GREENHOUSE GAS AND CRITERIA AIR POLLUTANT EMISSION INVENTORY FOR THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

Calendar Year 2007

Prepared for:

The Port Authority of New York & New Jersey
New York, NY

Prepared by:

Southern Research Institute
Durham, NC

and

E.H. Pechan & Associates, Inc.
Springfield, VA

March 2009

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

ACRONYMS AND ABBREVIATIONS

ATADS	Air Traffic Activity System
CAP	criteria air pollutant
CBECS	Commercial Building Energy Consumption Survey
CH_4	methane
CHE	cargo-handling equipment
CHRP	Central Heating and Refrigeration Plant
CMV	Commercial Marine Vessels
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DOE	U.S. Department of Energy
EDMS	Emission Dispersion Modeling System
EIA	Energy Information Administration
eGRID	Emissions & Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
GHG	greenhouse gas
GRP	General Reporting Protocol
GSE	ground support equipment
GVWR	gross vehicle weight rating
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HDDVs	heavy-duty diesel vehicles
HFCs	hydrofluorocarbons
I/M	inspection maintenance
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
KIAC	Kennedy International Airport Cogeneration
kg	kilogram
kWh	kilowatt hours
lbs	pounds
LDGT-1 and 2	light-duty gasoline trucks below 6,000 pounds
LDGT-3 and 4	light-duty gasoline trucks between 6,001 and 8,500 pounds
LDGV	light-duty gasoline vehicles
LPG	liquid petroleum gas

LTO	landing and takeoff
MMBtu	million British thermal units
mpg	miles per gallon
MSW	municipal solid waste
N_2O	nitrous oxide
NERC	North American Electric Reliability Council
NJDEP	New Jersey Department of Environmental Protection
NO_x	oxides of nitrogen
NYNJHS	New York New Jersey Harbor System
NYPA	New York Port Authority
OGV	ocean-going vessels
PANYNJ	Port Authority of New York and New Jersey
PATH	Port Authority Trans-Hudson
Pechan	E.H. Pechan & Associates, Inc.
PFCs	perfluorocarbons
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
SAR	Second Assessment Report
SCC	Source Classification Code
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
Southern	Southern Research Institute
TAR	Third Assessment Report
TCR	The Climate Registry
TEUs	twenty-foot equivalent units
TJ	terajoule
USACE	U.S. Army Corps of Engineers
UTV	Utility Track Vehicle
VMT	vehicle-miles traveled
VOC	volatile organic compound
WDCSD	World Business Council on Sustainable Development
WIP	work in progress
WRI	World Resources Institute

1.0 EXECUTIVE SUMMARY

1.1. BACKGROUND

The Port Authority of New York and New Jersey (PANYNJ) manages and maintains the bridges, tunnels, bus terminals, airports, Port Authority Trans-Hudson (PATH) commuter rail system, and marine terminals that are critical to the metropolitan New York and New Jersey region's trade and transportation capabilities. Major facilities owned, managed, operated, or maintained by the PANYNJ include John F. Kennedy International, Newark Liberty International, and LaGuardia airports; the George Washington Bridge; the Lincoln and Holland tunnels; Port Newark and the Howland Hook Marine Terminal; the Port Authority Bus Terminal; and the 16-acre World Trade Center site in Lower Manhattan.

As a cornerstone in its broader sustainability program, PANYNJ is implementing a program to reduce its greenhouse gas (GHG) emissions by 80 percent, from 2006 levels, by the year 2050. To establish an initial baseline required to monitor progress toward this goal, PANYNJ utilized the services of Southern Research Institute (Southern) and E.H. Pechan & Associates, Inc. (Pechan) to conduct a GHG and criteria air pollutant (CAP) emissions inventory of Port Authority facilities and operations for calendar year 2006. The results of that inventory effort are documented in the report entitled *Greenhouse Gas Emission Inventory for the Port Authority of New York & New Jersey, Calendar Year 2006*. This report provides an update of the PANYNJ's GHG and CAP emissions for calendar year 2007. The inventory includes the emissions of PANYNJ tenants (e.g., airlines and container terminals) and patrons (e.g., airport passengers and PATH riders).

1.1.1. Objectives

The emission inventory described in this report was developed for calendar year 2007. It is the second emission inventory year developed for the Port Authority. The following objectives were set for this emission inventory effort:

1. Account for all six GHGs identified by the Intergovernmental Panel on Climate Change (IPCC): carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6).
2. Account for the following CAPs: oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and particulate matter (PM).
2. Include direct and indirect emissions.
3. Maximize flexibility to prepare for future regulatory regimes (e.g., track emissions by department, facility, and type of emission, expressing emissions in absolute and normalized terms).

4. Ensure transparency.
5. Estimate emissions rather than rely on direct measurement.
6. Refine the system established for the calendar year 2006 inventory to allow for ease in annual reporting.
7. Adhere to the IPCC guidelines for conducting national GHG emission inventories and incorporate expert techniques in the inventory of corporate emissions, as well as of airports, marine terminals, and other transportation facilities. This includes the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
8. Express GHG emissions in tons of CO_2 equivalent units (CO_2e) as well as separately for each of the individual gases. Express CAP emissions in metric tons.

For non-CO_2 GHGs, the mass estimates of these gases were converted to CO_2e by multiplying the non-CO_2 GHG emissions in units of mass by their global warming potentials (GWPs). GWPs were developed by the IPCC to quantify the globally averaged relative radiative forcing effects of a given GHG, using CO_2 as the reference gas. In 1996, the IPCC published a set of GWPs for the most commonly measured GHGs in its Second Assessment Report (SAR). In 2001, the IPCC published its Third Assessment Report (TAR), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of CO_2. However, SAR GWPs are still used by international convention and the United States to maintain the value of the CO_2 currency. Therefore, the SAR GWP values are used in this analysis. Table 1-1 shows a comparison of the SAR and TAR GWPs.

Table 1-1. Comparison of Global Warming Potentials from the IPCC's Second and Third Assessment Reports

Greenhouse Gas	GWP (SAR, 1996)	GWP (TAR, 2001)
CO_2	1	1
CH_4	21	23
N_2O	310	296
HFC-23	11,700	12,000
HFC-125	2,800	3,400
HFC-134a	1,300	1,300
HFC-143a	3,800	4,300
HFC-152a	140	120
HFC-227ea	2,900	3,500
HFC-236fa	6,300	9,400
HFC-43-10mee	1,300	1,500
CF_4	6,500	5,700
C_2F_6	9,200	11,900
C_3F_8	7,000	8,600
C_4F_{10}	7,000	8,600
C_5F_{12}	7,500	8,900
C_6F_{14}	7,400	9,000
SF_6	23,900	22,000

1.1.2. Inventory Boundary

One of the first steps in the development of this, and any other, GHG emission inventory is determining the organizational boundary for reporting emissions. The organizational boundary decisions that were made during this project were done so that all methods for data collection were applied consistently across all operations, facilities, and sources of the PANYNJ. The objective of this exercise was to develop an inventory that meets the criteria for submittal to the California Climate Action Registry (or the equivalent Registry for New York and New Jersey). The California Climate Action Registry is based on the requirements of the accepted guidelines and principles in the World Resources Institute (WRI) GHG protocol.

The California Climate Action Registry and WRI GHG Protocol have two main options for determining the emissions that should be reported: management control or equity share. Under the management control option, 100 percent of the emissions from operations, facilities, and sources that the organization controls are reported. Under the equity share option, an organization reports emissions based on its share of financial ownership of an entity, operation, or source. Management control is more appropriate than equity share for an entity like the PANYNJ because it is a public organization. Equity share reporting is most common for profit-making corporations. An important reason for choosing to report emissions based on management control is that when the PANYNJ controls how an operation or a facility is managed, the organization is able to control factors such as capital investment and technology choice, how energy is used, and the level of emissions generated. Thus, reporting emissions under the management control approach reflects the ability of the PANYNJ to implement actions that could reduce GHG emissions.

Within the management control option, financial or operational criteria can be used to define emissions reporting. Operational control is the authority to develop and carry out the operating or health, safety, and environmental policies of an operation or at a facility (GHG Protocol, 2004). Financial control is the ability to dictate or direct the financial policies of an operation or facility, with the ability to gain the economic rewards from activities of the operation or the facility. It was decided that operational criteria would be used for this inventory.

Table 1-2 summarizes the boundaries that were applied in this study for the departments and facilities included in the 2007 emission inventory. This organizational boundary reflects the PANYNJ's interest in quantifying both direct and indirect emissions for the facilities for which it has operational control. Therefore, there are a number of facilities included in this inventory that are leased by tenants, because the PANYNJ may ultimately be able to implement actions that could reduce the emissions at these tenant run properties. In addition, the PANYNJ opted to account for indirect emissions from its patrons, within certain geographic boundaries that vary by PANYNJ department. The rationale for including these emissions was that the PANYNJ may be able to influence its patrons in ways that reduce emissions.

Table 1-2. Boundaries for each Department in the GHG Emissions Inventory

Department	Boundary
Aviation	• Civil and commercial use of airplanes, up to 3,000 feet • Aircraft ground support equipment • Vehicle trips attracted by the airport, including those of private vehicles, taxis, and buses
Port Commerce	• All vessels that call on Port Authority facilities within the three-mile demarcation line off the eastern coast of the United States • Cargo handling equipment /Automotive Shipping/On-Dock Locomotive Switchers • Drayage trucks/Rail freight to the first point of rest
Tunnels, Bridges, & Terminals	• Emissions based on vehicle volume, the roadway length of each facility, and the vehicle hours of delay in toll lane queues • Terminals include all vehicle travel within the terminal property
PATH	• Traction power • Commuters' vehicle trips to PATH stations • Fuel consumption of Utility Track Vehicles and other diesel equipment
Real Estate & Development	• Office space leased by the Port Authority • Buildings leased to tenants (operating and capital leases) • Excludes real estate projects that the Port Authority does not manage or operate
Construction	• Construction equipment used in Port Authority capital projects
Vehicle Fleet	• Fuel consumption
Employee Commuting	• Vehicle trips to and from work by Port Authority employees

Table 1-3 lists the PANYNJ facilities that are included in this emission inventory. The table is organized by department first, then by facility. The report sections follow this organization.

Table 1-3. Port Authority Facilities Included in the 2007 GHG Emission Inventory

AVIATION • John F. Kennedy International Airport • LaGuardia Airport • Newark Liberty International Airport • Teterboro Airport • Stewart International Airport • Downtown Manhattan Heliport • AirTrain JFK / AirTrain Newark • KIAC Cogeneration	**TUNNELS, BRIDGES, & TERMINALS** • George Washington Bridge • Bayonne Bridge • Goethals Bridge • Outerbridge Crossing • Lincoln Tunnel • Holland Tunnel • George Washington Bridge Bus Station • Port Authority Bus Terminal

REAL ESTATE & DEVELOPMENT
• Bathgate Industrial Park
• The Teleport
• The Legal Center
• World Trade Center
• Essex County Resource Recovery Facility
• PA leased space:
  • 225/233 Park Avenue South
  • One Madison Avenue
  • 115 Broadway
  • Gateway Plaza I, II, III
  • 5 Marine View
  • 777 Jersey Avenue
  • Port Authority Technical Center
  • KAL Building at JFK
	PORT COMMERCE
	• Port Newark / Elizabeth PA Marine Terminal
	• Howland Hook Marine Terminal and Port Ivory
	• Brooklyn PA Marine Terminal
	• Auto Marine Terminal and Greenville Yard
	• Elizabeth Landfill
	PATH
	• PATH Rapid Transit System
	  • 13.8 route miles
	  • 13 stations
	  • Journal Square Transportation Center
	  • Harrison Car Maintenance Facility
	  • Waldo Yard Buildings

1.2. RESULTS SUMMARIES

This section of the report summarizes the key results of the GHG emission estimates in CO_2e terms. The GHG emissions inventory for calendar year 2007 estimates that PANYNJ GHG direct and indirect emissions total approximately 5.89 million metric tons of CO_2e. Table 1-4 and Figure 1-1 show the 2007 CO_2e emissions by department. The Aviation Department has the highest GHG emissions (63.8 percent), followed by Port Commerce (15.3 percent), and Real Estate and Development (11.3 percent). Tunnels, Bridges and Terminals, PATH and mobile sources contribute the remaining 9.6 percent of 2007 GHG emissions.

Table 1-4. PANYNJ CO_2 Equivalent Emissions in 2007

Department	CO_2 Equivalent Emissions (metric tons)
Aviation	3,740,272
Port Commerce	909,206
Real Estate & Development	671,631
Tunnels, Bridges & Terminals	401,759
Mobile Sources	87,612
PATH	83,961
Totals	**5,894,441**

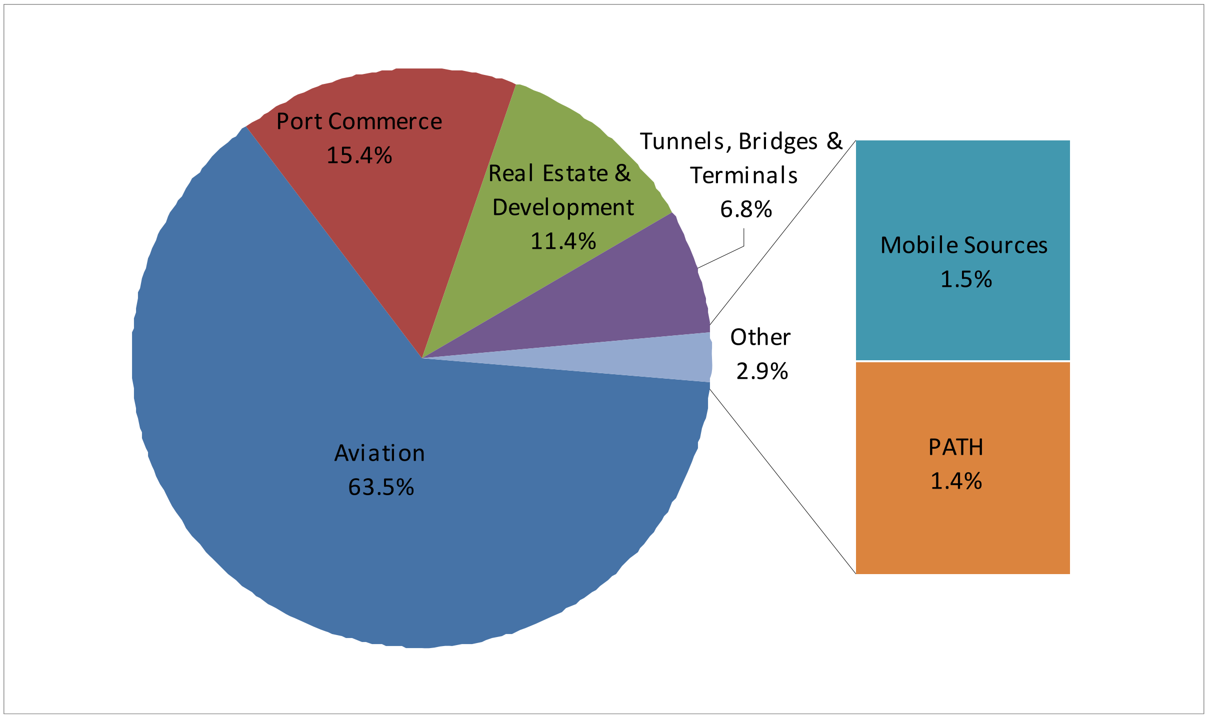

Figure 1-1. CO_2 Equivalent Emissions by Department

Figures 1-2 and 1-3 show how the department-level emissions break down when sorted according to whether they are direct GHG emissions, indirect electricity emissions, or other indirect GHG emissions. These types of breakdowns are important because several years ago, the WRI and the World Business Council on Sustainable Development (WRI/WBCSD) collaborated on a stakeholder process to develop a standardized protocol for voluntary corporate GHG inventories. The resulting WRI/WBCSD protocol has been widely accepted by the GHG community and identifies three potential scopes for a corporate GHG inventory. Scope 1 encompasses an organization's direct GHG emissions, whether from on-site energy production or other industrial activities. Scope 2 accounts for energy that is purchased off-site (primarily electricity, but also including energy such as steam). Scope 3 is much broader and can include anything from employee travel, to upstream emissions imbedded in products purchased or processed by the firm, to downstream emissions associated with transporting and disposing of products sold by the organization, or activities operated by third parties.

The WRI/WBCSD GHG protocol considers quantification of Scope 3 emissions optional when preparing an overall corporate GHG inventory, as do similar protocols such as the U.S. Environmental Protection Agency's (EPA's) Climate Leaders Program and the California Climate Action Registry. One reason for this is that one organization's Scope 3 emissions are usually another organization's Scope 1 and 2 emissions.

Figure 1-2 shows the contributions of the different departments to Scope 1 and Scope 2 GHG emissions. This figure shows that the Aviation Department produced 55.7 percent of the PANYNJ's Scope 1 and 2 GHG emissions, which is largely the electricity usage in airport buildings. The next largest Scope 1 and Scope 2 GHG emitter within the Port Authority was Mobile Sources, which is comprised of fleet vehicles and construction equipment. PATH produces 16.2 percent of the PANYNJ's Scope 1 and 2 emissions. This is primarily due to the electricity purchased to run the PATH trains. The only other department contributing five percent or more to the PANYNJ Scope 1 and Scope 2 emission totals was Tunnels, Bridges, and Terminals.

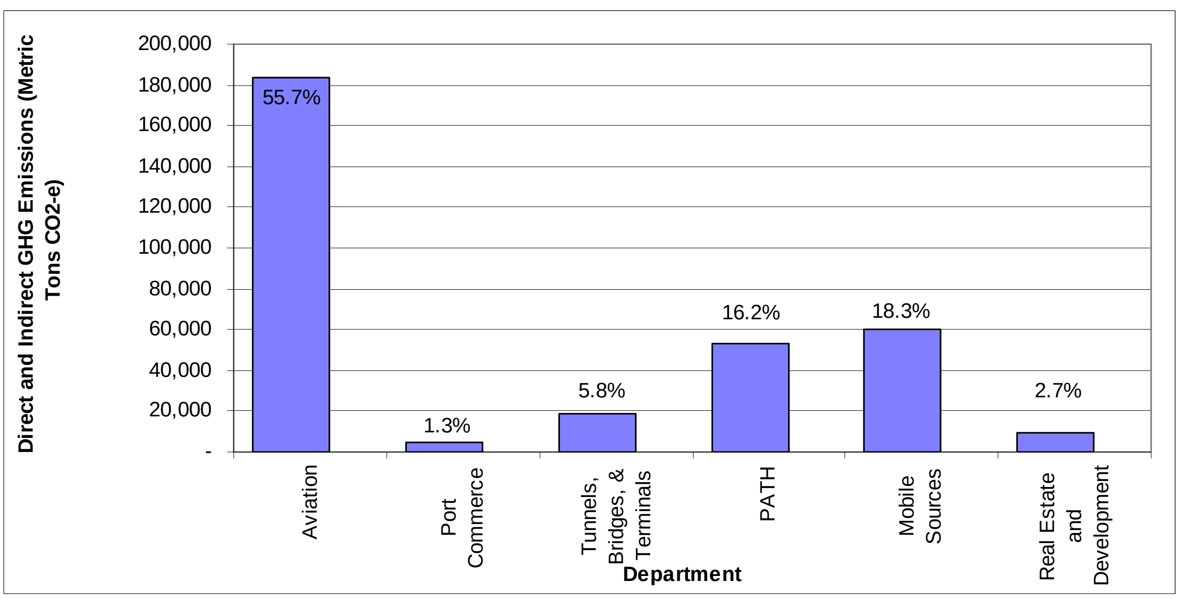

Figure1-2. CO_2 Equivalent Direct GHG (Scope 1) and Indirect Electricity (Scope 2) Emissions, by Department

Figure 1-3 displays the Port Authority's Scope 3 GHG emission estimates by department. The Scope 3 emissions are dominated by the following departments: Aviation (63.9 percent); Port Commerce (16.3 percent); and Real Estate and Development (11.9 percent). Aviation GHG emissions result predominantly from aircraft landing and takeoffs (LTO), as well as the attracted vehicle travel to the airports. Aircraft ground support equipment is only a minor contributor to the Aviation Department's GHG emissions. Within Port Commerce, commercial marine vessels, cargo handling equipment, and attracted vehicle travel are all important contributors to the GHG emissions.

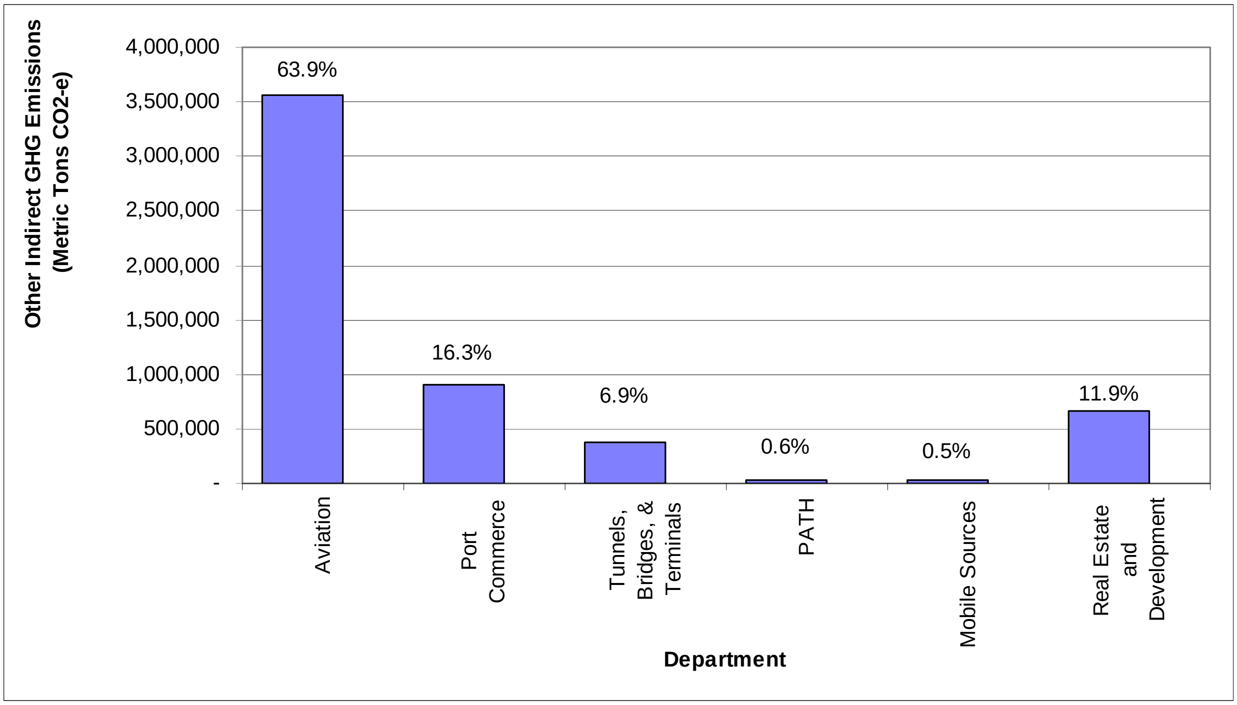

Figure1-3. CO_2 Equivalent Other Indirect (Scope 3) GHG Emissions, by Department

Figure 1-4 provides a breakdown of the sources of Scope 1 and 2 GHG emissions (under the direct management control of the Port Authority), irrespective of department. The figure shows that the Scope 1 and 2 GHG emissions are dominated by indirect electricity use (approximately 73.7 percent of total Scope 1 and 2 emissions; 17 percent of which is from PATH trains). The second most important Scope 1 and 2 emissions source is Construction Equipment operated at PANYNJ funded projects (approximately 15.6 percent). Most of this construction equipment is diesel-powered. Port Authority fleet vehicles also make a significant contribution to emissions (approximately 4.8 percent). Another important Scope 1 and 2 emissions source is heating fuel (primarily natural gas) combustion at facilities under direct PANYNJ management control (approximately 4.5 percent). Other GHG sources under the Port Authority's management control that contribute less than 2 percent of the GHG emissions include (in order of importance): the Elizabeth Landfill; Direct Fugitive Emissions; and PATH Diesel Equipment.

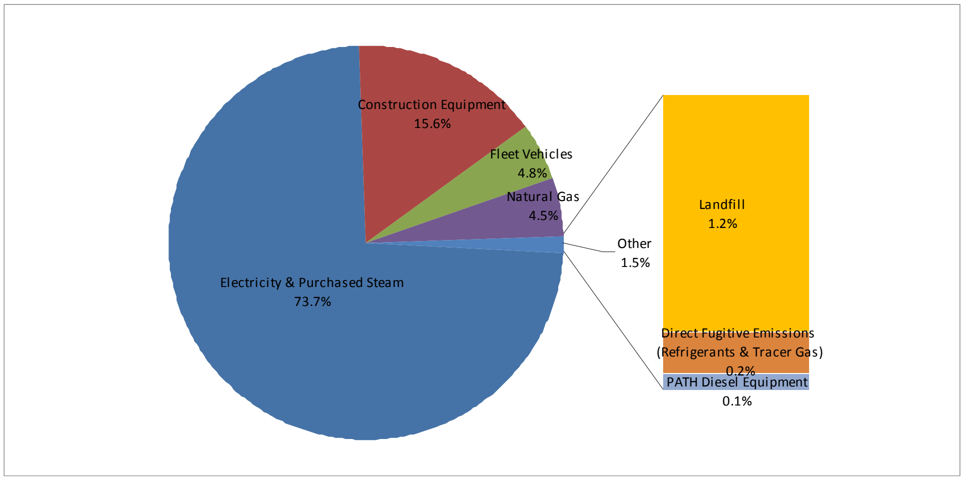

Figure1-4. GHG Emissions Under Direct Management Control

Figure 1-5 summarizes the GHG emissions by source for Scope 3 emissions (those outside PANYNJ's direct management control). Attracted vehicle travel to PANYNJ facilities accounts for approximately 37.9 percent and aircraft emissions account for approximately 37.5 percent of Scope 3 emissions. The remaining 24.7 percent of these emissions are fairly evenly spread among the Essex County Resource Recovery facility, indirect electricity use in buildings, commercial marine vessels, and cargo handling equipment.

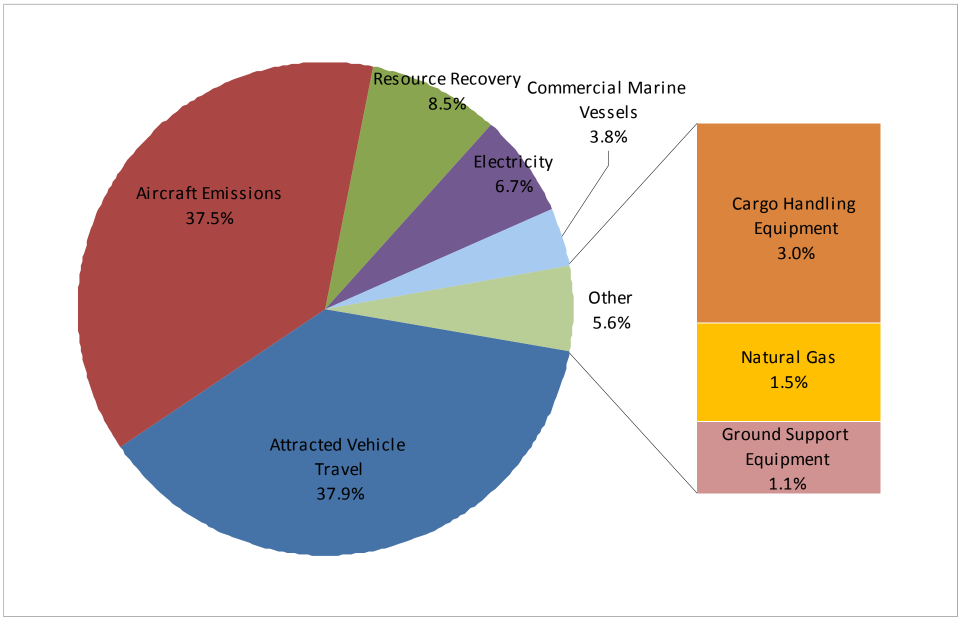

Figure 1-5. GHG Emissions Outside Management Control

Table 1-5 provides Scope 1, 2, and 3 GHG emissions reported by department and broken down by sector. The table also shows how the GHG emissions from energy use in buildings is allocated among direct energy use in PANYNJ-occupied space (Scope 1 emissions), indirect electricity usage in PANYNJ-occupied space (Scope 2 emissions) and direct energy and indirect electricity usage in tenant-occupied space (Scope 3 emissions). The table shows that

Scope 3 GHG emissions comprise 94.4 percent of the total organizational emissions. Scope 3 emissions are generated by tenants operating on PANYNJ properties. Figure 1-6 displays the information in Table 1-5 graphically. This figure shows the importance of aircraft and aviation-attracted travel in the overall Scope 1, 2, and 3 GHG emissions for the Port Authority.

Table 1-5. PANYNJ CO_2 Equivalent Emissions in 2007 (metric tons)

Department	Direct GHG Emissions Scope 1	Indirect Electricity GHG Emissions Scope 2	Other Indirect GHG Emissions Scope 3	Totals
Aviation				
Aircraft	-	-	2,085,041	2,085,041
AirTrain Emissions	-	29,219	-	29,219
Ground Support Equipment	-	-	61,502	61,502
Attracted Travel	-	-	1,208,804	1,208,804
Buildings	13,563	137,280	143,269	294,112
JFK Co-generation Plant	-	-	57,815	57,815
Fleet Vehicles	3,779	-	-	3,779
Port Commerce				
Commercial Marine Vessels	-	-	211,788	211,788
Cargo Handling Equipment	-	-	167,850	167,850
Attracted Travel	-	-	471,399	471,399
Buildings	-	-	53,774	53,774
Landfill	3,958	-	-	3,958
Fleet Vehicles	437	-	-	437
Tunnels and Bridges				
Attracted Travel	-	-	340,330	340,330
Queuing	-	-	23,954	23,954
Buildings	543	16,623	-	17,166
Direct Fugitive Emissions (Refrigerants)	18	-	-	18
Fleet Vehicles	1,827	-	-	1,827
Bus Terminals				
Attracted Travel	-	-	4,588	4,588
Buildings	-	-	13,863	13,863
Fleet Vehicles	13	-	-	13
PATH				
Trains	-	40,206	-	40,206
Attracted Travel	-	-	30,662	30,662
Buildings	-	12,632	-	12,632
Direct Fugitive Emissions (Refrigerants)	35	-	-	35
Diesel Equipment including Utility Track Vehicles and Generators	272	-	-	272
Fleet Vehicles	154	-	-	154
Mobile Sources				
Fleet Vehicles	136	-	-	136
Public Safety Department Fleet Vehicles	8,259	-	-	8,259
Direct Fugitive Emissions (Refrigerants)	637	-	-	637
Construction Equipment	51,382	-	-	51,382
Employee Commuting	-	-	27,198	27,198
Real Estate & Development				
Buildings	790	7,112	187,954	195,856
Resource Recovery Facility	-	-	474,668	474,668
Fleet Vehicles	1,107	-	-	1,107
Engineering				
Direct Fugitive Emissions	8	-	-	8
Total	**86,918**	**243,072**	**5,564,459**	**5,894,449**

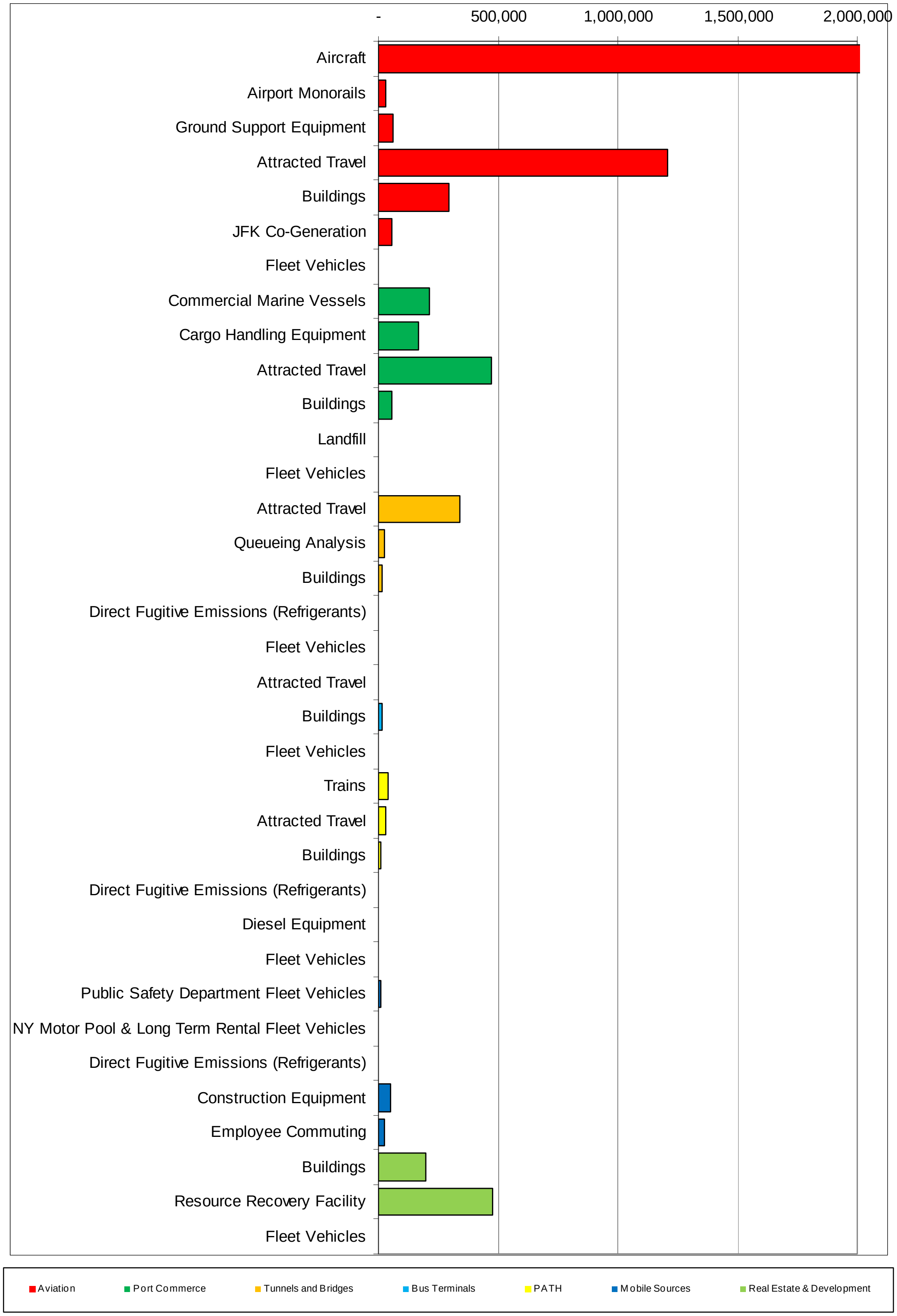

Figure 1-6. GHG Emissions by Activity Type

1.3. COMPARISON WITH PREVIOUS STUDY YEAR

This section compares the 2007 calendar year GHG emission estimates for the Port Authority with those developed previously for calendar year 2006. The overall CO_2 equivalent emissions increased from 5,763,157 metric tons in 2006 to 5,894,449 metric tons in 2007, an increase of 2.3 percent. The tables that follow provide 2006 versus 2007 GHG emission comparisons at differing levels of detail. Table 1-6 shows Scope 1 plus Scope 2 CO_2e emission estimates for the two years by Department. Scope 1 plus Scope 2 emissions decreased by 7.3 percent from 2006 to 2007 as slightly higher fuel use being reported for heat at buildings in 2007 was offset by reduced electricity plus steam use in these buildings.

Table 1-6. Comparison of Scope 1 and 2 CO_2 Equivalent Emissions by Department

	Total CO_2e Emissions (Metric Tons)			Percent
Department	**2006**	**2007**	**Difference**	**Difference**
Aviation	214,334	183,841	(30,493)	-14.2%
Port Commerce	4,550	4,395	(155)	-3.4
Tunnels, Bridges & Terminals	19,737	19,024	(713)	-3.6
PATH	49,363	53,299	3,936	8.0
Mobile Sources	54,611	60,414	5,804	10.6
Real Estate & Development	13,275	9,009	(4,266)	-32.1
Engineering	0	8	8	N/A
Total	**355,870**	**329,990**	**(25,880)**	**-7.3%**

Table 1-7 compares the 2006 and 2007 values for the total Scope 3 GHG emissions associated with each Port Authority department. Scope 3 Aviation Department emissions increases result largely from increased aircraft activity at JFK International Airport.

Table 1-7. Comparison of Scope 3 CO_2 Equivalent Emissions by Department

	Total CO_2e Emissions (Metric Tons)			Percent
Department	**2006**	**2007**	**Difference**	**Difference**
Aviation	3,384,615	3,556,431	171,816	5.1%
Port Commerce	886,579	904,811	18,232	2.1
Tunnels, Bridges & Terminals	390,965	382,735	(8,230)	-2.1
PATH	27,805	30,662	2,857	10.3
Mobile Sources	27,080	27,198	118	0.4
Real Estate & Development	690,243	662,622	(27,621)	-4.0
Total	**5,407,287**	**5,564,459**	**157,172**	**2.9%**

Table 1-8 compares the total GHG emissions for 2006 and 2007 by Department and source type. More information about the reasons for the year-to-year differences by Department and source are provided in the report chapters that follow.

Table 1-8. Comparison of Overall CO_2e Emissions by Department and Source

Department/Source	**Total CO_2e Emissions (Metric Tons)**			**Percent Difference**
	2006	**2007**	**Difference**	
Aviation				
Aircraft	1,963,359	2,085,041	121,682	6.2%
AirTrain Emissions	26,919	29,219	2,300	8.5
Ground Support Equipment	63,575	61,502	(2,073)	-3.3
Attracted Travel	1,169,468	1,208,804	39,336	3.4
Buildings	301,305	294,112	(7,193)	-2.4
JFK Co-generation Plant	71,360	57,815	(13,545)	-19.0
Fleet Vehicles	2,963	3,779	816	27.5
Port Commerce				
Commercial Marine Vessels	227,735	211,788	(15,947)	-7.0
Cargo Handling Equipment	158,404	167,850	9,446	6.0
Attracted Travel	449,871	471,399	21,528	4.8
Buildings	50,569	53,774	3,205	6.3
Direct Fugitive Emissions (Refrigerants)	18	-	(18)	-100.0
Landfill	4,221	3,958	(263)	-6.2
Fleet Vehicles	311	437	126	40.5
Tunnels and Bridges				
Attracted Travel	344,281	340,330	(3,951)	-1.1
Queuing	24,050	23,954	(96)	-0.4
Buildings	18,199	17,166	(1,033)	-5.7
Direct Fugitive Emissions (Refrigerants)	35	18	(17)	-49.2
Fleet Vehicles	1,491	1,827	336	22.5
Bus Terminals				
Attracted Travel	6,345	4,588	(1,757)	-27.7
Buildings	16,289	13,863	(2,426)	-14.9
Fleet Vehicles	12	13	1	8.3
PATH				
Trains	40,828	40,206	(622)	-1.5%
Attracted Travel	27,805	30,662	2,857	10.3
Buildings	12,743	12,632	(111)	-0.9
Direct Fugitive Emissions (Refrigerants)	18	35	17	97.7
Diesel Equipment including Utility Track Vehicles and Generators	284	272	(12)	-4.4
Fleet Vehicles	156	154	(2)	-1.3
Mobile Sources				
Fleet Vehicles	364	136	(228)	-62.6
Public Safety Department Fleet Vehicles	5,252	8,259	3,007	57.3
Direct Fugitive Emissions (Refrigerants)	708	637	(71)	-10.0
Construction Equipment	48,287	51,382	3,095	6.4
Employee Commuting	27,080	27,198	118	0.4
Real Estate & Development				
Buildings	222,075	195,856	(26,219)	-11.8
Resource Recovery Facility	480,073	474,668	(5,405)	-1.1
Fleet Vehicles	1,370	1,107	(263)	-19.2
Engineering	0	8	8	N/A
Total	**5,767,823**	**5,894,449**	**126,626**	**2.2%**

1.4. REPORT ORGANIZATION

The report is organized by department and sector, with each of the following sections providing information about the boundaries used to calculate GHG emissions, the facilities included, GHG emission estimation methods, resulting GHG emission estimates, CAP emission estimates, and comparisons with GHG emission estimates from any existing studies of that sector. CAP emission estimation methods will be detailed in a forthcoming Procedures Document. Because this is the second GHG emission inventory year for the Port Authority, the chapters that follow also include some comparisons between 2006 and 2007 GHG emission estimates. The conclusion of each chapter contains a summary of the GHG emission estimates for the department, showing all sources within the department.

There are some source categories where the 2007 GHG emission estimation methods differ from those used for the 2006 estimates. These methods changes were precipitated by either new activity or fuel usage information, or new information that was used to refine previous assumptions. An example of the former is source categories where Port Authority-sponsored studies provided emission estimates and activity data for 2006 or 2007 that represented significant updates from what was available previously. An example of a refinement is changing the estimate of the amount of fuel consumed during one hour of bus idling from 1.0 to 0.5 gallons per hour, based on an idling calculator developed by EPA.

For the 2006 versus 2007 GHG emission comparison tables presented in the chapters that follow, the 2006 GHG emissions have been re-calculated using the methods applied to estimate 2007 emissions. The 2006 GHG emissions appear as in the revised 2006 GHG inventory report (February 2009).

2.0 AVIATION

2.1. AIRCRAFT

2.1.1. Boundary

The boundary for aircraft includes civil-commercial use of airplanes up to 3,000 feet.

Emissions from aircraft cruising in the upper atmosphere are not within the boundaries of this emissions inventory for a number of reasons. Including only local emissions makes the inventory more relevant to its purpose because it constrains the emissions to better represent the Port Authority's area of influence. For criteria pollutants, the mixing zone is the layer of the earth's atmosphere where chemical reactions of pollutants can ultimately affect ground level pollutant concentrations. In order to be consistent with the methodology used for the criteria air pollutants, the mixing zone is used to demarcate the boundary for greenhouse gases as well. This is consistent with how the boundary would be defined for an ozone or $PM_{2.5}$ non-attainment area inventory.

For these reasons, only emissions stemming from landing and take-off (LTO) procedures are accounted for in this inventory. The boundary where cruising ends and approach begins, or where climb out ends and cruising begins is determined by the distance above the ground. Emissions only fall within the boundary of the airport when they are below the mixing height. For this greenhouse gas inventory, the boundary used was the U.S. Environmental Protection Agency's default mixing height for commercial aircraft, 3000 feet (ICF, 1999).

2.1.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. John F. Kennedy International Airport (JFK);
b. LaGuardia Airport (LGA);
c. Newark Liberty International Airport (EWR);
d. Teterboro Airport (TEB);
e. Downtown Manhattan Heliport; and
f. Stewart International Airport (SWF), of which Port Authority assumed management and operational control on October 31, 2007.

Five airports and one heliport controlled by the Port Authority are included in the 2007 GHG and CAP inventories (NYC, 2007). In New Jersey, Teterboro Airport and Newark Liberty International Airport are accounted for. In

New York, LaGuardia Airport and John F. Kennedy International Airport are included for the full year. November and December operations from Stewart International Airport, which is located in Orange County, New York, are included in the inventory this year because it came under Port Authority control October 31, 2007. The Downtown Manhattan Heliport is also included, although as of November 1, 2008 it is no longer under Port Authority control.

2.1.3. Methods

Activity data in the form of arrivals and departures along with emission factors from representative aircraft were used to estimate the total quantity of the pollutants. A complete LTO cycle consists of five parts: approach; taxi/idle in; taxi/idle out; takeoff; and climb out. The IPCC Guidelines for National Greenhouse Gas Inventories Table 3.6.9: LTO Emission Factors by Typical Aircraft were used as the source for the emission factors of all jet, turboprop, and propeller planes. Table 3.6.3: Correspondence between Representative Aircraft and Other Aircraft Types, from the same document, lists some other aircraft designations that have the same emissions as those in Table 3.6.9 (IPCC, 2006). The Port Authority provided activity data for LaGuardia, JFK, Teterboro, and Newark in the form of a table listing the number of arrivals and departures from each airport by aircraft model. The aircraft models were identified by four character abbreviations. Nearly three-quarters of the yearly operations were from aircraft with the exact model type as those found in one of the IPCC tables.

Remaining aircraft types were compared with those in the table on a number of properties in order to find the closest match and substitute emission factors. Additional information about both the unknown aircraft types and the aircraft types in the IPCC tables was taken from the Emission Dispersion Modeling System (EDMS). The EDMS model included more correspondence information than was available from the IPCC guidelines. This additional information made it possible to assign emission factors to all aircraft types. The information was also used to add the number of engines to the inventory for each equipment type.

A small percentage of the total aircraft operations were aircraft types without four character designations, or aircraft types with four character designations that were unrecognizable. These aircraft types had such a small number of operations that researching them would have been inefficient. These unknown operations at each airport were accounted for by applying the average of the known emission factors weighted by the number of operations associated with each factor.

For Stewart Airport, a different abbreviation system was used than the four character abbreviations used at the other three airports. These were also matched with equivalent aircraft types from the IPCC tables by hand, using recognition of the abbreviation and previously verified equivalences which were carried out for the other airports.

Helicopter emissions from the Downtown Manhattan Heliport were estimated based on 2007 operations at this facility. Emissions were calculated using the number of trips and emission factors from a representative model type.

Activity data for this sector was in the form of the number of complete trips which originated and terminated at the heliport. Emission factors (based on fuel consumed per hour) calculated for a typical model, the Bell 427 helicopter, were used for all operations. Due to the small number of operations compared to the airports, and considering that this property will no longer be under Port Authority control after the 2008 calendar year, a more detailed analysis, breaking down flights by helicopter model, was not performed.

Once emission factors for CO_2, CH_4, and N_2O were assigned to all operations, the number of arrivals and departures by aircraft type and airport were averaged to convert into LTOs, since the cycle includes both operations. Similar calculations were performed for the NO_x and SO_2 emission factors. Particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$) and 10 microns or less (PM_{10}) emission factors were applied uniformly, depending on the number of engines, which was retrieved from EDMS. The LTO activity data was multiplied by the emission factors, and then summed. The CH_4 and N_2O emission totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents. Finally, the total CO_2 equivalent is calculated.

2.1.4. Results

Table 2-1 summarizes the aircraft GHG emission estimates for the facilities included in the inventory. Aircraft GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O species being much less important. CO_2 emissions account for 99 percent of the CO_2e emissions.

Table 2-1. Aircraft Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)			
Airport	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Newark	604,761	23	20	611,369
Teterboro	102,399	18	4	103,921
LaGuardia	425,201	16	15	430,223
JFK	888,693	29	30	898,626
Stewart	2,491	1	0	2,552
Downtown Manhattan Heliport	38,015	0	1	38,350
Totals	**2,059,068**	**86**	**69**	**2,082,489**

Table 2-2 summarizes the aircraft CAP emission estimates for the facilities included in the inventory.

Table 2-2. Aircraft CAP Emissions by Gas

Airport	Criteria Pollutant Emissions Totals (metric tons)			
	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Newark	2,556	191	123	120
Teterboro	189	32	49	48
LaGuardia	1,611	134	109	106
JFK	4,078	281	137	134
Stewart	7	0.8	0.6	0.5
Downtown Manhattan Heliport	133	-	-	-
Port Authority	**8,567**	**639**	**418**	**408**

2.1.5. Comparison with Previous Estimates

In 2007, the Port Authority's airports handled a record total of 110 million passengers, an increase of 5.4 percent over 2006. Most of the growth was at JFK, which had an 11.9 percent increase over 2006 (PANYNJ, 2008a).

Table 2-3 compares the 2007 and 2006 aircraft GHG emission estimates in this study with those developed previously. Emissions from operations at Newark and LaGuardia both increased a small amount despite a small decline in total operations reported. This is due to a slight redistribution in the aircraft equipment types servicing these airports in 2007. The increase in operations at JFK in 2007 led to increased emissions, but this increase was ameliorated somewhat by a change in the distribution of the flights being serviced at the airport towards equipment with lower emission factors. Between 2006 and 2007, the number of operations at the Downtown Manhattan Heliport increased by 43.5 percent with a proportionate increase in emissions, as would be expected as the methodology uses one set of emission factors for all operations. The above factors, along with the addition of Stewart airport, led to a 6.2 percent increase in overall GHG emissions from aircraft at Port Authority facilities between 2006 and 2007.

Table 2-3. Aircraft CO_2 Equivalent GHG Emissions Comparison

Airport	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	%
Newark	595,538	611,369	2.6%
Teterboro	120,198	103,921	-13.5
LaGuardia	425,601	430,223	1.1
JFK	795,296	898,626	13.0
Stewart	N/A	2,552	N/A
Downtown Manhattan Heliport	26,725	38,350	43.4
Total	**1,963,358**	**2,085,041**	**6.2%**

The International Council for Local Environmental Initiatives (ICLEI) provides a different methodology for GHG emissions inventories that is better suited for municipalities. ICLEI's methodology calls for the accounting of emissions that aircraft generate over their entire flight routes. The City of New York used ICLEI's methodology in reporting the emissions of aircraft at JFK International Airport and LaGuardia Airport in 2005.

The “Inventory of New York City: Greenhouse Gas Emissions” for the year 2005 estimates that aviation is responsible for 10.4 million metric tons of CO_2e emissions. This estimate is based on the total fuel loaded onto aircraft at JFK and LaGuardia airports, and it includes LTO and cruise emissions (based on fuel performance). This inventory calculates the total CO_2e emissions from these two airports at approximately 1.2 million metric tons. Because the LTO emissions comprise approximately 10 percent of the total flight emissions, the totals are in reasonable agreement.

2.2. GROUND SUPPORT EQUIPMENT (GSE)

2.2.1. Boundary

The boundary for aircraft GSE is the airport property (tarmac) where aircraft are serviced, loaded, and towed. The types of equipment are consistent with the definitions used by EPA in its NONROAD model. Other PA-operated GSE equipment (i.e., police, fire, snow, admin, and maintenance) are included under Fleet Vehicles in the Mobile Sources section of the report.

2.2.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. John F. Kennedy International Airport;
b. LaGuardia Airport;
c. Newark Liberty International Airport;
d. Stewart International Airport; and
e. Teterboro Airport.

Five airports controlled by the Port Authority are included in the GHG inventory for the year 2007. Stewart International Airport is included in the inventory because it came under Port Authority control on October 31, 2007.

2.2.3. Methods

The primary method used to estimate airport GSE GHG emissions was to multiply reported fuel use (gasoline, diesel, and propane) by the CO_2, CH_4, and N_2O emission factors for those fuels. The emission factors were obtained from IPCC Guidelines Vol. 2 Tables 3.3.1 for Diesel and 4-stroke Motor Gasoline (IPCC, 2006). Emission factors for propane were taken from the LPG data in Table 3.2.1 and 3.2.2

To collect data about the GSE fuel use at each airport, the Port Authority solicited fuel consumption data from the major providers of ground support equipment services. The responses to this survey were incomplete, so some gap filling was required in order to complete the GHG-related activity information for this sector. This analysis was performed on an airport-by-airport basis. As an additional data source, the EPA's NONROAD model was run to estimate 2007 CAP emissions for aircraft GSE (EPA, 2005). This data source provides an additional data point that can be used either as a check on the completeness of fuel use data provided by airport tenants, or as an alternative data source for estimating GHG emissions by airport. While the Federal Aviation Administration's EDMS was an option that was considered for use in estimating airport GSE emissions, it was decided to use EPA's NONROAD model instead. The primary reason for not using EDMS is that its input requirements are much more extensive than those for NONROAD. For example, EDMS requires collecting and inputting gate-by-gate aircraft activity information. If EDMS was also being used to estimate aircraft GHG emissions, it would have made sense to use it to estimate GSE emissions. However, since EDMS was not used to estimate aircraft emissions, it was inefficient to use this model for airport GSE emission estimates. An analysis was performed comparing the GSE CAP emissions estimated for the 2006 inventory and CAP emissions estimated using EDMS. GSE emissions are modeled within EDMS based on emission factors from EPA's NONROAD model. The differences in emissions estimates between the two methodologies were generally more pronounced for GSE emissions than for aircraft. While there were some cases where EDMS CAP emissions were lower for a given airport versus the NONROAD emissions, there were more cases where EDMS estimates were higher. For example, the NONROAD model showed very little GSE activity for Bergen County, where Teterboro is located, whereas EDMS estimated higher emissions based on its default assignments. Since both GSE methodologies used the same source for emission factors (EPA's NONROAD model) it can be assumed that the emissions differences are based on the differences in how the approaches model equipment populations and activity.

Estimates of GSE activity at LaGuardia, JFK, Newark, and Teterboro airports were based largely on fuel usage reporting from tenants and fuel suppliers. For JFK airport, one major GSE provider reported significant gasoline fuel use in 2006, but did not respond to the request for data in 2007. To fill this data gap, a growth factor was developed using 2006 and 2007 Landing and Take-off (LTO) operations data obtained from the Federal Aviation Administration's (FAA) Air Traffic Activity System (ATADS) database (FAA, 2008). This growth factor was then applied to the 2006 gasoline fuel use that the provider reported to estimate 2007 gasoline fuel use. Similar methods were employed to address inconsistencies in the responses for data from one year to the next.

For Stewart airport, no GSE fuel consumption data was available for 2007. Emissions estimates for November and December 2007 were developed from EPA's NONROAD model. A model run was performed for each of the two months at the county level (for Orange County, New York). It was assumed that the GSE county level estimates obtained from the NONROAD model were equivalent to Stewart Airport because Stewart is the only commercial airport in Orange County. GHG emissions for Stewart airport were estimated using fuel use data obtained from the NONROAD model runs. CAP emissions were obtained directly from the NONROAD model. To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. NONROAD uses a national average engine activity estimate. Geographic allocation factors are used to distribute national equipment populations to counties or states. These factors are based on surrogate (i.e., alternate) indicators of equipment activity. The 2002 NEI aircraft NO_x emission inventory estimates, which are allocated mainly according to FAA LTO data, is the surrogate indicator used in allocating airport ground support equipment.

2.2.4. Results

Table 2-4 summarizes the airport GSE GHG emission estimates for the facilities included in the inventory. Airport GSE GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O species being much less important. CO_2 emissions account for 93 percent of the CO_2e emissions.

Table 2-4. Airport GSE Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)			
Airport	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
LaGuardia	10,100	6.4	2.7	11,058
JFK	31,403	43.8	3.2	33,303
Newark	15,150	15.6	2.7	16,314
Stewart	82	0.01	0.03	92
Teterboro	678	0.6	0.1	735
State				
New Jersey	15,828	16.2	2.8	17,049
New York	41,585	50.2	5.9	44,453
Port Authority Totals	**57,414**	**66.4**	**8.7**	**61,502**

Table 2-5 summarizes the estimated 2007 criteria air pollutant emissions for airport GSE at the facilities included in this inventory. GSE CAP emissions are dominated by NO_x and SO_2 emissions at JFK and Newark Airports.

Table 2-5. Airport GSE CAP Emissions by Facility

	Criteria Pollutant Emissions Totals (metric tons)			
Airport	**NO_x**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**
Newark	256	36	19	19
Teterboro	0.57	0.08	0.04	0.04
LaGuardia	229	33	18	17
JFK	230	32	17	17
Stewart	0.93	0.12	0.07	0.07
Port Authority	**717**	**102**	**53**	**54**

2.2.5. Comparison with Estimates in Previous Studies

Table 2-6 compares the 2007 and 2006 aircraft GSE GHG emission estimates in this study with those developed previously.

Table 2-6. Airport GSE CO_2 Equivalent GHG Emissions Comparison

Airport	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	**2007**	
Newark	16,568	16,314	-2%
Teterboro	733	735	0.3
LaGuardia	12,056	11,058	-8
JFK	34,218	33,303	-3
Stewart	N/A	92	N/A
Total	**63,575**	**61,502**	**-3%**

Overall emissions from airport GSE at Port Authority facilities decreased 3 percent between calendar year 2006 and 2007. In comparing facility (i.e., airport) level emission estimates, emissions from operations at JFK and LaGuardia both decreased from 2006 to 2007. This is because decreases in fuel use and associated emissions for one fuel type at both airports offset fuel and emission increases from the other fuel type (i.e., when changes in gasoline and diesel fuel use are considered) . For Newark and Teterboro airports, 2006 GHG emissions were recalculated based on the ratio of 2007/2006 LTOs and 2007 fuel use data to be consistent with the 2007 methodology. This update led to a 2 percent decrease in emissions at Newark and a 0.3 percent increase in emissions at Teterboro. For Stewart Airport, a comparison of 2006 to 2007 emissions was not possible since the airport didn't fall under Port Authority control until October 2007. It should be noted that the accuracy of the airport GSE emissions is dependent on the extent to which GSE providers report fuel consumption data.

2.3. ATTRACTED TRAVEL

2.3.1. Boundary

For attracted travel related to airports (excluding buses and cargo-related vehicles), the established boundary includes areas within a 100-mile radius of the facilities. This boundary was developed based on the county of origin data received from Port Authority's Aviation Department (Fushan, 2008). The information received showed that some of the passengers surveyed traveled as far as Nassau, NY; New London, CT; and Philadelphia, PA. For buses servicing the airport facilities, the boundaries vary according to the routes taken by each bus line. The established boundary for cargo-related vehicles at John F. Kennedy International airport includes routes used to access and egress the facility. This is consistent with the cargo information available for this facility.

2.3.2. Facilities Included in the Inventory

The facilities included in this inventory include:

a. John F. Kennedy International Airport (JFK);
b. Newark International Airport (EWR);
c. LaGuardia Airport (LGA);
d. Teterboro Airport (TBE); and
e. Stewart International Airport (SWF).

2.3.3. Methods

This portion of the GHG inventory includes emissions associated with vehicle trips that are attracted by airport facilities. Vehicle types (also referred to as travel mode) include privately-owned vehicles, taxis, buses, rental cars, limousines, vans, shuttle buses, public buses, and light- and heavy-duty goods vehicles. Vehicle miles traveled (VMT) for the airport facilities were calculated by mode and for the roundtrip to and from the airport.

In estimating VMT, trip origin, travel distance, trip distributions, and transport mode were utilized. Table 2-7 summarizes trip origin and estimated one way travel distances by airport. Distances reported in the table were estimated using Google Maps. Table 2-8 lists average travel party size by travel mode for all facilities. Data presented in Tables 2-7 and 2-8 along with the trip distribution data were applied in allocating number of passengers to number of vehicles. Percentages of trip distributions for each airport facility, as well as mode by trip origin are documented in the 2007 emissions inventory procedures document (Pechan, 2008). The methodology applied for estimating VMT is consistent for all vehicle types listed in Table 2-8. Different methods (data sources) were used to estimate taxi, rental cars, bus, shuttle bus, and cargo transport vehicle travel. These methods are summarized by vehicle type in the following subsections.

Table 2-7. Origin and Estimated Distance to Each Airport Facility (miles)

State/City	Trip Origin	Estimated Distance to (one way)			
		JFK	LGA	EWR	SWF
New York City	Manhattan	17.60	8.90	16.80	N/A
	Bronx	19.40	8.40	25.50	62.10
	Brooklyn	14.10	11.50	16.30	N/A
	Queens	6.80	6.90	26.50	N/A
	Staten Island	27.80	25.60	13.90	N/A
	Westchester	40.00	9.70	47.70	39.80
	Long Island	17.90	9.20	16.60	N/A
	Rockland	46.00	34.90	41.30	35.60
	Dutchess	N/A	82.80	N/A	42.00
	Putnam County	63.10	55.60	70.80	32.10
	Orange	74.80	63.80	70.30	24.20
	Sullivan	N/A	N/A	N/A	49.90

State/City	Trip Origin	Estimated Distance to (one way)			
		JFK	LGA	EWR	SWF
Other New York	Albany	100.00	100.00	100.00	89.10
	Columbia	100.00	N/A	100.00	89.70
	Delaware	N/A	N/A	N/A	99.90
	Dutchess	96.40	N/A	98.90	N/A
	Monroe	66.80	55.70	62.20	N/A
	Montgomery	N/A	N/A	N/A	10.50
	Rensselaer	100.00	N/A	N/A	89.40
	Suffolk	N/A	76.30	95.8	N/A
	Sullivan	N/A	N/A	N/A	49.90
	Ulster	100.00	N/A	100.00	43.80
	All Other Counties	100.00	100.00	100.00	100.00
New Jersey	Atlantic	100.00	N/A	N/A	N/A
	Bergen	33.60	22.40	27.50	54.00
	Burlington	87.30	N/A	62.70	N/A
	Camden	100.00	N/A	N/A	N/A
	Essex	37.90	35.60	17.60	N/A
	Gloucester	100.00	N/A	83.80	N/A
	Hudson	25.90	16.70	9.30	N/A
	Hunterdon	N/A	N/A	50.00	N/A
	Mercer	69.80	N/A	45.30	N/A
	Middlesex	53.00	50.60	30.10	N/A
	Monmouth	58.80	56.40	34.30	N/A
	Morris	57.70	46.50	22.40	N/A
	Ocean	69.70	N/A	45.20	N/A
	Passaic	30.70	27.40	14.70	N/A
	Somerset	54.80	N/A	30.30	44.20
	Sussex	75.00	N/A	58.80	62.40
	Union	38.30	N/A	9.40	N/A
	Warren	N/A	N/A	23.10	N/A
Connecticut	Fairfield	56.90	50.00	71.10	69.90
	Hartford	100.00	N/A	100.00	100.00
	Litchfield	100.00	100.00	N/A	80.00
	Middlesex	100.00	N/A	N/A	N/A
	New Haven	80.90	74.00	95.10	83.80
	New London	100.00	N/A	N/A	N/A
	Tolland	100.00	N/A	N/A	N/A
Pennsylvania	Bucks	100.00	N/A	93.70	N/A
	Lehigh	100.00	N/A	89.50	N/A
	Monroe	N/A	N/A	78.10	N/A
	Montgomery	100.00	N/A	98.80	N/A
	Northampton	N/A	98.20	77.40	N/A
	Philadelphia	100.00	100.00	80.50	N/A
	Pike	100.00	N/A	85.70	58.30
	All Other Counties	100.00	100.00	100.00	N/A
Others	Other US	100.00	100.00	100.00	100.00

Table 2-8. Average Travel Party Size by Travel Mode and Facility

Travel Mode	Average Travel Party Size by Facility			
	JFK	**LGA**	**EWR**	**SWF**
Private Cars, Limousine/Town Car[1]	2.42	2.77	2.06	2.42[4]
Rental Cars (applied to SWF only)[1]	2.42	2.77	2.06	2.42[4]
Chartered/Tour Bus[2]	45.86	45.86	45.86	45.86
Shared-Ride/Van Service, Hotel/Motel/Off-Airport Parking Shuttle/Van[3]	10.80	10.80	10.80	10.80

[1]Parsons Brinckerhoff, et al., 2006.
[2]Excellent, et al., 2008.
[3]Airlink, et al., 2008.
[4]Based on average travel party size (i.e., JFK, LGA, and EWR)

2.3.3.1. Limousines, Private Cars, Chartered Buses, Hotel/Motel Shuttles, Off-Airport Parking Shuttles, and Vans VMT

VMT for limousines, private cars, chartered bus, hotel/motel shuttle, off-airport parking shuttle, and vans was estimated using the number of passengers arriving at each airport as a surrogate (PANYNJ, 2007a). The estimated numbers of passengers did not include taxi passengers, rental car passengers (except SWF), public bus passengers, and Amtrak/LIRR/Subway/Air Train passengers (if applicable). For each facility (except Teterboro airport, for which no attracted travel information was available), the number of passengers was allocated by mode, trip origin, and average travel party size using the information listed in Tables 2-7 and 2-8. Trip distributions by mode are reported in the 2007 emissions inventory procedures document (Pechan, 2008). This provided an estimate of the number of vehicles. The estimated number of vehicles by mode and trip origin was then multiplied by the appropriate trip length listed in Table 2-7. For example, 16.72 percent of private car trips to JFK airport originated in Manhattan, with a one way distance of 17.6 miles, an average travel party size of 2.42, and the total number of passengers of 7,196,038. Therefore, VMT to and from each airport facility is estimated as follows:

*Private Car VMT = ((Number of Passengers * Percent Distribution) / Travel Party Size) * Trip Length * 2 to account for both directions) = (7,196,038 * (16.72 / 100) / 2.42) * 17.6 * 2 = 17,500,764 miles (roundtrip)*

2.3.3.1. Rental Car VMT

VMT for rental cars servicing JFK, LGA, and EWR was estimated based on the total number of rental vehicle transactions during 2007 (Caldas, 2008; Sarrinikolaou, 2008a). The number of vehicle transactions for these facilities was allocated by trip origin based on the percentage of airport passengers by trip origin (Fushan, 2008). The result for each trip origin was multiplied by the appropriate trip length reported in Table 2-7. Then, VMT was multiplied by a factor of two to account for travel to and from the airport.

Since no rental car information was received for SWF, VMT for this facility was estimated using the number of passengers arriving at this airport as a surrogate for this mode (PANYNJ, 2007a). The methodology used for estimating VMT for SWF is similar to the methodology described in Section 2.3.3.1

2.3.3.2. Taxi VMT

VMT for taxis servicing JFK, LGA, EWR, and SWF was estimated using the number of taxis dispatched obtained from Port Authority's 2007 airport traffic statistics report (PANYNJ, 2007b). The number of taxis dispatched was allocated by trip origin utilizing the percentage of airport passengers by trip origin (Fushan, 2008). VMT was then calculated by multiplying the resulting number of taxis dispatched by trip origin by the trip length. Trip length by origin is summarized in Table 2-7. The resulting VMT by trip origin was multiplied by a factor of two to account for travel to and from the airport.

2.3.3.3. Public Bus VMT

VMT for buses was based on the estimated number of buses, number of bus trips, and trip origin/destination. Information on buses servicing the airports was obtained from Port Authority's website and the New York City Online Directory & Guide - Airport Transportation website (PANYNJ, 2008b; Citidex, 2008). Trip lengths for each bus line were estimated using Google Maps. All routes taken by each bus line were accounted for in estimating trip lengths. VMT was derived by multiplying the number of bus trips by the estimated trip length to and from the airport. Information on public buses included in this inventory is described in the 2007 emissions inventory procedures document (Pechan, 2008).

2.3.3.4. Shuttle Bus VMT

Data received for shuttle buses include information such as fuel purchased (assumed as fuel consumed), fuel economy (mpg), and miles traveled (Sarrinikolaou, 2008b). The available information for JFK and LGA include fuel consumed and a shuttle bus fuel economy (mpg) value of 2.4. A fuel consumption of 81,320 gallons was reported for JFK, while a value of 26,507 gallons of fuel consumed was provided for LGA. These values account only for a six month period so they were multiplied by a factor of 2 to estimate the fuel consumed for the entire year. VMT was estimated by multiplying the calculated annual fuel consumed by the fuel economy value of 2.4 mpg. This method applies to both JFK and LGA airport facilities. For EWR, Olympia Trails (i.e., Newark Liberty Airport Express Bus to EWR) reported a total mileage of 925,631 miles (Sarrinikolaou, 2008b).

There was no hotel/motel shuttle bus information received for 2007. Therefore, this travel mode was estimated using the methodology consistent with limousine, private cars, etc.

2.3.3.5. Cargo VMT

Because cargo-related VMT was only available for JFK airport, cargo travel for LGA, EWR, and SWF airports was estimated using the 2007 ratio of cargo tons from JFK to the ratio of cargo tons at LGA, EWR, and SWF airports (PANYNJ, 2007b). 2006 activity data (i.e., daily number of trips) by travel mode was based on the air cargo truck movement study for JFK (URS, 2002). 2007 daily number of trips for each travel mode was estimated by multiplying the 2006 daily number of trips by the 2006 to 2007 cargo (freight only) ton ratio for JFK. 2006 and 2007 freight information were obtained from the airport traffic reports (PANYNJ, 2006; PANYNJ, 2007a).

VMT for cargo-related travel was derived using the number of trips multiplied by the estimated trip length of the access and egress routes obtained from the air cargo truck movement study conducted for JFK airport (URS, 2002).

Trip length by origin is provided in Table 2-9 and was estimated using Google Maps.

Table 2-9. Trip Origin and Estimated Distance to JFK Airport for Cargo Travel

Trip Origin	Distance (in miles, one way)
Van Wyck	5.10
On Airport	6.70
Rockway Blvd	2.80
Belt Parkway/Southern State	8.20
Other Routes[1]	5.70

[1]Average distance based on Van Wyck, On Airport, Rockaway Blvd, and Belt Parkway/Southern State trip length.

2.3.3.6. Emission Calculations

Once VMT estimates were developed for all attracted travel, VMT was summed by facility and mode. VMT was then allocated to four vehicle types: autos; buses; small trucks; and large trucks. Auto VMT includes limousines, taxis, rental cars, private cars, pick-up trucks, and vans. Bus VMT includes chartered/tour bus, hotel/motel shuttle bus, off-airport parking shuttle bus, public bus, and New York Airport Service Bus to JFK/LGA or Newark Liberty Airport Express Bus (i.e., Olympia Trails). After VMT were allocated to the four vehicle types, VMT were disaggregated to EPA's vehicle types and fuel type categories, so that the appropriate emission factors could be applied (EPA, 2003). Then, VMT were distributed by vehicle age (EPA, 2003; DEC, 2008).

Cold start emission factors for CH_4 and N_2O associated with the startup of a cooled vehicle engine were applied to all parked vehicles. Vehicle emissions for this category were calculated by multiplying the number of parked cars, based on Port Authority airport parking statistics (PANYNJ, 2007a), by the corresponding weighted cold start emission factor for each vehicle type. The cold start emission factors (in milligrams/start) by vehicle type and technology type were obtained from the IPCC report (IPCC, 2006).

2.3.3.7. Teterboro Airport Emission Calculations

Because no vehicle travel attraction statistics were available for Teterboro airport, Teterboro emissions estimates were derived using LGA airport emissions by passenger and fuel type as a surrogate. Estimated LGA emissions (per passenger) were multiplied by Teterboro's total number of 2007 passengers (FAA, 2007).

2.3.4. Results

This section reports GHG emissions from airport facilities. Table 2-10 summarizes the GHG emission estimates for highway vehicles for the facilities included in this inventory.

Table 2-10. Airport Facilities Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Facility Name	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
John F. Kennedy (JFK)	466,133	28	30	476,132
La Guardia (LGA)	195,095	12	13	199,437
Newark (EWR)	506,956	31	33	517,926
Teterboro (TBE)	248	0	0	254
Stewart International Airport (SWF)	14,720	1	1	15,055
Total	**1,183,152**	**73**	**78**	**1,208,804**

For 2007, airport attracted travel was estimated to have 1,208,804 metric tons of CO_2e emissions. As shown in Table 2-10, approximately 98 percent were emissions of CO_2. CH_4 and N_2O (both as CO_2e) only account for about 2 percent.

To the extent that vehicles accessing Port Authority's airports use the Port Authority's tunnels and bridges, the methods used to estimate PANYNJ-related vehicle travel in this report will overestimate GHG emissions. Vehicle trips to and from the airport facilities that use Port Authority's tunnels and bridges are also counted in the tunnels and bridges inventory.

In developing 2007 GHG emission estimates for airport facilities, the requisite level of detail was lacking in both the activity data (e.g., VMT, fuel consumption (except for shuttle buses)) and in information about vehicles types, which made it difficult to apply available emission factors. To compensate for the lack of vehicle activity data, expert judgment was relied upon in assessing the value of information received. Another source of uncertainty has to do with the differences in classifying vehicles by type. EPA's vehicle categories are broken down by vehicle weight and fuel types (e.g., light-duty gasoline vehicles, light-duty diesel vehicles), while the Port Authority classifies vehicles as autos, buses, vans, small trucks, large trucks, etc. Estimates of VMT fractions by vehicle type create yet another source of uncertainty. The fractions of VMT applied may not represent the actual mix of vehicles traveling to and from the airports. VMT mix fractions applied were estimated based on MOBILE6 default VMT mix values for calendar year 2007. Lastly, the use of distance traveled data may result in less accurate emission estimates than those computed based on actual fuel consumption quantities.

2.3.5. Comparison with Estimates in Previous Studies

This section provides a comparison of 2006 and 2007 GHG emissions results.

As presented in Table 2-11, estimated GHG emissions produced by airport facilities amounted to 1,208,804 metric tons (including SWF) in 2007 and 1,169,468 metric tons (excluding SWF) in 2006, a 39,336 metric tons increase in emissions. SWF GHG emissions estimates only account for 1.2 percent of the total CO_2e emissions estimates. Therefore, this facility is not the major cause of increase in emissions in 2007.

Table 2-11. Airport Facilities Attracted Travel CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006 (revised)	2007	
John F. Kennedy (JFK)	444,651	476,132	7.1%
La Guardia (LGA)	209,553	199,437	-4.8
Newark (EWR)	515,014	517,926	0.6
Teterboro (TBE)	250	254	1.6
Stewart International Airport (SWF)	Not Estimated	15,055	N/A
Total	**1,169,468**	**1,208,804**	**3.4%**

The increase in 2007 emissions is consistent with the change in the number of passengers, taxis dispatched, rental car vehicle transactions, and parked vehicles from previous year. The total number of passengers increased by 11.9 percent for JFK, 1.7 percent for EWR, and 3.7 percent for TBE, while the number of passengers for LGA decreased by 3.0 percent. The rental car vehicle transactions showed 31.9 percent and 33.9 percent increase for LGA and EWR, respectively, and decreased by 23.4 percent for JFK. Taxis dispatched in 2007 showed an increase of 8.8 percent and 4.6 percent for JFK and EWR, respectively, from the previous year. However, for LGA, taxis dispatched decreased by 5.6 percent. For parked cars, JFK showed an increase of 11.0 percent while LGA and EWR decreased by 10.2 percent and 4.9 percent, respectively. In addition, the cargo-related travel showed a decrease in the daily number of trips by 2.8 percent for JFK for all travel modes. Activity data associated with private cars, limousines, rental cars, taxis, and vans accounts for over 95 percent of the VMT.

2.4. JOHN F. KENNEDY INTERNATIONAL AIRPORT COGENERATION PLANT

2.4.1. Boundary

This section quantifies the direct emissions from the Kennedy International Airport Cogeneration (KIAC) plant, which is located on PANYNJ property. The emissions associated with electricity and thermal energy generated by the plant and used on the premises or with energy sold to the Port Authority and to metered tenants at the airport are accounted for in the buildings section of this report. The direct KIAC emissions from energy not used at the airport are covered in this section. Energy generated by the KIAC plant that is not used on the premises is considered a Scope 3 emissions source covered by this section. Non-utilized steam (waste steam) generated by the facility is also a Scope 3 emissions source. These emissions are considered to be Scope 3 because the generation of the emissions is not under management control of the PANYNJ.

2.4.2. Facilities Included in the Inventory

The KIAC plant contains two natural gas turbine-generator sets with attached heat recovery steam generators. The plant generates electricity for the entire airport (including AirTrain JFK) and sells the excess to Con Edison. In addition to electrical energy, the plant generates thermal energy from the capture of waste heat. The thermal energy produced is used to partially heat and cool the Central Terminal and AirTrain Facilities. KIAC Partners operate the plant under a 25-year agreement with the Port Authority, and also manage the existing Central Heating and Refrigeration Plant and related thermal distribution systems.

2.4.3. GHG Methods

The total number of kilowatt-hours of electricity generated during 2007 was retrieved from the EPA through the NO_x Budget Program database and verified by contacts at the cogen plant, as was the total fuel use and heat input (EPA, 2008). The amount of fuel use and heat used specifically for electricity generation was provided by the contacts at KIAC Partners, who manage the cogen for the Port Authority (KIAC, 2008). The PANYNJ provided the total electricity used by the terminal and AirTrain. Subtracting this number from the total electricity generated provides the amount of electricity sold to the grid or lost in transmission. Emissions from the portion of electricity that is supplied to the grid are the responsibility of KIAC Partners.. Any heat input not used to generate electricity is used to heat and cool the terminal and AirTrain facilities. Although in 2006 there was a small amount of steam (in terms of heat input) that was not used for generation or heating and cooling, in 2007 there was no evidence of unused heat input.

The total emissions are calculated using the heat inputs and emission factors from The Climate Registry (TCR) General Reporting Protocol (GRP) v 1.2. (TCR, 2008). The total emissions, divided into electricity and steam by energy, are shown in Table 2-12. These emissions are those that would be reported for registry purposes.

Table 2-12. Total KIAC Plant GHG Emissions by Gas and CO_2 Equivalent

	CO_2 (metric tons)	CH_4 (metric tons)	N_2O (metric tons)	CO_2 Equivalent (metric tons)
Electricity	259,230	24.4	0.5	259,894
Steam	6,853	0.6	0.0	6,870
Total	**266,083**	**25.1**	**0.5**	**266,765**

For the entire facility, the natural gas usage in terms of heat input was 5,014,754 million British thermal units (MMBtu). From the TCR GRP, the emissions factors are 53.06 kilograms (kg)/MMBtu CO_2, 0.005 kg/MMBtu CH_4, and 0.0001 kg/MMBtu N_2O . Therefore, for example, the total emissions from CO_2 are:

*5,014,754 Btu * 53.09 kg/Btu * 0.001 metric tons/kg = 266,083 metric tons.*

Emission factors must be derived for both electricity and steam to determine the share of emissions that fall under the responsibility of the KIAC Plant (as direct emissions) and the share that fall under the responsibility of PANYNJ (as indirect emissions from purchased electricity and steam). The electricity emission factor is calculated by dividing the total plant emissions from electricity generation by the total electricity generated. The steam emission factor is the total emissions from steam divided by the total heat input not used for electricity generation. The overall total heat input and the total heat input used for electricity generation in MMBtu and the millions of cubic feet of natural gas used were retrieved by compiling data KIAC reported to the Energy Information Administration in Survey EIA-920 (KIAC, 2008).

Electricity related emissions are then calculated by multiplying the electricity that is the cogeneration plant's responsibility by the electricity emission factor. The emissions associated with the waste steam are calculated by multiplying the heat input to produce the steam by the ratio of total emissions from steam generation to the heat input associated with steam generation.

2.4.4. GHG Results

Table 2-13 summarizes the activity data for electricity that fall under the boundary of this section, and the related GHG emissions.

Table 2-13. KIAC Plant Activity Data and GHG Emissions by Gas and CO_2 Equivalent

	Activity Data	CO_2 (metric tons)	CH_4 (metric tons)	N_2O (metric tons)	CO_2 Equivalent (metric tons)
Electricity Sold to the Grid	121,234,800 kilowatt hours (kWh)	57,667	5.43	0.11	57,815
Total	**--**	**57,667**	**5.43**	**0.11**	**57,815**

2.4.5. CAP Results

Table 2-14 summarizes the activity data for electricity which fall under the boundary of this section, and the related CAP emissions.

Table 2-14. KIAC Plant Activity Data and CAP Emissions by Gas

	Activity Data	NO_x (metric tons)	SO_2 (metric tons)	$PM_{2.5}$ (metric tons)	PM_{10} (metric tons)
Electricity Sold to the Grid	121,234,800 kWh	47.8	0.29	0.01	0.02
Total	**--**	**47.8**	**0.29**	**0.01**	**0.02**

2.4.6. Comparison with Estimates in Previous Studies

The emissions attributable to the KIAC decreased by about 19 percent between 2006 and 2007, as seen in Table 2-15, which compares the CO_2 equivalent gases between the two years. There were a number of reasons for this decrease.

Table 2-15. Kennedy Cogen CO_2 Equivalent GHG Emissions Comparison

Source	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Electricity Sold to ConEd	71,029	57,815	-18.6%
Waste Steam	331	0	-100
Total	**71,360**	**57,815**	**-19.0%**

In 2007, the entire KIAC cogen used 4.7 percent less natural gas than in 2006, reducing overall emissions, and the emissions attributable to the facility. In addition, the electricity demand from the JFK terminal and AirTrain increased by 5.5 percent, thus reducing the amount of the electricity generated left over for sale to the grid. The airport's heating and cooling demand for steam increased by nearly 12 percent between 2006 and 2007. This had two effects; the first was to decrease slightly the electricity generation efficiency of the plant, and secondly, to eliminate any waste steam in 2007, which was a minor contributor to the KIAC GHG emissions in 2006. Together these factors resulted in a decrease of emissions for which the cogeneration plant was responsible in 2007.

2.5. BUILDINGS

2.5.1. Boundary

The GHG emissions inventory boundary includes all Aviation department operated buildings; buildings leased to tenants; and office space that the Aviation Department leases from other organizations.

2.5.2. Facilities Included In the Inventory

All facilities listed in Table 2-16 are included in this building energy use category.

Table 2-16. Facilities within Aviation Department Boundary

Facility	Sub-Facility
Downtown Manhattan Heliport	Downtown Manhattan Heliport
John F. Kennedy International Airport	JFK
	JFK - Purchased Steam
AirTrain JFK	AirTrain JFK
	AirTrain JFK - Purchased Steam
LaGuardia Airport	LaGuardia
Newark Liberty International Airport	Newark Liberty International Airport
AirTrain Newark	AirTrain Newark
Stewart Airport	Stewart Airport
Teterboro Airport	Teterboro Airport

2.5.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the Aviation department were estimated in four steps.

The first step was to develop a list of sources of GHG emissions associated with energy consumption in buildings that are owned, or leased, within the Aviation Department's boundary. Step two focused on mapping sources with their corresponding energy consumption. Step three was spent processing raw data by means of unit conversion and emission rates application. The final step was to classify emission results according to scope. Emissions results were grouped into one of three emission scopes. Scope 1 included direct combustion of fuels such as natural gas, diesel, or propane. Scope 2 included indirect emissions from electricity purchased and used by PANYNJ. Indirect emissions from electricity purchased by PANYNJ (including purchased from the New York Port Authority [NYPA]) and resold to tenants were grouped as Scope 3. Finally, emissions from direct combustion of fuels by PANYNJ tenants were considered to be Scope 3 emissions.

Emission factors developed using eGRID were applied to electricity consumption values to estimate emissions. eGRID provided GHG and most CAP emission factors. Remaining CAP emissions were derived from state-wide emission values compiled in the NEI. Note that emissions differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation. GHG emission rates for natural gas were taken from The Climate Registry General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA's AP-42. The Climate Registry General Reporting Protocol also provided emission factors to quantify carbon dioxide emissions from fuel oils #2 and #4.

About one half of the electricity consumption in Newark Liberty International Airport came from electricity consumption summaries provided by the PANYNJ. The remaining electricity consumption was derived from a peak load analysis. A load analysis for Port Newark was received from PSE&G, which included the airport terminal, AirTrain, and Central Heating and Refrigeration Plant (CHRP), as well as Port Newark/Elizabeth North and South warehouses and Car Terminal. The data received showed the kilowatt hours used on a peak day in August 2007, when consumption was at its highest. To convert this data into annual activity data, eighteen power plants which supply electricity to four PSE&G subsidiaries in New Jersey were found using eGRID. Peak-to-annual electricity usage from these plants was analyzed using 2007 daily data queried from the EPA's Clean Air Markets Division website (EPA, 2007). On average, it was found that the annual electricity consumption was about 169 times peak day usage. This factor was used to supply the surrogate data for the airport terminal and the two marine terminals. This method provided consumption estimates in close agreement with billing kWh data received for the CHRP and AirTrain.

There was no way to distinguish between the electricity used by the Port Authority and the electricity resold to tenants in the New York airports using the 2007 activity data. However, PANYNJ provided Pechan with an approximate split between tenants and Port Authority consumption for JFK and LaGuardia airports. The split at LaGuardia was 56 percent (Scope 2-Port Authority) and 44 percent (Scope 3-tenants). For JFK main terminal electricity use, which is purchased from the KIAC Plant, the Port Authority accounted for 40.5 percent of electricity consumption in 2007, and tenants accounted for 29 percent. With a lack of better information, the remaining 23 percent was divided evenly between the Port Authority and tenants, making the final distribution 59.5 percent Scope 2 Port Authority use and 40.5 percent Scope 3 tenant use.

2.5.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 2-17, showing that most emissions come from facilities not directly under PANYNJ control.

Table 2-17. Aviation Buildings GHG Emissions by Facility and by Scope

Sub-Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)
Downtown Manhattan Heliport	0	0	117
JFK International Airport	11,922	109,930	88,267
AirTrain JFK	0	19,475	0
LaGuardia	1,123	19,161	15,055
Newark Liberty International Airport	114	7,073	39,286
AirTrain Newark	0	9,744	0
Stewart Airport	0	0	345
Teterboro Airport	404	1,116	199
Total	**13,563**	**166,498**	**143,269**

2.5.5. Comparison with Estimates in Previous Studies

Table 2-18 compares 2007 GHG emission estimates for Aviation Department buildings with those developed previously for calendar year 2006. GHG emissions decreased slightly (1.5 percent) between the two years.

Table 2-18. Aviation Buildings CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Downtown Manhattan Heliport	141	117	-17.0%
JFK International Airport	206,246	210,120	1.9
AirTrain JFK	17,716	19,475	9.9
LaGuardia	42,205	35,338	-16.3
Newark Liberty International Airport	51,356	46,472	-9.5
AirTrain Newark	9,203	9,744	5.9
Stewart Airport	Not Estimated	345	N/A
Teterboro Airport	1,357	1,719	26.7
Total	**328,223**	**323,330**	**-1.5%**

2.6. AVIATION DEPARTMENT GHG EMISSIONS SUMMARY

Table 2-19 summarizes the GHG emissions from all facilities within the Aviation department, specifying the source of the emissions and the amount that falls under each scope for each source. Some additional emissions from mobile sources that could not be allocated to facilities appear in Table 7-18.

Table 2-19. Aviation Department GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
John F. Kennedy International Airport	**13,697**	**129,405**	**1,554,143**	**1,697,245**
Aircraft	-	-	898,626	898,626
Ground Support Equipment	-	-	33,303	33,303
Attracted Travel	-	-	476,132	476,132
Buildings	11,922	109,930	88,267	210,119
Fleet Vehicles	1,775	-	-	1,775
AirTrain JFK	-	19,475	-	19,475
JFK Cogeneration Plant	-	-	57,815	57,815
LaGuardia Airport	**1,867**	**19,161**	**655,773**	**676,801**
Aircraft	-	-	430,223	430,223
Ground Support Equipment	-	-	11,058	11,058
Attracted Travel	-	-	199,437	199,437
Buildings	1,123	19,161	15,055	35,339
Fleet Vehicles	744	-	-	744
Newark Liberty International Airport	**1,355**	**16,817**	**1,184,895**	**1,203,067**
Aircraft	-	-	611,369	611,369
Ground Support Equipment	-	-	16,314	16,314
Attracted Travel	-	-	517,926	517,926
Buildings	114	7,073	39,286	46,473
Fleet Vehicles	1,241	-	-	1,241
AirTrain Newark	-	9,744	-	9,744

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Teterboro Airport	**416**	**1,116**	**105,109**	**106,641**
Aircraft	-	-	103,921	103,921
Ground Support Equipment	-	-	735	735
Attracted Travel	-	-	254	254
Buildings	404	1,116	199	1,719
Fleet Vehicles	12	-	-	12
Stewart Airport	**-**	**-**	**18,044**	**18,044**
Aircraft	-	-	2,552	2,552
Ground Support Equipment	-	-	92	92
Attracted Travel	-	-	15,055	15,055
Buildings	-	-	345	345
Downtown Manhattan Heliport	**7**	**-**	**38,467**	**38,474**
Aircraft	-	-	38,350	38,350
Buildings	-	-	117	117
Fleet Vehicles	7	-	-	7
AVIATION	**17,342**	**166,499**	**3,556,431**	**3,740,272**

2.7. AVIATION DEPARTMENT CAP EMISSIONS SUMMARY

Table 2-20 summarizes 2007 CAP emissions by facility for the Aviation Department.

Table 2-20. Aviation Department CAP Emissions by Facility (metric tons)

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
John F. Kennedy International Airport	**5,786**	**328**	**173**	**192**
Aircraft	4,078	281	134	137
Ground Support Equipment	230	32	17	17
Attracted Travel	1,038	10	21	37
Buildings	351	2	1	1
Fleet Vehicles	6	-	-	-
AirTrain JFK	35	3	-	-
JFK Cogeneration Plant	48	-	-	-
LaGuardia Airport	**2,315**	**229**	**135**	**144**
Aircraft	1,611	134	106	109
Ground Support Equipment	229	33	18	17
Attracted Travel	404	4	8	15
Buildings	69	58	3	3
Fleet Vehicles	2	-	-	-
Newark Liberty International Airport	**4,083**	**1,144**	**235**	**270**
Aircraft	2,556	191	120	123
Ground Support Equipment	256	36	19	19
Attracted Travel	1,105	11	22	40
Buildings	134	749	61	73
Fleet Vehicles	4	-	-	-
AirTrain Newark	28	157	13	15
Teterboro Airport	**195**	**52**	**50**	**51**
Aircraft	189	32	48	49
Ground Support Equipment	1	-	-	-
Attracted Travel	1	-	-	-
Buildings	4	20	2	2
Fleet Vehicles	-	-	-	-

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Stewart Airport	**40**	**3**	**2**	**2**
Aircraft	7	1	1	1
Ground Support Equipment	1	-	-	-
Attracted Travel	31	-	1	1
Buildings	1	2	-	-
Downtown Manhattan Heliport	**133**	**-**	**-**	**-**
Aircraft	133	-	-	-
Buildings	-	-	-	-
Fleet Vehicles	-	-	-	-
AVIATION	**12,552**	**1,756**	**595**	**659**

2.8. REFERENCES

Airlink, et al., 2008: "Shared-Ride/Van Service Passenger Capacity," Available at Airlink Shuttle, Carmel and Limousine Service, and Classic Limousine websites, October 2008

Caldas, 2008: Carol Caldas, "2007 Rental Cars Vehicle Transactions and Vehicle Transaction Days," Various Data Files, October 2008 (via email).

Citidex, 2008: Citidex.com, "New York City Online Directory & Guide - Airport Transportation," http://www.citidex.com/special/airporttrans/jfk_mta.html, November 2008.

DEC, 2008: New York State Department of Environmental Conservation, "2007 Enhanced I/M Program Annual Report: Appendix A," http://www.dec.ny.gov/chemical/45777.html, 2008.

EPA, 2003: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, "User's Guide to MOBILE6.1 and MOBILE6.2 - Mobile Source Emission Factor Model," EPA420-R-03-010, August 2003.

EPA, 2005: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, *NONROAD2005*, [Computer software], available at (http://www.epa.gov/otaq/nonrdmdl.htm#model), December 7, 2005.

EPA, 2007: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005," EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

EPA, 2008: U.S. Environmental Protection Agency, Clean Air Markets Division. NO_x Budget Program data queried from "Data and Maps, Emissions section" at http://camddataandmaps.epa.gov/gdm/. October 2008.

Excellent, et al., 2008: "Chartered Bus Passenger Capacity," Available at Excellent Bus Service Inc., Leprechaun Bus Line, and Classic Limousine websites, October 2008.

FAA, 2007: Federal Aviation Administration, "Passenger and All-Cargo Statistics," http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy07_prelim_all_enplanements.xls, 2007.

FAA, 2008: Federal Aviation Administration, "2006 and 2007 JFK LTO Operations," obtained from ATADS, http://aspm.faa.gov/opsnet/sys/Main.asp?force=atads, October 2008.

Fushan, 2008: Port Authority of New York and New Jersey, CCCAS Division, Aviation Department, Passenger and Trip Distributions by Origin, "2008 O-D Pas Transportation Mode By Trip Origin.xls," October 10, 2008.

ICF, 1999: ICF Consulting Group, "Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft," prepared for U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, April 1999.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 3, Table 3.2.3. N_2O and CH_4 Emission Factors for USA Gasoline and Diesel Vehicles," 2006.

KIAC, 2008: KIAC Partners, "EIA 920 Data for KIAC," sent via email on November 7, 2008.

NYC, 2007: New York City, "Inventory of New York City Greenhouse Gas Emissions," Mayor's Office of Operations, Office of Long-term Planning and Sustainability, April 2007.

PANYNJ, 2006: Port Authority of New York & New Jersey, "2006 Annual Airport Traffic Report," 2006.

PANYNJ, 2007a: Port Authority of New York & New Jersey, "2007 Annual Airport Traffic Report," 2007.

PANYNJ, 2007b: Port Authority of New York & New Jersey, "2007 Monthly Summaries of Airport Activities," http://www.panynj.gov/CommutingTravel/airports/html/traffic_2007.html, 2007.

PANYNJ, 2008a: Port Authority of New York and New Jersey, "Comprehensive Annual Financial Report for the Year Ended December 31, 2007," April 2008.

PANYNJ, 2008b: Port Authority of New York & New Jersey website, http://www.panynj.gov/CommutingTravel/airport, 2008.

Parsons Brinckerhoff, et al., 2006: Brinckerhoff, Parsons, et al., "FAA Regional Air Service Demand Study – PANYNJ Air Passenger Survey Findings Final Report," April 19, 2006.

Pechan, 2008: E.H. Pechan & Associates, Inc., "Calendar Year 2007 Emissions Inventory Procedures Document," prepared for Port Authority of New York and New Jersey, November 2008.

Sarrinikolaou, 2008a: George Sarrinikolaou, "Rental Cars Vehicle Transactions and Transaction Days," Various Data Files, October 2008 (via email).

Sarrinikolaou, 2008b: George Sarrinikolaou, "Airport Shuttle Bus Information," October 2008 (via email).

TCR, 2008: The Climate Registry, "General Reporting Protocol – Version 1.1", http://www.theclimateregistry.org/reference.html, May 2008.

URS, 2002: URS Corporation, "John F. Kennedy International Airport – Air Cargo Truck Movement Study," prepared for Port Authority of New York & New Jersey Traffic Engineering, May 2002.

3.0 PORT COMMERCE

3.1. COMMERCIAL MARINE VESSELS

3.1.1. Boundary

The boundary for Commercial Marine Vessels (CMV) corresponds to the New York-Northern New Jersey-Long Island Ozone Non-attainment Area (NYNJLINA) and includes all facilities that are under the management control of the PANYNJ. Emissions out to the three-mile demarcation line off the eastern coast of the United States are included under this boundary. Emissions from vessels calling on facilities that are not under the management control of the PANYNJ are not included in this emissions inventory.

3.1.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. Auto Marine Terminal;
b. Port Newark;
c. Elizabeth Marine Terminal;
d. Brooklyn/Red Hook Container Terminal; and
e. Howland Hook Marine Terminal.

3.1.3. Methods

CMVs are classified into three major categories: ocean going vessels (OGV); towboats; and harbor vessels. This classification system is consistent with previous reports commissioned by the PANYNJ, including the emissions inventories conducted by Starcrest. The OGV and harbor vessel categories have been further broken down into subcategories. The OGV are classified into the following subcategories for ship call information specific to PANYNJ facilities: containerships, car carriers/roll-on/roll-off vessels, cruise ships, tankers and bulk carriers.

Within the harbor vessel category, four sub-categories exist: assist tugs; dredging vessels; ferry/excursion vessels; and government vessels. Of these, only emissions from assist tugs and dredging vessels were considered under the management control of the PANYNJ. While the Port Authority serves as a ferry transportation clearinghouse for the New York/New Jersey metropolitan area, it was determined that the PANYNJ does not have management control over ferry/excursion operations, as these services operate from marine terminals and landing sites not under the management control of the PANYNJ. It was also determined that government vessels did not operate from

PANYNJ facilities. Therefore, emissions associated with both of these sub-categories were not included in this inventory. Emissions associated with OGV anchorages were also considered to be outside the management control of the PANYNJ.

There are three potential emission sources for CMVs: main engines (used to power the vessel's propellers); auxiliary engines (used to power the vessel's internal systems including heating and cooling requirements); and boilers (used to provide hot water and to keep the main engines warm when at port). Each CMV category has emissions from one or more of these engine categories.

The majority of CMV activity data was obtained from the 2006 calendar year Starcrest Port of New York and New Jersey emissions inventory at PANYNJ facilities (Starcrest, 2008a). Details on the methods used to develop activity and emissions for the categories listed in Table 3-1 are included in the Starcrest report. Dredging data was provided by PANYNJ Port Commerce Waterways Unit.

Starcrest's 2006 CMV emissions by subcategory were extrapolated to 2007 for each vessel type using historical port-wide ship call data provided by the Port Authority. Towboat activity estimates for both 2006 and 2007 were also provided by Port Authority and used to extrapolate the towboat/pushboat emissions to 2007. The scaling factors used are shown in Table 3-1. The ship call data and the percent change adjustments applied to the 2006 Starcrest emissions are shown in Table 3-1

Table 3-1. 2006-2007 Ship Call Data and Scaling Factors

	Ship Calls		
	2006	**2007**	**Factor (%)**
Containership	2,552	2,516	-1.4%
Car Carrier / Roll On/Roll Off	769	699	-9.1
Cruise Ship	41	50	21.9
Tanker	81	97	19.8
Bulk Carrier	119	136	14.3
Towboats/Pushboats	4,237	4,648	9.7
Assist Tugs	3,562	3,498	-1.8

Calendar year 2007 dredging data (in cubic yards) was obtained from the Port Authority's Waterways Unit. Emission factors for dredging were derived from emission factors calculated by Starcrest for dredging criteria air pollutant (CAP) emissions, in tons/million cubic yards. (Starcrest, 2003a) These CAP emission factors were translated into greenhouse gas emission factors by applying a conversion ratio calculated using the relative ratios between the main engine GHG emission factors provided by Entec and EPA (Entec, 2002). For CO_2 and N_2O, NO_x was used as an emissions factor indicator. For CH_4, volatile organic compound (VOC) was used as the indicator. The dredging emission factors were then converted from tons/million cubic yards into metric tons/cubic yards. In 2007, the Port Authority Waterways Unit reported 2,074,420 cubic yards of dredging in the New York Harbor system, as compared to 5,549,189 cubic yards in 2006. These dredging activity data reflects volumes dredged from the Port Authority/U.S. Army Corps of Engineers joint Harbor Deepening Project, as well as dredging from Port Authority berths. All of this dredging activity is considered to be within the Port Authority's boundary.

3.1.4. Results

Dredging emissions found in Table 3-2 are the result of applying the emission factors to this activity data. Table 3-3 summarizes the CMV GHG emission estimates for the different vessel types included in the inventory. CMV GHG emissions are dominated by CO_2 emissions (99 percent), with methane and nitrous oxide contributing significantly less. Table 3-3 also provides an estimate of the split among the vessel categories, which indicates that approximately 86 percent of CMV GHG emissions are from OGV, 7 percent are from towboats, and 6 percent are from harbor vessels. Table 3-4 summarizes the CMV CAP emissions estimates for the different vessel types included in the inventory. Dredging emissions are included within the harbor vessels category.

Table 3-2. GHG and CAP Emissions from Dredging Activity

Emissions (metric tons)						
CO_2	CH_4	N_2O	CO_2 Equivalent	NO_x	$PM_{2.5}$	PM_{10}
3,042	0.10	0.07	3,067	56.11	1.30	1.41

Table 3-3. Commercial Marine Vessel GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)					
CMV Category	CO_2	CH_4	N_2O	CH_4 CO_2e	N_2O CO_2e	Total CO_2 Equivalent
Ocean Going Vessels	175,887	16	4	330	1,378	**177,595**
Towboats	14,613	5	2	106	540	**15,259**
Harbor Vessels	12,363	3	1	71	377	**12,811**
Port Authority	**202,863**	**24**	**7**	**507**	**2,295**	**205,665**

Table 3-4. Commercial Marine Vessel CAP Emissions by Gas

	Criteria Air Pollutant Emissions Totals (metric tons)			
CMV Category	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Ocean Going Vessels	3,299	2,938	249	311
Towboats	288	30	14	16
Harbor Vessels	243	21	11	10
Port Authority	**3,830**	**2,988**	**274**	**337**

3.1.5. Comparison with Estimates in Previous Studies

The City of New York's GHG emissions inventory for the year 2005 estimates that the transportation of freight by water generates 6.2 million metric tons of CO_2e emissions. GHG emissions from shipping for the New York City inventory were taken from the study entitled *Estimating Transportation Related Greenhouse Gas Emissions and Energy Use in New York State* (NYC, 2007). The methodology used by the New York City inventory estimated GHG emissions based on the statewide use of residual and diesel fuel (whereas the Starcrest 2006 calendar year emissions inventory uses activity-based data). This fuel use was allocated to counties based on the proportion of water freight tonnage in each county. The 2005 New York City inventory notes that the methodology employed to estimate shipping emissions "confers results which may be less accurate than other sections of this inventory." The *IPCC Climate Change 2007: Mitigation of Climate Change* report recognizes the "substantial discrepancies" between emissions estimates derived from fuel use versus those derived from activity based data. Corbett and Koehler (2003) also recognized the discrepancy between activity-based inventories and fuel-based inventories.

Except for the emissions from dredging operations, the GHG emission estimates provided in this section of the inventory are, based on the use of ship call data for the year 2006 emissions found in the Starcrest report (Starcrest, 2008a). Emissions from dredging operations changed in proportion with changes in activity data, which decreased 67 percent from 2006 to 2007, with a resultant decrease in emissions. In Table 3-5, the 2006 estimates are taken from the Starcrest report plus the dredging estimate from the calendar year 2006 "Greenhouse Gas Emission Inventory for the Port Authority of New York & New Jersey." The resultant 3.4 percent decrease in CMV emissions is largely because of the decrease in dredging activity, a drop of 6,233 metric tons. The relative change in emissions from other operations was relatively small.

Table 3-5. Commercial Marine Vessels CO_2 Equivalent GHG Emissions Comparison

CMV Category	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Ocean Going Vessels	179,318	177,595	-1.0%
Towboats	13,911	15,259	9.7
Harbor Vessels	19,749	12,811	-35.1
Total	**212,977**	**205,665**	**-3.4%**

3.2. CARGO HANDLING EQUIPMENT (CHE)

3.2.1. Boundary

The boundary for this category includes cargo-handling diesel equipment used in three different operations at the terminals leased by the PANYNJ:

- CHE at container terminals;
- Switch locomotives at container terminals and Line haul locomotives within the boundary of the New York/New Jersey Non-Attainment Area (NYNJLINA), and
- Vehicle movement at auto-marine terminals.

Privately-owned terminals (e.g., Global Terminals) were not included in the inventory.

3.2.2. Facilities Included in the Inventory

This category covers CHE at five of the PANYNJ leased container terminals, including:

- American Stevedoring, Inc. (ASI)/Brooklyn Port Authority Marine Terminal;
- New York Container Terminal (NYCT)/Howland Hook Terminal;
- APM Terminal/Elizabeth PA Marine Terminal;
- Maher Terminal/Elizabeth PA Marine Terminal; and
- Port Newark Container Terminal (PNCT).

The predominant types of equipment used at container terminals include: terminal tractors; straddle carriers; forklifts; and top loaders. Several other types of off-road equipment, including cranes, comprise this category.

Switch locomotive activity includes all locomotive activity related to movement of cargo within the boundaries of the Port Authority's five marine terminals. Line haul locomotive activity includes all activity related to the movement of cargo from the Port Authority facilities to destinations outside the boundary of the Port Authority facilities, but within the NYNJLINA.

The auto-marine terminals include:

a. BMW;
b. Distribution Auto Service;
c. FAPS, Inc.;
d. Northeastern Auto-Marine Terminal; and
e. Toyota Logistic Services.

This category includes the movement of imported and exported vehicles and worker transport vans at auto-marine terminals.

3.2.3. Methods

A 2006 GHG and CAP emission inventory for container terminals, switch and line haul locomotives was prepared for the New York and New Jersey Port District (Starcrest, 2008a). For container terminal CHE, switch and line haul locomotives, the 2006 GHG and CAP estimates formed the basis of 2007 GHG and CAP emissions. Details on the procedures and emission factors used to prepare the container terminal CHE and locomotive emissions are included in the background report (Starcrest, 2008b).

A 2002 criteria pollutant emission inventory for automarine terminals was prepared for the five container terminals leased by the Port Authority (Starcrest, 2003b). The 2002 activity and emission estimates formed the basis for 2007 GHG and CAP emissions for automarine terminals. Details on the methods used to develop 2002 activity and emissions for the automarine terminals are included in the background report (Starcrest, 2003b).

The methods used to develop 2007 GHG and CAP emission estimates for each of these three CHE categories are described more fully below.

3.2.3.1. Container Terminal CHE

2006 GHG and CAP container terminal CHE emissions were prepared for the New York and New Jersey Port District. The emissions were reported in total and not categorized by state. The change in the number of loaded and empty twenty-foot equivalent units (TEUs) handled in the port between 2006 and 2007 was used as the surrogate indicator to estimate 2007 activity (PANYNJ, 2008a). 2007 GHG and CAP emissions were estimated by applying this change in TEUs between 2006 and 2007 to the emissions reported for 2006.

3.2.3.2. Switch and Line Haul Locomotives

2006 GHG and CAP switch and line haul locomotive emissions were prepared for activities within the Port Authority leased marine terminals, and to destinations outside the boundary of the Port Authority facilities, but within the NYNJLINA. To estimate the GHG and CAP emissions for 2007, the 2006 switch and line haul locomotive emissions were grown to 2007 using the number of containers handled by the switch locomotives. In 2007, the locomotives associated with the Port Authority marine terminals handled 358,043 containers, compared with 262,157 in 2006 (PANYNJ, 2008b).

3.2.3.3. Auto-Marine Terminals

Based on the 2002 inventory, activity at auto-marine terminals represents a relatively small fraction (less than 1 percent) of total port-related CHE fuel consumption and emissions. As such, an effort was not made to obtain 2007 fuel consumption, and the 2007 activity was instead based in part on the VMT associated with imported, exported, and worker vehicles compiled for the 2002 CHE study.

VMT were estimated for the 2002 CHE study for three categories of vehicles: light-duty gasoline vehicles (LDGVs); light-duty gasoline trucks below 6,000 pounds (LDGT-1 and 2); and light-duty gasoline trucks between 6,001 and 8,500 pounds (LDGT-3 and 4). VMT were estimated by multiplying the number of vehicles by the average driving distance in the terminal, as obtained via survey. The driving distances represent an average estimate for worker transport vehicles operating on the ground at the terminal, as well as imported vehicles driven very short distances (e.g., to be stored in parking lots before loading on trucks). The 2007 VMT was estimated by growing the 2002 VMT using information provided by the PANYNJ on the number of vehicles arriving or departing PANYNJ facilities via vessel for each year (PANYNJ, 2008c). This value was reported as 634,100 in 2002 and 747,288 vehicles in 2007. Fuel consumption associated with the 2007 VMT was estimated using data from the 2008 Annual Energy Outlook (DOE, 2008), which lists the miles per gallon (mpg) of 2007 model year light-duty vehicles as 29.5 mpg and light-duty trucks as 22.0 mpg.

Fuel consumption was used in conjunction with CO_2 default emission factors from IPCC Guidelines Table 3.2.1 for Motor Gasoline, and CH_4 and N_2O emission factors from IPCC Table 3.2.2 for Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later (IPCC, 2006). The emission factors developed by EPA and applied to the auto-marine terminal fuel consumption account for both start and running emissions. Emission factors are expressed in kg/terajoule (TJ). Gasoline fuel volumes were converted to an energy basis using a conversion factor of 1.2946 E-4 TJ per gallon of gasoline (IOR, 2007).

3.2.4. Cargo Handling Equipment GHG Results

Table 3-6 summarizes the GHG emission estimates for the CHE categories included in the inventory. Container terminal CHE is the predominant contributor to the CHE inventory. Information was not available to assign container terminal, switch locomotive, line haul locomotive and auto-marine terminal activity or emissions to states.

GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions are approximately 99 percent of the CO_2e emissions.

Table 3-6. Cargo Handling Equipment GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)			
Category (Portwide)	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Container Terminal CHE	146,275	4	8	147,603
Switch Locomotive	6,748	0.533	0.178	6,814
Line Haul Locomotive	13,147	1.038	0.341	13,277
Auto-marine Terminal	152	8.3E-03	1.2E-02	156
Totals	**166,322**	**6**	**9**	**167,850**

3.2.5. Cargo Handling Equipment CAP Results

Table 3-7 summarizes the CAP emission estimates for the CHE categories included in the inventory. Container terminal CHE is the predominant contributor to the CHE inventory. CAP emissions are dominated by NO_x and SO_2 emissions.

Table 3-7. Cargo Handling Equipment CAP Emissions

Category (Portwide)	CAP Emissions Totals (metric tons)			
	NO_x	SO_2	PM_{10}	$PM_{2.5}$
Container Terminal CHE	1,443	225	96	89
Switch Locomotive	174	15	6	5
Line Haul Locomotive	217	29	8	7
Auto-marine Terminal)	0.778	0.037	0.006	0.005
Totals	**1,835**	**269**	**110**	**101**

3.2.6. Comparison with Estimates in Previous Studies

Table 3-8 compares 2006 and 2007 CO_2 equivalent emissions for CHE. For the switch and line haul locomotives, the 36 percent increase in emissions is a result of the increase in the number of containers handled. Even with the large percentage increase in CO_2 equivalent emissions for switch and line haul locomotives, the total CHE emissions increased only 6 percent from 2006 to 2007.

Table 3-8. Cargo Handling Equipment CO_2 Equivalent GHG Emissions Comparison

Category (Portwide)	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Container Terminal CHE	143,544	147,603	3%
Switch Locomotive	4,989	6,814	37
Line Haul Locomotive	9,721	13,227	36
Auto-marine Terminal	150	156	4
Total	**158,404**	**167,850**	**6%**

3.3. ATTRACTED TRAVEL

3.3.1. Boundary

The boundary for attracted travel at the PANYNJ Port Commerce facilities includes the following activities:

- Truck idling within the marine terminal area;
- Truck travel within the marine terminal area;
- Truck trips to and from the terminal areas to deliver or pick up containers at the port terminals.

3.3.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. Auto-Marine Terminal;
b. Port Newark / Port Elizabeth Marine Terminal;
c. Red Hook Container Terminal;

d. Howland Hook Marine Terminal.

3.3.3. Methods

Activity data for each attracted travel category were multiplied by the relevant emission factors to estimate total GHG emissions. The activity used for truck idling was the number of hours of idling and this was calculated by multiplying the number of trucks entering the terminals in 2007 by an estimate of the average amount of time spent idling at the terminal per trip. The activity indicator used for truck travel within the terminal area was the VMT within the terminal area. This was calculated by multiplying the 2007 annual one-way gate count by an estimate of the average VMT per terminal trip. The activity used for truck travel to and from the terminal area was the VMT associated with the trip to deliver and the trip to pick-up the cargo or container. This was calculated by multiplying the annual one-way gate count by estimates of the average trip length.

The growth rate in container traffic from 2006 to 2007 calculated from the 2007 PANYNJ Annual Report (PANYNJ, 2008d) was applied to the 2006 total annual HDDV trips from the Starcrest emission inventory report (Starcrest, 2008b) to get the 2007 one-way gate count. The 2007 gate counts were allocated to each marine terminal based on average daily terminal gate count data previously provided by the Port Authority for May 2006. The terminal ratios were calculated as the terminal-specific average daily May 2006 gate count to the total average May daily gate counts for all Port Authority terminals The 2006 average daily gate counts for the Auto Marine Terminal and the Red Hook Container Terminal were estimated by first multiplying the Port Authority total TEUs by 0.234 percent (the proportion of TEUs attributable to this terminal based on information provided by the Port Authority) and then by scaling the TEU data to gate counts in the same proportion as the other terminals, based on total marine terminal activity data from the PANYNJ Annual Report (PANYNJ, 2008d).

Once the 2006 proportions of gate counts by terminal were calculated , these ratios were applied to the total 2007 gate count from Starcrest (Starcrest, 2008b) to estimate the 2007 gate counts by terminal. Other data used in calculating the activity were obtained from a truck origin-destination survey (Vollmer, 2006) and a CAP emission inventory report for the ports (Starcrest, 2008b). GHG emission factors were obtained from EPA's latest GHG emission inventory report (EPA, 2008a). Table 3-9 summarizes the activity data used to calculate emissions from attracted travel at the marine terminals.

3.3.3.1. Truck Idling Activity within the Terminal Area

As mentioned above, the activity indicator used for truck idling was the number of hours of idling. This was calculated by multiplying the 2007 annual gate count data by an estimate of the average amount of time spent idling at the terminal per trip. The emission inventory report prepared by Starcrest (Starcrest, 2008b) provides a table of

Table 3-9. Summary of Activity Data for Port Commerce Attracted Travel

Terminals	Estimated Annual 2007 Gate Count (One-way)	Estimated Average Miles per Trip within Terminal (miles)[a]	Estimated Total Miles Traveled within Terminal (miles)	Estimated Idling Hours per Trip in Terminal (hours)[a]	Estimated 2007 Total Truck Idling Hours in Terminal (hours)	Estimated One-Way Trip Length To or From Terminal (miles)	2007 VMT for Trip to and from Terminal (miles)
Port Newark/ Port Elizabeth	2,979,254	1.08	3,223,272	1.36	4,062,231	42.7	254,406,531
Howland Hook Marine Terminal	468,413	1.13	527,231	1.40	655,201	42.7	39,999,030
Red Hook Container Terminal/Auto Marine Terminal	16,699	0.39	6,455	1.68	28,061	42.7	1,425,950

[a]SOURCE: Estimated by Pechan from data in Starcrest, 2007

on-terminal operating characteristics based on 2006 survey data that summarizes annual trips, VMT, average speed, and idling hours by terminal type. The total on-terminal idling hours were divided by the total annual on-terminal trips for each terminal type to estimate the average number of idling hours per trip. The terminal types included in the Starcrest 2006 survey data are: Auto Terminals, Container Terminals, and Warehouses. The Howland Hook Marine Terminal truck trip data used idling hours from Starcrest Container Terminals, the Red Hook Container Terminal and Auto Marine Terminal used idling data from Starcrest Auto Terminals, and the Port Newark and Elizabeth terminals truck trips used idling hours from the average of all Starcrest terminal types.. The Red Hook Container Terminal and Auto Marine Terminal categories were grouped together due to a lack of gate count and travel activity data available for each, so the Starcrest Auto Terminals idling data was used for this category. Once the idling values were applied to each terminal, they were multiplied by each terminal's estimated annual 2007 gate count to determine the total number of hours that trucks spent idling at the port terminals in 2007. Each truck was estimated to consume 0.5 gallon of diesel fuel per hour of idling (EPA, 2007). The estimates of the total hours of idling for each terminal are shown in Table 3-9.

3.3.3.2. Truck Travel Activity within the Terminal Area

The activity used for truck travel within the terminal area was the amount of VMT within the terminal area. This was calculated by multiplying the gate count data by an estimate of the average VMT per terminal trip by terminal type. The VMT associated with each trip within each terminal was calculated in a manner similar to the estimation of idling hours per trip. The summary data referenced above from the Starcrest report (Starcrest, 2008b) were used to calculate the average on-terminal VMT per truck trip by dividing the total on-terminal VMT by terminal type by the number of annual terminal truck trips by terminal type. This resulted in an average on-terminal VMT per truck trip of 1.08 miles within the Port Newark and Elizabeth terminals, 1.13 miles per trip within the Howland Hook terminal, and 0.39 miles per trip within the Red Hook and Auto Marine terminals . These values were multiplied by each terminal's estimated annual 2007 gate count to determine the total VMT that trucks drove within the port terminals during the year. The total VMT estimated within the terminals is shown in Table 3-9.

3.3.3.3. Truck Travel Activity To and From the Terminal Area

The activity used for truck travel to and from Port Commerce terminal areas was the VMT associated with the trip to deliver and the trip to pick up the cargo or containers from the terminal and was calculated by multiplying gate count data by estimates of the average trip length. The source of the average trip length data was the Vollmer terminal survey report (Vollmer, 2006). This report summarized the distribution of truck origins and destinations by county, state, or region. A weighted average trip length was estimated by multiplying the distribution percentage by the distance from the terminals (assumed to be at the centroid of Union County, NJ) to the centroid of the origin or destination county. Data on highway miles between county centroids were obtained from the Center for Transportation Analysis at the Oak Ridge National Laboratory (CTA, 2008). In cases where the origin or destination is listed as a State or region rather than a county, a surrogate county was selected in which a major metropolitan area is located. Trip lengths were capped at a maximum of 400 miles per trip (the distance a truck could travel in an eight-hour day at 50 mph). Separate analyses were performed to estimate a weighted average origin trip length and a weighted average destination trip length. Table 3-10 shows the distribution of origin and destination trips, the surrogate counties used, and the mileage from the terminals to each origin or destination. This calculation resulted in an average origin trip length of 45.0 miles and an average destination trip length of 40.4 miles. The sum of these two values (85.4 miles) was then multiplied by the annual gate counts for each terminal to estimate the 2007 VMT to and from the terminals. Table 3-9 summarizes the estimated VMT associated with the trips to and from the terminals.

3.3.3.4. Emission Factors and Emission Calculations

Emission factors for trucks were obtained from EPA's latest GHG Inventory report (EPA, 2007). The emission factors associated with heavy-duty diesel vehicles (HDDVs) were used for CH_4 and N_2O, in terms of grams per mile, while the emission factor associated with diesel fuel consumption was used for CO_2, in terms of mass per gallon. The CH_4 and N_2O emission factors for HDDVs do not vary by model year or emission control technology. Annual VMT from truck travel, both within the terminals and on the trips to and from the terminals was converted to annual fuel consumption for estimating CO_2 emissions by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy by model year and vehicle type, were obtained from the Department of Energy's Annual Energy Outlook reports (DOE, 1996-2008). The diesel CO_2 emission factor was multiplied by the total fuel consumed by the trucks during idling, traveling within the terminals, and traveling to and from terminals. The HDDV CH_4 and N_2O emission factors were multiplied by the total truck VMT within the terminals, and VMT to and from terminals to obtain the emissions from vehicle travel.

The resulting emissions were then summed by activity and terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

3.3.4. Results

Table 3-11 summarizes the GHG emission estimates for the Port Commerce attracted travel activities included in this 2007 inventory. A majority of the emissions are associated with the truck travel to and from the port terminals. While the estimates of total gate counts should be fairly certain, the allocations of gate counts by terminal have a higher degree of uncertainty.

Table 3-10. Port Commerce Distribution of Truck Origin and Destinations – All Terminals

State/Region	County	Surrogate County Used	Truck Origins Percent of Total	Truck Destinations Percent of Total	Distance from Union County, NJ (highway miles)
NJ	Bergen		2.3%	2.4%	24.8
	Essex		23.3	23.3	10.8
	Hudson		21.9	22.7	14.4
	Mercer		0.5	0.5	42.4
	Middlesex		9.3	9.8	16.9
	Monmouth		0.7	0.4	35.9
	Morris		0.7	0.9	24.2
	Ocean		0.1	0.1	55.7
	Passaic		0.9	1.1	22.6
	Somerset		0.8	0.9	27.9
	Union		12.4	14.4	5.3
	Other	Atlantic County (Atlantic City)	2.5	2.8	106.3
NY	Bronx		1.1	0.6	33.9
	Kings		3.5	3.0	27.1
	New York		0.9	0.5	26.1
	Queens		0.8	0.9	32.0
	Richmond		0.9	1.2	12.0
	Dutchess		0.2	0.2	96.6
	Nassau		1.4	1.0	48.8
	Orange		0.3	0.4	72.2
	Putnam		0.0	0.0	82.2
	Rockland		0.1	0.1	41.6
	Suffolk		0.2	0.2	69.3
	Westchester		0.4	0.5	45.7
	Upstate	Onondaga County (Syracuse)	1.5	1.4	241.2
CT	Fairfield		0.3	0.1	80.1
	New Haven		0.4	0.3	107.1
	Other		0.4	0.2	146.3
Western MA		Hampden County (Springfield)	0.2	0.0	165.6
Eastern MA & RI		Suffolk County (Boston)	1.4	1.1	237.0
Northern New England		Hillsborough County (Manchester, NH)	0.1	0.1	262.0
NE Pennsylvania		Lackawanna County (Scranton)	2.2	1.8	112.6
SE Pennsylvania		Philadelphia County	2.6	2.5	77.7

State/Region	County	Surrogate County Used	Truck Origins Percent of Total	Truck Destinations Percent of Total	Distance from Union County, NJ (highway miles)
Central Pennsylvania		Dauphin County (Harrisburg)	1.5%	1.4%	151.3
Western Pennsylvania		Allegheny County (Pittsburgh)	0.4	0.3	358.6
DE		New Castle County (Wilmington)	0.2	0.1	109.7
MD and DC		Baltimore City	0.8	0.4	174.6
Midwest			0.9	0.9	400.0
Pacific Northwest			0.1	0.0	400.0
Pacific Southwest			0.1	0.0	400.0
Canada			1.6	1.5	400.0
Weighted Average Origin Trip Length (highway miles)					45.0
Weighted Average Destination Trip Length (highway miles)					40.4
Average Trip Length (highway miles)					***42.7***

SOURCE : Vollmer, 2006, Table VI-1; CTA, 2008

Table 3-11. Port Commerce Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Activity and Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	**CH_4**	**N_2O**	**CO_2 Equivalent**
Idling Within Terminal				
Port Newark/Port Elizabeth	20,622	0.00	0.00	20,622
Howland Hook Marine Terminal	3,326	0.00	0.00	3,326
Red Hook Container Terminal/Auto Marine Terminal	142	0.00	0.00	142
Total	***24,091***	***0.00***	***0.00***	***24,091***
Travel Within Terminal				
Port Newark/Port Elizabeth	4,807	0.02	0.02	4,813
Howland Hook Marine Terminal	786	0.00	0.00	787
Red Hook Container Terminal/Auto Marine Terminal	10	0.00	0.00	10
Total	***5,603***	***0.02***	***0.02***	***5,609***
Travel To and From Terminal				
Port Newark/Port Elizabeth	379,442	1.30	1.22	379,848
Howland Hook Marine Terminal	59,658	0.20	0.19	59,722
Red Hook Container Terminal/Auto Marine Terminal	2,127	0.01	0.01	2,129
Total	***441,226***	***1.51***	***1.42***	***441,698***
Total Attracted Travel				
Port Newark/Port Elizabeth	404,872	1.31	1.24	405,283
Howland Hook Marine Terminal	63,770	0.21	0.19	63,835
Red Hook Container Terminal/Auto Marine Terminal	2,279	0.01	0.01	2,281
Total	***470,921***	***1.53***	***1.44***	***471,399***

GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions account for more than 99 percent of the CO_2e emissions.

In comparison with 2006 emissions from attracted travel, 2007 total CO_2e emissions increased 4.8 percent. This increase is consistent with the 3.6 percent increase in container traffic and the 4.0 percent increase in TEUs from 2006 to 2007. Emissions from idling within terminals increased 3.7 percent while emissions from both travel within and travel to and from terminals grew by about 4.9 percent. According to NY Metropolitan Area vehicle registration data, the average weighted fuel economy of heavy-duty vehicles decreased 1.2 percent between 2006 and 2007.

3.3.5. Comparison with Estimates in Previous Studies

Table 3-12 shows the 2007 inventory in comparison to the 2006 estimates. The attracted travel GHG emission estimates increased by about 5 percent from 2006 to 2007.

Table 3-12. Port Commerce Attracted Travel CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Idling Within Terminal	23,239	24,091	3.67%
Travel Within Terminal	5,350	5,609	4.84
Travel To and From Terminal	421,282	441,698	4.85
Total Attracted Travel	**449,871**	**471,399**	**4.79%**

3.4. LANDFILL

3.4.1. Boundary

Historical aerial photography suggests that landfill dumping began in the Elizabeth landfill area sometime in the 1940’s and ended in 1970.

According to the New Jersey Department of Environmental Protection (NJDEP) records, the total acreage of the landfill area is 155 acres. The landfill’s exact boundaries are not known and could not be accurately determined through aerial photography review alone given the uncontrolled nature of filling employed at the landfill during its use. However, based on information from NJDEP and a review of boring logs, it can be determined that the general boundary for the main portion of the landfill lies south of Bay Avenue between the Conrail railroad tracks and east to McLester Street. The southern boundary runs south past North Avenue to where the present day Jersey Gardens Mall is located. Moreover, the landfill is subdivided into two portions. The primary portion of the former landfill is currently owned by IKEA. The PANYNJ owns the remainder. The Port Commerce Department manages this property, leasing it to tenants.

3.4.2. Facilities Included in the Inventory

Elizabeth Landfill.

3.4.3. Methods

Activity data in the form of total solid waste deposited (metric tons) in the landfill was used to estimate the CH_4 emissions from the landfill. To estimate the depth of the landfill, the stratigraphic profile map of the landfill provided by PANYNJ was used. The profile map shows contours of the top of the organics layer, the bottom of the refuse fill, and the thickness of the refuse fill. Starting from the ground surface, the stratigraphic sequence of the landfill consists of the following units: silty sand, organic silt, dredged material, waste material/organic layer, and top layer of fill sand. The depth of the landfill was estimated by subtracting the elevation of the top of the organics layer from the bottom of the refuse fill. The refuse thickness was estimated to be between 6 to 8 feet. The density of solid waste multiplied by the volume of the landfill was used to estimate the amount of waste emplaced. Solid waste density was assumed to be 0.6 tons/cubic yard (EPA, 2005), which resulted in an estimate solid waste-in-place of 1,091,208 metric tons.

EPA's LandGEM model was used to estimate the amount of landfill gas produced and the resultant annual emissions of methane from the landfill gas (EPA, 2005). LandGEM is based on the gas generated from anaerobic decomposition of waste in the landfill, which has a methane content of between 40 and 60 percent. Default pollutant concentrations used by LandGEM have already been corrected for air infiltration, as stated in AP-42 (EPA, 1995). The annual waste emplacement estimate was input to LandGEM for each year of operation. The model assumptions also include: the methane generation potential of 3,204 cubic feet per ton of waste and a methane generation rate constant of 0.065 (1/year). The methane generation rate constant, determines the rate of methane generation for the mass in the landfill. The higher the value of constant, the faster the methane generation rate increase and then decays over time. It depends on moisture content of the waste mass, availability of nutrients for methanogens, pH and temperature of the landfill waste.

Landfill gas is a mixture of substances generated when bacteria decompose the organic materials contained in the solid waste emplaced. By volume, MSW landfill gas is about 50 percent CH_4 and 50 percent CO_2. The amount and rate of CH_4 generation depends upon the quantity and composition of the landfill's material, as well as the surrounding landfill environment. The stratigraphic profile map provided by the PANYNJ shows dredge material in the landfill, and dredge material produces very small quantities of methane. Since the contribution from this layer is minimal, the estimates show the total methane emissions from both the refuse and dredge layers within the landfill. The waste-in-place estimate was divided by the number of estimated operating years of the landfill (30 years) to estimate an average annual waste emplacement during the assumed years of operation, 1940 to 1970.

There was no detailed and accurate data available on the yearly waste deposits and the composition of waste deposited each year in the landfill. Therefore, the LandGEM model was used instead of the IPCC-based waste model.

3.4.4. Results

Table 3-13 summarizes the landfill GHG emission estimates for both departments' shares of the facility included in the inventory. Although the landfill produces emissions of both CO_2 and CH_4, only the methane emissions are reported here, based on IPCC guidelines, the CO_2 is considered to be of primarily biogenic origin (e.g., decomposable paper, vegetation). There is also some evidence that landfills produce N_2O emissions; however, sufficient measurements are not yet available to evaluate these emissions from U.S. landfills.

Emissions generated by the Elizabeth Landfill have been determined to be Scope 1. Neither the California Climate Action Registry, nor the WRI/WBCSD Greenhouse Protocol offer explicit guidance on ownership of emissions from a closed landfill in the case of leased land. In the case of the Elizabeth Landfill, the PANYNJ owns and manages most of this property and leases it to tenants. There is no landfill gas capturing system in place. For other types of leased operations (such as buildings), where the owner does not exert operational control, the emissions are deemed to rest with the tenant (Scope 3 emissions for the owner). However, the case of emissions from closed landfills is slightly different, as the leasing operator is not assuming operational control of the closed landfill site. If the tenant were to move its operations away from PANYNJ owned land, the emissions from the landfill would remain.

Table 3-13. Landfill GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Elizabeth Landfill – Port Commerce Department	0	189	0	3,958

3.4.5. Comparison with Estimates in Previous Studies

The 2007 total GHG emissions from Elizabeth Landfill were estimated to be 3,958 tons, a decrease of 6 percent compared with 2006 emissions. The CH_4 generation potential of the waste that is disposed in a certain year decreases gradually throughout the following years. As a result, there is slight decrease in the emissions from year 2006 to 2007. Table 3-14 shows the total CO_2e emissions, a reduction of 6 percent from year 2006.

Table 3-14. Total CO_2 Equivalent GHG Emissions Comparison for Elizabeth Landfill

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Elizabeth Landfill	4,224	3,958	-6%
Total	**4,224**	**3,958**	**-6%**

3.5. BUILDINGS

3.5.1. Boundary

The GHG emissions inventory boundary includes all Port Commerce Department operated buildings, and buildings leased to tenants.

3.5.2. Facilities Included In the Inventory

All facilities listed in Table 3-15 are included in this building energy use category.

Table 3-15. Facilities within Port Commerce Department Boundary

Facility
Auto Marine Terminal and Greenville Yard
Brooklyn PA Marine Terminal
Howland Hook Marine Terminal and Port Ivory
Port Newark Terminal / Elizabeth Marine Terminal

3.5.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the PANYNJ were estimated in four steps.

The first step consisted of developing a list of sources responsible for GHG emissions associated with energy consumption in buildings that are owned, or leased, within the Port Commerce department boundary. Step two focused in mapping sources with their corresponding energy consumption. Step three was spent processing raw data by means of unit conversion and emission rates application. The final step consisted in classifying emission results according to scope. Emissions results were grouped into one of three emission scopes. Scope 1 included direct combustion of fuels such as natural gas, diesel, or propane. Scope 2 included indirect emissions from electricity purchased and used by PANYNJ. Indirect emissions from electricity purchased by PANYNJ (including purchased from NYPA) and resold to tenants were grouped as Scope 3. Finally, emissions from direct combustion of fuels by PANYNJ tenants were considered to be Scope 3 emissions.

During step two, emission factors and emission rates were selected as follows. For emission estimates from electricity consumption, emission factors developed by eGRID were applied to consumption values (EPA, 2008b). eGRID provided emission factors to estimate GHG and most CAP emissions. Remaining CAP emissions were derived from state-wide emission values compiled in the EPA NEI. It is important to note that emissions differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation. GHG emission rates for natural gas were taken from The Climate Registry General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA's AP-42 (EPA, 1995).

Electricity usage data was unavailable for Elizabeth Marine Terminal. Rather than develop square footage estimates for these very large areas, a load analysis for Port Newark was received from PSE&G, which included the airport terminal, AirTrain, and Central Heating and Refrigeration Plant (CHRP), as well as Port Newark/Elizabeth North and South warehouses and Car Terminal. The data received showed the kilowatt hours used on a peak day in August, when consumption was at its highest. To convert this data into annual activity data, eighteen power plants which supply electricity to four PSE&G subsidiaries in New Jersey were found using eGRID. Peak to annual electricity usage from these plants was analyzed using 2007 daily data queried from the EPA's Clean Air Markets Division website (EPA, 2007). On average, it was found that the annual electricity consumption was about 169 times more than the usage on a peak day. This factor was used to supply the surrogate data for the airport terminal and the two marine terminals. The accuracy of this method was demonstrated as it provided numbers in close agreement with billing kWh data received for the CHRP and AirTrain.

3.5.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 3-16, showing that all emissions come from facilities not directly under PANYNJ control.

Table 3-16. GHG Emissions by Facility and by Scope

Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)
Auto Marine Terminal and Greenville Yard	0	0	3,514
Brooklyn PA Marine Terminal	0	0	190
Howland Hook Marine Terminal and Port Ivory	0	0	2,211
Port Newark Terminal / Elizabeth Marine Terminal	0	0	47,859
Total	**0**	**0**	**53,780**

3.5.5. Comparison with Estimates in Previous Studies

Table 3-17 compares the 2007 GHG emission estimates from this study with those estimated previously for 2006.

Table 3-17. Port Commerce Buildings CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Auto Marine Terminal and Greenville Yard	3,537	3,514	-0.7%
Brooklyn PA Marine Terminal Red Hook Container Terminal	219	190	-13.2
Port Newark Terminal/Elizabeth Marine Terminal	44,424	47,859	7.7
Howland Hook Marine Terminal/Port Ivory	2,389	2,211	-7.3
Total	**50,570**	**53,775**	**6.3%**

3.6. PORT COMMERCE DEPARTMENT GHG EMISSIONS SUMMARY

Table 3-18 summarizes the GHG emissions from all facilities within the Port Commerce Department, specifying the source of the emissions and the amount which falls under each Scope for each source. Some additional emissions from mobile sources which could not be allocated to specific facilities appear in Table 7-18.

Table 3-18. Port Commerce Department GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
All Port Authority Marine Terminals	**-**	**-**	**379,638**	**379,638**
Commercial Marine Vessels	-	-	211,788	211,788
Cargo Handling Equipment	-	-	167,850	167,850
Port Newark/Elizabeth Terminal	**340**	**-**	**453,142**	**453,482**
Attracted Travel	-	-	405,283	405,283
Buildings	-	-	47,859	47,859
Fleet Vehicle	340	-	-	340
Howland Hook Marine Terminal/Port Ivory	**14**	**-**	**66,046**	**66,060**
Attracted Travel	-	-	63,835	63,835
Buildings	-	-	2,211	2,211
Fleet Vehicle	14	-	-	14
Brooklyn PA Marine Terminal	**83**	**-**	**2,471**	**2,554**
Attracted Travel	-	-	2,281	2,281
Buildings	-	-	190	190
Fleet Vehicle	83	-	-	83
Auto Marine Terminal and Greenville Yard	**-**	**-**	**3,514**	**3,514**
Attracted Travel	-	-	Included in Red Hook	
Buildings	-	-	3,514	3,514
Elizabeth Landfill	**3,958**	**-**	**-**	**3,958**
PORT COMMERCE DEPARTMENT	**4,395**	**-**	**904,811**	**909,206**

3.7. PORT COMMERCE DEPARTMENT CAP EMISSIONS SUMMARY

Table 3-19 summarizes the CAP emissions by Port Commerce facilities, specifying the source of emissions and the amount which falls under each pollutant.

In comparing the attracted travel CAP emissions estimated in this report to the 2006 HDDV CAP emissions estimated by Starcrest, the emissions are similar for all pollutants with the exception of SO_2. 2007 SO_2 emissions estimated in this report are only one-third of the 2006 SO_2 emissions estimated by Starcrest (Starcrest, 2008a). This difference can be attributed to the lower sulfur content in diesel fuel in 2007 compared with 2006.

Table 3-19. Port Commerce Department CAP Emissions by Facility (metric tons)

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
All Port Authority Marine Terminals	**5,560**	**3,227**	**379**	**438**
Commercial Marine Vessels	3,942	2,987	277	344
Cargo Handling Equipment	1,618	240	102	94
Port Newark/Elizabeth Terminal	**2,479**	**78**	**63**	**77**
Attracted Travel	2,398	10	58	70
Buildings	81	68	5	7
Fleet Vehicle	-	-	-	-
Howland Hook Marine Terminal/Port Ivory	**378**	**2**	**9**	**11**
Attracted Travel	378	2	9	11
Buildings	-	-	-	-
Fleet Vehicle	-	-	-	-
Brooklyn PA Marine Terminal	**14**	**0**	**0**	**0**
Attracted Travel	14	0	0	0

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Buildings	-	-	-	-
Fleet Vehicle	-	-	-	-
Auto Marine Terminal and Greenville Yard	**-**	**-**	**-**	**-**
Buildings	-	-	-	-
PORT COMMERCE DEPARTMENT	**8,431**	**3,307**	**452**	**526**

3.8. REFERENCES

Corbett and Koehler, 2003: Corbett, J. J. and H. W. Koehler, "Updated Emissions from Ocean Shipping," J. Geophys. Res., 108(D20), 4650, doi:10.1029/2003JD003751, 2003.

CTA, 2008: Center for Transportation Analysis, Oak Ridge National Laboratory, "County-to-County Distance Matrix," downloaded February 27, 2008 from http://cta.ornl.gov/transnet/SkimTree.htm.

DOE, 1996-2008: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2008 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2008," Report # DOE/EIA-0383(2008), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, June 2008.

DOE, 2008: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2008 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2008," Report # DOE/EIA-0383(2008), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, April 2008.

ENTEC, 2002: ENTEC, "Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community," Final Report, prepared for the European Commission, July 2002.

EPA, 1995: U.S. Environmental Protection Agency, "AP-42 Compilation of Air Pollutant Emission Factors," January 1995, accessible in the web at http://www.epa.gov/ttn/chief/ap42/.

EPA, 2007: U.S. Environmental Protection Agency, Clean School Bus USA, National Idle-Reduction Campaign, Idle-Reduction Background, October 19, 2007, retrieved November 11, 2008 from: http://www.epa.gov/otaq/schoolbus/antiidling.htm.

EPA, 2008a: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006," EPA #430-R-08-005, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2008.

EPA, 2008b: U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Protection Partnerships Division, "Emissions & Generation Resource Integrated Database," http://www.epa.gov/cleanenergy/energy-resources/egrid/faq.html, November 2008.

IOR, 2007: IOR Energy, "Engineering Conversion Factors," available at (http://www.ior.com.au/ecflist.html), 2007.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," Volume 2, Energy, 2006.

NYC, 2007: New York City, "Inventory of New York City Greenhouse Gas Emissions," Mayor's Office of Operations, Office of Long-term Planning and Sustainability, April 2007.

PANYNJ, 2007: Port Authority of New York & New Jersey, Spreadsheet entitled, "2006_Port_Truck_data.xls," 2007.

PANYNJ, 2008a: Port Authority of New York and New Jersey, Spreadsheet titled "PCD – 2006-2007 PA cargo data.xls," provided by George Sarrinikolaou, August 2008.

PANYNJ, 2008b: Port Authority or New York and New Jersey, Memo titled "Outstanding Data Issues Memo - Pechan Oct 3 2008 - GS Responses," provided by email from George Sarrinikolaou, October 2008.

PANYNJ, 2008c: Port Authority of New York and New Jersey, Spreadsheet titled "PCD – 2006-2007 PA vessels data.xls," provided by George Sarrinikolaou, August 2008.

PANYNJ, 2008d: Port Authority of New York & New Jersey, "Annual Report 2007," April 2008.

Starcrest, 2003a: Starcrest Consulting Group, LLC, "New York, Northern New Jersey, Long Island Non-attainment Area Commercial Marine Vessel Emissions Inventory," prepared for The Port Authority of New York and New Jersey and the United States Army Corps of Engineers – New York District, 2003.

Starcrest, 2003b: Starcrest Consulting Group, LLC, "The Port of New York and New Jersey Emissions Inventory for Container Terminal Cargo Handling Equipment, Auto-marine Terminal Vehicles, and Associated Locomotives," prepared for the Port Authority of New York and New Jersey, June 2003.

Starcrest, 2007: Starcrest Consulting Group, LLC, "The Port of New York and New Jersey Heavy-Duty Diesel Vehicle Emissions Inventory," prepared for the Port Authority of New York and New Jersey, July, 2007.

Starcrest, 2008a: Starcrest Consulting Group, LLC, Spreadsheet titled "Draft PANYNJ 2006 EI emission details tables (20 Oct 08).xls," provided by email, October 2008.

Starcrest, 2008b: Starcrest Consulting Group, LLC, "2006 Baseline Multi-Facility Emissions Inventory of Cargo Handling Equipment, Heavy-Duty Diesel Vehicles, Railroad Locomotives and Commercial Marine Vessels," prepared for the Port Authority of New York and New Jersey, November 2008.

Vollmer, 2006: Vollmer Associates, Eng-Wong, Taub & Associates, Stump/Hausman, New Jersey Institute of Technology, Stevens Institute of Technology, "Port Authority Marine Container Terminals Truck Origin-Destination Survey 2005," draft report prepared for the Port Authority of New York & New Jersey, February 27, 2006.

4.0 TUNNELS AND BRIDGES

4.1. ATTRACTED TRAVEL

This chapter provides emissions estimates from vehicle travel at the Port Authority's tunnels and bridges. The vehicle emissions reflect travel through the facilities, as well as queuing at these facilities.

4.1.1. Boundary

The established boundaries for vehicle travel are the length of each bridge and the average length of each tunnel (PANYNJ, 2007). Table 4-1 provides the roadway length and traffic volume for each facility.

Table 4-1. Tunnels and Bridges Roadway Length and Traffic Volume by Facility

Facility Type	Facility Name	Roadway Length[1]		Annual Traffic Volume[2] (one way)
		Feet	Miles	
Bridges	George Washington Bridge	13,389	2.54	53,956,332
	Bayonne Bridge	9,900	1.88	3,983,735
	Goethals Bridge	8,052	1.53	14,222,513
	Outerbridge Crossing	10,824	2.05	15,651,883
Tunnels	Lincoln Tunnel	19,800	3.75	21,841,288
	Holland Tunnel	17,160	3.25	17,348,303

[1]DATA SOURCE: PANYNJ, 2007.
[2]DATA SOURCE: Kovach, 2008.

4.1.2. Facilities Included in the Inventory

Tunnel and bridge facilities included in this inventory are listed in Table 4-1.

4.1.3. Methods

This section summarizes the procedures applied for developing GHG emissions inventory from highway vehicles traveling via the Port Authority's tunnels and bridges. Activity data were developed based on the annual traffic volume and length of the facility (see Table 4-1) received from Port Authority's Tunnels, Bridges, and Terminal TB&T department (PANYNJ, 2007; Kovach, 2008). CO_2 emissions estimates were calculated using a fuel-based methodology. Emissions estimates for CH_4 and N_2O were calculated using a distance-based methodology.

VMT accumulated during travel across the tunnel and bridge facilities were derived by multiplying annual traffic volumes by the roadway length in miles. Since GHG emission factors from highway vehicles are calculated based on vehicle types (CH_4 and N_2O) and fuel types (CO_2), VMT were allocated to these vehicle categories: auto; buses;

small trucks; and large trucks. Vehicle type distributions applied were developed based on 2007 traffic volumes (Kovach, 2008). After VMT were allocated to these four vehicle types, VMT were disaggregated to vehicle categories equivalent to EPA's vehicle types and fuel types, which were needed for proper allocation of emission factors and fuel economy data. Table 4-2 provides a summary of the fraction of VMT accrued by each vehicle type. The table also shows how the total VMT for each Port Authority vehicle type was allocated among the corresponding EPA vehicle types. These allocation fractions were developed based on default data from EPA's MOBILE6 emission factor model.

Table 4-2. Vehicle Classifications and Allocation Factor Applied for All Facilities

Vehicle Type	Estimated VMT Mix Fractions by PA's Vehicle Type	EPA Vehicle Type	Allocation Factors
AUTO	0.917946	LDGV	0.425936
		LDGT1	0.389772
		LDGT2	0.133415
		HDGV	0.032304
		LDDV	0.000428
		LDDT	0.002034
		HDDV	0.010037
		MC	0.006076
SMALL TRUCKS	0.028292	HDGV	0.206525
		HDDV	0.793475
LARGE TRUCKS	0.050857	HDGV	0.000059
		HDDV	0.999941
BUSES	0.002905	HDGV	0.094336
		HDDV	0.905664

After VMT were disaggregated to vehicle categories equivalent to EPA's vehicle types and fuel types, VMT were then distributed across 25 model years, so that the appropriate emission factors could be applied as described in EPA's GHG inventory report (EPA, 2008a). Vehicle age-specific distribution data were developed based on 2007 vehicle registration data for gasoline- and diesel powered light-duty and heavy-duty vehicles. Vehicle registration data were obtained from the New York State's 2007 enhanced inspection maintenance (I/M) program annual report (DEC, 2008). Vehicle age-specific distribution data (i.e., 25-year range, 1983 through 2007) were then utilized in estimating GHG emissions and were used for all facilities.

CO_2 emissions were estimated by multiplying VMT by the average model year-specific fuel economy factors and multiplying by fuel-specific emission factors expressed in grams per gallon. Fuel economy data were derived from a combination of EPA's default values and various U.S. Department of Energy (DOE) Energy Information Administration (EIA) Annual Energy Outlook reports (EPA, 2003; DOE, 1996-2007; DOE, 2008a). Fuel-specific emission factors for CO_2 were obtained from DOE's EIA's voluntary reporting of GHG program website (DOE, 2008b).

Emissions estimates for CH_4 and N_2O were developed by multiplying VMT by the corresponding model year-specific technology weighted emission factors (in grams/mile) by EPA's vehicle category. Emission factors in units of grams/mile for CH_4 and N_2O were also obtained from the EPA's GHG inventory report (EPA, 2008a).

Once emission estimates were calculated by vehicle category and model year group, emissions were summed for all model years and vehicle categories for each GHG gas type. The CH_4 and N_2O emissions were converted into their respective CO_2e emissions by multiplying the CH_4 and N_2O emissions in metric tons by their corresponding 100-year GWPs.

4.1.4. Results

This section contains GHG emissions estimates for tunnel and bridge facilities. Table 4-3 summarizes the transportation-related GHG emission estimates for the facilities included in this inventory.

Table 4-3. Tunnels and Bridges Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Facility Name	**Greenhouse Gas Emissions Totals (metric tons)**			
	CO_2	**CH_4**	**N_2O**	**CO_2 Equivalent**
Bridges				
George Washington Bridge	135,465	7	7	137,777
Bayonne Bridge	7,546	0	0	7,672
Goethals Bridge	21,944	1	1	22,310
Outerbridge Crossing	29,802	2	2	30,356
Tunnels				
Lincoln Tunnel	92,742	4	4	94,093
Holland Tunnel	47,122	3	3	48,122
Total	**334,621**	**16**	**17**	**340,330**

In 2007, 340,330 metric tons of CO_2e GHG emissions were associated with travel across PANYNJ's tunnels and bridges. As expected, these GHG emission estimates are dominated by the most heavily traveled bridges and tunnels, which are the George Washington Bridge and the Lincoln and Holland Tunnels. As shown in Table 4-3, approximately 98 percent were emissions of CO_2, less than 1 percent was from CH_4 (as CO_2e), and about 2 percent was from N_2O (as CO_2e).

4.1.5. Comparison with Estimates in Previous Studies

This section provides a comparison of 2006 and 2007 **CO_2 equivalent** emissions results. Table 4-4 presents emissions results for calendar years 2006 and 2007.

Table 4-4. CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	**2007**	
Bridges			
George Washington Bridge	139,967	137,777	-1.6%
Bayonne Bridge	8,277	7,672	-7.3
Goethals Bridge	20,503	22,310	8.8
Outerbridge Crossing	32,063	30,356	-5.3
Tunnels			
Lincoln Tunnel	94,486	94,093	-0.4
Holland Tunnel	48,985	48,122	-1.7
Total	**344,281**	**340,330**	**-1.2%**

The 2007 GHG emissions inventory for attracted travel crossing tunnel and bridge facilities showed an overall decrease in GHG emissions by 1.2 percent from 2006. As presented in Table 4-4, the estimated GHG emissions produced by tunnel and bridge facilities amounted to 340,330 metric tons in 2007 and 344,281 metric tons in 2006, a 3,951 metric ton decrease in emissions from 2006 to 2007. The decrease in emission values were expected since there was a decrease in the annual vehicle volumes from the previous year for all facilities except Goethals Bridge. The Goethals Bridge showed an 8.8 percent increase in emissions.

4.2. QUEUING ANALYSIS

4.2.1. Boundary

The boundary for queuing on the bridges and tunnels includes the volume of queued vehicles accessing toll facilities on the bridge and tunnel crossings, as well as the outbound queues that occur at the Lincoln Tunnel.

4.2.2. Facilities Included in the Inventory

The facilities included in this analysis are:

a. George Washington Bridge;
b. Bayonne Bridge;
c. Goethals Bridge;
d. Outerbridge Crossing;
e. Lincoln Tunnel; and
f. Holland Tunnel.

4.2.3. Methods

Activity data for queuing activity on the tunnels and bridges was multiplied by fuel-specific CO_2 emission factors, in terms of mass per gallons of fuel consumed, to estimate GHG emissions. The activity used for queuing was the number of hours of vehicle delay estimated for the 2006 GHG emissions inventory (Pechan, 2008). The estimated number of vehicle hours of delay was then multiplied by an estimate of idling fuel consumption (gallons per hour) to calculate the amount of fuel consumed during queuing at the toll facilities.

One of the primary data sources for estimating queuing times was based on the 2006 Transcom data that was electronically collected on most of the PA bridges and tunnels (PANYNJ, 2008). The PA provided data on the total number of annual vehicle hours of delay on the Lincoln Tunnel, Bayonne Bridge, Goethals Bridge, and Outerbridge Crossing (PANYNJ, 2008).

Since Transcom data did not include the Holland Tunnel or the George Washington Bridge, the sources of data on vehicle queuing times for these two facilities were based on two Skycomp studies conducted in 2006 for the PANYNJ (Skycomp, 2006a; Skycomp, 2006b). These studies presented data on volumes and queue travel times based on aerial photos of the surveyed facilities. Two spring flights and two fall flights were performed during both the morning peak hours (spanning 5:30 a.m. to 10:00 a.m.) and the afternoon/evening peak hours (spanning 3:00 p.m. to 8:00 p.m.), for a total of eight flights on weekdays. Additional flight surveys were conducted on a Saturday and two Sundays in July and August 2007.

For each facility, season, and peak period, the 2006 Skycomp survey data presented hourly volumes and the average hourly queue travel time. The 2006 hourly volumes and the average hourly queue travel time data from Skycomp were used to estimate vehicle hours of delay for each facility by hour, season, and peak period. This estimate involved multiplying the hourly volume by the average hourly travel time. The vehicle hours of delay were then summed across peak period hours. Volume weighted vehicle hours of delay were then calculated for each facility and peak period to obtain a typical daily estimate of vehicle hours of delay for each facility and peak period based on the spring and fall data for weekdays. This analysis was performed for traffic heading through the toll facilities for all facilities. In addition, summer weekend, outbound traffic for Holland Tunnel is also included in this analysis. Table 4-5 summarizes the resulting 2006 estimated daily average vehicle hours of delay at each facility on an average weekday, Saturday, and Sunday. Total annual vehicle hours of delay were calculated by multiplying the weekday estimates by 261 days and the weekend estimates by 52 days each.

Table 4-5. 2006 Estimated Daily Average Vehicle-Hours of Delay by Tunnel and Bridge Facility

	Average Daily Vehicle-Hours of Delay		
	Weekday	**Saturday**	**Sunday**
Facility	**2006**	**2006**	**2006**
Holland Tunnel	2,055.6	3,384.1	5,795.0
Lincoln Tunnel	7,332.0	2,840.2	2,840.2
George Washington Bridge	3,894.7	5,177.2	10,139.7

Facility	Average Daily Vehicle-Hours of Delay		
	Weekday 2006	Saturday 2006	Sunday 2006
Goethals Bridge	725.8	694.3	694.3
Outerbridge Crossing	73.5	208.4	208.4
Bayonne Bridge	0.4	0.4	0.4

Once the 2006 annual vehicle hours of delay were estimated, they were allocated by vehicle type using ratios of the traffic volumes by vehicle type (derived for the attracted travel analysis of the bridges and tunnels) to the total facility traffic volumes. This step was performed because the CO_2 emission factors are fuel-specific. The resulting vehicle hours of delay by vehicle type were converted to fuel consumption by vehicle type, assuming 0.5 gallon of fuel is consumed per hour for all vehicle types during idling (EPA, 2008b). Then, the 2006 CO_2 emission estimates from queuing were calculated by multiplying the vehicle type fuel consumption values by fuel-specific emission factors. Emission factors were obtained from EPA's GHG inventory report (EPA, 2007). The resultant 2006 queuing values were then used to calculate 2007 GHG emissions.

The 2006 CO_2 queuing emissions were grown to 2007 by multiplying the 2006 facility-specific queuing emissions by the ratio of 2007 to 2006 CO_2 facility-specific emissions from attracted travel on each of the tunnels and bridges.

4.2.4. Results

Table 4-6 summarizes the GHG emission estimates from queuing at the Port Authority's tunnels and bridges. About 75 percent of the queuing emissions occurred on the approaches to the George Washington Bridge and the Lincoln Tunnel. GHG emission estimates for queuing at the Holland Tunnel accounted for 19 percent of the total CO_2 equivalent emissions. The remaining 6 percent of total queuing emissions can be attributed to the Bayonne Bridge, Goethals Bridge, and Outerbridge Crossing facilities. The estimated GHG emissions are entirely CO_2 emissions, as CH_4 and N_2O emissions were not calculated.

Table 4-6. Tunnels and Bridges Queuing GHG Emissions by Gas and CO_2 Equivalent

Facility Name	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Bridges				
George Washington Bridge	8,059	0	0	8,059
Bayonne Bridge	1	0	0	1
Goethals Bridge	1,287	0	0	1,287
Outerbridge Crossing	174	0	0	174
Tunnels				
Lincoln Tunnel	9,975	0	0	9,975
Holland Tunnel	4,458	0	0	4,458
Total	**23,954**	**0**	**0**	**23,954**

The uncertainty in GHG emission estimates for the queuing for the tunnel and bridge facilities stems primarily from the procedures and data used to estimate the hourly queue volumes and average queue travel times. Some of the survey data were incomplete for the above facilities due to possible incidents (e.g., blocked lanes, crashes, etc.) or events (e.g., concerts, ball games) that occurred during the date and time the survey was conducted. Most importantly, 2006 survey data were based only on 1 – 2 day flight surveys. Therefore, observed data may not be a representative sample of conditions during the entire year.

4.2.5. Comparison with Estimates in Previous Studies

This section provides a comparison of 2007 results from the previous year. Table 4-7 provides a comparison of the 2006 and 2007 CO_2 equivalent results.

Table 4-7. CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Bridges			
George Washington Bridge	8,167	8,059	-1.3%
Bayonne Bridge	1	1	-7.1
Goethals Bridge	1,180	1,287	9.1
Outerbridge Crossing	183	174	-5.1
Tunnels			
Lincoln Tunnel	9,994	9,975	-0.2
Holland Tunnel	4,525	4,458	-1.5
Total	**24,050**	**23,954**	**-0.4%**

As estimated in this report, GHG emissions estimates from queuing showed an overall decrease of 0.4 percent from 2006 to 2007. The increase or decrease in 2007 queuing emissions results for all facilities is consistent with the 2006 to 2007 CO_2 emissions results change rates from attracted travel across these facilities. As with the 2006 queuing emissions results, a majority of the 2007 queuing emissions occurred at these facilities: Lincoln Tunnel, George Washington Bridge, and Holland Tunnel. This is expected since these are the most heavily traveled facilities.

4.3. BUILDINGS

4.3.1. Boundary

The GHG emissions inventory boundary includes all Tunnel and Bridges department operated buildings; buildings leased to tenants; and office space that this Department leases from other organizations.

4.3.2. Facilities Included In the Inventory

All facilities listed in Table 4-8 are included in this building energy use category.

Table 4-8. Facilities within Tunnel and Bridges Boundary

Facility
George Washington Bridge
Holland Tunnel
Lincoln Tunnel
Staten Island Bridges (Bayonne, Goethals, & Outerbridge)

4.3.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the PANYNJ were estimated in four steps.

The first step consisted in developing a list of sources responsible for GHG emissions associated with energy consumption in buildings that are owned, or leased, within the Tunnel and Bridges department boundary. Step two focused in mapping sources with their corresponding energy consumption. Step three was spent processing raw data by means of unit conversion and emission rates application. The final step consisted in classifying emission results according to scope. Emissions results were grouped into one of three emission scopes. Scope 1 included direct combustion of fuels such as natural gas, diesel, or propane. Scope 2 included indirect emissions from electricity purchased and used by PANYNJ. Indirect emissions from electricity purchased by PANYNJ (including purchased from NYPA) and resold to tenants were grouped as Scope 3. Finally, emissions from direct combustion of fuels by PANYNJ tenants were considered to be Scope 3 emissions.

During step two, emission factors and emission rates were selected as follows. For emission estimates from electricity consumption, emission factors developed by eGRID were applied to consumption values (EPA, 2008c). eGRID provided emission factors to estimate GHG and most CAP emissions. Remaining CAP emissions were derived from state-wide emission values compiled in the National Emissions Inventory. It is important to note that emissions differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation. GHG emission rates for natural gas were taken from The Climate Registry General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA’s AP-42 (EPA, 1995).

4.3.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 4-9.

Table 4-9. GHG Emissions by Facility and by Scope

Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)
George Washington Bridge	0	2,959	0
Holland Tunnel	80	4,847	0
Lincoln Tunnel	38	7,536	0
Bayonne Bridge	0	232	0
Goethals Bridge	295	673	0
Outerbridge Crossing	130	376	0
Total	**542**	**16,622**	**0**

4.3.5. Comparison with Estimates in Previous Studies

Table 4-10 compares 2006 and 2007 GHG emissions for Tunnels & Bridges building utility use.

Table 4-10. CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
George Washington Bridge	3,095	2,959	-4.4%
Holland Tunnel	5,589	4,927	-11.9
Lincoln Tunnel	7,569	7,574	0.1
Bayonne Bridge	268	232	-13.4
Goethals Bridge	1,109	967	-12.8
Outerbridge Crossing	566	505	-10.8
Total	**18,197**	**17,164**	**-5.7%**

The CAP emissions summary for tunnels and bridges is provided in Table 5-5 in the next chapter.

4.4. REFERENCES

DEC, 2008: New York State Department of Environmental Conservation, “2007 Enhanced I/M Program Annual Report: Appendix A,” (http://www.dec.ny.gov/chemical/45754.html), 2008.

DOE, 1996-2007: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007,” Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

DOE, 2008a: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2008 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2008,” Report # DOE/EIA-0383(2008), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, June 2008.

DOE, 2008b: U.S. Department of Energy, Energy Information Administration, “Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients,” http://www.eia.doe.gov/oiaf/1605/coefficients.html, 2008.

EPA, 1995: U.S. Environmental Protection Agency, "AP-42 Compilation of Air Pollutant Emission Factors," January 1995, accessible on the web at http://www.epa.gov/ttn/chief/ap42/.

EPA, 2003: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, "User's Guide to MOBILE6.1 and MOBILE6.2 - Mobile Source Emission Factor Model," EPA420-R-03-010, August 2003.

EPA, 2007: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005," EPA430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

EPA, 2008a: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006," EPA430-R-08-005, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2008.

EPA, 2008b: U.S. Environmental Protection Agency, "National Idle-Reduction Campaign, Idle-Reduction Background," http://www.epa.gov/otaq/schoolbus/antiidling.htm, November 2008.

EPA, 2008c: U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Protection Partnerships Division, "Emissions & Generation Resource Integrated Database," http://www.epa.gov/cleanenergy/energy-resources/egrid/faq.html, November 2008.

Kovach, 2008: Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminal Department, "Total Traffic at each Facility for 2007 by Vehicle Types (Eastbound Only)," July 30, 2008.

PANYNJ, 2007: Port Authority of New York and New Jersey, "Master List of GHG Emissions Inventory Comments/Questions - Comment #23, Comments-questions - master list012208.doc," January 22, 2008.

PANYNJ, 2008: Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminals, "Summary Transcom Vehicle Hours of Delay," data file 2008-0214 Summary.xls, provided to Pechan February 14, 2008.

Pechan, 2008: Southern Research Institute and E.H. Pechan & Associates, Inc., "Greenhouse Gas Emission Inventory for the Port Authority of New York & New Jersey – Calendar Year 2006," March, 2008.

Pechan, 2008b: E.H. Pechan & Associates, Inc., "Calendar Year 2007 Emissions Inventory Procedures Document," prepared for Port Authority of New York and New Jersey, November 2008.

Skycomp, 2006a: Skycomp, Inc., "2006 Summer Weekend Traffic Congestion Survey," final report, prepared for the Port Authority of New York and New Jersey, 2006.

Skycomp, 2006b: Skycomp, Inc., “2006 Annual Report of Interstate Toll Delay,” final report, prepared for the Port Authority of New York and New Jersey, 2006.

5.0 BUS TERMINALS

5.1. IN TERMINAL VEHICLE EMISSIONS

5.1.1. Boundary

For the analysis of GHG emissions associated with the PANYNJ bus terminals, the boundary was defined as the property lines of the terminals. Emissions were estimated based on the bus and vehicle travel within the terminals, the idling emissions that occur when the buses are parked in the facility, and the start-up emissions for vehicles parked within the facility. Defining the boundary in this way eliminates double-counting of emissions from trips through or across the Port Authority tunnels and bridges.

5.1.2. Facilities Included in the Inventory

Two bus terminals are included in this analysis:

a. George Washington Bridge Bus Station (GWBBS); and
b. Port Authority Bus Terminal (PABT).

5.1.3. Methods

GHG emissions were estimated from buses traveling through the Port Authority bus terminals and from personal vehicles parking in the bus terminals. Bus activity is defined as the mileage traveled within the terminals and the fuel consumed while idling in the terminals. Activity for personal vehicles is the mileage traveled within the terminals and the vehicle starts within the terminals. To estimate emissions, analysts multiplied these activity data by emission factors for CO_2 (in terms of mass per gallon of fuel consumed) and CH_4 and N_2O (in terms of mass per mile and mass per vehicle start).

Emissions for buses were calculated in two parts: (1) emissions that occur while traveling within the bus terminals and (2) emissions that occur while buses are idling. The activity associated with the emissions that occur while a bus is moving is the VMT. This was estimated by multiplying the total number of bus movements at each terminal by the estimated distance that the bus travels within the terminal. The average distance traveled within a bus terminal was estimated to be twice the length plus the width of the bus terminal. Table 5-1 summarizes the total 2007 bus movements and dimensions of both bus terminals.

Table 5-1. Bus Terminal Activity Data

Terminal	Terminal Length (ft)	Terminal Width (ft)	Total Bus Movements[a]	Total Vehicles Parked
George Washington Bridge Bus Station	400[b]	185[b]	305,000	36,500[c]
Port Authority Bus Terminal	1,200[d]	200[d]	2,169,000	432,200[e]

[a]SOURCE: PANYNJ, 2007.
[b]SOURCE: http://www.panynj.gov/CommutingTravel/bus/html/gabout.html.
[c]Estimated as 100 vehicles parked per day multiplied by 365 days per year.
[d]Terminal size: 400 by 800 ft in 1963; expanded by 50 percent in late 1980s; original length of 800 ft was multiplied by 1.5 to obtain current length of 1,200 ft.
[e]From the file 'Leased Parking Stats-PABT.xls' provided by PANYNJ, October 2007.

The emission factor for CO_2 is expressed in units of mass per gallon of fuel, therefore the total bus VMT were converted to gallons of diesel fuel consumed. This was done by dividing the total VMT by an estimated bus fuel economy of 4.23 miles per gallon (Larsen, 2006). In addition to bus travel through the terminal, this analysis also accounts for the VMT as buses circulated on city streets when there was no available space at the GWBBS and the PABT. Based on information the Port Authority provided, the diversion of buses at the GWBBS totals 1,980 feet, affecting 15 buses per hour on weekdays from 7 a.m. to 8 p.m. The PABT diversion of buses covers a distance of 2,681 feet, with 10 buses circulating at any given time from 5 p.m. to 6:45 p.m. on weekdays. This results in an additional 19,086 miles per year of bus travel at the GWBBS and 22,838 miles per year at the PABT.

The average time spent idling per bus was estimated from data in a PANYNJ report that surveyed and analyzed bus movements within the PABT (PANYNJ, 2007). From the data in this report, the average time each bus spends within the terminal was calculated. The amount of time it takes a bus to travel through the facility at a nominal speed of 5 miles per hour was subtracted from the total time. The remaining time was assumed to be the average bus idling time. It should be noted that New York City law prohibits buses from idling for more than three minutes. However, information on enforcement of this law was not available, so idling times were not limited to three minutes. Total bus idling time was then calculated by multiplying the average per-bus idling time by the number of bus movements. To estimate the amount of fuel consumed during idling, it was assumed that 0.5 gallons of diesel fuel is consumed for each hour of idling (EPA, 2008) and this factor was multiplied by the total bus idling time.

Emission factors for buses were obtained from EPA's latest GHG Inventory report (EPA, 2007), applying heavy-duty diesel vehicle emission factors. The CO_2 emission factor is expressed in units of mass per gallon of fuel consumed, while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. Thus, the CO_2 emission factor was multiplied by the total fuel consumed by the buses while traveling and idling within the bus terminals. The CH_4 and N_2O emission factors were multiplied by the total bus VMT within the bus terminals. It should be noted that 60 buses fueled on compressed natural gas (CNG) belonging to New Jersey Transit enter and exit the bus terminals daily. However, based on current research, GHG emissions from CNG buses are expected to be comparable to those from diesel buses. CNG buses have lower CO_2 emissions than diesel buses (14.47 versus 19.95 kg c/MMBtu), but higher CH_4 emission rates (1.966 versus 6.0051 grams per mile) (TCR, 2008).

Emissions for the vehicles parked within the terminals were also calculated in two parts: (1) emissions that occur while traveling within the bus terminals to parking spaces and (2) emissions that occur when the vehicle is started after having been parked (cold start emissions). The vehicles parked at the bus terminals were assumed to be a mix of light-duty cars, light-duty trucks, and motorcycles. The per-vehicle VMT that accrues when a vehicle is traveling through a bus terminal were estimated in the same manner as the bus VMT (twice the length plus the width of the bus terminal). The per-vehicle VMT were then multiplied by the total number of vehicles parked at the bus terminals, shown in Table 5-1. The number of vehicle starts was assumed to be equal to the number of vehicles parked. Cold start emissions from buses were not calculated, as the IPCC emission factors for cold starts from diesel vehicles are negative, which indicates that a vehicle starting cold produces fewer emissions than a vehicle starting warm or running warm (IPCC, 2006).

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2007), while the emission factors for vehicle starts were obtained from the IPCC guidelines (IPCC, 2006). Both the running and cold start CH_4 and N_2O emission factors varied by vehicle category and emission control technology. Weighted emission factors were estimated based on the expected distribution of vehicles by control technology and vehicle category. Annual VMT from the vehicles parking at the bus terminals were converted to annual fuel consumption to estimate CO_2 emissions. This was done by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy data were obtained from DOE's Annual Energy Outlook (DOE, 2007). The weighted CO_2 emission factor was multiplied by the total fuel consumed by the vehicles while traveling within the bus terminals. The weighted CH_4 and N_2O running emission factors were multiplied by the total VMT to obtain the running emissions. The weighted cold start CH_4 and N_2O emission factors were multiplied by the total number of vehicles parked to obtain the cold start emissions.

The resulting emissions from both buses and vehicles were then totaled by bus terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

5.1.4. Results

Table 5-2 summarizes the GHG emission estimates that occur within the PANYNJ bus terminal boundaries. These emissions are categorized by facility, as well as for buses and other private vehicles. Emissions at the PABT are approximately nine times greater than the emissions at the GWBBS. The difference appears reasonable, given the greater magnitude of bus operations at the PABT, as shown in Table 5-1. The bus terminal GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for over 99 percent of the CO_2e emissions. The amount of time the buses spend idling within the terminals and the speeds the buses travel within the terminals are relatively uncertain. If the assumed speeds are significantly different from the actual speeds through the terminal, or if the buses generally turn their engines off while they are parked in the terminal, idling emissions could be significantly different.

Table 5-2. Bus Terminal GHG Emissions by Gas and CO_2 Equivalent

State	Facility		Greenhouse Gas Emissions Totals (metric tons)			
			CO_2	CH_4	N_2O	CO_2 Equivalent
NY	George Washington Bridge Bus Station	Buses	391	0.001	0.001	391
		Vehicles	2	0.002	0.004	4
		Total	*393*	*0.002*	*0.004*	*395*
NY	Port Authority Bus Terminal	Buses	4,101	0.006	0.005	4,103
		Vehicles	75.366	0.025	0.046	90
		Total	*4,176*	*0.030*	*0.051*	*4,193*
		Total	***4,570***	***0.033***	***0.056***	***4,588***

5.1.5. Comparison with Estimates in Previous Studies

Table 5-3 summarizes the Port Authority bus terminal emissions in the 2006 and 2007 inventories. The table shows that GHG emissions from these terminals dropped by one percent from 2006 to 2007.

Table 5-3. Bus Terminal CO_2 Equivalent GHG Emissions Comparison

	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
GWBBS and PABT, Total	4,636	4,588	-1.0 %

5.2. BUILDINGS

5.2.1. Boundary

The GHG emissions inventory boundary includes all Bus Terminals owned by the Port Authority.

5.2.2. Facilities Included In the Inventory

All facilities listed in Table 5-4 are included in this building energy use category.

Table 5-4. Facilities within Bus Terminals Boundary

Facility
George Washington Bridge Bus Station
Port Authority Bus Terminal

5.2.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the PANYNJ were estimated in four steps.

The first step consisted in developing a list of sources responsible for GHG emissions associated with energy consumption in buildings that are owned, or leased, within Terminals boundary. Step two focused in mapping sources with their corresponding energy consumption. Step three was spent processing raw data by means of unit conversion and emission rates application. The final step consisted in classifying emission results according to scope. All emissions in Terminals were categorized as Scope 3 emissions.

During step two, emission factors and emission rates were selected as follows. For emission estimates from electricity consumption, emission factors developed by eGRID were applied to consumption values (EPA, 2008c). eGRID provided emission factors to estimate GHG and most CAP emissions. Remaining CAP emissions were derived from state-wide emission values compiled in the National Emissions Inventory. It is important to note that emissions differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation. GHG emission rates for natural gas were taken from The Climate Registry General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA's AP-42 (EPA, 1995). The Port Authority Bus Terminal reported some steam usage for heating in 2007. Scope 2 indirect emissions for this heating were calculated by assuming a total generation and delivery efficiency of 75% in accordance with The Climate Registry protocol. The steam was assumed to be generated half by natural gas and half by distillate oil, as it was municipal purchased steam.

5.2.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 5-5.

Table 5-5. GHG Emissions by Facility and by Scope

Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)
George Washington Bridge Bus Station	0	0	2,396
Port Authority Bus Terminal	0	0	11,467
Total	**0**	**0**	**13,863**

5.2.5. Comparison with Estimates in Previous Studies

Table 5-6 compares 2006 and 2007 GHG emissions for bus terminal buildings.

Table 5-6. CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
George Washington Bridge Bus Station	3,417	2,396	-29.9%
Port Authority Bus Terminal	12,872	11,467	-10.9
Total	**13,632**	**11,898**	**-14.9%**

5.3. TUNNELS, BRIDGES, AND TERMINALS GHG EMISSIONS SUMMARY

Table 5-7 summarizes the GHG emissions from all facilities within the tunnels, bridges and terminals department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be allocated by facility appear in Table 7-18.

Table 5-7. Tunnels, Bridges and Terminals Department GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
George Washington Bridge	**431**	**2,959**	**145,836**	**149,226**
Attracted Travel	-	-	137,777	137,777
Queuing	-	-	8,059	8,059
Buildings	-	2,959	-	2,959
Fleet Vehicle Emissions	431	-	-	431
Staten Island Bridges (Bayonne, Goethals, & Outerbridge Crossing)	**347**	**-**	**-**	**347**
Fleet Vehicle Emissions	347	-	-	
Bayonne Bridge	**-**	**232**	**7,673**	**7,905**
Attracted Travel	-	-	7,672	7,672
Queuing	-	-	1	1
Buildings	-	232	-	232
Goethals Bridge	**295**	**673**	**23,597**	**24,565**
Attracted Travel	-	-	22,310	22,310
Queuing	-	-	1,287	1,287
Buildings	295	673	-	968
Outerbridge Crossing	**130**	**376**	**30,530**	**31,036**
Attracted Travel	-	-	30,356	30,356
Queuing	-	-	174	174
Buildings	130	376	-	506
Lincoln Tunnel	**666**	**7,536**	**104,068**	**112,270**
Attracted Travel	-	-	94,093	94,093
Queuing	-	-	9,975	9,975
Buildings	38	7,536	-	7,574
Fleet Vehicle Emissions	610	-	-	610
Direct Fugitive Emissions	18	-	-	18
Holland Tunnel	**519**	**4,847**	**52,580**	**57,946**
Attracted Travel	-	-	48,122	48,122
Queuing	-	-	4,458	4,458
Buildings	80	4,847	-	4,927
Fleet Vehicle Emissions	439	-	-	439
George Washington Bridge Bus Station	**-**	**-**	**2,791**	**2,791**
Buildings	-	-	2,396	2,396

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
In Terminal Bus Emissions	-	-	391	391
In Terminal Private Vehicle Emissions	-	-	4	4
Port Authority Bus Terminal	**13**	**-**	**15,660**	**15,673**
Buildings	-	-	11,467	11,467
Fleet Vehicle Emissions	13	-	-	13
In Terminal Bus Emissions	-	-	4,103	4,103
In Terminal Private Vehicle Emissions	-	-	90	90
TUNNELS, BRIDGES & TERMINALS	**2,401**	**16,623**	**382,735**	**401,759**

5.4. TUNNELS, BRIDGES, AND TERMINALS CAP EMISSIONS SUMMARY

Table 5-8 shows the estimated Tunnels, Bridges, and Terminals CAP emissions by facility.

Table 5-8. Tunnels, Bridges, and Terminals CAP Emission Estimates

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
George Washington Bridge	**410**	**51**	**13**	**18**
Attracted Travel	389	3	9	13
Queuing	11	0	0	0
Buildings	9	48	4	5
Fleet Vehicle Emissions	1	-	-	-
Staten Island Bridges (Bayonne, Goethals, & Outerbridge Crossing)	**1**	**-**	**-**	**-**
Fleet Vehicle Emissions	1	-	-	-
Bayonne Bridge	**24**	**-**	**-**	**1**
Attracted Travel	24	-	-	1
Queuing	-	-	-	-
Buildings	-	-	-	-
Goethals Bridge	**67**	**2**	**1**	**2**
Attracted Travel	64	1	1	2
Queuing	2	0	0	0
Buildings	1	1	-	-
Outerbridge Crossing	**86**	**2**	**2**	**3**
Attracted Travel	85	1	2	3
Queuing	0	-	-	0
Buildings	1	1	-	-
Lincoln Tunnel	**426**	**92**	**14**	**19**
Attracted Travel	388	2	7	10
Queuing	17	0	0	0
Buildings	20	90	7	9
Fleet Vehicle Emissions	1	-	-	-
Holland Tunnel	**116**	**38**	**5**	**7**
Attracted Travel	100	1	2	4
Queuing	4	0	0	0
Buildings	11	37	3	3
Fleet Vehicle Emissions	1	-	-	-
George Washington Bridge Bus Station	**7**	**4**	**-**	**-**
Buildings	5	4	-	-
In Terminal Bus Emissions	2	-	-	-
In Terminal Private Vehicle Emissions	-	-	-	-

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Port Authority Bus Terminal	**45**	**19**	**2**	**2**
Buildings	23	19	1	1
Fleet Vehicle Emissions	-	-	-	-
In Terminal Bus Emissions	22	0	1	1
In Terminal Private Vehicle Emissions	-	-	-	-
TUNNELS, BRIDGES & TERMINALS	**1,182**	**208**	**37**	**52**

5.5. REFERENCES

DOE, 2007: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007," Report # DOE/EIA-0383(2007), February, 2007, http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls.

EPA, 2007: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005," EPA #430-R-07-002, April, 2007, http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

EPA, 2008: U.S. Environmental Protection Agency, "National Idle Reduction Campaign, Idling Calculator," http://www.epa.gov/otaq/schoolbus/antiidling.htm, 2008.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), published: IGES, Japan, 2006.

Larsen, 2006: Bent Larsen, New Jersey Transit buses average about 4.23 miles per gallon; overroad buses are typically 3.70 - 4.88 miles per gallon; some older local buses are as low as 2.64 mpg, 2006.

PANYNJ, 2007: Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminals, "Port Authority Bus Terminal Bus Operations – Data Collection," Technical Memorandum, Final Draft, prepared by Port Authority of NJ and NJ Engineering Department, in association with Edwards and Kelcey, October 2, 2007.

TCR, 2008: The Climate Registry, "General Reporting Protocol for the Voluntary Reporting Program," May 2008.

6.0 PATH

6.1. TRAINS

6.1.1. Boundary

The boundary associated with PATH trains consists of the traction power used to power the trains. Emissions associated with the rest of PATH facilities and stations are included in Section 6.4 Buildings. Only emissions associated with the electricity used by the trains are within this boundary. This means that the energy totals used as activity data do not account for the losses associated with generation and transmission. Only the electricity delivered to the site falls within the boundary of this inventory.

6.1.2. Facilities Included in the Inventory

The traction power of all PATH trains is included in the inventory. Therefore, all trains which ran during 2007 – regardless of which stations they traveled to – are included in this inventory.

6.1.3. Methods

The traction power comes from the main PSE&G account associated with PATH (PathCorpWashSt_All) for which the Port Authority provided electricity consumption data. The account is largely a traction power account, but it also includes some non-traction power. PATH estimates that traction power accounts for 85 percent of the electricity usage. Therefore, traction power is estimated as 85 percent of the total kWh billed during 2007. GHG emission factors corresponding to electricity generation were taken from the EPA's Emissions & Generation Resource Integrated Database (eGRID) as the average emission factors associated with the power pool of the North American Electric Reliability Council (NERC) sub-region containing New Jersey (EPA, 2008a). eGRID is a comprehensive source of data on the environmental characteristics of electric power generated in the United States. The emission factors for CO_2, CH_4, and N_2O were multiplied by the activity data to find the annual emissions of each gas in metric tons. The CO_2 equivalents for CH_4 and N_2O were calculated using the IPCC SAR GWPs from Table 1-1.

6.1.4. Results

Table 6-1 shows the GHG emissions associated with the traction power used to run the PATH trains. Emissions from traction power make up the majority of the PATH GHG emissions. The emissions are strongly dominated by CO_2, which comprises over 99 percent of the total GHG emissions.

Table 6-1. PATH Train GHG Emissions by Gas and CO_2 Equivalent

PATH Power Use	CO_2 (metric tons)	CH_4 (metric tons)	N_2O (metric tons)	CO_2 Equivalent (metric tons)
Traction Power	39,970	1.11	0.67	40,206

6.1.5. Comparison with Estimates in Previous Studies

Table 6-2 summarizes the PATH train GHG emissions and shows that GHG emissions decreased by 1.5 percent from 2006 to 2007. PATH ridership in 2007 totaled 71.6 million passengers, a 6.9 percent increase over 2006.

Table 6-2. PATH Train CO_2 Equivalent GHG Emissions Comparison

	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	%
Traction Power	40,828	40,206	-1.5%

6.2. ATTRACTED TRAVEL

6.2.1. Boundary

For the analysis of GHG emissions associated with the attracted travel at PATH train stations, the boundary was defined as the vehicle trips associated with PATH commuters. These commuters are those who drive, or are driven, to access a PATH station. This captures home-to-station trips and returns. Bus trips to and from the Journal Square Transportation Station are also included. This includes the distance traveled from the stop to Journal Square and the distance traveled from Journal Square to the next bus stop.

6.2.2. Facilities Included in the Inventory

This analysis includes riders at any of the 13 stations on the PATH route. It also includes buses traveling to and from Journal Square Transportation Center.

6.2.3. Methods

Direct GHG emissions were estimated from vehicles traveling to or from the PATH train stations and from buses traveling to and from Journal Square Transportation Center. The activity indicator for both modes of travel is VMT. Cold start emissions were also calculated based on vehicle trips. These activity data were multiplied by emission factors for CO_2 (in terms of mass per gallon of fuel consumed) and CH_4 and N_2O emission factors (in terms of mass per mile and mass per vehicle start) to estimate emissions associated with attracted travel at PATH train stations.

6.2.3.1. Vehicle Access to PATH Train Stations

Activity for vehicles bringing passengers to the PATH train stations was estimated based on the total number of PATH passengers in 2007 (PANYNJ, 2008a) and a 2007 PATH passenger travel study that assigned travel modes to PATH passengers (Eng-Wong, Taub & Associates, 2008). In this survey, the PATH access and egress modes associated with personal vehicles included the following: Auto: Drove; Auto: Passenger; Commuter Van; and Taxi. The total number of 2007 PATH passengers was multiplied by the fraction of PATH commuters using one of these listed modes. This was performed separately for weekdays, weekends, and holidays. Once the number of passengers using personal vehicles to travel to the PATH stations was determined, estimates of vehicle occupancy were used to determine the number of vehicles traveling to and from the PATH stations. Table 6-3 shows the number of passengers estimated by access/egress mode, the vehicle occupancy assumed for each type of vehicle mode, and the estimated one-way trip length for each mode. The five-mile auto and taxi commuting distance to PATH stations was estimated by taking the national average one-way commuting distance of 12 miles (Pisarski, 2006) and subtracting the estimated average PATH train ride distance of seven miles (from Journal Square to 33rd Street). There was insufficient information for estimating the average commuter van travel distance to PATH stations, so it was assumed to be 4 times the distance of auto travel to PATH stations. The average vehicle occupancy for auto: drove, and auto: passenger modes are estimated by summing the total number of passengers by auto and dividing by the number of passengers that drove. This estimation assumes that all passengers who arrived and departed from the PATH stations by automobile are with drivers who also rode PATH. The average taxi vehicle occupancy of 1.63 is taken from the 2001 National Household Travel Survey for all trip purposes (Hu and Reuscher, 2004). The assumption of 8 passengers per commuter van is based on an EPA report on vanpool benefits (EPA, 2005). Total VMT associated with vehicle travel for each mode was then calculated by multiplying the number of passengers by the estimated trip length and dividing by the average vehicle occupancy. The number of passengers accounts for both passengers entering the train stations and those leaving the stations.

Table 6-3. Activity Data for Vehicle Travel To and From PATH Train Stations

PATH Access/Egress Mode	2007 Total Passengers	Estimated Trip Length (miles)	Average Vehicle Occupancy	Assumed Number of Starts per Trip	2007 Total VMT (miles)
Auto: drove	7,912,187	5	1.49	1	26,579,619
Auto: Passenger	3,864,261	5	1.49	1	12,981,314
Commuter Van	1,135,167	20	8	1	2,837,918
Taxi	3,415,439	5	1.63	0	10,476,808
Total					**52,875,659**

Emissions for the vehicles bringing passengers to the PATH stations were calculated in two parts: (1) emissions that occur while traveling to or from the PATH stations, and (2) emissions that occur when the vehicles are started after having been parked (cold start emissions). The vehicles carrying passengers to the PATH stations were assumed to be a mix of light-duty cars, light-duty trucks, and motorcycles. The number of vehicle starts by access mode is shown in Table 6-3.

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2008b), while the emission factors for vehicle starts were obtained from the IPCC Guidelines (IPCC, 2006). Both the running and cold start CH_4 and N_2O emission factors varied by vehicle category. Weighted emission factors were estimated based on the expected distribution of vehicles by vehicle category. Annual VMT from the vehicles traveling to the PATH stations were converted to annual fuel consumption by dividing the VMT by vehicle fuel economy in miles per gallon. Weighted average fuel economy for light duty vehicles was derived from the Department of Energy's Annual Energy Outlook (DOE, 1996-2008). The weighted CO_2 emission factor was multiplied by the total fuel consumed by the vehicles while traveling to and from the PATH stations. The weighted CH_4 and N_2O running emission factors were multiplied by the total VMT to obtain the running emissions. The weighted cold start CH_4 and N_2O emission factors were multiplied by the total number of vehicle starts associated with the trips to and from the PATH stations to obtain the cold start emissions.

6.2.3.2. Bus Travel To and From Journal Square Transportation Center

The activity associated with the bus emissions is VMT. This was estimated by multiplying the total number of 2007 bus departures from the Journal Square Transportation Center by an estimated trip length of five miles from Journal Square. Again, the 5-mile commuting distance to Journal Square was estimated by taking the national average one-way commuting distance of 12 miles (Pisarski, 2006) and subtracting the estimated average PATH train ride distance of seven miles (from Journal Square to 33rd Street). The resulting VMT was multiplied by two to account for both the trip to and the trip from Journal Square. Annual bus departure data for 2007 was provided by PANYNJ (PANYNJ, 2008b). This showed that 469,640 buses departed from the Journal Square Transportation Center in 2007. Since the CO_2 emission factor is expressed in units of mass per gallon of fuel, the total bus VMT was converted to gallons of diesel fuel consumed by dividing the total VMT by an estimate of the bus fuel economy of 4.23 miles per gallon (Larsen, 2006).

Emission factors were obtained from EPA's latest GHG Inventory report (EPA, 2008), applying emission factors from the heavy-duty diesel vehicle category for buses. The CO_2 emission factor is expressed in units of mass per gallon of fuel consumed while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. Thus, the CO_2 emission factor was multiplied by the total fuel consumed by the buses while traveling within the bus terminals as well as during idling. The CH_4 and N_2O emission factors were multiplied by the total bus VMT accumulated in the immediate trip to and from Journal Square.

The resulting emissions from both the buses and vehicles were then totaled by bus terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

6.2.4. Results

Table 6-4 summarizes the GHG emission estimates that occur through the attracted vehicle trips to the PATH stations, as well as for the bus trips to and from the PATH Journal Square Station. Emissions from vehicle trips account for a majority of the PATH attracted travel emissions. The PATH attracted travel GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for almost 98 percent of the CO_2e emissions.

In comparison with 2006 emissions from PATH attracted travel, 2007 total CO_2e emissions increased 10.3 percent. Emissions from bus trips from Journal Square stayed constant, while emissions from vehicle trips increased 17.3 percent in 2007. This increase in vehicle trips emissions is congruent with the 15.1 percent increase in the number of PATH ridership from 2006 to 2007. The number of Journal Square bus departures for 2007 were essentially the same as in 2006, which explains why there is no change in emissions in this category from last year.

Table 6-4. PATH Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	**CH_4**	**N_2O**	**CO_2 Equivalent**
PATH Vehicle Trips Attracted	18,728	1.58	2.00	19,382
Bus Trips at PATH Journal Square Station	11,273	0.02	0.02	11,280
PATH Attracted Travel Total	***30,001***	***1.60***	***2.03***	***30,662***

6.2.5. Comparison with Estimates in Previous Studies

Table 6-5 summarizes the 2006 PATH attracted travel emissions and shows a 10 percent increase over this period. This increase is slightly higher than the 6.9 percent ridership increase in 2007.

Table 6-5. PATH Attracted Travel CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	**2007**	
PATH Vehicle Trips Attracted	16,526	19,382	17.28%
Bus Trips at PATH Journal Square Station	11,279	11,280	0.01
Total	**27,805**	**30,662**	**10.28%**

6.3. DIESEL EQUIPMENT

6.3.1. Boundary

All diesel equipment operated by PATH is included within the boundary of this inventory. There are a number of utility track vehicles (UTVs) which perform track maintenance services along the PATH system in both New Jersey and New York, as well as within rail yards. The UTVs operate throughout the PATH system, which includes the following counties/municipalities: Hudson County, NJ (Jersey City, Kearny, Harrison, and Hoboken), Essex County, NJ (Newark), and New York County (Manhattan).

6.3.2. Facilities Included in the Inventory

All PATH locations where equipment is used, including all tracks and the Harrison Car Maintenance Facility, are included in this inventory.

6.3.3. Methods

PATH reported their overall diesel fuel use in gallons. Emissions were calculated using the diesel fuel use as activity data, and using GHG emission factors for diesel fuel retrieved from the IPCC Guidelines (IPCC, 2006)

6.3.4. Results

Table 6-6 summarizes the emissions from diesel equipment.

Table 6-6. PATH Diesel Fuel Use GHG Emissions by Gas and CO_2 Equivalent

	GHG (metric tons)			
Diesel Usage (Gallons)	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
21,842	243	1.36E-02	9.37E-02	272

6.3.5. Comparison with Estimates in Previous Studies

Table 6-7 compares 2007 GHG emission estimates for PATH diesel equipment with those made previously for 2006.

Table 6-7. PATH Diesel Equipment CO_2 Equivalent GHG Emissions Comparison

	CO_2 Equivalent (metric tons)		
Facility	**2006**	**2007**	**Percentage Difference**
Diesel Equipment	284	272	-4%

6.4. BUILDINGS

6.4.1. Boundary

The GHG emissions inventory boundary includes all PATH department operated buildings; buildings leased to tenants; and office space that the PATH department leases from other organizations.

6.4.2. Facilities Included In the Inventory

All facilities listed in Table 6-8 are included in this building energy use category.

Table 6-8. Facilities within PATH Boundary

Facility
PATH Rapid Transit System
Journal Square Transportation Center

6.4.3. Methods

GHG emissions associated with energy consumption in buildings that are owned by the PANYNJ, or leased to tenants, were estimated in four steps.

The first step consisted in developing a list of sources responsible for GHG emissions associated with energy consumption in buildings that are owned, or leased, within PATH department boundary. Step two focused in mapping sources with their corresponding energy consumption. Step three was spent processing raw data by means of unit conversion and emission rates application. The final step consisted in classifying emission results according to scope. Emissions results were grouped into one of three emission scopes. Scope 1 included direct combustion of fuels such as natural gas, diesel, or propane. Scope 2 included indirect emissions from electricity purchased and used by PANYNJ. Indirect emissions from electricity purchased by PANYNJ (including purchased from NYPA) and resold to tenants were grouped as scope 3. Finally, emissions from direct combustion of fuels by PANYNJ tenants were considered to be scope 3 emissions.

During step two, emission factors and emission rates were selected as follows. For emission estimates from electricity consumption, emission factors developed by eGRID were applied to consumption values. eGRID provided emission factors to estimate GHG and most CAP emissions. Remaining CAP emissions were derived from state-wide emission values compiled in the EPA NEI. It is important to note that emission differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation.

6.4.4. Results

All emissions were the result of indirect emissions from electricity use. As of the publication of this report, year 2007 activity data for the electricity use at Journal Square Transportation Center (1 PATH Plaza) were unavailable. Therefore as a surrogate, the activity data for 2006 was used to estimate emissions for 2007. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 6-9.

Table 6-9. PATH Buildings GHG Emissions by Facility and by Scope

Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)
PATH Buildings	-	7,095	-
Journal Square Transportation Center	-	5,537	-
Total	**0**	**12,632**	**0**

6.4.5. Comparison with Estimates in Previous Studies

Table 6-10 compares 2007 GHG emission estimates for PATH Buildings with those made previously for 2006. GHG emissions decreased by 1 percent during this period.

Table 6-10. PATH Buildings CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	**2007**	
PATH Buildings	7,205	7,095	-1.5%
Journal Square Transportation Center	5,537	5,537	N/A
Total	**12,743**	**12,632**	**-0.9%**

6.5. PATH GHG EMISSIONS SUMMARY

Table 6-11 summarizes the GHG emissions from all facilities within the PATH department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be categorized by facility appear in Table 7-18.

Table 6-11. PATH Department GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Attracted Travel	-	-	30,662	30,662
Buildings	-	12,632	-	12,632
Direct Fugitive Emissions	35	-	-	35
Vehicle Fleet	154	-	-	154
Indirect Emissions from Purchased Traction Power	-	40,206	-	40,206
Diesel Equipment	272	-	-	272
PATH RAPID TRANSIT SYSTEM	**461**	**52,838**	**30,662**	**83,961**

6.6. PATH CAP EMISSIONS SUMMARY

Table 6-12 summarizes the CAPs emissions estimates for PATH trains, buildings, attracted travel, and diesel equipment within the Port Authority's PATH department.

Table 6-12. PATH CAP Emission Estimates

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Attracted Travel	74	1	2	3
Buildings	37	204	17	20
Vehicle Fleet	1	-	-	-
Indirect Emissions from Purchased Traction Power	116	649	53	64
Diesel Equipment	6	0	0	0
PATH RAPID TRANSIT SYSTEM	**234**	**854**	**72**	**87**

6.7. REFERENCES

DOE, 1996-2008: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2008 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2008," Report # DOE/EIA-0383(2008), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, June 2008.

Eng-Wong, Taub & Associates, 2008: Eng-Wong, Taub, & Associates, "2007 PATH System-Wide Passenger Survey," Final Report Appendices, January 2008.

EPA, 1995: U.S. Environmental Protection Agency, "AP-42 Compilation of Air Pollutant Emission Factors," January 1995, accessible on the web at http://www.epa.gov/ttn/chief/ap42/, 1995.

EPA, 2005: U.S. Environmental Protection Agency, "Vanpool Benefits: Implementing Commuter Benefits as one of the Nation's Best Workplaces for Commuters," from EPA 420-S-01-003, http://www.bestworkplaces.org/pdf/vanpoolbenefits_07.pdf, October 2005.

EPA, 2008a: U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Protection Partnerships Division, "Emissions & Generation Resource Integrated Database," http://www.epa.gov/cleanenergy/energy-resources/egrid/faq.html, November 2008.

EPA, 2008b: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006," EPA #430-R-08-001, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2008.

Hu and Reuscher, 2004: Patricia S. Hu and Timothy R. Reuscher, "Summary of Travel Trends: 2001 National Household Travel Survey," prepared for the U.S. Department of Transportation, Federal Highway Administration, http://nhts.ornl.gov/2001/pub/STT.pdf, December 2004.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), published: IGES, Japan, 2006.

Larsen, 2006: Bent Larsen, New Jersey Transit buses average about 4.23 miles per gallon; overroad buses are typically 3.70 - 4.88 miles per gallon; some older local buses are as low as 2.64 mpg, 2006.

PANYNJ, 2008a: Data file provided by the Port Authority of New York & New Jersey, "2007pathyearend.xls," 2008.

PANYNJ, 2008b: Data file provided by the Port Authority of New York & New Jersey, "JSQBUS@PARK STATS 2007.xls," 2008.

Pisarski, 2006: Alan Pisarski, "Commuting in America III: The Third National Report on Commuting Patterns and Trends," published by Transportation Research Board, Washington DC, 2006.

7.0 MOBILE SOURCES

7.1. FLEET VEHICLES

7.1.1. Boundary

The boundary for fleet vehicles includes the mileage traveled by all on-road motor vehicles (including cars, trucks, buses, and motorcycles) owned or operated by the PANYNJ and any non-road fuel usage from non-road vehicles.

7.1.2. Facilities Included in the Inventory

The fleet vehicles included in this inventory are associated with all facilities owned or operated by the PANYNJ.

7.1.3. GHG Methods

Direct GHG emissions were estimated for all motor vehicles in PANYNJ fleets, with the estimated fuel usage in 2007 as the primary activity data for CO_2 using fuel-based emission factors. The estimated VMT was used as the primary activity data for CH_4 and N_2O with emission factors distinguished by vehicle type and model year group. Emission estimates were based on the specific vehicles that PANYNJ operates; gallons of fuel used; and fuel type. In total, 1,509 on-road and 859 non-road fleet vehicles were identified from the data provided by PANYNJ. These vehicles were estimated to travel 14.28 million miles and consume 1.44 million gallons of fuel in 2007.

Data on individual fleet vehicles was provided by the Central Automotive Division of the PANYNJ (PANYNJ, 2008a). This data file included information on the make, model, and year of each vehicle; the state and facility to which the vehicle was registered; descriptive information on the use, classification, and gross vehicle weight rating (GVWR) class of the vehicle; the fuel type of the vehicle; the estimated gallons of fuel consumed in 2007; and the miles traveled in 2007. The fuel estimate was used in the absence of actual fuel use, including fuel purchased off-site by emergency vehicles or personnel refueling at vendors not in the Central Automotive Division’s system. This data set included both on-road vehicles and non-road engine and equipment data, for which emissions were calculated separately. The CO_2 and CAP emissions were calculated based on the reported fuel usage for both onroad and non-road vehicles. In addition, the fuel usage was used to estimate CH_4 and N_2O emissions for the non-road vehicles. For on-road vehicles, CH_4 and N_2O emissions were calculated using VMT.

For this analysis, the fuel use and fuel class data were used to estimate fleet vehicle activity during 2007. For on-road vehicles, each vehicle was assigned to one of the following vehicle types, based on the reported weight or, if not reported, the vehicle make and model: light-duty vehicle; light-duty truck 1 (up to 6,000 pounds GVWR); light-duty truck 2 (greater than 6,000 pounds GVWR); heavy-duty vehicle; and motorcycle. Vehicles were also classified by the following fuel types: gasoline, hybrid, diesel, bio-diesel, bi-fuel, flex-fuel, and CNG. For each vehicle, both on-road and non-road, the gallons of fuel use reported or calculated was used as the primary activity data. For CNG and bi-fuel vehicles, vehicle-specific CNG usage was unavailable. This was accounted for in the updated Port Authority fuel estimate for these vehicles. The average CNG values were assigned to all dedicated CNG vehicles for their fuel usage. CNG consumption for bi-fuel vehicles was included in this overall total, which was distributed solely to the CNG vehicles. The fuel use reported with the bi-fuel vehicles was the gasoline fuel use. Emissions from this gasoline use were allocated to the bi-fuel vehicles. In the future, actual CNG use for individual CNG vehicles, and both gas and CNG data for bi-fuel vehicles would be preferable to this method. Similarly, flex-fuel vehicles reported only gasoline use and were accounted for as such.

CO_2, CH_4, and N_2O emission factors were assigned to each vehicle type. The CO_2 emission factors varied only by fuel type (gasoline, diesel, biodiesel, CNG, flex-fuel, bi-fuel, and propane). The CO_2 emission factors are expressed in units of mass per gallon of fuel consumed, while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. For on-road vehicles, the CH_4 and N_2O emission factors were dependent upon the vehicle type, fuel type, and model year of the vehicle. The model year was used to determine the mix of technology types available, in order to weight the relevant CH_4 and N_2O emission factors. These emission factors were obtained from EPA's latest GHG Inventory report (EPA, 2008). For non-road vehicles, CH_4 and N_2O emission factors in units of mass per gallon of fuel consumed were assigned to all vehicles, dependent only on fuel type. These emission factors came from the IPCC Guidelines (IPCC, 2006).

Once emission factors for CO_2, CH_4, and N_2O were assigned to all fleet vehicles, emissions of each of these gases were calculated by multiplying the emission factor by the corresponding activity – gallons consumed for CO_2 and VMT for CH_4 and N_2O in the case of on-road vehicles and gallons consumed for non-road vehicles. The resulting emissions were then totaled by facility. All Public Safety department vehicles were evaluated collectively, regardless of facility. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

In addition to the data provided by the Central Automotive Division, there was also data provided about propane use in firefighting equipment at JFK International Airport (PANYNJ, 2008b). Emissions from this non-road equipment were calculated entirely using fuel use, and were added to the public safety department emissions total.

7.1.4. GHG Results

Table 7-1 summarizes the GHG emission estimates from PANYNJ on-road fleet vehicles and Table 7-2 summarizes GHG emissions from off-road engine/vehicle fuel use reported by the Central Automotive Division. In both cases, emissions are further broken down by the facility the vehicles are associated with. The fleet vehicle GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for over 98 percent of the CO_2e emissions.

Table 7-1. On-road Fleet Vehicle GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)			
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Brooklyn Piers	73	4.01E-03	6.42E-03	75
Downtown Heliport	7	3.89E-04	5.84E-04	7
George Washington Bridge	271	1.49E-02	3.38E-02	282
Holland Tunnel	245	1.35E-02	3.43E-02	256
JFK Int. Airport	1,529	8.40E-02	1.52E-01	1,578
LGA Airport	648	3.56E-02	5.91E-02	667
Lincoln Tunnel	476	2.62E-02	6.09E-02	495
Long Term Rental Pool	61	3.42E-03	5.54E-03	63
New Jersey Marine Terminal	4	2.35E-04	3.49E-04	4
New York Marine Terminal	14	7.68E-04	1.15E-03	14
New York Teleport	0	5.45E-06	1.76E-08	0
Newark Legal Center	3	1.56E-04	2.34E-04	3
Newark Liberty Int. Airport	1,104	6.07E-02	1.05E-01	1,138
NY Motor Pool	56	3.07E-03	4.60E-03	57
P.A. Bus Terminal	11	5.94E-04	8.84E-04	11
P.A. Technical Center	884	4.87E-02	8.85E-02	913
P.A. Technical Center Short Term Pool	74	4.07E-03	6.08E-03	76
Park Avenue Offices	48	2.65E-03	3.97E-03	50
PATH Rail Transportation	147	8.07E-03	1.26E-02	151
Port Newark Facilities	44	2.39E-03	4.46E-03	45
Port Newark Marine Terminal	242	1.33E-02	2.60E-02	250
Rehabilitation Shop at 777	6	3.02E-04	4.54E-04	6
Staten Island Bridge Facilities	298	1.64E-02	2.80E-02	307
Teterboro Airport	11	5.85E-04	8.71E-04	11
World Trade Center	9	5.19E-04	7.78E-04	10
Public Safety Department Total	4,745	2.60E-01	3.98E-01	4,874
On-road Fleet Vehicles Total	**11,011**	**6.05E-01**	**1.03E+00**	**11,344**

Table 7-2. Non-road Fleet Vehicle GHG Emissions by Gas and CO_2 Equivalent

Facility	GHG Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Brooklyn Piers	8	4.27E-04	1.11E-03	8
George Washington Bridge	134	7.51E-03	4.80E-02	149
Holland Tunnel	164	9.16E-03	6.30E-02	183
JFK Int. Airport	180	1.00E-02	5.37E-02	197
LGA Airport	70	3.89E-03	2.21E-02	77
Lincoln Tunnel	103	5.74E-03	3.80E-02	114
Long Term Rental Pool	14	7.66E-04	5.28E-03	15
Newark Liberty Int. Airport	93	5.19E-03	3.34E-02	103
P.A. Bus Terminal	2	1.22E-04	8.42E-04	2
P.A. Technical Center	47	2.64E-03	1.73E-02	53
PATH Rail Transportation	2	1.38E-04	8.48E-04	3
Port Newark Facilities	23	1.29E-03	3.88E-03	25
Port Newark Marine Terminal	14	7.97E-04	5.39E-03	16
Staten Island Bridge	36	2.01E-03	1.20E-02	40
Teterboro Airport	1	4.07E-05	2.80E-04	1
Public Safety Department Total	2,397	6.21E-02	2.02E-01	3,385
Non-road Fleet Vehicles Total	**3,288**	**1.12E-01**	**5.08E-01**	**4,371**

7.1.5. CAP Emissions Results

Table 7-3 summarizes the CAP emission estimates from PANYNJ on-road fleet vehicles and Table 7-4 summarizes CAP emissions from off-road engine/vehicle fuel use reported by the Central Automotive Division. In both cases, emissions are further broken down by facility.

Table 7-3. On-road Fleet Vehicle CAP Emissions by Gas

Facility	CAP Emissions Totals (metric tons)			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Brooklyn Piers	1.06E-01	8.09E-04	1.96E-03	3.14E-03
Downtown Heliport	8.76E-03	8.80E-05	9.00E-05	1.95E-04
George Washington Bridge	5.27E-01	5.68E-03	1.07E-02	1.50E-02
Holland Tunnel	3.41E-01	2.85E-03	6.13E-03	8.89E-03
JFK Int. Airport	4.49E+00	3.98E-02	8.62E-02	1.20E-01
LGA Airport	1.24E+00	1.00E-02	2.22E-02	3.34E-02
Lincoln Tunnel	8.87E-01	8.82E-03	1.78E-02	2.48E-02
Long Term Rental Pool	5.02E-01	1.50E-03	7.31E-03	1.11E-02
New Jersey Marine Terminal	2.14E-02	7.53E-05	3.04E-04	4.91E-04
New York Marine Terminal	4.90E-02	1.95E-04	7.56E-04	1.08E-03
New York Teleport	3.96E-03	4.99E-05	6.68E-05	1.44E-04
Newark Legal Center	2.18E-03	3.03E-05	5.18E-05	1.13E-04
Newark Liberty Int. Airport	2.90E+00	2.35E-02	5.29E-02	7.68E-02
NY Motor Pool	1.53E-01	1.84E-03	2.63E-03	5.71E-03
P.A. Bus Terminal	1.01E-02	1.17E-04	1.45E-04	3.13E-04
P.A. Technical Center	2.56E+00	2.58E-02	4.70E-02	7.75E-02
P.A. Technical Center Short Term Pool	1.34E-01	1.69E-03	2.92E-03	6.22E-03
Park Avenue Offices	1.80E-01	2.15E-03	2.86E-03	6.19E-03
PATH Rail Transportation	5.82E-01	2.92E-03	9.87E-03	1.37E-02
Port Newark Facilities	7.41E-02	1.01E-03	1.73E-03	2.67E-03

Facility	CAP Emissions Totals (metric tons)			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Port Newark Marine Terminal	6.97E-01	5.53E-03	1.32E-02	1.89E-02
Rehabilitation Shop at 777	2.75E-03	3.47E-05	4.64E-05	1.00E-04
Staten Island Bridge Facilities	8.54E-01	6.46E-03	1.44E-02	2.21E-02
Teterboro Airport	5.95E-03	7.72E-05	1.12E-04	2.43E-04
World Trade Center	1.90E-02	1.04E-04	3.29E-04	4.66E-04
Public Safety Department Total	1.51E+01	1.71E-01	3.32E-01	4.43E-01
On-road Fleet Vehicles Total	**31.45**	**0.31**	**0.63**	**0.89**

Table 7-4. Non-road Fleet Vehicle CAP Emissions by Gas

Facility	CAP Emissions Totals (metric tons)			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Brooklyn Piers	7.21E-03	8.60E-05	1.71E-04	2.08E-04
George Washington Bridge	6.28E-01	8.83E-03	1.61E-02	1.91E-02
Holland Tunnel	3.75E-01	5.20E-03	9.56E-03	1.13E-02
JFK Int. Airport	1.47E+00	2.00E-02	3.71E-02	4.41E-02
LGA Airport	1.18E+00	1.67E-02	3.04E-02	3.60E-02
Lincoln Tunnel	3.54E-01	4.67E-03	8.80E-03	1.05E-02
Long Term Rental Pool	6.50E-02	9.22E-04	1.68E-03	1.98E-03
Newark Liberty Int. Airport	8.01E-01	1.13E-02	2.06E-02	2.44E-02
P.A. Bus Terminal	2.19E-02	3.10E-04	5.64E-04	6.67E-04
P.A. Technical Center	1.57E-01	2.21E-03	4.03E-03	4.77E-03
PATH Rail Transportation	8.39E-03	1.19E-04	2.16E-04	2.56E-04
Port Newark Facilities	4.75E-02	4.94E-04	1.06E-03	1.31E-03
Port Newark Marine Terminal	2.20E-02	3.12E-04	5.67E-04	6.71E-04
Staten Island Bridge	2.86E-01	3.89E-03	7.22E-03	8.59E-03
Teterboro Airport	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Public Safety Department Total	2.06E+00	2.90E-02	5.29E-02	6.26E-02
Non-road Fleet Vehicles Total	**7.48**	**0.10**	**0.19**	**0.23**

7.1.6. Comparison with Estimates in Previous Studies

Table 7-5 compares the fleet vehicle CO_2 equivalent emissions between 2006 and 2007. This table shows that overall GHG emissions increased by approximately 32 percent between 2006 and 2007 because there was a significant increase in the amount of fuel use between the two years. In 2006, 1.07 million gallons of fuel use were reported by the Port Authority for both on-road and non-road fleet vehicles. In 2007, there were approximately 1.44 million gallons of fuel used, an increase of approximately 35 percent.

Table 7-5. Fleet Vehicles CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Brooklyn Piers	77	83	7.6%
Downtown Heliport	6	7	23.1
George Washington Bridge	323	431	33.5
Holland Tunnel	392	439	12.0
JFK Int. Airport	1,332	1,775	33.3
LGA Airport	687	744	8.3

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Lincoln Tunnel	511	610	19.3%
Long Term Rental Pool	229	78	-65.8
New Jersey Marine Terminal	0	4	N/A
New York Marine Terminal	11	14	33.5
New York Teleport	0	0	N/A
Newark Legal Center	3	3	-2.8
Newark Liberty Int. Airport	932	1,241	33.2
NY Motor Pool	135	57	-57.5
P.A. Bus Terminal	12	13	13.2
P.A. Technical Center	1,076	965	-10.3
P.A. Technical Center Short Term Pool	148	76	-48.6
Park Avenue Offices	135	50	-63.3
PATH Rail Transportation	156	154	-1.6
Port Newark Facilities	65	70	6.5
Port Newark Marine Terminal	158	266	68.6
Rehabilitation Shop at 777	2	6	179.4
Staten Island Bridge Facilities	265	347	30.9
Teterboro Airport	6	12	99.7
World Trade Center	6	10	60.8
Public Safety Department Total	5,252	8,259	57.3
Fleet Vehicles Total	**11,919**	**15,715**	**31.8%**

7.2. CONSTRUCTION EQUIPMENT

7.2.1. Boundary

The boundary for construction equipment includes any construction equipment used during the 2007 calendar year in Port Authority capital projects.

7.2.2. Facilities Included in the Inventory

PANYNJ provided 2007 construction work in progress (WIP) spending data for its facilities (PANYNJ, 2008c). The PANYNJ WIP spending data was then assigned to counties. For PATH facilities, PANYNJ provided the county assignments. Table 7-6 lists the facilities included in this inventory by county where construction equipment operated during 2007. The assumptions used in assigning the facilities to counties were as follows:

1. For Tunnels and Bridges, the WIP construction spending for each bridge and tunnel was split evenly between the two counties that the bridge or tunnel spans.
2. For all the "multi-facilities," the WIP construction spending was split in proportion to the total WIP spending by county for the other facilities.

In so doing, it was determined that there was no report of construction WIP spending in Bronx County, New York for PANYNJ facilities.

Table 7-6. PANYNJ Facilities Where Construction Occurred in 2007

Facility	County/State
AVIATION	
John F. Kennedy International Airport	Queens, NY
LaGuardia Airport	Queens, NY
Newark Liberty International Airport	Essex, NJ
Teterboro Airport	Bergen, NJ
JFK Light Rail	Queens, NY
Stewart Airport	Orange, NY
REAL ESTATE & DEVELOPMENT	
World Trade Center	New York, NY
Port Authority Technical Center	Hudson, NJ & New York, NY
Battery Park Marine Terminal	New York, NY
TUNNELS & BRIDGES	
George Washington Bridge	New York, NY & Bergen, NJ
Bayonne Bridge	Richmond, NY & Hudson, NJ
Geothals Bridge	Richmond, NY & Essex, NJ
Outerbridge Crossing	Richmond, NY & Union, NJ
Lincoln Tunnel	New York, NY & Hudson, NJ
Holland Tunnel	New York, NY & Hudson, NJ
Port Authority Bus Terminal	New York, NY
Arthur Kill	Union, NJ & Richmond, NY
PORT COMMERCE	
NJ Marine Terminals	Essex, NJ & Union, NJ
Brooklyn Piers	Kings, NY
Howland Hook	Richmond, NY
SECURITY	
John F. Kennedy International Airport	Queens, NY
LaGuardia Airport	Queens, NY
Newark Liberty International Airport	Essex, NJ
Teterboro Airport	Bergen, NJ
Port Authority Technical Center	Hudson, NJ & New York, NY
World Trade Center/PAT	New York, NY
George Washington Bridge	New York, NY & Bergen, NJ
Bayonne Bridge	Richmond, NY & Hudson, NJ
Outerbridge Crossing	Richmond, NY & Union, NJ
Lincoln Tunnel	New York, NY & Hudson, NJ
Holland Tunnel	New York, NY & Hudson, NJ
Port Authority Bus Terminal	New York, NY
Journal Square Transportation Center	Union, NJ
Port Newark	Essex, NJ
Port Elizabeth	Essex, NJ
Howland Hook	Richmond, NY

7.2.3. Methods

Construction equipment emissions were estimated using information about construction spending by the PANYNJ during 2007 as a surrogate for fuel use by construction equipment. Because there is no direct link between construction spending and GHG emissions, EPA's NONROAD model was used to estimate fuel use and associated GHG emissions at the county-level for the New York and New Jersey counties where the PANYNJ had some construction activity in 2007. Data were then obtained from McGraw-Hill on the county-level construction dollars spent during 2007. The McGraw-Hill data were used to compute the ratio of PANYNJ construction spending to total county-level construction spending.

EPA's NONROAD2005 Model (EPA, 2005) was run to estimate 2007 construction equipment emissions for the following counties:

- Bergen County, NJ;
- Essex County, NJ;
- Hudson County, NJ;
- Union County, NJ;
- Bronx County, NY;
- Kings County, NY;
- New York County, NY;
- Orange County, NY;
- Queens County, NY; and
- Richmond County, NY.

To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. Geographic allocation factors are used to distribute national equipment populations to counties and states. These factors are based on surrogate indicators of equipment populations. For example, the 2003 value of construction adjusted for geographic construction material cost differences is the surrogate indicator used in allocating construction equipment. NONROAD uses a national average engine activity (i.e., load factor times annual hours of use).

The construction equipment emissions, including fuel consumption, are reported by equipment type and fuel type in the NONROAD model. For this analysis, the county-level emissions were summed up to the fuel type level. The model estimates emissions for the following fuel types: 2-stroke gasoline; 4-stroke gasoline; diesel fuel; liquid petroleum gas (LPG); and CNG.

County-level fuel consumption obtained from the NONROAD model runs were used in conjunction with CO_2, CH_4, and N_2O default emission factors from IPCC Guidelines Table 3.3.1 for Motor Gasoline and Diesel (IPCC, 2006) and Tables 3.2.1 and 3.2.2 for LPG and CNG (IPCC, 2006) to estimate GHG emissions. Emission factors are expressed in kg/TJ; therefore, gasoline fuel consumption was converted to an energy basis using a conversion factor of 1.2496E-4 TJ per gallon gasoline (IOR, 2007). Diesel fuel consumption was converted to an energy basis using a conversion factor of 1.4990E-4 TJ per gallon of diesel fuel (IOR, 2007). LPG fuel consumption was converted to an energy basis using a conversion factor of 9.58E-5 TJ per gallon LPG (IOR, 2007). CNG fuel consumption was converted to an energy basis using a conversion factor of 2.41E-5 TJ/gallon CNG (CNG, 2007). GHG emissions were estimated by multiplying the converted fuel consumption by the GHG emission factors from Tables 3.3.1, 3.2.1, and 3.2.2 of the 2006 IPCC Guidelines. The ratios of PANYNJ construction spending to total county-level spending were multiplied by the county-level CO_2, CH_4, and N_2O emissions to yield the PANYNJ GHG estimates.

For the World Trade Center facility, 2007 diesel fuel consumption was provided by PANYNJ (PANYNJ, 2008d). No estimates of non-diesel fuel use (e.g., gasoline) were reported for 2007. This fuel consumption was used instead of NONROAD fuel estimates as the basis for the WTC facility construction activity. To estimate the GHG emissions, the diesel fuel consumption was multiplied by the CO_2, CH_4, and N_2O default emission factors from IPCC Guidelines Table 3.3.1 for Motor Gasoline and Diesel. For the remaining portion of New York County, fuel use was estimated by first calculating a fuel consumption factor that related total New York County diesel fuel consumption (from NONROAD) to total county construction spending (from McGraw-Hill). This factor was then applied to the construction spending for the non-WTC facilities only to estimate fuel consumption for these remaining non-WTC facility projects in New York County. This activity estimate was then multiplied by IPCC diesel emission factors to estimate GHG emissions. The WTC GHG emissions were added to the remaining New York County emissions to estimate total county GHG emissions.

An adjustment was made to the county-level diesel fuel VOC, carbon monoxide (CO), PM_{10}, and $PM_{2.5}$ emissions to account for diesel retrofit control devices on all construction equipment above 50 horsepower. EPA has developed a software program called the "Diesel Emissions Quantifier" to calculate the emission reductions achievable from diesel retrofits (EPA, 2007). The diesel emission quantifier uses emission factors and other information in estimating emission benefits of diesel retrofits. This tool was used to estimate average emission reductions for 2007 for the PANYNJ construction vehicle fleet. Engine specific inputs were required to run the quantifier program. These data were collected from the NONROAD2005 model runs performed to estimate fuel consumption and CAP emissions for the relevant New York and New Jersey counties. In addition, some horsepower and model year distribution data were obtained from a national NONROAD2005 model run for year 2007. Some of the assumptions used in the runs included:

- Fuel Type was assumed to be Ultra Low Sulfur Diesel (ULSD)
- Technology types used were Diesel Particulate Filter (DPF) + ULSD and Diesel Oxidation Catalyst (DOC) + ULSD
- 83 percent of the total engine population was assumed to be retrofitted. Pechan assumed that all 2006 and 2007 model year construction equipment populations were already controlled to a level not requiring additional retrofit technology. This percentage was calculated based on a national estimate of pre-2006 and 2007 model year construction equipment populations relative to the total construction equipment population for all model years in 2007.

- Of the 83 percent of the population to be retrofitted, 75 percent of the engines employed DPFs and the remaining 25 percent employed DOCs (PANYNJ, 2008c).

The program can be run for only one equipment type (i.e., Source Classification Code [SCC]) at a time. Pechan ran the program for the top four equipment types, based on highest PM_{10} emissions, and comparable emission reductions were obtained for all four applications. As such, Pechan applied these reductions to all diesel construction SCCs in the inventory. The reductions calculated by pollutant were: VOC (62 percent); CO (63 percent); and PM (61 percent). The retrofit technologies selected in Pechan's Diesel Quantifier simulations did not result in any NO_x reductions.

Once the emissions reductions were estimated, the percent reductions were applied to the county-level diesel CAP emissions. The PM reduction was applied to both PM_{10} and $PM_{2.5}$ emissions.

7.2.4. Construction Equipment GHG Emissions Summary

Table 7-7 summarizes the construction equipment GHG emission estimates for the facilities included in the inventory. Diesel-fueled construction equipment is the predominant contributor of emissions in all facilities, with Aviation facilities being the predominant contributor of emissions across all fuel types. GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions are approximately 90 percent of the total CO_2e emissions.

Table 7-7. Construction Equipment GHG Emissions by Gas and CO_2 Equivalent

			Greenhouse Gas Emissions Totals (metric tons)			
Facility	**State**	**County**	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Aviation						
Teterboro Airport*	New Jersey	Bergen	1,417	0	1	1,585
Newark Airport*	New Jersey	Essex	12,112	0	5	13,550
Stewart Airport	New York	Orange	33	0	0	36
Jamaica Station	New York	Queens	46	0	0	51
JFK Airport*	New York	Queens	6,153	0	2	6,884
JFK Light Rail System	New York	Queens	250	0	0	279
LaGuardia Airport*	New York	Queens	4,972	0	2	5,563
NYC Heliport - security	New York	Queens	1	0	0	1
PATH						
PATH*	New Jersey	Hudson	1,782	0	1	1,993
PATH*	New York	New York	742	0	0	831
Battery Park Marine Terminal	New York	New York	283	0	0	317
Ports						
NJ Marine Terminals*	New Jersey	Essex	6,653	0	3	7,443
NJ Marine Terminals	New Jersey	Union	4,372	0	2	4,891
Brooklyn Piers	New York	Kings	159	0	0	178
Ports - Multi-Facility	New York	Kings	28	0	0	31
Howland Hook*	New York	Richmond	13	0	0	14
Ports - Multi-Facility	New York	Richmond	2	0	0	3

Facility	State	County	Greenhouse Gas Emissions Totals (metric tons)			
			CO_2	CH_4	N_2O	CO_2 Equivalent
TB&T						
George Washington Bridge*	New Jersey	Bergen	1,132	0	0	1,267
Goethals Bridge	New Jersey	Essex	99	0	0	111
TB&T - Multi-Facility	New Jersey	Essex	5	0	0	5
Bayonne Bridge*	New Jersey	Hudson	151	0	0	169
Holland Tunnel*	New Jersey	Hudson	737	0	0	824
Lincoln Tunnel*	New Jersey	Hudson	289	0	0	323
TB&T - Multi-Facility	New Jersey	Hudson	2	0	0	2
Outerbridge Crossing*	New Jersey	Union	110	0	0	123
Arthur Kill	New Jersey	Union	34	0	0	38
Journal Square Transportation Center - security	New Jersey	Union	1	0	0	1
TB&T - Multi-Facility	New Jersey	Union	6	0	0	6
Port Authority Bus Terminal*	New York	New York	1,409	0	1	1,578
George Washington Bridge*	New York	New York	526	0	0	590
Holland Tunnel*	New York	New York	306	0	0	343
Lincoln Tunnel*	New York	New York	120	0	0	135
Bayonne Bridge*	New York	Richmond	3	0	0	3
Goethals Bridge	New York	Richmond	2	0	0	2
Outerbridge Crossing*	New York	Richmond	3	0	0	4
Arthur Kill	New York	Richmond	1	0	0	1
TB&T - Multi-Facility	New York	Richmond	0	0	0	0
World Trade Center						
World Trade Center*	New York	New York	1,970	0	1	2,207
		Total	**45,924**	**2**	**17**	**51,382**

*Includes security projects.

7.2.5. Construction Equipment CAP Emissions Summary

Table 7-8 summarizes the estimated criteria air pollutant emissions for construction activity during 2007. NO_x and SO_2 emissions are dominated by construction activity at Port Authority Airport facilities.

Table 7-8. Construction Equipment Criteria Air Pollutant Emissions by Facility (metric tons)

Facility	State	County	CAP Emission Totals (metric tons)			
			NO_x	SO_2	PM_{10}	$PM_{2.5}$
Aviation						
Teterboro Airport*	New Jersey	Bergen	14	2	1	1
Newark Airport*	New Jersey	Essex	117	17	5	4
Stewart Airport	New York	Orange	0	0	0	0
Jamaica Station	New York	Queens	0	0	0	0
JFK Airport*	New York	Queens	60	9	2	2
JFK Light Rail System	New York	Queens	2	0	0	0
LaGuardia Airport*	New York	Queens	48	7	2	2
NYC Heliport - security	New York	Queens	0	0	0	0
PATH						
PATH*	New Jersey	Hudson	17	2	1	1
PATH*	New York	New York	7	1	0	0
Battery Park Marine Terminal	New York	New York	3	0	0	0
Ports						
NJ Marine Terminals*	New Jersey	Essex	65	9	3	2
NJ Marine Terminals	New Jersey	Union	42	6	2	2
Brooklyn Piers	New York	Kings	2	0	0	0

Facility	State	County	CAP Emission Totals (metric tons)			
			NO_x	SO_2	PM_{10}	$PM_{2.5}$
Ports - Multi-Facility	New York	Kings	0	0	0	0
Howland Hook*	New York	Richmond	13	2	1	1
Ports – Multi-Facility	New York	Richmond	2	0	0	0
TB&T						
George Washington Bridge*	New Jersey	Bergen	11	2	0	0
Goethals Bridge	New Jersey	Essex	1	0	0	0
TB&T - Multi-Facility	New Jersey	Essex	0	0	0	0
Bayonne Bridge*	New Jersey	Hudson	1	0	0	0
Holland Tunnel*	New Jersey	Hudson	7	1	0	0
Lincoln Tunnel*	New Jersey	Hudson	3	0	0	0
TB&T - Multi-Facility	New Jersey	Hudson	0	0	0	0
Outerbridge Crossing*	New Jersey	Union	1	0	0	0
Arthur Kill	New Jersey	Union	0	0	0	0
Journal Square Transportation Center - security	New Jersey	Union	0	0	0	0
TB&T - Multi-Facility	New Jersey	Union	0	0	0	0
Port Authority Bus Terminal*	New York	New York	14	2	0	0
George Washington Bridge*	New York	New York	5	1	0	0
Holland Tunnel*	New York	New York	3	0	0	0
Lincoln Tunnel*	New York	New York	1	0	0	0
Bayonne Bridge*	New York	Richmond	3	0	0	0
Goethals Bridge	New York	Richmond	2	0	0	0
Outerbridge Crossing*	New York	Richmond	3	0	0	0
Arthur Kill	New York	Richmond	1	0	0	0
TB&T - Multi-Facility	New York	Richmond	0	0	0	0
World Trade Center						
World Trade Center*	New York	New York	19	3	1	1
		Total	**471**	**68**	**18**	**18**

*Includes security projects.

7.2.6. Comparison with Estimates in Previous Studies

Table 7-9 compares the 2007 CO_2 equivalent emissions to the 2006 estimates and shows that two counties had dramatic increases in emissions from 2006 to 2007; Essex County, NJ and Union County, NJ. These increases along with the smaller ones in other counties can be attributed to an increase in construction spending from one year to the next. This would include both construction spending provided by the Port Authority and the total county-level construction spending obtained from McGraw Hill. The significant increases for Essex and Union Counties are offset by decreases in estimated spending and emissions for Queens County and Richmond County, NY, so that the total Port Authority emissions only increased from 2006 to 2007 by 6 percent.

The uncertainty associated with emission estimates for construction is high. This is due to the use of a national model that relies on a surrogate indicator (dollar value of construction) to estimate activity and emissions at the county level, coupled with the use of Port Authority spending data to further allocate county-level emissions to the facility level. A more robust method would rely on actual fuel use records by construction projects for the year of interest, similar to what the Port Authority provided for the World Trade Center.

Table 7-9. Construction Equipment CO_2 Equivalent GHG Emissions Comparison

State/County	2006 CO_2 Equivalent (metric tons)	2007 CO_2 Equivalent (metric tons)	Percent Difference
New Jersey			
Bergen	2,668	2,852	7%
Essex	6,463	21,108	227
Hudson	2,679	3,311	24
Union	464	5,059	991
New York			
Kings	187	209	12
New York	5,606	6,001	7
Orange	N/A	36	N/A
Queens	16,190	12,778	-21
Richmond	14,032	28	-100
Total	**48,289**	**51,382**	**6%**

7.3. EMPLOYEE COMMUTING

7.3.1. Boundary

The GHG emissions from PANYNJ employee commuting are those associated with the employees commuting to and from work. Employee commuting in vehicles not owned or controlled by the PANYNJ, such as light rail, train, subway, buses, and employees' cars are indirect emissions categorized under Scope 3 emissions. Emissions from business travel by employees via train, commercial plane, and non-company owned cars are not included in the emissions estimate.

7.3.2. Facilities Included In the Inventory

The PANYNJ facilities shown in Table 7-10 are included in the operational boundary for estimating emissions from employee commuting.

Table 7-10. PANYNJ Facilities Included in Employee Commuting Emission Estimates

Number	Facility Name
1	115 Broadway
2	225 Park Avenue South
3	233 Park Avenue South
4	5 Marine View
5	777 Jersey Avenue
6	AirTrain JFK/ AirTrain Network
7	Auto Marine Terminal and Greenville Yard
8	Bayonne Bridge
9	Brooklyn PA Marine Terminal
10	Downtown Manhattan Heliport
11	Gateway Plaza I
12	Gateway Plaza II

Number	Facility Name
13	Gateway Plaza III
14	George Washington Bridge
15	George Washington Bridge Bus Station
16	Goethals Bridge
17	Harrison Car Maintenance Facility
18	Holland Tunnel
19	Howland Hook Marine Terminal and Port Ivory
20	John F. Kennedy International Airport
21	Journal Square Transportation Center
22	KAL Building at JFK
23	LaGuardia Airport
24	Lincoln Tunnel
25	Newark Liberty International Airport
26	One Madison Avenue
27	Outerbridge Crossing
28	PATH station
29	Port Authority Bus Terminal
30	Port Authority Technical Center
31	Port Newark/Elizabeth Marine Terminal
32	Teterboro Airport
33	The Teleport
34	Waldo Yard Buildings
35	World Trade Center

7.3.3. GHG Methods

7.3.3.1. Activity Data for Employee Commuting

PANYNJ employee commuting emissions were estimated by activity data measured as total distance that employees travel to and from work, the modes of transportation they use to travel, and CO_2 emission factors for each travel mode. PANYNJ is a relatively large organization with over 7,000 employees. GHG Protocol based "Working 9 to 5 on Climate Change: An Office Guide" and calculation tools based on a survey method developed by WRI were used to estimate employee commuting emissions (WRI, 2002).

To determine employee commuting activity, a web-based survey was developed and implemented during December 2007. PANYNJ employees were queried for the following information:

- Mode of transportation (e.g., car, bus, train, walk, skateboard, others);
- Average round trip distance traveled by the employee between work and home;
- Average number of days per week the employee commutes;
- For the employees who drive to work, the fuel efficiency of the employee's vehicle, fuel type, and the number of people who travel with the employee; and
- Information about commuting combinations used. For example, an employee may drive to a central location such as a train station or a bus depot and then travel the rest of the way to work by train or bus.

Distance traveled is the principal activity indicator for all modes of transportation except cars, for which fuel use is used to estimate GHG emissions.

In addition to the commuting survey, in 2007, the Port Authority provided information on PATH employee shuttles that were incorporated in the emissions estimates. The Port Authority hires a contractor to operate an employee shuttle which runs between the PATC and the two nearest PATH stations, JSTC, and Hoboken. Port Authority provided fuel and mileage estimates for the shuttle buses and wagons used for these operations.

7.3.3.2. Activity Data & Emissions – Car Travel

The methodology to estimate emissions from car use is based on a fuel use approach. A three-step calculation methodology described in the GHG Protocol based “Working 9 to 5 on Climate Change: An Office Guide” developed by WRI was used to estimate the total fuel use for commuting by car (WRI, 2002).

Step 1. The total distance traveled by an employee’s typical commute was captured using the survey. Total distance traveled by an employee in a year was estimated using information provided on the number of days worked in the organization per year. This estimate took into consideration that the PANYNJ observes 11 holidays per year.

*Total annual distance traveled = Number of commuting days per annum * Distance traveled per day*

Step 2. Total fuel use was estimated using the total distance traveled times the fuel efficiency of the car. Each car has a different fuel economy and fuel type, so the calculations were made separately for each fuel type and employee. For survey responses where personal vehicle fuel economy values were missing, default values were obtained from DOE (DOE, 2007). Table 7-11 shows average fuel economy values.

*Fuel use = Total annual distance traveled by employee * Fuel economy of the car*

Table 7-11. Passenger Car Commuting Fuel Economy Values

Fuel Type	Miles per Gallon
Gasoline Mileage	24.7
Diesel Mileage	24.0

Step 3. Fuel use per employee was estimated by dividing the total fuel usage by the number of people sharing the car. Estimates of vehicle occupancy rates were taken from survey responses.

Fuel use per employee = Estimated fuel use / Number of people in car

Car travel emission factors based on fuel use and the corresponding emission factors from GHG Protocol's calculation tools for service-sector companies were used to estimate the emissions (WRI, 2006). Table 7-12 shows emission factors by fuel type.

Table 7-12. Passenger Car Commuting Emission Factors

Fuel Type	kg CO_2/Gallon
Gasoline	8.87
Diesel	10.15

7.3.3.3. Activity Data & Emissions – Train, Light Rail, and Bus Travel

Emissions from train, light rail, and bus travel are estimated as CO_2 per passenger mile or kilometer traveled. The emission factors from the GHG Protocol's calculation tools for service-sector companies were used to estimate the emissions (WRI, 2006) and are shown in Table 7-13.

Table 7-13. Bus and Rail Commuting Emission Factors

Train Type	kg CO_2/mile
US Intercity Rail (i.e., Amtrak)	0.314
US Transit Rail (e.g., subway, PATH)	0.169
US Commuter Rail (i.e., NJ Transit)	0.163
CNG, urban (buses)	0.228

The following assumptions were made based on the information obtained from the American Public Transportation Association (APTA, 2007).

- Subway emission factors were based on U.S. Transit Rail.
- Metro North emission factors were based on U.S. Commuter Rail.
- PATH Train emission factors were based on U.S. Transit Rail.
- NJ Transit Train emission factors were based on U.S. Commuter Rail.
- Long Island Railroad emission factors were based on U.S. Commuter Rail.
- Amtrak Train emission factors were based on U.S. Intercity Rail.
- Bus emissions were calculated using the CNG emission factor.

To avoid double counting the emissions from employees who take the employee shuttle, the survey activity data removed bus emissions for employees who reported that they work at PATC, take PATH part of the trip, and ride bus/van/carpool from 1-2 miles per one-way trip. In future year versions of the survey, the employee shuttle will be an explicit choice, to refine this methodology.

7.3.3.4. Activity Data & Emissions – Employee Shuttle

Employee shuttle GHG emissions were based on the estimated fuel use provided by Port Authority and default fuel emission factors from the IPCC Guidelines (IPCC, 2006). Emissions for each GHG were calculated individually, then emissions for each gas were multiplied by the appropriate global warming potential and all were summed to find the CO_2 equivalent. CAP emissions were estimated using the Port Authority mileage estimates and the default MOBILE 6.2 emission factors for Heavy Duty Diesel Vehicles and Heavy Duty Gasoline Vehicles, as appropriate. Both GHG and CAP emission factors for employee shuttles are shown in Table 7-14 below.

Table 7-14. Employee Shuttle GHG and CAP Emission Factors

Vehicle	Fuel Type	CO_2 (kg/gallon)	CH_4 (kg/gallon)	N_2O (kg/gallon)	NO_x (g/mile)	SO_2 (g/mile)	$PM_{2.5}$ (g/mile)	PM_{10} (g/mile)
Buses	Diesel	8.97	4.92E-04	7.38E-04	10.13	0.14	0.26	0.31
Wagons	Gasoline	11.11	6.22E-04	4.29E-03	3.46	0.02	0.06	0.08

7.3.4. Results

The emissions from each mode of transport were summed to obtain the total estimated emissions for all employees that completed the survey. The survey captured a total of 1,166 valid responses out of 1,185 responses collected. This sample is appropriate for a 7,000 employee organization according to "Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations" (EPA, 2005). The survey sample was extrapolated to the entire population using the following equation:

*Total estimated emissions = Emissions from sample group * Ratio (number of employees in organization / number of employees in sample group)*

GHG emissions estimates are summarized in Table 7-15.

Table 7-15. Employee Commuting GHG Emissions by Gas and CO_2 Equivalent

Source	Greenhouse Gas Emission Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2e (metric Tons)
Employee Survey	27,074	N/A	N/A	27,074
Employee Shuttle	119	6.52E-03	1.58E-02	124
Total	**27,193**	**6.52E-03**	**1.58E-02**	**27,198**

Emissions from car travel accounted for 66 percent of total emissions. 20 percent of the emissions estimated were from Metro North, NJ Transit, and Long Island RR travel. Table 7-16 summarizes annual CAP emissions for employee commuting.

Table 7-16. Employee Commuting CAP Emissions Summary

Source	CAP Emissions (metric tons)			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Survey	842.2	48.7	19.7	21.4
Shuttles	6.57E-01	9.10E-03	1.67E-02	1.99E-02
Total	842.9	48.7	19.7	21.5

7.3.5. Comparison with Estimates in Previous Studies

The calendar year 2006 employee commuting GHG emissions estimate was based on an employee commuting survey that was given to Port Authority employees in December of 2007, so the same survey data was used to estimate 2007 emissions. However, in 2007, the Port Authority provided additional data, in the form of fuel and mileage estimates for the employee shuttles running from PATH to PATC. Though the survey results were altered to avoid double counting emissions for the shuttle bus trip segment for PATC employees, the calculated shuttle emissions still resulted in a small net increase in employee commuting emissions as shown in Table 7-17.

Table 7-17. Employee Commuting CO_2 Equivalent GHG Emissions Comparison

Source	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	%
Survey	27,080	27,074	-0.02%
Shuttles	N/A	124	N/A
Total	**27,080**	**27,198**	**0.44%**

7.4. MOBILE SOURCES GHG EMISSIONS SUMMARY

Table 7-18 summarizes the GHG emissions from mobile sources which could not be separated by department, specifying the source of the emissions and the amount which falls under each scope for each source. Fleet vehicle GHG emissions that could be identified with a specific Department are included in the summary tables for those Departments (in the preceding chapters).

Table 7-18. Mobile Sources GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Fleet Vehicles- NY Motor Pool & Long Term Rental Pool	136	-	-	136
Public Safety Department Fleet Vehicles	8,259	-	-	8,259
Direct Fugitive Emissions - Central Automotive Division	637	-	-	637
Construction	51,382	-	0	51,382
Employee Commuting	-	-	27,198	27,198
Mobile Sources: Multiple Departments	**60,414**	**-**	**27,198**	**87,612**

7.5. MOBILE SOURCES CAP EMISSIONS SUMMARY

Table 7-19 summarizes 2007 mobile source CAP emissions which could not be separated by department. Fleet vehicle emissions that could be identified with a specific department are included in the summary tables for those departments (in the preceding chapters).

Table 7-19. Mobile Sources CAP Emissions by Facility (metric tons)

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Fleet Vehicles- NY Motor Pool & Long Term Rental Pool	1	-	-	-
Public Safety Department Fleet Vehicles	17	-	-	-
Construction	471	68	18	18
Employee Commuting	843	49	20	22
Mobile Sources: Multiple Departments	**1,332**	**117**	**38**	**40**

7.6. REFERENCES

APTA, 2007: American Public Transportation Association, commuter rail information was obtained from APTA and is available at http://www.apta.com/research/stats/rail/crservuse.cfm, 2007.

CNG, 2007: CNG Service of Arizona, "Compressed Natural Gas," available at http://www.cngaz.com/forms/WhatCNG.pdf, 2007.

DOE, 2007: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007," Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

EPA, 2005: U.S. Environmental Protection Agency, "Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations," 2005.

EPA, 2007: U.S. Environmental Protection Agency, *Diesel Quantifier*, [Computer software], available at http://cfpub.epa.gov/quantifier/, August 31, 2007.

EPA, 2008: U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006," EPA #430-R-08-001, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2008.

IOR, 2007: IOR Energy, "Engineering Conversion Factors," available at http://www.ior.com.au/ecflist.html, 2007.

IPCC, 2006: Intergovernmental Panel on Climate Change, “2006 IPCC Guidelines for National Greenhouse Gas Inventories,” Volume 2, Energy, 2006.

PANYNJ, 2008a: Port Authority of New York and New Jersey, data spreadsheet PANYNJ vehicle fleet data-2007.xls, provided by George Sarrinikolaou, PANYNJ, August 1, 2008.

PANYNJ, 2008b: Port Authority of New York and New Jersey, data spreadsheet Aviation-Fuel consumption-Heating 06-07.xls, provided by George Sarrinikolaou, PANYNJ September 15, 2008

PANYNJ, 2008c: Port Authority of New York and New Jersey, “2007-construction data-except WTC,” sent via email on August 1, 2008.

PANYNJ, 2008d: Port Authority of New York and New Jersey, “WTC fuel consumption data 2006-2007,” sent via email on August 1, 2008.

WRI, 2002: World Resources Institute, “Working 9 to 5 on Climate Change: An Office Guide,” prepared by Samantha Putt del Pino and Pankaj Bhatia, 2002.

WRI, 2006: World Resources Institute, “CO_2 Emissions from Employee Commuting, Version 2.0, June 2006,” June 2006.

8.0 REAL ESTATE AND DEVELOPMENT

8.1. BUILDINGS

8.1.1. Boundary

The GHG emissions inventory boundary includes all Real Estate and Development Department operated buildings; buildings leased to tenants; and office space that the Real Estate and Development Department leases from other organizations.

8.1.2. Facilities Included In the Inventory

All facilities listed in Table 8-1 are included in this building energy use category. Facilities marked with an asterisk represent office space leased by PANYNJ.

Table 8-1. Facilities within Real Estate and Development Department Boundary

Facility
Bathgate Industrial Park
The Legal Center
The Teleport
World Trade Center
115 Broadway *
225 Park Avenue South *
233 Park Avenue South *
5 Marine View *
777 Jersey Avenue *
Gateway Plaza I, II, III *
KAL Building at JFK *
One Madison Avenue *
Port Authority Technical Center *

8.1.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the Real Estate and Development Department were estimated in four steps.

The first step was to develop a list of sources responsible for GHG emissions associated with energy consumption in buildings that are owned, or leased, within the Real Estate and Development Department boundary. Step two focused on mapping sources with their corresponding energy consumption. Step three was computing emissions by means of unit conversion and emission rates application. The final step was classifying emissions according to scope. Emissions results were grouped into one of three emission scopes. Scope 1 included direct combustion of fuels such as natural gas, diesel, or propane. Scope 2 included indirect emissions from electricity purchased and used by PANYNJ. Indirect emissions from electricity purchased by PANYNJ (including purchased from NYPA) and resold to tenants were classified as Scope 3. Finally, emissions from direct combustion of fuels by PANYNJ tenants were considered to be Scope 3 emissions.

During step two, emission factors and emission rates were selected as follows. For emission estimates from electricity consumption, emission factors developed by eGRID were applied to consumption values. eGRID provided emission factors to estimate GHG and most CAP emissions (EPA, 2008). Remaining CAP emissions were derived from state-wide emission values compiled in the EPA National Emissions Inventory. It is important to note that emissions differ according to electrical grid regions due to the characteristics of the fuel mix during electricity generation. GHG emission rates for natural gas were taken from The Climate Registry General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA's AP-42 (EPA, 1995). The Climate Registry General Reporting Protocol also provided emission factors to quantify carbon dioxide emissions from various other fossil fuels. Where fuel usage was not available, GHG emissions for commercial building energy consumption were estimated using emission rates for typical office buildings in lbs per square foot. These estimates are based on the DOE, EIA's 2003 Commercial Building Energy Consumption Survey (CBECS).[1] Further analysis of the CBECS tables allowed Pechan to develop custom emissions for the Bathgate Industrial Park and the GWBBS based on the square footage used by various source types within the facilities (e.g., Education, Food Service, and Warehouse).

8.1.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Facility total CO_2 equivalent emissions and division of emissions by scope are included in Table 8-2, showing that most emissions come from facilities not directly under PANYNJ control. Facilities marked with an asterisk represent office space leased by PANYNJ.

[1] CBECS available at http://www.eia.doe.gov/emeu/cbecs/contents.html

Table 8-2. Real Estate and Development Buildings GHG Emissions by Facility and by Scope

Sub-Facility	Scope 1 (metric tons)	Scope 2 (metric tons)	Scope 3 (metric tons)	Totals
Bathgate Industrial Park	-	-	6,342	6,342
The Legal Center	-	-	5,493	5,493
The Teleport	62	-	28,670	28,732
World Trade Center (including ERP)	-	-	147,449	147,449
115 Broadway *	-	608	-	608
225 Park Avenue South *	55	1,500	-	1,555
233 Park Avenue South *	0	219	0	219
5 Marine View *	0	76	0	76
777 Jersey Avenue *	0	764	0	764
Gateway Plaza I *	0	4	0	4
Gateway Plaza II *	0	552	0	552
Gateway Plaza III*	0	75	0	75
KAL Building at JFK *	0	28	0	28
One Madison Avenue *	0	449	0	449
Port Authority Technical Center *	672	2,838	0	3,510
Total	**790**	**7,112**	**187,955**	**195,857**

8.1.5. Comparison with Estimates in Previous Studies

Table 8-3 compares the calendar year 2007 GHG emission estimates with those made previously for 2006. This comparison shows that buildings GHG emissions dropped by 12 percent and that this emissions change is primarily attributable to a lower CO_2 emission factor for the NPCC NYC/Westchester, NY eGRID subregion for the most recent year of record. This CO_2 emission factor is 15 percent lower now than it was in the previous year. This lower emission factor could be attributable to more CO_2 efficient generation technologies being used, a change in how existing units were dispatched to meet power generation needs, or a change in how units were assigned to this region.

Table 8-3. Real Estate and Development Buildings CO_2 Equivalent GHG Emissions Comparison

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Bathgate Industrial Park	7,685	6,342	-17.5%
The Legal Center	6,914	5,493	-20.6
The Teleport	30,148	28,732	-4.7
World Trade Center	165,423	147,449	-10.9
PA Leased Property	**11,905**	**7,840**	**-34.1%**
115 Broadway	694	608	-12.4
225 Park Avenue South	2,390	1,555	-34.9
233 Park Avenue South	466	219	-53.0
5 Marine View	77	76	-0.6
777 Jersey Avenue	944	764	-19.0
Gateway Plaza I	4	4	-11.2
Gateway Plaza II	596	552	-7.5
Gateway Plaza III	92	75	-19.3
KAL Building at JFK	32	28	-12.4
One Madison Avenue	1,566	449	-71.3
Port Authority Technical Center	5,044	3,511	-30.4
Total	**222,075**	**195,857**	**-11.8%**

8.2. RESOURCE RECOVERY FACILITY

8.2.1. Boundary

The GHG emissions from the Essex County Resource Recovery facility include emissions from municipal solid waste (MSW) combustion as well as combustion of fossil fuel for auxiliary usage. Emissions associated with hauling and tipping of waste is not included in the total emissions estimates from this facility, since they are considered outside of the operational boundaries of the facility.

8.2.2. Facilities Included in the Inventory

The Essex County Resource Recovery Facility.

8.2.3. Methods

8.2.3.1. Solid Waste Combustion

Activity data in the form of the amount of waste combusted were used along with emissions factors to estimate the total quantity of pollutants emitted. Total MSW combusted in 2007 was 888,079 short tons (805,660 metric tons). These data were provided by the facility owners. A waste characterization study was unavailable.

The method for estimating CO_2 emissions from incineration of MSW was based on an estimate of the fossil carbon content in the waste combusted multiplied by the oxidation factor, and an estimate of the amount of fossil carbon oxidized to CO_2. The activity data are the waste inputs into the incinerator and the emission factors are based on the oxidized carbon content of the waste that is of fossil origin. Relevant data include the amount of and composition of the waste, the dry matter content, the total carbon content, the fossil carbon fraction, and the oxidation factor.

Table 8-4 lists EPA's waste characterization data for discarded solid waste that were used to define the waste composition of MSW combusted at this facility. Non-combustible materials such as glass, metals, and other inert material were assumed to be separated from the waste combusted and were therefore excluded from the composition. The 2006 EPA MSW characterization data table provides data to derive weight percentages for the different components of the solid waste stream combusted at the facility (e.g., percent by weight of plastics, metals, glass, paper, food, yard debris, etc.). That level of detail is needed in order to assess the fossil based CO_2 emissions versus the biogenic CO_2 emissions from the facility (to account for the fossil based CO_2 in the inventory). No site-specific study that provides sampling, sorting, and weights of individual components of the waste stream was available for 2006 or 2007. The method based on the total amount of waste combusted by waste composition is outlined in the following equation:

$$CO_2 = (MSW * Dry\ Matter\ Content * Carbon\ Content * Fossil\ Carbon * Oxidation\ Factor * 44/12)$$

Table 8-4. Assumed Waste Composition of MSW Combusted GHG Emissions

MSW Component	Composition (mass %)
Paper/Cardboard	29.0
Textiles	7.0
Food Waste	21.0
Wood	9.0
Garden and Park Waste	9.0
Other (Diapers)	3.0
Rubber and Leather	4.0
Plastics	19.0
Metal	-
Glass	-
Other, Inert Waste	-

Dry matter, carbon content, and fossil carbon content were estimated using IPCC data. The assumed waste composition data shown in Table 8-4 was used to revise the IPCC default values based on a comparison of the U.S. and IPCC waste characteristics. The most important variable is the fossil carbon content, which could be adjusted using the plastics content from the two waste profiles. Dry matter content data provided in *Volume 5, Chapter 2, Waste Generation, Composition and Management Data* of 2006 IPCC Guidelines were used (IPCC, 2006a).

CH_4 emissions from waste incineration are dependent on the continuity of the incineration process, the incineration technology, and management practices. N_2O emissions from waste incineration are determined by type of technology and combustion conditions, the technology applied for NO_x reduction, as well as the contents of the waste stream. The CH_4 and N_2O emission factors provided in Table 5.3 and Table 5.6 of *Volume 5, Chapter 5,* Incineration and Open Burning of Waste, 2006 IPCC Guidelines were used in estimating the emissions. Emissions were estimated by multiplying tons of waste combusted by each pollutant's emission factor (IPCC, 2006b). CH_4 and N_2O emission factors are shown in Table 8-5.

Table 8-5. Waste Combustion CH_4 and N_2O Emission Factors

Type of Incineration	CH_4 Emission Factor (kg/GT)	N_2O Emissions Factor (g/T waste)
Continuous Incineration	0.2	50

8.2.3.2. Fuel Combustion

The Essex County Resource Recovery Facility also combusted Type 2 distillate fuel in plant operations in 2007. The fuel was used as auxiliary fuel in the boilers. Activity data in the form of amount of fuel combusted along with emission factors were used to estimate emissions. The facility reported that the fuel oil combusted in plant operations during 2007 was 278,852 gallons. The total emissions from fuel combustion were calculated by multiplying gallons of fuel consumed with each pollutant's emission factor.

Emission factors for CO_2 provided in *Table C.6: Carbon Dioxide Emission Factors and Oxidation Rates for Stationary Combustion* (CCAR, 2007) were used to estimate CO_2 emissions. Emission factors for CH_4 and N_2O provided in *Table C.7: Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type* (CCAR, 2007) were used to estimate the emissions. The emission factors are shown below in Table 8-6.

Table 8-6. Fuel Based Emission Factors (Distillate Fuel Oil)

Pollutant	**Emission Factor (kg/Gallon)**
CO_2	10.15
CH_4	0.0014
N_2O	0.0001

The CO_2 emission factor already incorporates a factor for the fraction of carbon oxidized. The CO_2 fraction reflects the fact that slightly less than 100 percent of the carbon in the fuel consumed is completely oxidized.

8.2.4. Results

Emission estimates from the facility account for combustion processes only. It does not include the emissions associated with trucking and hauling of waste as well as fuel use in support equipment. Emission estimates are not adjusted for the GHGs that are avoided by electricity generation, recovery of metals, and methane emissions from landfills. This is because emissions inventories of this type are accountings of direct greenhouse gas emissions and do not account for the difference in emissions from alternative practices. Emissions from waste combustion were 90 percent of total emissions.

Estimated emissions are summarized in Table 8-7. The IPCC GWP factors were used to convert CH_4 and N_2O into their CO_2 equivalents.

Table 8-7. Essex County Resource Recovery Facility GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emission Totals (metric tons)			
Source	**CO_2**	**CH_4**	**N_2O**	**CO_2e (metric Tons)**
MSW Combustion	459,330	0.2	40	471,821
Fuel Combustion	2,830	0.3	0.03	2,847
Totals	**462,160**	**1**	**40**	**474,668**

Table 8-8 summarizes the estimated criteria air pollutant emissions for the Resource Recovery Facility during 2007.

Table 8-8. Essex County Resource Recovery Facility CAP Emissions

Source	CAPs			
	NO_x	SO_2	PM_{10}	$PM_{2.5}$
MSW Combustion	838	645	39	39
Fuel Combustion	3	18	0	0
Totals	**841**	**662**	**39**	**39**

8.2.5. Comparison with Estimates in Previous Studies

Essex County Resource Recovery Facility GHG emissions slightly decreased in year 2007. These emissions are comparable, yet the slight difference is a result of decrease in the total waste combusted. The facility reported 805,660 tons of MSW combusted in 2007, compared with 808,416 tons of waste combusted in year 2006. The decrease in total waste combusted is potentially the result of better sorting and recycling before combustion or a reduction in the amount of waste accepted at the facility. Table 8-9 summarizes the change in emissions from 2006 to 2007 as result of MSW combustion and auxiliary fuel combustion.

The Essex County Resource Recovery Facility reported their 2006 anthropogenic CO_2e emissions from the combustion of MSW and fuel usage to be 298,715 metric tons. Emission estimates can differ because of differences in waste characterization data. Emission estimates in this report are potentially higher than those developed by the facility as a result of a higher percentage of plastics in EPA's waste characterization data.

Table 8-9. Total CO_2 Equivalent GHG Emissions Comparison from Resource Recovery Facility

Facility	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Resource Recovery Facility – MSW Combustion	477,912	471,821	-1.3%
Resource Recovery Facility – Fuel Combustion	2,161	2,847	32
Total	**480,073**	**474,668**	**-1.1%**

8.3. REAL ESTATE AND DEVELOPMENT GHG EMISSIONS SUMMARY

Table 8-10 summarizes the GHG emissions from all facilities within the Real Estate and Development department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be attributed to a specific facility appear in Table 7-18.

Table 8-10. Real Estate and Development Department GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Bathgate Industrial Park	**-**	**-**	**6,342**	**6,342**
Buildings	-	-	6,342	6,342
The Teleport	**62**	**-**	**28,670**	**28,732**
Buildings	62	-	28,670	28,732
The Legal Center	**3**	**-**	**5,493**	**5,496**
Buildings	-	-	5,493	5,493
Fleet Vehicles	3	-	-	3

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
World Trade Center (including WTC ERP)	**10**	**-**	**147,449**	**147,459**
Buildings	-	-	147,449	147,449
Fleet Vehicles	10	-	-	10
PA leased office space	**1,822**	**7,112**	**-**	**8,934**
Buildings	728	7,112	-	7,840
Fleet Vehicles	1,094	-	-	1,094
Essex County Resource Recovery Facility	**-**	**-**	**474,668**	**474,668**
Mixed Solid Waste Combustion Emissions	-	-	471,821	471,821
Fuel Combustion Emissions	-	-	2,847	2,847
REAL ESTATE & DEVELOPMENT	**1,897**	**7,112**	**662,622**	**671,631**

8.4. REAL ESTATE AND DEVELOPMENT CAP EMISSIONS SUMMARY

Table 8-11 summarizes the estimated criteria air pollutant emissions for the Real Estate and Development Department during 2007. NO_x and SO_2 emissions for this Department are dominated by solid waste combustion at the Essex County Resource Recovery Facility.

Table 8-11. Real Estate and Development Department CAP Emissions by Facility (metric tons)

	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Bathgate Industrial Park	**18**	**96**	**8**	**9**
Buildings	18	96	8	9
The Teleport	**57**	**48**	**2**	**3**
Buildings	57	48	2	3
The Legal Center	**15**	**81**	**7**	**8**
Buildings	15	81	7	8
Fleet Vehicles	-	-	-	-
World Trade Center (including WTC ERP)	**295**	**248**	**13**	**15**
Buildings	295	248	13	15
Fleet Vehicles	-	-	-	-
PA leased office space	**20**	**69**	**6**	**7**
Buildings	17	69	6	7
Fleet Vehicles	3	-	-	-
Essex County Resource Recovery Facility	**841**	**663**	**39**	**39**
Mixed Solid Waste Combustion Emissions	838	645	39	39
Fuel Combustion Emissions	3	18	-	-
REAL ESTATE & DEVELOPMENT	**1,246**	**1,205**	**75**	**81**

8.5. REFERENCES

CCAR, 2007: California Climate Action Registry, "California Climate Action Registry General Reporting Protocol," Reporting Entity-Wide Greenhouse Gas Emissions Version 2.2, March 2007.

EPA, 2008: U.S. Environmental Protection Agency, Office of Atmospheric Programs, Climate Protection Partnerships Division, "Emissions & Generation Resource Integrated Database," http://www.epa.gov/cleanenergy/energy-resources/egrid/faq.html, November 2008.

EPA, 1995: U.S. Environmental Protection Agency, Office of Transportation and Air Quality. "AP-42 Compilation of Air Pollutant Emission Factors," January 1995, accessible on the web at http://www.epa.gov/ttn/chief/ap42/

EPA, 2005: U.S. Environmental Protection Agency, "LandGEM - Landfill Gas Emissions Model, Version 3.02, User's Guide," (EPA-600/R-05/047), Office of Research and Development, Clean Air Technology Center, http://epa.gov/lmop/, May 2005.

IPCC, 2006a: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 2: Waste Generation, Composition and Management Data," prepared by the National Greenhouse Gas Inventories Programme, Riitta Pipatti (Finland), Chhemendra Sharma (India), Masato Yamada (Japan), published: IGES, Japan, 2006.

IPCC, 2006b: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5: Incineration and Open Burning of Waste," prepared by the National Greenhouse Gas Inventories Programme, G.H. Sabin Guendehou (Benin), Matthias Koch (Germany), Leif Hockstad (USA), Riitta Pipatti (Finland), and Masato Yamada (Japan), published: IGES, Japan, 2006.

9.0 DIRECT FUGITIVE EMISSIONS

9.1. BOUNDARY

The boundary for reporting direct fugitive emissions is the PANYNJ operated facilities listed in the Executive Summary of this report. Fugitive emissions are intentional and unintentional releases of GHGs from joints, seals, gaskets, etc. Direct emissions from sources that are owned or controlled by the Port Authority are included in this inventory as Scope 1 emissions.

9.2. FACILITIES INCLUDED IN THE INVENTORY

All PANYNJ departments and facilities that use refrigerants are included. Direct fugitive emission estimates also include SF_6 emissions from vapor monitoring operations conducted by the Port Authority's engineering department.

9.3. METHODS

Leakage from refrigeration systems, such as air conditioners and refrigerators, is common across a wide range of entities. Only those refrigerants that contain or consist of compounds of GHGs are reported. HFCs are the primary GHG of concern for refrigeration systems, particularly for motor vehicle air conditioners. Today, HFC-134a is the standard refrigerant for mobile air conditioning systems.

Ideally, HFC emissions from air conditioners are estimated by performing a mass balance calculation and then converting each HFC emission to CO_2 equivalents. The mass balance method starts with a base inventory of all HFCs in use, and adjusts the total based on purchases and sales of HFCs and changes to the total refrigerant charge remaining in the equipment. The used HFCs that cannot be accounted for are assumed to have been emitted to the atmosphere.

Due to limited data availability, 2007 refrigerant emissions for the PANYNJ were estimated based on purchases of HFCs during the calendar year. While this does not provide a full accounting of refrigerant losses using a mass balance method, this estimation method is common for organizations in their first years of GHG emissions accounting.

Table 9-1 summarizes the reported PANYNJ refrigerant purchases during 2007. Freon gas (R-22) is subject to phase-out as a hydrochlorofluorocarbon (HCFC) under the Montreal protocol regulations, so it is not counted as a GHG under reporting protocols such as the California Climate Action Registry. The U.S. Clean Air Act enforcement of the Montreal Protocol includes limiting HCFC consumption to a specific level and reducing the supply of HCFCs in a step-wise fashion beginning January 1, 2004. On September 21, 2007, the Montreal Protocol agreed to accelerate the phase-out of HCFCs. By 2010, in developed countries, the accelerated schedule calls for a 75 percent reduction from baseline consumption. By 2020, HCFC production is supposed to cease with a 0.5 percent of baseline for service permitted only until 2030. Therefore, GHG emission estimates for refrigerants are based on HFC-134a purchases only.

Table 9-1. 2007 Purchased Quantities of Refrigerants

Department/Facility	Freon Refrigerant R134A (lbs)
PATH	60
TBT-Lincoln Tunnel	30
Operations Services Department-Central Automotive Division	1,080
Total	**1,170**
NOTE: The purchased quantities are recorded in 30-pound cylinders.	

In addition to refrigerant leakages, the Port Authority conducted 2 vapor monitoring operations in 2007, using SF_6 as a tracer gas. These operations were conducted by the Engineering Department and cannot be attributed to any one facility within the Port Authority. The emissions were calculated based on the volume of gas used. The volume was measured through controlled release of the gas using a pressure regulator for set release times in a number of temporary enclosures. The total mass of gas released was calculated based on the density of the gas at sea level (where it was released.) The final calculated mass of SF_6 released during 2007 was 0.324 kg.

9.4. RESULTS

GHG emission estimates for refrigerants purchased by the PANYNJ during calendar year 2007 are shown in Table 9-2. These estimates are based on Freon amounts that were ordered during 2007 and may not reflect what was used during the year. Future estimates should account for balances on hand at the beginning and end of the year.

Table 9-2. Direct Fugitive Loss GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emission Totals (metric tons)		
Department/Facility	**HFC-134a**	**SF_6**	**CO_2e**
PATH	0.0272	0	35.4
TBT-Lincoln Tunnel	0.0136	0	17.7
Operation Services Department-Central Automotive Division	0.49	0	636.8
Engineering Department	0	0.000324	7.8
Totals	**0.5986**	**0.000324**	**697.7**

9.5. COMPARISON WITH ESTIMATES IN PREVIOUS STUDIES

As shown in Table 9-3, the GHG emissions from fugitive emissions did not change very much from 2006 to 2007. In addition to the inclusion of a new emissions source and GHG in SF_6, there were some changes in the amounts of

HFC-134a used by individual departments. Overall, direct fugitive loss emissions were 10 percent lower during 2007 than they were in 2006.

Table 9-3. Direct Fugitive Loss – CO_2 Equivalent GHG Emissions Comparison

Department	CO_2 Equivalent (metric tons)		Percentage Difference
	2006	2007	
Aviation-Newark Airport	0	0	0%
Aviation-JFK Airport	0	0	0
PATH	17.7	35.4	100
Port Commerce-NJ Marine Terminals	17.7	0	-100
TBT-George Washington Bridge	0	0	0
TBT-Lincoln Tunnel	35.4	17.7	-50
Operation Services Department-Central Automotive Division	707.5	636.8	-10
Engineering	0	7.8	N/A
Totals	**778.3**	**697.7**	**-10%**