristics of the vessels calling at NYNJHS berths in 2006 are summarized in Table 5.29, and the same characteristics reported for 2000 are shown in Table 5.30. It should be noted that the 2000 report listed horsepower as the power values for main engines – the values presented in the table below have been converted to kilowatts. In both tables, the far right column contains the call-weighted average main engine power for all size classes combined.

Table 5.29: 2006 – Average OGV Main Engine Power (kW) by Size Group

	Call-Weighted Avg. Prop. Engine Power by DWT Groups					Average
Vessel Type	<10,000	10,000 - 49,999	50,000 - 99,999	100,000 - 149,999	150,000+	All DWT Groups
Containership	5,399	20,718	38,341	NA	NA	29,501
Car Carrier / RORO	3,288	12,886	NA	NA	NA	12,329
Cruise Ship	47,619	77,049	NA	NA	NA	58,866
Tanker	3,824	8,490	11,539	13,849	16,934	9,554
Bulk Carrier	NA	7,234	9,712	NA	NA	7,663
Miscellaneous	3,349	10,116	10,297	NA	NA	7,242

Table 5.30: 2000 – Average OGV Main Engine Power (kW) by Size Group

	Call-Weighted Avg. Prop. Engine Power by DWT Groups					Average
Vessel Type	<10,000	10,000 - 49,999	50,000 - 99,999	100,000 - 149,999	150,000+	All DWT Groups
Containership	6,790	19,355	35,568	NA	NA	23,296
Car Carrier / RORO	5,011	11,289	NA	NA	NA	15,452
Cruise Ship	8,667	8,759	NA	NA	NA	58,866
Tanker	3,426	7,916	10,768	14,067	17,634	8,945
Bulk Carrier	NA	8,344	9,437	NA	NA	7,906
Miscellaneous	4,673	7,770	11,072	NA	NA	10,027

On a size category basis, the main engine power did not change significantly between 2000 and 2006 for most vessel types, except for cruise ships – the average engine power of cruise ships went up several-fold due to the great increase in the size of these vessels over the past few years.

In terms of the overall weighted average power, the migration to larger containerships is reflected in an increase of 27% from 23,296 kW to 29,501 kW. The same increase did not occur with the bulk and miscellaneous vessels, which also showed a move toward more vessels in the larger size categories, possibly because there is a relatively small difference in engine power among different sized bulk ships.

Average auxiliary engine power for each vessel type was derived from LRF data. Auxiliary boiler capacity is not included in the LRF data so values for this parameter were obtained from previously released marine vessel emissions inventories.[25] These values for the 2006 emission estimates are presented in Table 5.31.

Table 5.31: 2006 – Average OGV Auxiliary Engine and Boiler Power (kW)

Vessel Type	Auxiliry Power (kW)	Boiler Power (kW)
Containership	6,216	6,217
Car Carrier / RORO	4,322	281
Cruise Ship	NA	NA
Tanker	2,843	3,000
Bulk Carrier	2,050	109
Miscellaneous	1,233	371

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.). Operating profiles reported in the 2000 emissions inventory were used as the basis for the 2006 calculations, with updated emission factors consistent with other recently published emissions inventories.[26] Table 5.32 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.

[25] Puget Sound Maritime Air Emissions Inventory – April 2007
[26] Puget Sound Emissions Inventory, EPA Best Practices document

Table 5.32: Assist Tug Operating Data and Assumptions

OGV Type	Destination	2006 data Ocean Calls	Trips in + out	Assist Tugs/Trip
Containership	Maher	1,139	2,278	1 - 2
Car / RORO	Port Newark	569	979	1
Containership	APM	500	1,000	2
Containership	PNCT	399	798	2
Containership	NYCT	388	776	2
Car / RORO	Auto Marine Terminal	200	241	1
Containership	Red Hook	126	252	2
Bulk Carrier	Port Newark	119	238	1 - 2
Tanker	Port Newark	81	162	1 - 2
Cruise	Passenger Terminal	41	82	1
Totals		**3,562**	**6,806**	

5.3.1.3 Towboats/Pushboats

The Port Authority provided a record of the towboat/pushboat arrivals and departures related to Port Authority marine terminals during 2006. 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 Port Authority activity record includes the origins and destinations of the trips and formed the basis of estimates of horsepower-hours in the various counties through which the boats pass, based on the estimated distances and speeds between trip origins and destinations. The vessel profiles of speed and operating characteristics such as onboard engine horsepower and average load factors have been kept consistent with the 2000 emissions inventory. Table 5.33 lists the towboat origins and destinations, estimated transit distance, and number of trips in 2006. As noted above, the same emission factors were used for these vessels as for assist tugs, because the vessels share many of the same characteristics.

Table 5.33: Towboat/Pushboat Routes and Calls

From	To	Estimated Distance (miles)	# Trips
Howland Hook	Hackensack River Processing Sites	16.5	18
New Jersey Marine Terminals	Hackensack River Processing Sites	11.7	23
	Fresh Kills - Staten Is.	9.9	3
	HARS	28.2	22
Red Hook	Port Newark (NJ Marine Terminals)	9.9	379
New Jersey Marine Terminals	Out of area (Boston)	106.6	104
	Out of area (Norfolk)	54.1	104
Arthur Kill - Tosco, Hess	Automarine Terminal	16.5	189
	Red Hook Container Terminal	18.4	301
	Howland Hook	8.2	228
	New Jersey Marine Terminals	13.1	1,439
Port Newark (BP)	Automarine Terminal	10.9	85
	Red Hook Container Terminal	12.1	75
	Howland Hook	6.6	50
	New Jersey Marine Terminals	2.1	617
Out of area (PA, DE)	Port Newark (BP)	26.0	154
Port Newark	Out of area (Baltimore)	54.1	4
Out of area (Albany)	Port Newark	68.7	54
Bronx Sound	Port Newark	24.2	6
Staten Island - north shore	Automarine Terminal	6.8	6
	Howland Hook	2.0	2
	New Jersey Marine Terminals	3.6	18

5.3.2 Estimating Methodology

Emission estimates have been developed for the three combustion emission source types associate 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 profiles, and the methods of estimating emissions, are discussed below for the three source types – differences between transit and dwelling methodologies are discussed where appropriate.

5.2.2.1 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) 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

MCR power = maximum continuous rated power, derived from LRF data as discussed above

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

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[27] and have been used in recent vessel emissions inventories in the U.S. The particulate emission factor has been updated based on new information[28] while the emission factors for N_2O and CH_4 are from an EPA publication on greenhouse gases.[29] The emission factors used for main and auxiliary engines and for auxiliary boilers are listed in Tables 5.34 (criteria pollutants) and 5.35 (greenhouse gases).

Table 5.34: OGV Criteria Pollutant Emission Factors (g/kW-hr)

Engine Category	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
Slow Speed Main	18.1	1.3	1.04	0.6	1.4	10.5
Medium Speed M	14	1.3	1.04	0.5	1.1	11.5
Steam Main and E	2.1	0.8	0.64	0.1	0.2	16.5
Auxiliary	14.7	1.3	1.04	0.4	1.1	12.3

Table 5.35: OGV Greenhouse Gas Emission Factors (g/kW-hr)

[27] 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.

[28] 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) See Appendix 2 for PM factors.

[29] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2006. ANNEX 3 Methodological Descriptions for Additional Source or Sink Categories

Engine Category	CO_2	N_2O	CH_4
Slow Speed Main	670	0.016	0.045
Medium Speed Main	677	0.017	0.049
Steam Main and Boiler	970	0.024	0.07
Auxiliary	722	0.017	0.049

In keeping with recent practice,[30] 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 5.36 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 upward.

[30] Best Practices in Preparing Port Emission Inventories, Prepared for U.S. EPA by ICF Consulting

Table 5.36: OGV Low Load Adjustment Factors

Load	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2
1%	11.47	19.23	19.23	59.37	19.38	1.00
2%	4.63	7.32	7.32	21.21	9.71	1.00
3%	2.92	4.35	4.35	11.7	6.48	1.00
4%	2.21	3.1	3.1	7.72	4.87	1.00
5%	1.83	2.45	2.45	5.62	3.9	1.00
6%	1.6	2.05	2.05	4.36	3.26	1.00
7%	1.45	1.79	1.79	3.53	2.8	1.00
8%	1.35	1.61	1.61	2.95	2.45	1.00
9%	1.27	1.48	1.48	2.53	2.18	1.00
10%	1.22	1.38	1.38	2.21	1.97	1.00
11%	1.17	1.3	1.3	1.96	1.79	1.00
12%	1.14	1.24	1.24	1.76	1.65	1.00
13%	1.11	1.19	1.19	1.6	1.52	1.00
14%	1.08	1.15	1.15	1.47	1.42	1.00
15%	1.06	1.11	1.11	1.36	1.32	1.00
16%	1.05	1.09	1.09	1.26	1.24	1.00
17%	1.03	1.06	1.06	1.18	1.17	1.00
18%	1.02	1.04	1.04	1.11	1.11	1.00
19%	1.01	1.02	1.02	1.05	1.05	1.00
20%	1.00	1.00	1.00	1.00	1.00	1.00

5.3.2.2 OGV Auxiliary Engines

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

Equation 5.2

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

Where:

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

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

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

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

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

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

Operating hours are based on the same distance/speed calculation as for main engines for periods the vessels are in motion, and on the average dwelling times for periods at berth.

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 are equipped with economizers that recover main engine exhaust heat. The auxiliary boilers start up as vessel speed decreases, and they are assumed to be fully operating during maneuvering conditions.

The boiler kW values shown in Table 5.8 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 load factor assumptions are presented below in Table 5.37.

Table 5.37: OGV Engine and Boiler Load Factors

Vessel Type	Main Engines Bay	Main Engines Channel	Main Engines Maneuver	Auxiliary Engines Transit	Auxiliary Engines Maneuver	Auxiliary Engines Dwelling	Boilers Harbor	Boilers Dwelling
Bulk Carrier	37%	16%	2%	17%	45%	10%	100%	100%
Car Carrier	50%	10%	2%	15%	45%	26%	100%	100%
Containership	30%	6%	2%	13%	50%	18%	100%	100%
Cruise Ship	26%	5%	2%	45%	80%	45%	100%	100%
Tanker	48%	21%	2%	24%	33%	26%	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,[31] and which has been used widely since that time.[32] The 43% factor for auxiliary engines is widely used and has been reported by EPA,[33] and has also been used in this effort for the towboat/pushboat emission estimates. The main engine load factor for towboats/pushboats is 68% (reported in the referenced documents).

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 2006. The operating time of towboats and pushboats has been estimated from the number of visits to the terminals, the distance over routes taken from trip origins (for trips bringing cargo or materials to the terminals) or trip destinations (for trips taking cargo or materials away from the terminals), and the average speeds traveled.

The emission factors used for assist tug, towboat, and pushboat main and auxiliary engines are listed in Table 5.38.

[31] 2001 POLA Baseline Emissions Inventory
[32] Best Practices in Preparing Port Emission Inventories, previously cited
[33] Best Practices as above

Table 5.38: Assist Tug and Towboat/Pushboat Emission Factors, g/kW-hr

Engine Type	NO_x	PM_{10}	$PM_{2.5}$	CO	HC	SO_2	CO_2	N_2O	CH_4
Main engines (Category 2)	13.2	0.72	0.66	1.10	0.50	1.35	690	0.08	0.23
Auxiliary engines (Category 1)	10.0	0.40	0.37	1.70	0.27	1.35	690	0.08	0.23

While the characteristics of the vessels used in assist tug duty vary, in general their main (propulsion) engines are of the size categorized as Category 2 (single-cylinder displacement between 5 and 30 liters) and their smaller auxiliary engines are typically Category 1 (single-cylinder displacement between 1 and 5 liters). Because the characteristics of individual assist tugs serving Port Authority owned marine terminals are not known, these general assumptions have been used in determining which emission factors to use. These emission factors have been documented by EPA in the previously cited Best Practices document, except for greenhouse gases; the emission factor for CO_2 is from the previously cited Entec study, and the emission factors for N_2O and CH_4 are from the previously cited EPA publication "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006."

5.4 Description of Marine Vessels and Vessel Activity

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

5.4.1 Ocean-Going Vessels

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

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

Figure 5.14: 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.

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.

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.

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.

Figure 5.18: Tanker

Combination/Miscellaneous Vessels – Vessels that combine features of the vessel categories above. For example, vessels that combine the features of containers and break bulk functions, or containers and Ro/Ro functions.

5.4.2 Assist Tugs, Towboats, Pushboats

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

Figure 5.19: Tugboat