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

# CALENDAR YEAR 2008

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


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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ATADS | Air Traffic Activity System |
| CAP | criteria air pollutant |
| CBECS | Commercial Building Energy Consumption Survey |
| CCAR | California Climate Action Registry |
| $CH_4$ | 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 |

| | |
|---|---|
| LGOP | Local Government Operations Protocol |
| 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 |
| TB&T | tunnels, bridges, and terminals |
| 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 2008. The inventory includes direct PANYNJ emissions (e.g. energy use at administration buildings and employee travel) plus 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 2008. It is the third 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 (Scope 1 and 2) and indirect emissions (Scope 3).

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 (inventory through modeling past events) emissions rather than rely on direct measurement (air monitoring).
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 ($CO_2$e) 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 $CO_2$e 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 $CO_2$ and these GWPs were adjusted again during 2007 in the Fourth Assessment Report. 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, TAR, and Fourth Assessment Report GWPs.

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

| Greenhouse Gas | GWP (SAR, 1996) | GWP (TAR, 2001) | GWP (FAR, 2007) |
|---|---|---|---|
| $CO_2$ | 1 | 1 | 1 |
| $CH_4$ | 21 | 23 | 25 |
| $N_2O$ | 310 | 296 | 298 |
| HFC-23 | 11,700 | 12,000 | 14,800 |
| HFC-125 | 2,800 | 3,400 | 3,500 |
| HFC-134a | 1,300 | 1,300 | 1,430 |
| HFC-143a | 3,800 | 4,300 | 4,470 |
| HFC-152a | 140 | 120 | 124 |
| HFC-227ea | 2,900 | 3,500 | 3,220 |
| HFC-236fa | 6,300 | 9,400 | 794 |
| HFC-43-10mee | 1,300 | 1,500 | 1,640 |
| $CF_4$ | 6,500 | 5,700 | 7,390 |
| $C_2F_6$ | 9,200 | 11,900 | 12,200 |
| $C_3F_8$ | 7,000 | 8,600 | 8,830 |
| $C_4F_{10}$ | 7,000 | 8,600 | 8,860 |
| $C_5F_{12}$ | 7,500 | 8,900 | 9,160 |
| $C_6F_{14}$ | 7,400 | 9,000 | 9,300 |
| $SF_6$ | 23,900 | 22,000 | 22,800 |

### 1.1.2. GHG and CAP 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 (CCAR) (or the equivalent Registry for New York and New Jersey – which currently is The Climate Registry [TCR]). CCAR is based on the requirements of the accepted guidelines and principles in the World Resources Institute (WRI) GHG protocol.

TCR 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. Equity share reporting is most common for profit-making corporations. Management control is more appropriate than equity share for an entity like the PANYNJ because 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 because it was the most complete and comprehensive way for the Port Authority to report its emissions.

Table 1-2 summarizes the boundaries that were applied in this study for the departments and facilities included in the 2008 emission inventory. The organizational boundary established for GHGs was also applied to CAPs in that CAP emission estimates were developed for all of the emission sources listed in Table 1-2. 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 and CAP Emissions Inventory**

| Department | Boundary |
|---|---|
| Aviation | • Civil and commercial use of airplanes, up to 3,000 feet<br>• Aircraft ground support equipment<br>• Vehicle trips attracted by the airport, including those of private vehicles, taxis, and buses<br>• Aviation Terminal Buildings (excluding those leased to tenants and accounted for under Real Estate and Development)<br>• AirTrain System |
| Port Commerce | • All vessels that call on and support vessels that call on Port Authority facilities within the three-mile demarcation line off the eastern coast of the United States<br>• Cargo handling equipment /Automotive Shipping/On-Dock Locomotive Switchers<br>• Drayage trucks/Rail freight to the first point of rest<br>• Marine Terminal Buildings (excluding those leased to tenants and accounted for under Real Estate and Development) |
| Tunnels, Bridges, & Terminals (TB&T) | • Emissions based on vehicle volume, the roadway length of each facility, and the vehicle hours of delay in toll lane queues<br>• Terminals include all vehicle travel within the terminal property |
| PATH | • Traction power<br>• Commuters' vehicle trips to PATH stations<br>• Fuel consumption of Utility Track Vehicles and other diesel equipment<br>• PATH Terminal Buildings |
| Real Estate & Development | • Office space leased by the Port Authority<br>• Buildings leased to tenants (operating and capital leases)<br>• 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 of PA owned and/or operated vehicles |
| 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 2008 GHG Emission Inventory**

<table>
<tr><td>AVIATION<br>• John F. Kennedy International Airport<br>• LaGuardia Airport<br>• Newark Liberty International Airport<br>• Teterboro Airport<br>• Stewart International Airport<br>• Downtown Manhattan Heliport<br>• AirTrain JFK / AirTrain Newark<br>• KIAC Cogeneration Plant</td><td>TUNNELS, BRIDGES, & TERMINALS<br>• George Washington Bridge<br>• Bayonne Bridge<br>• Goethals Bridge<br>• Outerbridge Crossing<br>• Lincoln Tunnel<br>• Holland Tunnel<br>• George Washington Bridge Bus Station<br>• Port Authority Bus Terminal</td></tr>
<tr><td rowspan="2">REAL ESTATE & DEVELOPMENT<br>• Bathgate Industrial Park<br>• The Teleport<br>• The Legal Center<br>• World Trade Center<br>• Essex County Resource Recovery Facility<br>• PA leased space:<br>  • 225/233 Park Avenue South<br>  • One Madison Avenue<br>  • 115 Broadway<br>  • Gateway Plaza I, II, III<br>  • 5 Marine View<br>  • 777 Jersey Avenue<br>  • Port Authority Technical Center<br>  • KAL Building at JFK</td><td>PORT COMMERCE<br>• Port Newark / Elizabeth PA Marine Terminal<br>• Howland Hook Marine Terminal and Port Ivory<br>• Brooklyn PA Marine Terminal<br>• Auto Marine Terminal and Greenville Yard<br>• Elizabeth Landfill</td></tr>
<tr><td>PATH<br>• PATH Rapid Transit System<br>  • 13.8 route miles<br>  • 13 stations<br>  • Journal Square Transportation Center<br>  • Harrison Car Maintenance Facility<br>  • Waldo Yard Buildings</td></tr>
</table>



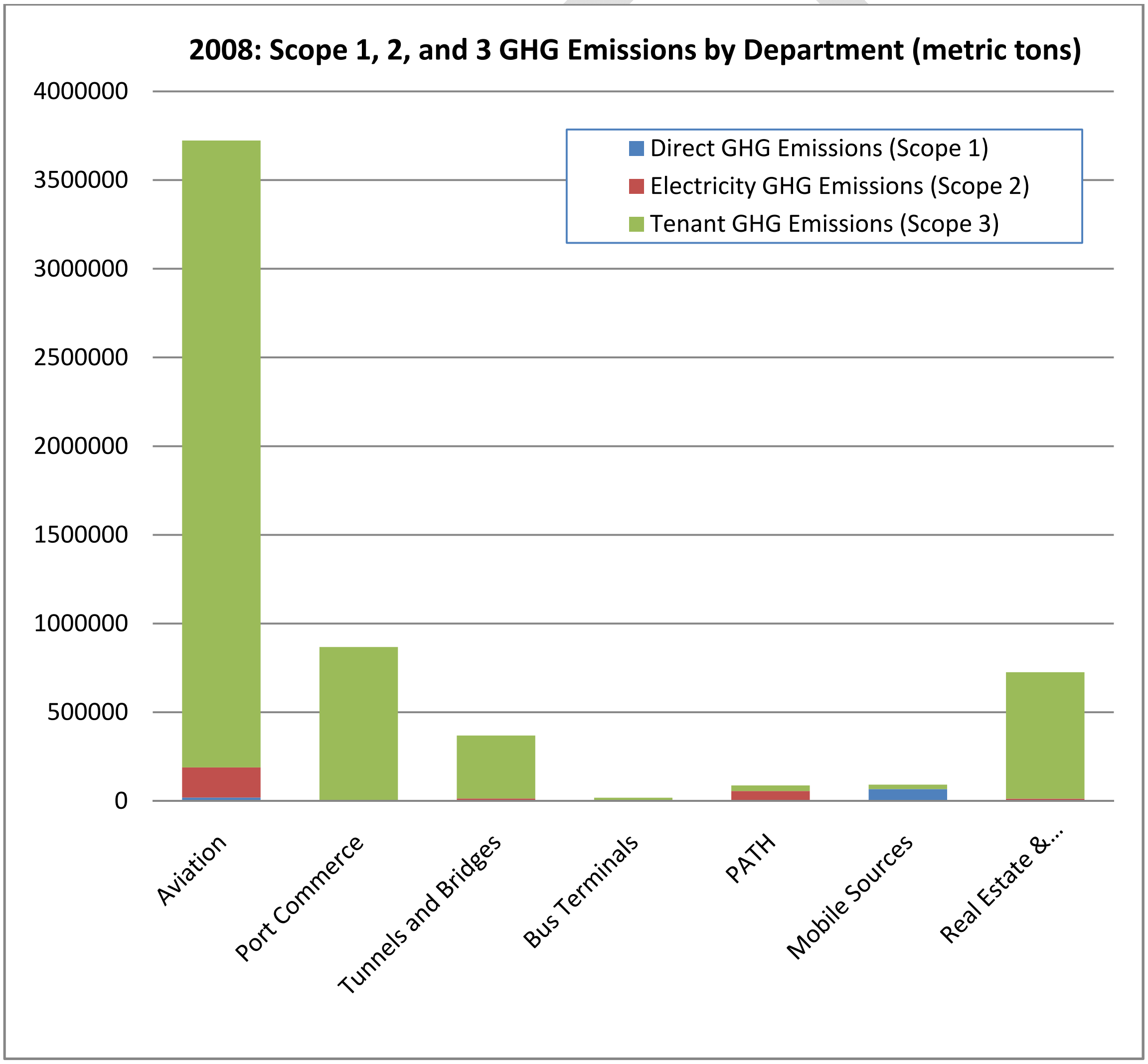
## 1.2. RESULTS SUMMARIES

### 1.2.1. GHG Results

This section of the report summarizes the key results of the GHG emission estimates in $CO_2$e terms. The GHG emissions inventory for calendar year 2008 estimates that PANYNJ GHG direct and indirect emissions total approximately 5.88 million metric tons of $CO_2$e. PANYNJ GHG direct and indirect emissions were approximately 5.89 million metric tons of $CO_2$e in 2007 and 5.77 million metric tons of $CO_2$e in 2006. A comparison of annual emissions between 2006 – the baseline year – and 2008 can be found in Table 1-8. Table 1-4 and Figure 1-1 show the 2008 $CO_2$e emissions by department. The Aviation Department has the highest GHG emissions (63.3 percent), followed by Port Commerce (14.7 percent), and Real Estate and Development (12.3 percent). Tunnels, Bridges and Terminals, PATH and mobile sources contribute the remaining 9.6 percent of 2008 GHG emissions.

**Table 1-4. Total (Scope 1, 2, and 3) PANYNJ $CO_2$ Equivalent Emissions in 2008 (metric tons)**

| Department | Direct GHG Emissions Scope 1 | Indirect Electricity GHG Emissions Scope 2 | Other Indirect GHG Emissions Scope 3 | Totals |
|---|---|---|---|---|
| **Aviation** | 19,195 | 169,837 | 3,534,382 | **3,723,414** |
| **Port Commerce** | 4,394 | 0 | 862,877 | **867,271** |
| **Tunnels and Bridges** | 2,513 | 10,600 | 355,842 | **368,955** |
| **Bus Terminals** | 23 | 0 | 18,212 | **18,235** |
| **PATH** | 703 | 55,177 | 31,597 | **87,477** |
| **Mobile Sources** | 66,800 | 0 | 24,949 | **91,749** |
| **Real Estate & Development** | 3,117 | 9,404 | 713,177 | **725,698** |
| **Total** | **96,745** | **245,018** | **5,541,036** | **5,882,799** |



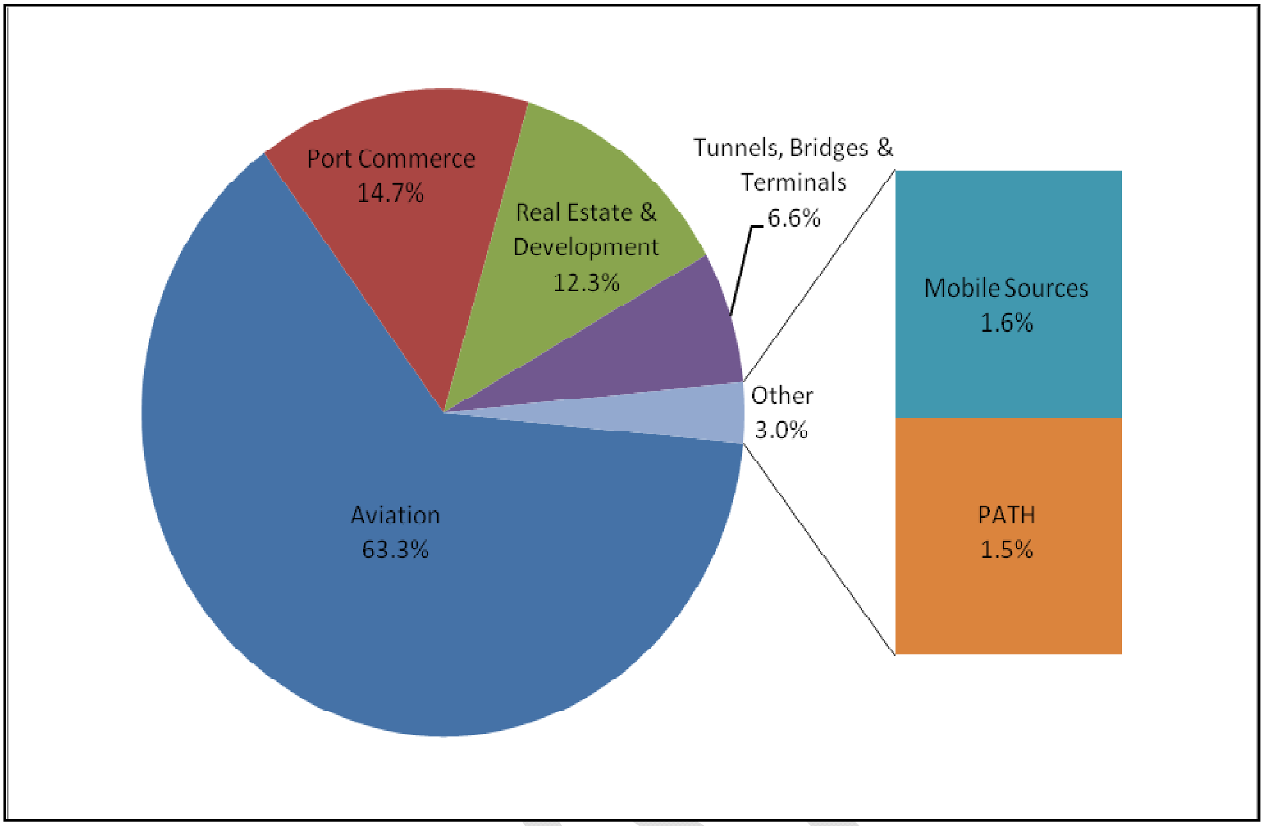



**Figure 1-1. $CO_2$ Equivalent Emissions by Department**

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, including CCAR and TCR, 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 TCR. One reason for treating Scope 3 emissions as optional is that one organization's Scope 3 emissions are usually another organization's Scope 1 and 2 emissions. This GHG inventory reports Scope 3 emissions along with Scope 1 and 2 emissions.

Figure 1-2 shows the contributions of the different departments to Scope 1 and Scope 2 GHG emissions during 2008. This figure shows that the Aviation Department produced 55.3 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 16.4 percent of the PANYNJ's Scope 1 and 2 emissions. This is primarily due to the electricity purchased to run the PATH trains. The remainder of the Scope ½ GHG emissions were divided between Tunnels, Bridges, and Terminals and Real Estate and Development, dominated by fleet vehicles and buildings emissions, and Port Commerce, dominated by landfill gas emissions.

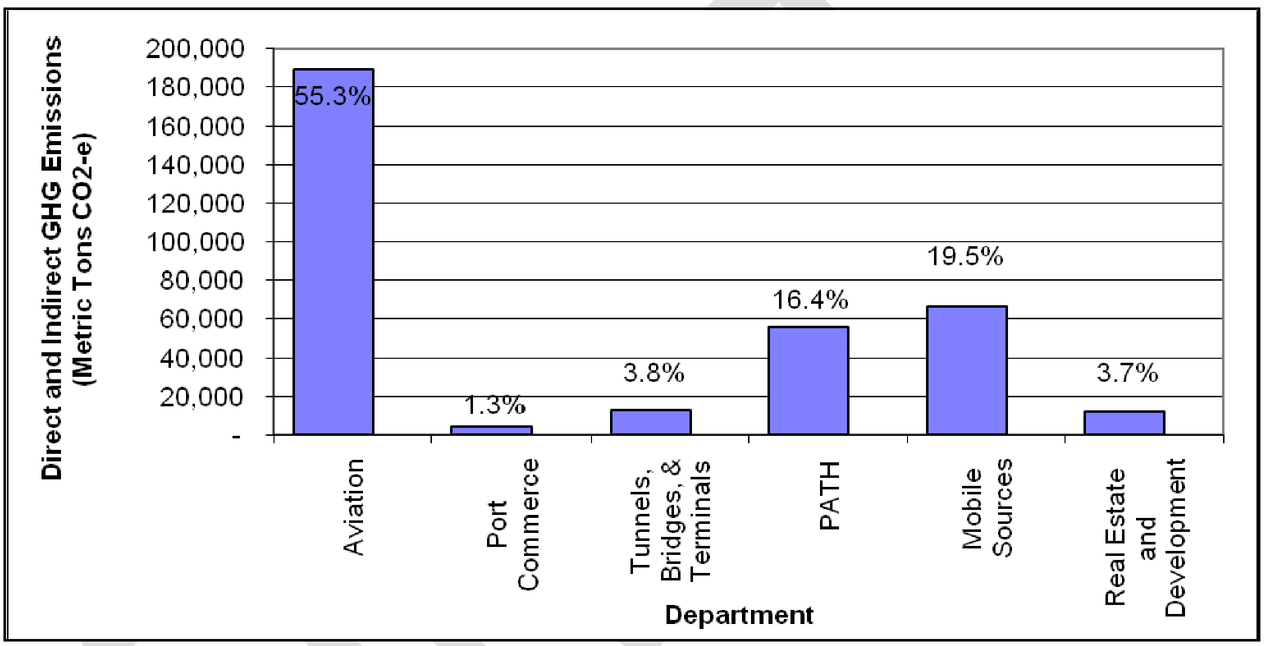



**Figure 1-2. $CO_2$ Equivalent Total (Direct and Indirect) GHG Emissions, by Department (Total=5,882,787 metric tons)**

Figure 1-3 displays the Port Authority's 2008 calendar year Scope 3 GHG emission estimates by department. The Scope 3 emissions are dominated by the following departments: Aviation (63.8 percent); Port Commerce (15.6 percent); and Real Estate and Development (12.9 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.

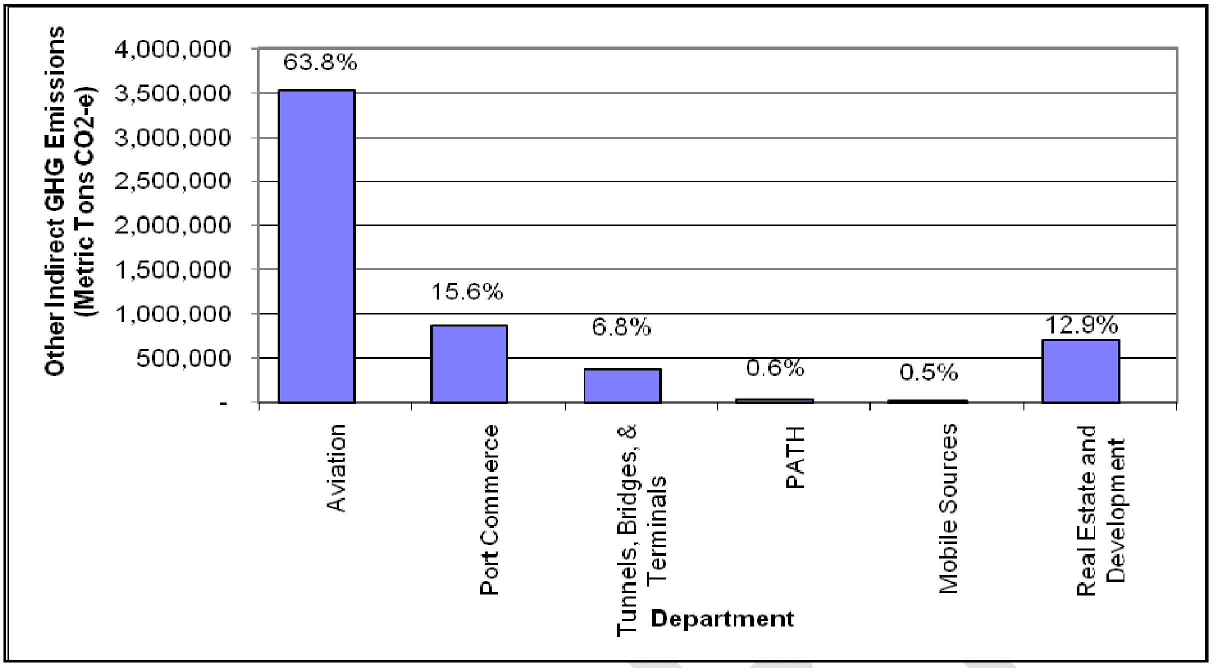



**Figure 1-3. $CO_2$ Equivalent Indirect (Scope 3) GHG Emissions, by Department**

As seen in Figure 1-4, 94.2 percent of the total emissions reported in this 2008 GHG inventory are Scope 3 emissions, which are shown in detail in Table 1-3. The Scope 1 and 2 emissions make up the remaining 1.6 percent and 4.2 percent, respectively.

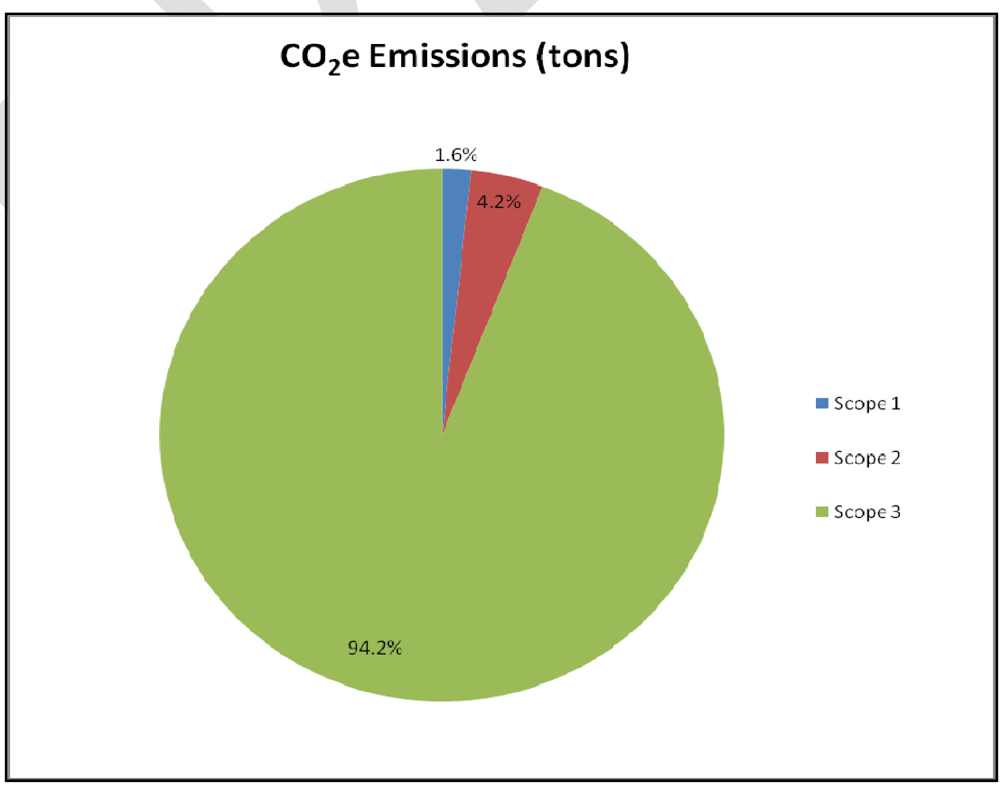


**Figure 1-4. Port Authority 2008 GHG Emissions by Scope**

Figure 1-5 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 71.7 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 18.3 percent). Most of this construction equipment is diesel-powered. Port Authority fleet vehicles also make a significant contribution to emissions (approximately 3.4 percent). Another important Scope 1 and 2 emissions source is heating fuel (primarily natural gas) combustion at facilities under direct PANYNJ management control (approximately 5.1 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.

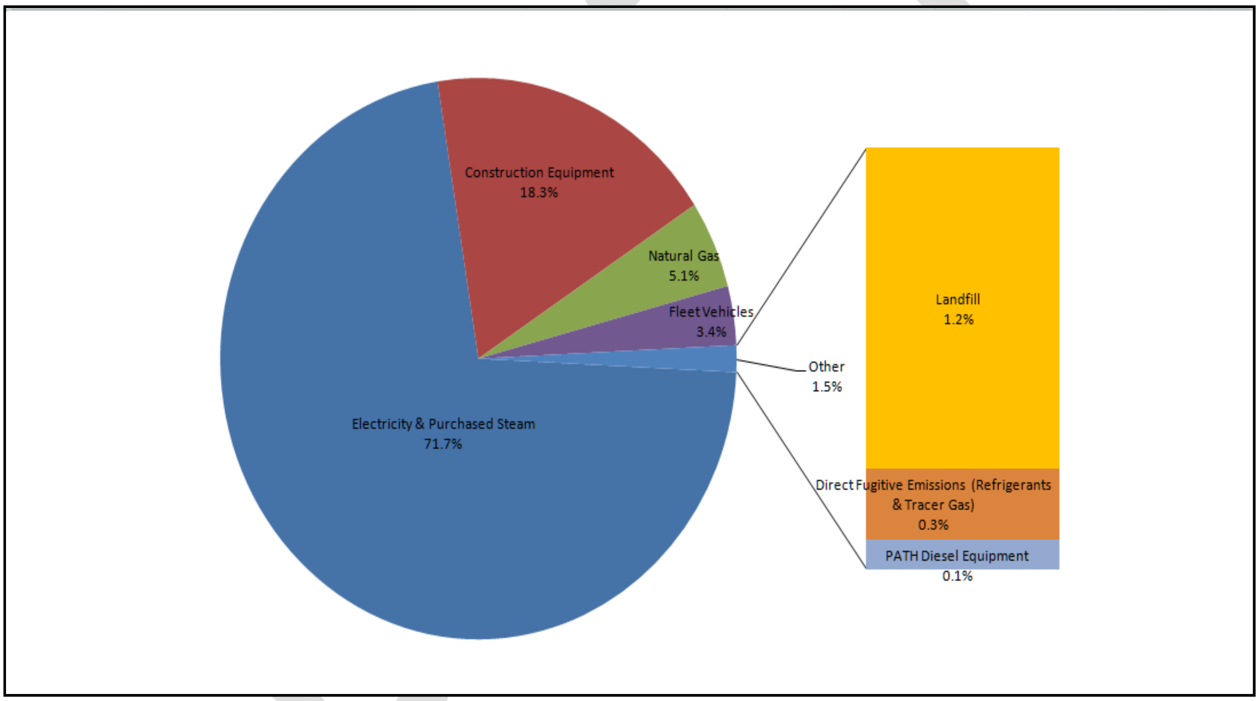



**Figure 1-5. GHG Emissions Under Direct Management Control**

Figure 1-6 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 37.4 percent, and aircraft emissions account for approximately 37.1 percent, of Scope 3 emissions. The remaining 25.4 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.

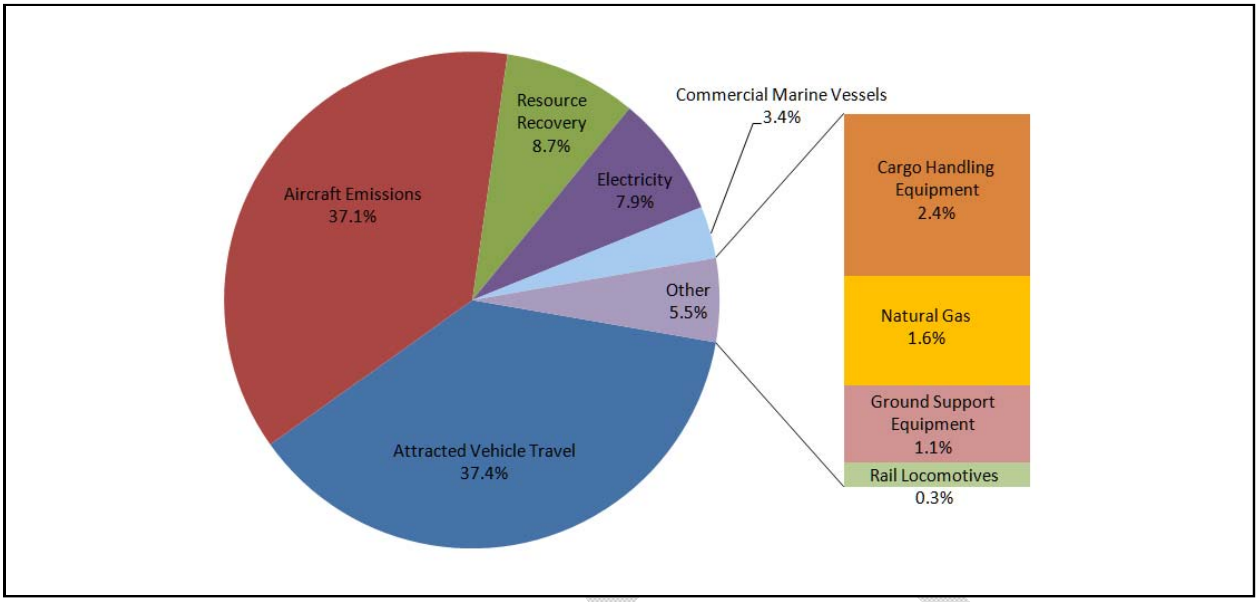



**Figure 1-6. GHG Emissions Outside Management Control**

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 94.2 percent of the total organizational emissions. Scope 3 emissions are generated by tenants operating on PANYNJ properties. Figure 1-7 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 2008 (metric tons)**

| Department | Direct GHG Emissions Scope 1 | Indirect Electricity GHG Emissions Scope 2 | Other Indirect GHG Emissions Scope 3 | Totals |
|---|---|---|---|---|
| **Aviation** | | | | |
| Aircraft | 0 | 0 | 2,058,306 | 2,058,306 |
| AirTrain | 0 | 29,219 | 0 | 29,219 |
| Ground Support Equipment | 0 | 0 | 62,974 | 62,974 |
| Attracted Travel | 0 | 0 | 1,185,261 | 1,185,261 |
| Buildings | 14,449 | 140,618 | 167,724 | 322,791 |
| JFK Co-generation Plant | 0 | 0 | 60,117 | 60,117 |
| Fleet Vehicles | 4,233 | 0 | 0 | 4,233 |
| Direct Fugitive Emissions (Refrigerants) | 513 | 0 | 0 | 513 |
| **Port Commerce** | | | | |
| Commercial Marine Vessels | 0 | 0 | 187,943 | 187,943 |
| Cargo Handling Equipment | 0 | 0 | 131,863 | 131,863 |
| Rail Locomotives | 0 | 0 | 19,233 | 19,233 |
| Heavy-Duty Vehicles | 0 | 0 | 469,873 | 469,873 |
| Buildings | 0 | 0 | 53,965 | 53,965 |

| Department | Direct GHG Emissions Scope 1 | Indirect Electricity GHG Emissions Scope 2 | Other Indirect GHG Emissions Scope 3 | Totals |
|---|---|---|---|---|
| Landfill | 4,011 | 0 | 0 | 4,011 |
| Fleet Vehicles | 383 | 0 | 0 | 383 |
| **Tunnels and Bridges** | | | | |
| Attracted Travel | 0 | 0 | 332,377 | 332,377 |
| Queuing | 0 | 0 | 23,465 | 23,465 |
| Buildings | 720 | 10,600 | 0 | 11,320 |
| Direct Fugitive Emissions (Refrigerants) | 20 | 0 | 0 | 20 |
| Fleet Vehicles | 1,773 | 0 | 0 | 1,773 |
| **Bus Terminals** | | | | |
| In Terminal Vehicle Emissions | 0 | 0 | 4,676 | 4,676 |
| Buildings | 0 | 0 | 13,536 | 13,536 |
| Fleet Vehicles | 23 | 0 | 0 | 23 |
| **PATH** | | | | |
| Trains | 0 | 42,194 | 0 | 42,194 |
| Attracted Travel | 0 | 0 | 31,597 | 31,597 |
| Buildings | 0 | 12,983 | 0 | 12,983 |
| Direct Fugitive Emissions (Refrigerants) | 39 | 0 | 0 | 39 |
| Diesel Equipment including Utility Track Vehicles and Generators | 373 | 0 | 0 | 373 |
| Fleet Vehicles | 291 | 0 | 0 | 291 |
| **Mobile Sources** | | | | |
| Fleet Vehicles | 66 | 0 | 0 | 66 |
| Public Safety Department Fleet Vehicles | 3,853 | 0 | 0 | 3,853 |
| Direct Fugitive Emissions (Refrigerants) | 295 | 0 | 0 | 295 |
| Construction Equipment | 62,586 | 0 | 0 | 62,586 |
| Employee Commuting | 0 | 0 | 24,949 | 24,949 |
| **Real Estate & Development** | | | | |
| Buildings | 2,101 | 9,404 | 232,381 | 243,886 |
| Resource Recovery Facility | 0 | 0 | 480,796 | 480,796 |
| Fleet Vehicles | 1,004 | 0 | 0 | 1,004 |
| **Engineering** | 12 | 0 | 0 | 12 |
| **Total** | **96,745** | **245,018** | **5,541,036** | **5,882,799** |

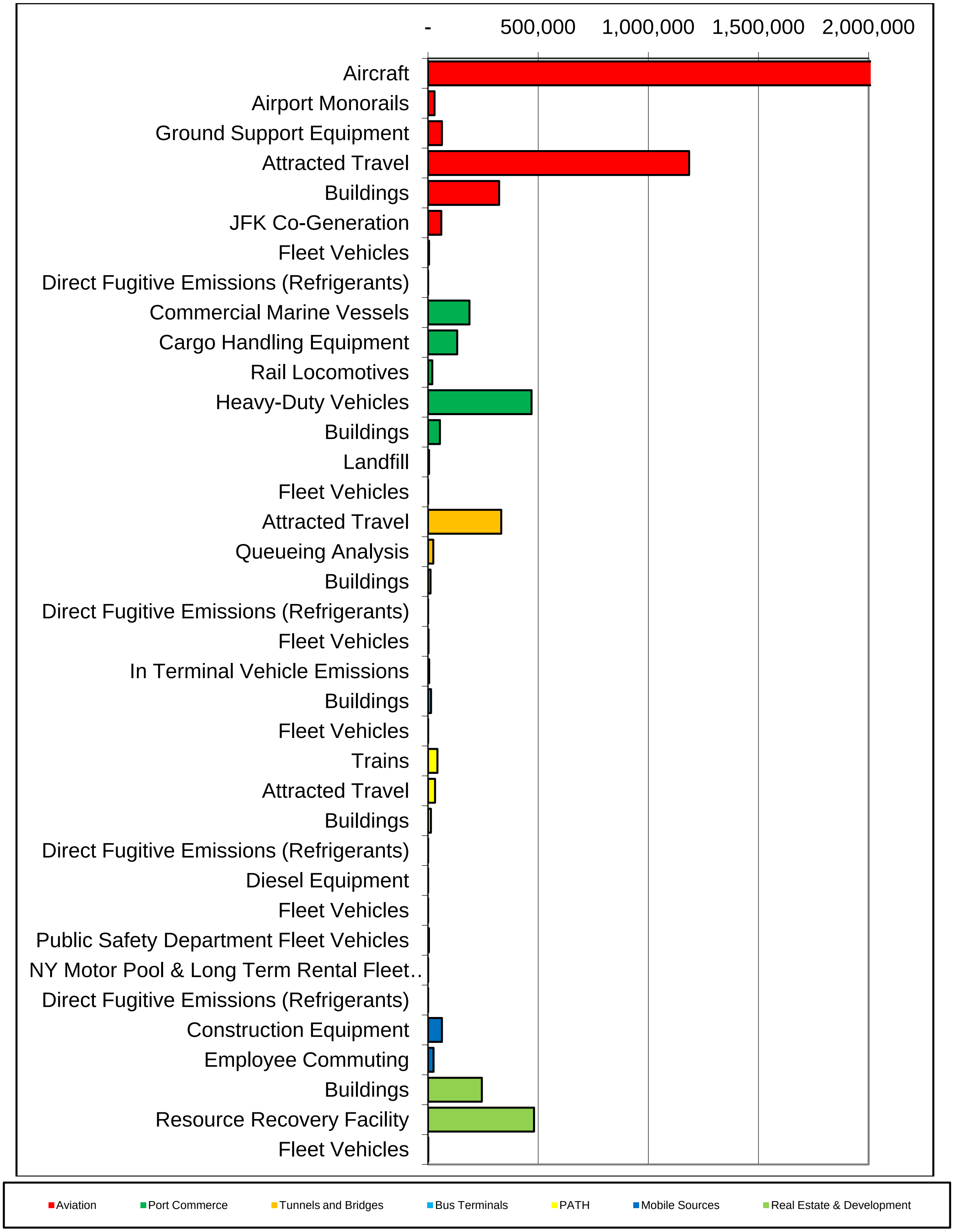



**Figure 1-7. GHG Emissions by Activity Type**

## 1.3. COMPARISON WITH PREVIOUS STUDY YEARS

This section compares the 2008 calendar year GHG emission estimates for the Port Authority with those developed previously for calendar years 2006 and 2007. The overall $CO_2$ equivalent emissions went from 5,752,987 metric tons in 2006 to 5,882,799 metric tons in 2008, a 2 percent increase. The tables that follow provide 2006 versus 2008 GHG emission comparisons at differing levels of detail. Table 1-6 shows Scope 1 plus Scope 2 $CO_2$e emission estimates for the three 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, and then increased slightly between 2007 and 2008, so that CY2008 GHG emissions are 4.0 percent below 2006 baseline levels. GHG mobile sources emissions are the only ones that have risen each year during the three year period, and this is mostly attributable to construction equipment fuel usage. The methods used to estimate construction equipment emissions use construction spending as a surrogate for construction activity, and do not account for any efficiency improvements that may be occurring in Port Authority construction projects.

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

| Department | Total $CO_2$e Emissions (Metric Tons) | | | | Percent Difference (2008-2006) |
|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | Difference (2008-2006) | |
| Aviation | 214,334 | 183,841 | 189,032 | (25,302) | -11.8% |
| Port Commerce | 4,550 | 4,395 | 4,394 | (156) | -3.4% |
| Tunnels, Bridges & Terminals | 19,737 | 19,024 | 13,136 | (6,601) | -33.4% |
| PATH | 49,363 | 53,299 | 55,880 | 6,517 | 13.2% |
| Mobile Sources | 54,611 | 60,414 | 66,800 | 12,190 | 22.3% |
| Real Estate & Development | 13,275 | 9,009 | 12,509 | (766) | -5.8% |
| Engineering | 0 | 8 | 12 | 12 | N/A |
| **Total** | **355,870** | **329,990** | **341,763** | **(14,107)** | **-4.0%** |

Table 1-7 compares the 2006, 2007, and 2008 total Scope 3 GHG emissions associated with each Port Authority department. Overall, Scope 3 GHG emissions increased by 2.5 percent from 2006 to 2008.

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

| Department | Total $CO_2$e Emissions (Metric Tons) | | | | Percent Difference (2008-2006) |
|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | Difference (2008-2006) | |
| Aviation | 3,384,615 | 3,556,431 | 3,534,382 | 149,767 | 4.4% |
| Port Commerce | 886,579 | 904,811 | 862,877 | (23,702) | -2.7% |
| Tunnels, Bridges & Terminals | 390,965 | 382,735 | 374,054 | (16,911) | -4.3% |
| PATH | 27,805 | 30,662 | 31,597 | 3,792 | 13.6% |
| Mobile Sources | 27,080 | 27,198 | 24,949 | (2,131) | -7.9% |
| Real Estate & Development | 690,243 | 662,622 | 713,177 | 22,934 | 3.3% |
| **Total** | **5,407,287** | **5,564,459** | **5,541,036** | **133,749** | **2.5%** |

Table 1-8 compares the total GHG emissions for 2006, 2007, and 2008 by Department and source type. Aircraft emissions increased by about 5 percent from 2006 to 2008. This increase really occurred between 2006 and 2007, when JFK increased the number of allowable flights per hour and LTOs increased. The Port Authority took over responsibility for Stewart Airport in November 2007, but including the LTOs from this airport in the GHG emissions during 2008 was less of a factor in the overall increase in aircraft GHGs than the LTO increases at JFK and increased helicopter activity at the downtown Manhattan Heliport. Newark, Teterboro, and LaGuardia airports all had lower GHG emissions in 2008 than in 2006. The GHG emission estimation methods used for 2006-2008 account for differences in the aircraft types that used these airports, but it does not capture differences in operations that may be occurring to save fuel.

Some increases in aviation attracted travel and buildings GHG emissions occurred between 2006 and 2008, but these increases were smaller in magnitude than the aircraft emission increases. The JFK Cogeneration plant GHG emissions (direct emissions from energy not used at the airport) dropped by 16 percent from 2006 to 2008 as KIAC burned a lower amount of natural gas in 2008 compared with 2006.

Port Commerce GHG emissions are fairly stable (a 1 percent overall reduction) over the 2006 to 2008 period as estimated increases in heavy-duty vehicle activity and buildings energy use is offset by reductions in commercial marine vessel emissions and cargo handling equipment emissions. Commercial marine vessel emission reductions are mostly attributable to reduced dredging activity in 2008.

TB&T GHG emissions in 2008 are below 2006 levels primarily because of lower vehicle volumes on bridges and tunnels and because building energy consumption for this department declined significantly from 2007 to 2008.

PATH train and attracted travel GHG emissions increased 6.6 percent from 2006 to 2008. It should be recognized that this PATH system utilization provides a net GHG emission reduction for the New York City region because PATH train travel is more GHG efficient than passenger car travel.

Overall increases in mobile source GHG emissions from 2006 to 2008 are attributable mostly to construction equipment. Construction equipment GHG emissions are estimated using construction spending as a surrogate for activity and emissions. Construction equipment GHG emissions increased by 30 percent from 2006 to 2008.

In the mobile sources category, there are significant year to year changes in the public safety department vehicle GHG emission estimates with a significant increase between 2006 and 2007, and a large drop from 2007 to 2008. This suggests that there are anomalies in the fuel use and vehicle-miles traveled (VMT) reporting for this vehicle category in the reporting period.

Changes in Real Estate and Development Department GHG emissions between 2006 and 2008 (almost a 10 percent increase) are directly related to changes in buildings energy consumption. Essex County Resource Recovery Facility GHG emissions and activity are constant across the analysis years.

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

| Department/Source | Total $CO_2e$ Emissions (Metric Tons) | | | | Percent Difference (2008-2006) |
|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | Difference (2008-2006) | |
| **Aviation** | | | | | |
| Aircraft | 1,963,359 | 2,085,041 | 2,058,306 | 94,947 | 4.8% |
| AirTrain | 26,919 | 29,219 | 29,219 | 2,300 | 8.5% |
| Ground Support Equipment | 63,575 | 61,502 | 62,974 | (601) | -0.9% |
| Attracted Travel | 1,169,468 | 1,208,804 | 1,185,261 | 15,793 | 1.4% |
| Buildings | 301,305 | 294,112 | 322,791 | 21,486 | 7.1% |
| JFK Co-generation Plant | 71,360 | 57,815 | 60,117 | (11,243) | -15.8% |
| Fleet Vehicles | 2,963 | 3,779 | 4,233 | 1,270 | 42.9% |
| Direct Fugitive Emissions (Refrigerants) | - | - | 513 | 513 | N/A |
| **Port Commerce** | | | | | |
| Commercial Marine Vessels | 227,735 | 211,788 | 187,943 | (39,792) | -17.5% |
| Cargo Handling Equipment | 130,223 | 133,905 | 131,729 | 1,506 | 1.2% |
| Rail Locomotives | 13,345 | 18,226 | 19,233 | 5,888 | 44.1% |
| Heavy-Duty Vehicles | 449,871 | 471,399 | 469,873 | 20,002 | 4.4% |
| Buildings | 50,569 | 53,774 | 53,965 | 3,396 | 6.7% |
| Direct Fugitive Emissions (Refrigerants) | 18 | - | - | (18) | -100.0% |
| Landfill | 4,221 | 3,958 | 4,011 | (210) | -5.0% |
| Fleet Vehicles | 311 | 437 | 383 | 72 | 23.2% |
| **Tunnels and Bridges** | | | | | |
| Attracted Travel | 344,281 | 340,330 | 332,377 | (11,904) | -3.5% |
| Queuing | 24,050 | 23,954 | 23,465 | (585) | -2.4% |
| Buildings | 18,199 | 17,166 | 11,320 | (6,879) | -37.8% |
| Direct Fugitive Emissions (Refrigerants) | 35 | 18 | 20 | (15) | -43.5% |
| Fleet Vehicles | 1,491 | 1,827 | 1,773 | 282 | 18.9% |
| **Bus Terminals** | | | | | |
| In Terminal Vehicle Emissions | 6,345 | 4,588 | 4,676 | (1,669) | -26.3% |
| Buildings | 16,289 | 13,863 | 13,536 | (2,753) | -16.9% |
| Fleet Vehicles | 12 | 13 | 23 | 11 | 91.7% |
| **PATH** | | | | | |
| Trains | 40,828 | 40,206 | 42,194 | 1,366 | 3.3% |
| Attracted Travel | 27,805 | 30,662 | 31,597 | 3,792 | 13.6% |
| Buildings | 12,743 | 12,632 | 12,983 | 240 | 1.9% |
| Direct Fugitive Emissions (Refrigerants) | 18 | 35 | 39 | 21 | 120.3% |
| Diesel Equipment including Utility Track Vehicles and Generators | 284 | 272 | 373 | 89 | 31.2% |
| Fleet Vehicles | 156 | 154 | 291 | 135 | 86.5% |
| **Mobile Sources** | | | | | |
| Fleet Vehicles | 364 | 136 | 66 | (298) | -81.9% |
| Public Safety Department Fleet Vehicles | 5,252 | 8,259 | 3,853 | (1,399) | -26.6% |
| Direct Fugitive Emissions (Refrigerants) | 708 | 637 | 295 | (413) | -58.3% |
| Construction Equipment | 48,287 | 51,382 | 62,586 | 14,299 | 29.6% |
| Employee Commuting | 27,080 | 27,198 | 24,949 | (2,131) | -7.9% |
| **Real Estate & Development** | | | | | |
| Buildings | 222,075 | 195,856 | 243,886 | 21,811 | 9.8% |
| Resource Recovery Facility | 480,073 | 474,668 | 480,796 | 723 | 0.2% |
| Fleet Vehicles | 1,370 | 1,107 | 1,004 | (366) | -26.7% |
| **Engineering** | 0 | 8 | 12 | 12 | N/A |
| **Total** | **5,752,987** | **5,878,730** | **5,882,799** | **129,812** | **2.3%** |

Figure 1-8 provides an evaluation of the Port Authority airport GHG emissions from 2006 to 2008 and how these emissions have changed on a per operations basis. At the four major airports operated by the Port Authority during 2006-2008, the number of operations increased from 1.42 million in 2006 to 1.46 million in 2008. The $CO_2e$ emissions at these four airports increased from 1.936 million metric tons to 1.971 million metric tons. However, on a per aircraft operations basis, the GHG emissions declined from 1.366 tonnes per passenger to 1.354 tonnes. This is a one percent drop in the per aircraft operations GHG emission rate over these three years.

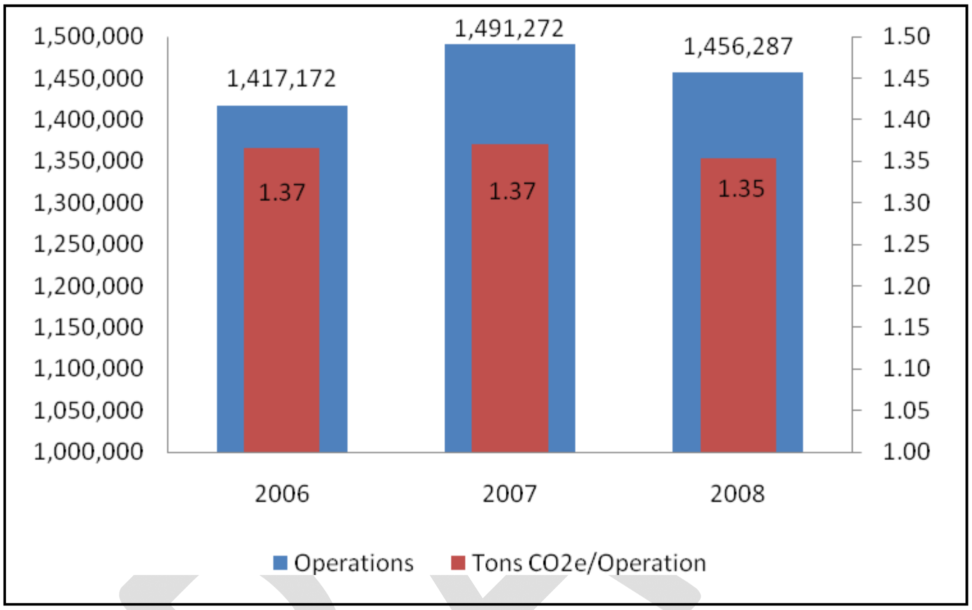



**Figure 1-8. Aircraft Emissions per Operation at JFK, Newark, LaGuardia, and Teterboro**

Passenger data for the three analysis years is only available for Newark, LaGuardia, and JFK airports, so the per passenger GHG analysis shown in Figure 1-9 is limited to these three airports. The number of passengers at these three airports was 104.2 million during 2006, increasing to 107.2 million in 2007, and decreasing to 106.2 million in calendar year 2008. The per passenger GHG emission rates changed from 17.43 kg per person in 2006 to 18.1 kg per person in 2007, and then declined to 17.72 kg per passenger in 2008 as shown in Figure 1-9.

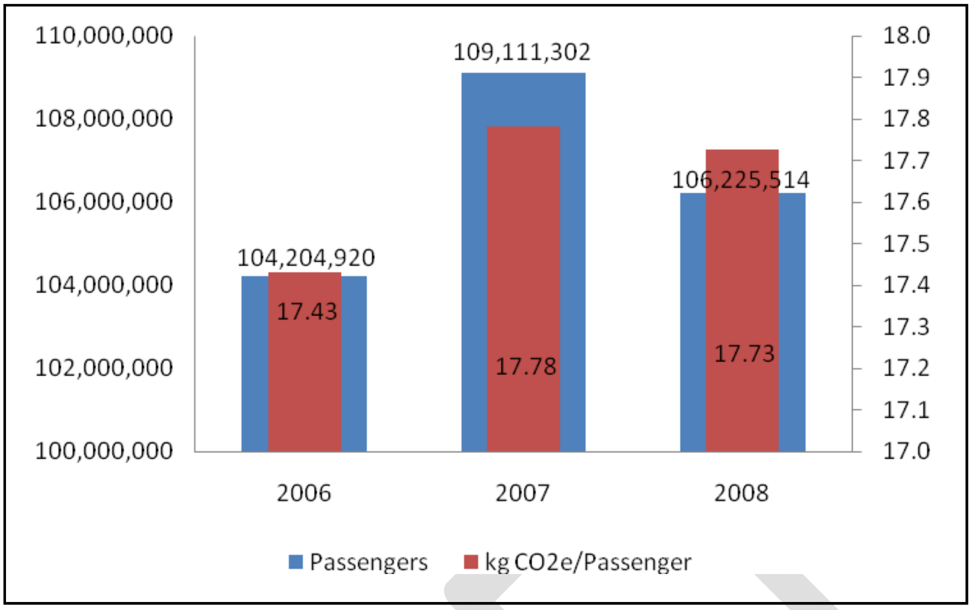



**Figure 1-9. Aircraft Emissions per Passenger at JFK, Newark, and LaGuardia**

Figure 1-10 shows how Port Commerce source category GHG emissions have changed from 2006 to 2008 using an indicator of the amount of cargo being handled in the port terminals as a metric for examining GHG emissions per unit of cargo handled. Figure 1-10 shows $CO_2$e emissions for the three years per twenty foot equivalent unit (TEU) for the three most prominent GHG emission sources within these port terminals – commercial marine vessels, cargo handling equipment, and locomotives. $CO_2$e emissions for commercial marine vessels drop from 43.5 kg $CO_2$e per TEU in 2006 to 37.5 kg $CO_2$e per TEU in 2008. This decline is probably attributable to reduced dredging activity. Cargo handling equipment emissions when expressed per TEU, increase from 24.8 kg $CO_2$e to 26.3 kg $CO_2$e in 2008 – a 6 percent increase. Locomotive emissions per TEU increased during this period – as shown in Figure 1-10 – because rail locomotives were used more frequently as an option for moving freight from the port terminals in 2007 and 2008 than during 2006. Rail is a more GHG efficient travel mode than moving freight by truck, so changing the travel mix to favor rail is providing overall GHG emission reductions.

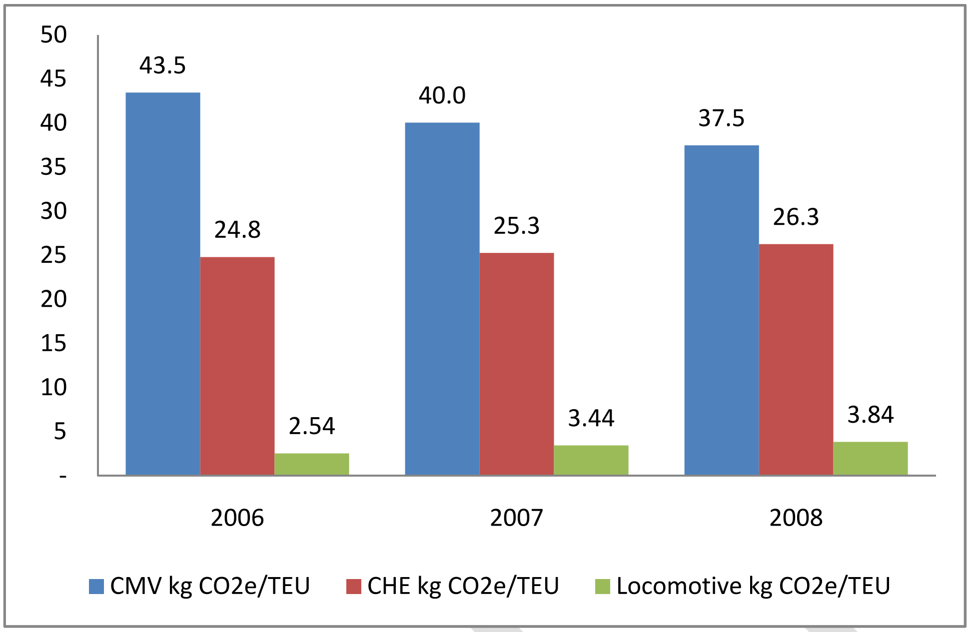



**Figure 1-10. Port Commerce Emissions Per Twenty Foot Equivalent Units (TEU) Handled**

## 1.4. CRITERIA AIR POLLUTANTS

Table 1-9 summarizes the Port Authority CAP emission estimates by pollutant for 2006 through 2008.

**Table 1-9. Port Authority Annual Criteria Air Pollutant Emissions (metric tons)**

| Year | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| 2006 | 23,978 | 5,457 | 1,134 | 1,021 |
| 2007 | 24,274 | 5,954 | 1,153 | 1,360 |
| 2008 | 23,327 | 6,138 | 1,328 | 1,156 |

The criteria pollutant emission estimates have remained relatively stable over this analysis period. $NO_x$ is probably the most important of these pollutants because of its importance as an ozone precursor and the New York City area's continuing ozone nonattainment area status. $NO_x$ emissions in 2008 from Port Authority owned and operated facilities in 2008 are slightly less than they were estimated to be in 2006. The Port Authority's $NO_x$ emissions are dominated by Aviation and Port Commerce emission sources. Key sources include aircraft, airport attracted travel, commercial marine vessels and Port Commerce-cargo handling equipment. The slight upward trend in $SO_2$ emissions from 2006 to 2008 (a 12 percent increase) is mostly attributable to buildings energy use increases in 2008. Commercial marine vessels are the largest $SO_2$ source in the inventory, but commercial marine vessel emissions in 2008 are just below what they were during 2006.

## 1.5. 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 third GHG emission inventory year for the Port Authority, the chapters that follow also include some comparisons among 2006, 2007, and 2008 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.

For the GHG emission comparison tables presented in the chapters that follow, 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 $PM_{2.5}$ nonattainment 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 EPA'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. Stewart International Airport (SWF); and
f. Downtown Manhattan Heliport, on which Port Authority ended its lease in 2007, but continued to manage during most of 2008.

Five airports and one heliport controlled by the Port Authority are included in the 2008 GHG and CAP inventories (NYC, 2007). In New Jersey, Teterboro Airport and Newark Liberty International Airport are accounted for. In

New York, LaGuardia Airport, John F. Kennedy International Airport and Stewart International Airport are accounted for. The Downtown Manhattan Heliport is also included, although as of November 1, 2008 it is no longer under Port Authority control. (Air Charter Journal, 2008)

### 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 in the form of a table listing the number of arrivals and departures from each airport by aircraft model for LaGuardia, JFK, Teterboro, and Newark. The aircraft models were identified by four character abbreviations.

The aircraft models provided by the Port Authority were matched to the models with IPCC emission factors either directly or approximately using data taken from the Federal Aviation Administration’s Emission Dispersion Modeling System (EDMS). The majority of operations were directly matched with emission factors. The EDMS 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 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. Overall, over 94 percent of the operations at the airports were successfully mapped to aircraft with IPCC emission factors.

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.

In the absence of activity data, helicopter emissions from the Downtown Manhattan Heliport were estimated based on projected 2008 operations at this facility. Projections were based on the gross revenues attributed to the facility in the Port Authority annual reports from 2006-2008 and the activity data provided by Port Authority in 2006 and 2007. 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 was calculated.

The methodology used for this inventory uses GHG and CAP emission factors in terms of LTO activity, which factors in uniform assumptions about the LTO cycle. The emission factors are based on default time in mode assumptions, which in reality vary from flight to flight. Most significantly, there are assumptions about the amount of time spent taxiing and idling, which can be influenced by scheduling. As such, this inventory does not account for any potential emissions reductions from the Port Authority's delay reduction measures, which aim to decrease idling time. Updated methodologies that can account for the different times in mode for different airports are being considered for future year inventories.

### 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 $CO_2$e 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 | 582,026 | 21 | 19 | 588,366 |
| Teterboro | 86,959 | 15 | 3 | 88,230 |
| LaGuardia | 423,700 | 17 | 15 | 428,742 |
| JFK | 856,435 | 26 | 29 | 866,027 |
| Stewart | 35,317 | 2 | 1 | 35,790 |
| Downtown Manhattan Heliport | 50,704 | 0 | 1 | 51,151 |
| **Port Authority** | **2,035,141** | **80** | **69** | **2,058,306** |

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 | 2,486 | 184 | 122 | 119 |
| Teterboro | 156 | 27 | 42 | 41 |
| LaGuardia | 1,616 | 134 | 108 | 105 |
| JFK | 3,924 | 271 | 134 | 131 |
| Stewart | 115 | 11.2 | 9.6 | 9.4 |
| Downtown Manhattan Heliport | 6 | 3.5 | 20.8 | 20.3 |
| **Port Authority** | **8,304** | **630** | **436** | **425** |

### 2.1.5. Comparison with Estimates in Previous Studies

In 2008, the Port Authority's airports handled a total of 107 million passengers, a slight downturn from the record totals in 2007. Most of the reductions were at LaGuardia, which had a 7.7 percent decrease from 2007 (PANYNJ, 2009d).

Table 2-3 compares the 2008 aircraft GHG emission estimates in this study with those developed previously. Emissions from operations at the four largest airports declined during 2008 due to the decrease in passengers and flights. Stewart Airport was accounted for all 12 months in this inventory, as opposed to the 2007 inventory where it only was under Port Authority control for two months. The Downtown Manhattan Heliport also had a large increase in emissions, because the number of operations increased dramatically compared to the baseline. The declines in passengers and emissions in 2008 did not erode all of the gains in 2007 at JFK, which left a net increase in emissions compared to baseline. The large number of operations at the Downtown Manhattan Heliport, along with the additional months of operations at Stewart Airport, led to a 4.6 percent increase in overall GHG emissions from aircraft at Port Authority facilities between the baseline of 2006 and 2008. If Stewart Airport is removed from the totals, aircraft GHG emissions during 2008 were 3 percent lower than during 2007 and 3 percent higher than in 2006.

**Table 2-3. Aircraft $CO_2$ Equivalent GHG Emissions Comparison**

| Airport | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | % |
| Newark | 595,538 | 611,369 | 588,366 | -1.20% |
| Teterboro | 120,198 | 103,921 | 88,230 | -26.60% |
| LaGuardia | 425,601 | 430,223 | 428,742 | 0.74% |
| JFK | 795,296 | 898,626 | 866,027 | 8.89% |
| Stewart | N/A | 2,552 | 35,790 | N/A |
| Downtown Manhattan Heliport | 26,725 | 38,350 | 45,859 | 71.60% |
| **Total** | **1,963,358** | **2,085,041** | **2,053,014** | **4.57%** |

The Local Government Operations Protocol (LGOP) provides a different methodology for GHG emissions inventories that is better suited for municipalities. LGOP's aviation methodology calls for the accounting of emissions that aircraft generate over their entire flight routes. The City of New York used the LGOP methodology in reporting the emissions of aircraft at JFK International Airport and LaGuardia Airport in 2008.

The Airport Cooperative Research Program published a Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories in 2009 which contains a number of methods for calculating GHG emissions from aircraft. These guidelines are different from the IPCC guidelines and offer a good alternative for future calendar year inventories as well as a method for recalculating the baseline year emissions. They are fuel sales based and focused on capturing total flight emissions. They also offer the ability to differentiate LTO emissions using EDMS to calculate LTO fuel use and apply appropriate GHG emission factors. In the near future, FAA is expected to release its Aviation Environmental Design Tool/System for Assessing Aviation's Global Emissions (AEDT/SAGE) tool which is consistent with EDMS for the LTO cycle, and consistent with the EPA's national GHG inventory for the total flight emissions (ACRP, 2009).

The "Inventory of New York City: Greenhouse Gas Emissions" for the year 2008 estimates that aviation is responsible for 14.3 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 1.3 million metric tons. Because the LTO emissions comprise approximately 10 percent of the total flight emissions, the totals are in reasonable agreement.

Of the criteria air pollutant emission estimates, the PM emission estimates are the most uncertain because they are based on default emission factors per engine/LTO from the 2005 National Emissions Inventory. Aircraft specific PM emission factors are available in EDMS which could likely refine the current estimate in future years.

## 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, such as baggage tractors, fuel carts, and aircraft tow tractors, 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. Methods

The primary method used to estimate airport GSE GHG emissions for JFK, LaGuardia, Newark, and Teterboro airports was to grow the 2007 emissions to 2008 using total airport operations data obtained from the individual airports. For Stewart airport, fuel use data (gasoline, diesel, and propane) obtained from the NONROAD model was multiplied by the $CO_2$, $CH_4$, and $N_2O$ emission factors for those fuels. The NONROAD model was also used to estimate 2008 CAP aircraft GSE emissions for all the airports (EPA, 2009).

For LaGuardia, JFK, Newark, and Teterboro airports, 2007 emissions were based largely on fuel usage reporting from tenants and fuel suppliers. Since this level of data was not made available for 2008, growth factors were developed using 2007 and 2008 LTO data obtained from FAA's ATADS. These growth factors were then applied to the 2007 GHG emissions to estimate 2008 GHG emissions. For Stewart airport, GHG emissions were estimated using EPA's NONROAD model. 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 by multiplying the fuel use data obtained from the NONROAD model runs by fuel-specific emission factors. 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.

The aircraft GSE 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.

The Federal Aviation Administration’s EDMS was an option that was considered for use in estimating airport GSE emissions, but since EDMS was not used to estimate aircraft emissions, it was inefficient to use this model for airport GSE emission estimates.

### 2.2.3. 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 92 percent of the $CO_2e$ emissions.

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

| Airport | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ Equivalent |
| LaGuardia | 9,950 | 6 | 3 | 10,894 |
| JFK | 30,874 | 43 | 3 | 32,743 |
| Newark | 15,025 | 16 | 3 | 16,180 |
| Stewart | 554 | 0.06 | 0.21 | 620 |
| Teterboro | 612 | 0.55 | 0.13 | 663 |
| **Port Authority Totals** | **57,017** | **66** | **9** | **61,100** |

Table 2-5 summarizes the estimated 2008 criteria air pollutant emissions for airport GSE at the facilities included in this inventory. GSE CAP emissions are dominated by $NO_x$ emissions at all airports.

**Table 2-5. Airport GSE CAP Emissions by Facility**

| Airport | Criteria Pollutant Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $NO_x$ | $SO_x$ | $PM_{10}$ | $PM_{2.5}$ |
| Newark | 230 | 5 | 15 | 16 |
| Teterboro | 0.51 | 0.01 | 0.03 | 0.04 |
| LaGuardia* | 208 | 5 | 14 | 15 |
| JFK* | 205 | 5 | 13 | 14 |
| Stewart | 4.77 | 0.11 | 0.32 | 0.33 |
| **Port Authority** | 648 | 15 | 43 | 45 |

*For LaGuardia and JFK airports, which are both in the same county, facility-specific emissions were not available from the NONROAD model. Emissions for each airport were estimated by applying the percent fuel use at each airport to the county-level estimates obtained from the model.

### 2.2.4. Comparison with Estimates in Previous Studies

Table 2-6 compares the 2006, 2007, and 2008 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 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Newark | 16,568 | 16,314 | 16,180 | -2% |
| Teterboro | 733 | 735 | 663 | -10% |
| LaGuardia | 12,056 | 11,058 | 10,894 | -10% |
| JFK | 34,218 | 33,303 | 32,743 | -4% |
| Stewart | N/A | 92 | 620 | N/A |
| **Total** | **63,575** | **61,502** | **61,100** | **-4%** |

In comparing facility (i.e., airport) level emission estimates, emissions from operations at Newark, Teterboro, LaGuardia, and JFK airports decreased from 2006 to 2008 due to a decrease in activity between the years. For Stewart Airport, a comparison of 2006 to 2008 emissions was not possible since the airport did not fall under Port Authority control until October 2007. The large increase in emissions (574 percent) between 2007 to 2008 is due to the fact that 2007 emissions were based on two months of fuel use data, while the 2008 emissions were based on 12 months of fuel use data. 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 cargo-related data was only available for John F. Kennedy International Airport (JFK). Therefore, the established boundary for cargo-related vehicles was based on JFK and includes routes used to access and egress 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. VMT for the airport facilities were calculated by mode and for the roundtrip to and from the airport.

In estimating VMT, data on trip origin, travel distance, trip distributions to each passenger origin, and transport mode were utilized. Table 2-7 summarizes trip origin and estimated one way travel distances by airport (except TBE). Distances reported in the table were estimated using Google Maps. Table 2-8 lists average travel party size by travel mode for all facilities (except TBE). 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 to each passenger origin by travel mode for each airport facility were obtained from Port Authority's Aviation Department (Fushan, 2008). The methodology applied for estimating VMT is consistent for private cars, limousines, chartered buses, hotel/motel/off-airport shuttle buses, and van services vehicle categories. Different methods (data sources) were used to estimate taxi, rental cars, bus, airport 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)** [1]

| 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 |
| 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 |

| State/City | Trip Origin | Estimated Distance to (one way) | | | |
|---|---|---|---|---|---|
| | | JFK | LGA | EWR | SWF |
| 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 |

[1]Estimated distance greater than 100 miles was capped to 100-miles.
N/A = not applicable.

**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 | 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 adjusted number of passengers arriving at each airport as a surrogate (PANYNJ, 2009a). The total estimated numbers of passengers was adjusted to exclude passengers travelling by taxi, rental car, public bus, and Amtrak/LIRR/Subway/Air Train (if applicable) using the data included in the Airport Traffic Report (PANYNJ, 2009a) because the emissions from these modes are more appropriately calculated using other activity data (e.g., number of taxis dispatched). For each facility (except TBE airport, for which no attracted travel information was available), the number of passengers (adjusted) was allocated by travel mode and trip origin to obtain number of vehicles. The number of vehicles by travel mode and trip origin was estimated using number of passengers (adjusted), trip distributions by travel mode to each passenger origin, average travel party size, and estimated distance traveled. Trip distributions by mode to each passenger origin were obtained from Port Authority's Aviation

Department (Fushan, 2008). Information on distance traveled and average travel party size are listed in Tables 2-7 and 2-8, respectively.

For example, 7,209,609 JFK passengers had trips originating in Manhattan; 16.72 percent of these passengers used a private car for the trip to JFK airport, with a one way distance of 17.6 miles, and an average travel party size of 2.42. Therefore, VMT to and from each airport facility is estimated as follows:

*Private Car VMT = ((Number of Passengers (adjusted) * Percent Distribution by trip origin and travel mode) / Travel Party Size) * Trip Length * 2 to account for both directions)*
*= (7,209,609 * (16.72 / 100) / 2.42) * 17.6 * 2*
*= 17,533,769 miles (roundtrip)*

2.3.3.1. Rental Car VMT

VMT for rental cars servicing JFK, LGA, EWR, and SWF was estimated based on the total number of rental vehicle transactions during 2008 (PANYNJ, 2009b). 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.

2.3.3.2. Taxi VMT

VMT for taxis servicing JFK, LGA, EWR, and SWF was estimated using the number of taxis dispatched (outbound passengers) obtained from Port Authority's 2008 annual airport traffic report (PANYNJ, 2009a). 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 2008 emissions inventory procedures document (Pechan, 2010).

#### 2.3.3.4. Shuttle Bus VMT

Data received for shuttle buses include information such as fuel consumed, fuel economy (mpg), and miles traveled (PANYNJ, 2009c). The available information for JFK, LGA, and SWF include fuel consumed. A fuel consumption of 182,318 gallons was reported for JFK, while a value of 51,427 gallons of fuel consumed was provided for LGA. For SWF, a fuel consumption value of 9,750 gallons was reported. These values account for the entire year. VMT was estimated by multiplying the calculated annual fuel consumed by the fuel economy value. This method applies to JFK, LGA, and SWF. A fuel economy value of 1.8 mpg was applied to JFK and SWF and 2.4 mpg was applied to LGA (Sarrinikolaou, 2008b). For EWR, a total mileage value of 1,157,462 miles was reported (PANYNJ, 2009d).

There was no hotel/motel shuttle bus information received for 2008. Therefore, this travel mode was estimated using the methodology described in Section 2.3.3.1.

#### 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 2008 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). 2008 daily number of trips for each travel mode was estimated by multiplying the 2006 daily number of trips by the 2006 to 2008 cargo (freight only) ton ratio for JFK. 2006 and 2008 freight information were obtained from the airport traffic reports (PANYNJ, 2006; PANYNJ, 2009a).

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. 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. Vehicle age-specific distribution data were developed based on vehicle registration data obtained from the New York State's 2008 enhanced inspection maintenance (I/M) program annual report (DEC, 2009).

Emission estimates for $CO_2$ were calculated by multiplying fuel used by fuel-specific emission factors. Fuel-specific emission factors in units of pounds per gallon (lbs/gal) for $CO_2$ were obtained from DOE's EIA's voluntary reporting of GHG program website (DOE, 2008b). Fuel used was derived by dividing estimated VMT by the appropriate fuel economy value.

Emissions estimates for $CH_4$ and $N_2O$ were developed by multiplying VMT by the corresponding emission factors (in grams/mile). Emission factors in units of grams/mile for $CH_4$ and $N_2O$ were derived from the EPA's GHG inventory report (EPA, 2008b).

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, 2009a) 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 2008 passengers (FAA, 2009).

### 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) | 464,134 | 26 | 27 | 472,965 |
| La Guardia (LGA) | 189,115 | 11 | 11 | 192,833 |
| Newark (EWR) | 496,482 | 28 | 29 | 505,967 |
| Teterboro (TBE) | 206 | 0 | 0 | 210 |
| Stewart International Airport (SWF) | 13,026 | 1 | 1 | 13,286 |
| **Total** | **1,162,962** | **67** | **67** | **1,185,261** |

For 2008, airport attracted travel was estimated to produce 1,185,261 metric tons of $CO_2$e emissions. As shown in Table 2-10, approximately 98 percent were emissions of $CO_2$. $CH_4$ and $N_2O$ (both as $CO_2$e) 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 2008 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 2008. 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, 2007, and 2008 GHG emissions results.

As presented in Table 2-11, estimated GHG emissions produced by airport facilities amounted to 1,185,261 metric tons (including SWF) in 2008 and 1,169,468 metric tons (excluding SWF) in 2006, a 15,793 metric tons increase in emissions. Out of the 15,793 metric tons increase in 2006 to 2008 emissions, 13,286 metric tons are associated with SWF. SWF GHG emissions estimates account for 1.1 percent of the 2008 total $CO_2$e emissions estimates.

Therefore, the overall increase of 1.4 percent in 2008 emissions estimates can be attributed to JFK and SWF facilities.

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

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 (revised) | 2007 | 2008 | |
| John F. Kennedy (JFK) | 444,651 | 476,132 | 472,965 | 6.4% |
| La Guardia (LGA) | 209,553 | 199,437 | 192,833 | -8.0% |
| Newark (EWR) | 515,014 | 517,926 | 505,967 | -1.8% |
| Teterboro (TBE) | 250 | 254 | 210 | -15.8% |
| Stewart International Airport (SWF) | Not Estimated | 2,945[1] | 13,286 | N/A |
| **Total** | **1,169,468** | **1,208,804** | **1,185,261** | **1.4%** |

[1]2007 emissions for SWF are based on PANYNJ operation of this airport being limited to November and December.

## 2.4. JOHN F. KENNEDY INTERNATIONAL AIRPORT COGENERATION PLANT

### 2.4.1. Boundary

This section quantifies the direct emissions from the 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 that sold to the Port Authority and to metered tenants on the premises are accounted for in the Real Estate and Development – 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 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 sufficient to heat and cool the Central Terminal and Light Rail 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 heat input and heat input for electricity use were taken from the DOE form EIA-923 (DOE, 2008a). The total natural gas use and natural gas use for electricity generation were calculated by dividing the heat inputs by the

Btu factor for the fuel delivered to the KIAC plant, which was found in Schedule 2 of EIA-923 (DOE, 2008b). The total electricity generated and the amount of electricity used by the facility was found in EIA-923, Schedule 6 (DOE, 2008c). The PANYNJ provided the amount of electricity used by the terminal and the AirTrain. The amount of electricity sold to Con Edison or lost in transmission was calculated by subtracting the amount of electricity consumed from the total electricity generated. This amount of electricity was the responsibility of the cogeneration plant. In 2008, all the heat input not used to generate electricity was used on site for heating and cooling purposes.

The total emissions by the facility were calculated by multiplying the total heat input by emission factors from The California Climate Action Registry's General Reporting Protocol. TCR's General Reporting Protocol Version 1.1 (TCR, 2008 – Tables 12.1 U.S. Default Factors for Calculating $CO_2$ Emissions from Fossil Fuel Combustion, and 12.9 Default $CH_4$ and $N_2O$ Emission Factors). For 2008, the total heat input to the facility was 4,659,192 MMBtu. From the TCR GRP, the emissions factors are 53.06 kg/million British thermal units (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:

*4,659,192 MMBtu * 53.06 kg/MMBtu * 0.001 metric tons / kg = 245,912 metric tons*

The total GHG emissions and their $CO_2$ equivalence are shown in the table below.

**Table 2-12. 2008 Greenhouse Gas Emission Totals from JFK KIAC Plant**

| JFK KIAC Cogen Plant Emissions | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ Equivalent |
| Electricity | 232,123 | 26 | 0.44 | 232,804 |
| Steam | 13,789 | 2 | 0.03 | 13,830 |
| Total | 245,912 | 27 | 0.47 | 246,634 |

Emission factors for electricity and steam were then calculated in order to determine the emissions that fall under the responsibility of the cogeneration plant as direct emissions, and those allocated to the PANYNJ as indirect emissions from purchased electricity. The electricity emission factors are calculated by dividing the total plant emissions by the total electricity generated. Steam emission factors are then calculated by dividing the total emissions by the amount of steam not used for electricity generation.

**Table 2-13. Calculated 2008 GHG Emission Factors for KIAC Electricity**

| | $CO_2$ (metric tons/kWh) | $CH_4$ (metric tons/kWh) | $N_2O$ (metric tons/kWh) |
|---|---|---|---|
| Electricity | 4.06E-04 | 4.54E-08 | 7.70E-10 |

### 2.4.4. CAP Methods

The CAP emissions were calculated using emission factors from eGRID 2006 for $NO_x$ and $SO_2$ (EPA, 2004). $PM_{2.5}$ and $PM_{10}$ emission factors were derived from the proportion of PM to $SO_2$ from electric generating units in New

York based on the 2002 National Emissions Inventory (EPA, 2007). These emission factors are shown in Table 2-14. All emissions were calculated using the amount of gas used in million cubic feet.

**Table 2-14. CAP Emission Factors**

| Natural Gas Emission Factors (lbs/million $ft^3$) | | | |
|---|---|---|---|
| $SO_2$ | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ |
| 3.5 | 327 | 0.18 | 0.21 |

Again, the emissions were allocated to both the electricity and steam based on the throughput used for generation and the total throughput. The electricity emission factor was calculated as the total emissions from fuel combustion for generation divided by the total electricity generation. These factors are shown in Table 2-15 below. These emission factors were applied to the amount of electricity not used locally by the JFK terminal and light rail. These emissions were assumed to be the responsibility of the cogen either through losses or sale to Con-Ed.

**Table 2-15. Electricity Emission Factors**

| | $SO_2$ (metric tons/kWh) | $NO_x$ (metric tons/kWh) | $PM_{10}$ (metric tons/kWh) | $PM_{2.5}$ (metric tons/kWh) |
|---|---|---|---|---|
| Electricity | 1.26E-08 | 1.18E-06 | 7.39E-10 | 6.43E-10 |

### 2.4.5. GHG Results

Table 2-16 shows the total estimated greenhouse emissions for the JFK KIAC plant in calendar year 2008.

**Table 2-16. Estimated KIAC GHG Emissions from Sold Electricity and Steam**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Source** | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$ |
| Electricity Sold to the Grid | 60,001 | 7 | 0 | 60,117 |

### 2.4.6. CAP Results

Table 2-17 shows the total estimated criteria air pollutant emissions for the JFK KIAC plant in calendar year 2008.

**Table 2-17. Estimated KIAC CAP Emissions from Sold Electricity and Steam**

| | Criteria Air Pollutant Totals (metric tons) | | | |
|---|---|---|---|---|
| **Source** | $NO_X$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| Electricity Sold to the Grid | 172 | 2 | .11 | .09 |

### 2.4.7. Comparison with Estimates in Previous Studies

**Table 2-18. GHG Three Year Comparison at JFK KIAC Cogen**

| JFK KIAC Cogen Plant | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Electricity Sold to the Grid | 71,029 | 57,815 | 60,117 | -15.4% |
| Waste Steam | 331 | 0 | 0 | -100% |
| **Total** | **71,360** | **57,815** | **60,117** | **-15.8%** |

In 2008, the KIAC plant consumed 12 percent less natural gas overall (4,472 MMcf in 2008 versus 5,099 MMcf in 2006), resulting in the lower emissions totals seen above. The estimated reduced electricity sold to the grid also contributes to reduced emissions.

## 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 2-19 are included in this building energy use category. For facilities in which partial, or no 2008 data was available, 2007 values were substituted for the purposes of this evaluation. An asterisk identifies properties within the boundary in which 2008 data was used.

**Table 2-19. 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 five 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. Step four encompassed filling in missing fields with 2007 data. 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 TCR General Reporting Protocol Version 1.1 Tables 12.1 and 12.9. Emission rates for CAPs were derived from EPA's AP-42. TCR General Reporting Protocol also provided emission factors to quantify $CO_2$ emissions from fuel oils #2 and #4.

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 2008 activity data. However, in 2007, 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. These same ratios were applied to 2008 data

### 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 2-20.

**Table 2-20. 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 | 147 |
| JFK International Airport | 10,904 | 111,618 | 102,377 |
| AirTrain JFK | 0 | 19,475 | 0 |
| LaGuardia | 3,431 | 21,927 | 20,660 |
| Newark Liberty International Airport | 114 | 7,073 | 39,286 |
| AirTrain Newark | 0 | 9,744 | 0 |
| Stewart Airport | 0 | 0 | 3632 |
| Teterboro Airport | 0 | 0 | 1622 |
| **Total** | **14,449** | **169,837** | **167,724** |

### 2.5.5. Comparison with Estimates in Previous Studies

Table 2-21 compares 2008 GHG emission estimates for Aviation Department buildings with those developed for baseline year 2006. GHG emissions were 7.25 percent above the baseline.

**Table 2-21. Aviation Buildings $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Downtown Manhattan Heliport | 141 | 117 | 147 | 4.26% |
| JFK International Airport | 206,246 | 210,120 | 224,899 | 9.04% |
| AirTrain JFK | 17,716 | 19,475 | 19,475 | 9.93% |
| LaGuardia | 42,205 | 35,338 | 46,018 | 9.03% |
| Newark Liberty International Airport | 51,356 | 46,472 | 46,473 | -9.51% |
| AirTrain Newark | 9,203 | 9,744 | 9,744 | 5.88% |
| Stewart Airport | Not Estimated | 345 | 3,632 | N/A |
| Teterboro Airport | 1,357 | 1,719 | 1,622 | 19.53% |
| **Total** | **328,223** | **323,330** | **352,010** | **7.25%** |

## 2.6. AVIATION DEPARTMENT GHG EMISSIONS SUMMARY

Table 2-22 summarizes the 2008 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 2-22. 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** | **12,873** | **131,093** | **1,534,792** | **1,678,758** |
| Aircraft | - | - | 866,027 | 866,027 |
| Ground Support Equipment | - | - | 33,306 | 33,306 |
| Attracted Travel | - | - | 472,965 | 472,965 |
| Buildings | 10,904 | 111,618 | 102,377 | 224,899 |
| Fleet Vehicles | 1,774 | - | - | 1,774 |
| AirTrain JFK | - | 19,475 | - | 19,475 |
| JFK Co-generation Plant | - | - | 60,117 | 60,117 |
| Direct Fugitive Emissions | 195 | - | - | 195 |
| **LaGuardia Airport** | **4,506** | **21,927** | **653,472** | **679,905** |
| Aircraft | - | - | 428,742 | 428,742 |
| Ground Support Equipment | - | - | 11,236 | 11,236 |
| Attracted Travel | - | - | 192,833 | 192,833 |
| Buildings | 3,431 | 21,927 | 20,660 | 46,018 |
| Fleet Vehicles | 1,022 | - | - | 1,022 |
| Direct Fugitive Emissions | 53 | - | - | 53 |
| **Newark Liberty International Airport** | **1,814** | **16,817** | **1,150,787** | **1,169,418** |
| Aircraft | - | - | 588,366 | 588,366 |
| Ground Support Equipment | - | - | 17,168 | 17,168 |
| Attracted Travel | - | - | 505,967 | 505,967 |
| Buildings | 114 | 7,073 | 39,286 | 46,473 |
| Fleet Vehicles | 1,435 | - | - | 1,435 |
| AirTrain Newark | - | 9,744 | - | 9,744 |
| Direct Fugitive Emissions | 265 | - | - | 265 |
| **Teterboro Airport** | **2** | **-** | **90,706** | **90,708** |
| Aircraft | - | - | 88,230 | 88,230 |
| Ground Support Equipment | - | - | 644 | 644 |
| Attracted Travel | - | - | 210 | 210 |
| Buildings | - | - | 1,622 | 1,622 |
| Fleet Vehicles | 2 | - | - | 2 |
| **Stewart Airport** | **-** | **-** | **53,328** | **53,328** |
| Aircraft | - | - | 35,790 | 35,790 |
| Ground Support Equipment | - | - | 620 | 620 |
| Attracted Travel | - | - | 13,286 | 13,286 |
| Buildings | - | - | 3,632 | 3,632 |
| **Downtown Manhattan Heliport** | **-** | **-** | **51,298** | **51,298** |
| Aircraft | - | - | 51,151 | 51,151 |
| Buildings | - | - | 147 | 147 |
| Fleet Vehicles | - | - | - | - |
| **AVIATION** | **19,195** | **169,837** | **3,534,383** | **3,723,415** |

## 2.7. AVIATION DEPARTMENT CAP EMISSIONS SUMMARY

Table 2-23 summarizes 2008 CAP emissions by facility for the Aviation Department.

**Table 2-23. Aviation Department CAP Emissions by Facility (metric tons)**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| **John F. Kennedy International Airport** | **5,816** | **297** | **184** | **165** |
| Aircraft | 3,924 | 271 | 134 | 131 |
| Ground Support Equipment | 226 | 5 | 15 | 15 |
| Attracted Travel | 936 | 10 | 35 | 19 |
| Buildings | 510 | 6 | - | - |
| Fleet Vehicles | 7 | 0 | 0 | 0 |
| AirTrain JFK | 35 | 3 | - | - |
| JFK Co-generation Plant | 179 | 2 | 0 | 0 |
| **LaGuardia Airport** | **2,244** | **173** | **139** | **130** |
| Aircraft | 1,616 | 134 | 108 | 105 |
| Ground Support Equipment | 229 | 5 | 16 | 16 |
| Attracted Travel | 359 | 4 | 14 | 7 |
| Buildings | 38 | 30 | 2 | 2 |
| Fleet Vehicles | 1 | 0 | 0 | 0 |
| **Newark Liberty International Airport** | **3,892** | **1,107** | **264** | **230** |
| Aircraft | 2,486 | 184 | 122 | 119 |
| Ground Support Equipment | 253 | 6 | 17 | 17 |
| Attracted Travel | 988 | 11 | 38 | 20 |
| Buildings | 134 | 749 | 73 | 61 |
| Fleet Vehicles | 2 | 0 | 0 | 0 |
| AirTrain Newark | 28 | 157 | 15 | 13 |
| **Teterboro Airport** | **159** | **36** | **43** | **42** |
| Aircraft | 156 | 27 | 42 | 41 |
| Ground Support Equipment | 1 | 0 | 0 | 0 |
| Attracted Travel | - | - | - | - |
| Buildings | 2 | 9 | 1 | 1 |
| Fleet Vehicles | 1 | 0 | 0 | 0 |
| **Stewart Airport** | **149** | **13** | **11** | **11** |
| Aircraft | 115 | 11 | 10 | 9 |
| Ground Support Equipment | 5 | 0 | 0 | 0 |
| Attracted Travel | 25 | - | 1 | 1 |
| Buildings | 3 | 2 | - | - |
| **Downtown Manhattan Heliport** | **6** | **3** | **21** | **20** |
| Aircraft | 6 | 3 | 21 | 20 |
| Buildings | - | - | - | - |
| Fleet Vehicles | - | - | - | - |
| **AVIATION** | **12,266** | **1,629** | **663** | **599** |

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# 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 nonattainment 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, such as Coast Guard Vessels that transit the Port, but do not lease berth space from the Port, 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) and harbor craft (HC). This classification system is consistent with previous reports commissioned by the PANYNJ, including the emissions inventories conducted by Starcrest. The OGV and HC 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 HC, five sub-categories exist: assist tugs; towboats and pushboats; dredging vessels; ferry/excursion vessels; and government vessels. Of these, only emissions from assist tugs, towboats and pushboats, 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 fuel at a constant temperature/viscosity. 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 that report. Dredging data for 2008 was provided by PANYNJ Port Commerce Waterways Unit.

Starcrest's 2006 CMV emissions by subcategory were projected to future years for each vessel type using historical port-wide ship call data provided by the Port Authority. Towboat activity estimates for 2006 through 2008 were also provided by Port Authority and used to project the 2006 towboat/pushboat emissions to 2007 and 2008. The ship call data and the percent change adjustments applied to the 2006 Starcrest emissions are shown in Table 3-1.

**Table 3-1. 2006-2008 Ship Call Data and Scaling Factors**

| | **Ship Calls** | | | |
|---|---|---|---|---|
| **Vessel Type** | **2006** | **2007** | **2008** | **2006-2008 Factor (%)** |
| Containership | 2,552 | 2,516 | 2,257 | -11.56% |
| Car Carrier / Roll On/Roll Off | 769 | 699 | 609 | -20.81% |
| Cruise Ship | 41 | 50 | 60 | 46.34% |
| Tanker | 81 | 97 | 98 | 20.99% |
| Bulk Carrier | 119 | 136 | 127 | 6.72% |
| Towboats/Pushboats | 4,237 | 4,648 | 3,934 | -7.15% |
| Assist Tugs | 3,562 | 3,498 | 3,151 | -11.54% |

Calendar year 2008 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 short 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 short tons/million cubic yards into metric tons/cubic yards. In 2008, the Port Authority Waterways Unit reported 1,035,872 cubic yards of dredging in the New York Harbor system, as compared to 2,074,420 cubic yards in 2007 and 5,549,189 cubic yards in 2006. These dredging activity data reflect 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

Tables 3-2 to 3-4 show the emissions from the various sources described above. Dredging emissions found in Table 3-2 are the result of applying the emission factors to the dredging 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 harbor vessels, and 7 percent are from towboats. 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** | **$NO_x$** | **$PM_{2.5}$** | **$PM_{10}$** |
| 4,551 | 0.15 | 0.11 | 4,589 | 84 | 1.95 | 2.11 |

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

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **CMV Category** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **Total $CO_2$ Equivalent** |
| Ocean Going Vessels | 159,775 | 14 | 4 | **161,326** |
| Towboats | 12,369 | 4 | 1 | **12,916** |
| Harbor Vessels | 13,308 | 3 | 1 | **13,720** |
| **Port Authority** | **185,452** | **21** | **7** | **187,943** |

**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 | 2,988 | 2,669 | 226 | 282 |
| Towboats | 235 | 24 | 12 | 13 |
| Harbor Vessels | 250 | 17 | 10 | 11 |
| **Port Authority** | **3,473** | **2,710** | **248** | **306** |

### 3.1.5. Comparison with Estimates in Previous Studies

CMV GHG emissions associated with Port Authority terminals and activities have declined by almost 18 percent since 2006. A significant portion of this decline is attributable to reduced marine vessel dredging activity from 2006 to 2008. There was also some reduction in ocean-going vessel travel during this period.

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

| CMV Category | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Ocean Going Vessels | 179,318 | 177,595 | 161,326 | -10.0% |
| Towboats | 13,890 | 15,237 | 12,897 | -7.2% |
| Harbor Vessels | 34,906 | 19,327 | 13,720 | -60.7% |
| **Total** | **228,115** | **212,159** | **187,943** | **-17.6%** |

## 3.2. CARGO HANDLING EQUIPMENT (CHE)

### 3.2.1. Boundary

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

- CHE at container terminals; 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.

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 was prepared for the New York and New Jersey Port District (Starcrest, 2008b). For container terminal CHE, the 2006 GHG and CAP estimates formed the basis of 2008 GHG and CAP emissions. Details on the procedures and emission factors used to prepare the container terminal CHE 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 2008 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 2008 GHG and CAP emission estimates for these two CHE categories are described more fully below.

#### 3.2.3.1. Container Terminal CHE

2006 GHG and CAP container terminal CHE emissions estimates were prepared for the New York and New Jersey Port District. 2006 CAP emissions were estimated using the NONROAD2005 model. Activity data collected replaced the default model inputs. Adjustments were made to the $SO_2$, $PM_{10}$, and $PM_{2.5}$ emissions for the equipment that was reported to also use on-highway fuel.

While the NONROAD model estimates $CO_2$ emissions, the model does not report $N_2O$ or $CH_4$ emissions. The other GHG emissions were developed using emission factors obtained from EPA (EPA, 2008a). The emission factors were in terms of grams/kg of fuel. The amount of fuel was calculated from the $CO_2$ emissions obtained from the

NONROAD2005 model since the emissions are directly proportional to fuel consumption, using an average fuel carbon content of 86 percent (Starcrest, 2008b).

The change in the number of loaded and empty twenty-foot equivalent units (TEUs) handled in the port between 2006 and 2008 was used as the surrogate indicator to estimate 2008 activity (PANYNJ, 2009c). In 2008, the TEUs handled in the port were 4,711,288, compared with 4,657,424 in 2006. 2008 GHG and CAP emissions were estimated by applying this change in TEUs between 2006 and 2008 to the emissions reported for 2006.

#### 3.2.3.2. 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 2008 fuel consumption, and the 2008 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 2008 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, 2009c). This value was reported as 634,100 in 2002 and 723,550 vehicles in 2008. Fuel consumption associated with the 2008 VMT was estimated using data from the 2008 Annual Energy Outlook (DOE, 2008), which lists the miles per gallon (mpg) of 2008 model year light-duty vehicles as 33.2 mpg and light-duty trucks as 23.7 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 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 $CO_2$e 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 | 130,544 | 7.45 | 3.32 | 131,729 |
| | | | | |
| | | | | |
| Auto-marine Terminal | 131 | 0.01 | 0.01 | 134 |
| **Totals** | **130,675** | **8** | **3** | **131,863** |

### 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**

| | CAP Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Category (Portwide)** | **$NO_x$** | **$SO_2$** | **$PM_{10}$** | **$PM_{2.5}$** |
| Container Terminal CHE | 1,288 | 201 | 86 | 79 |
| Auto-marine Terminal | 0.683 | 0.032 | 0.005 | 0.004 |
| **Totals** | **1,289** | **201** | **86** | **79** |

### 3.2.6. Comparison with Estimates in Previous Studies

Table 3-8 compares 2006, 2007, and 2008 $CO_2$ equivalent emissions for CHE. The 11 percent decrease in auto-marine terminal emissions from 2006 to 2008 is a result of the decrease in the number of vehicles arriving or departing PANYNJ facilities. The total CHE emissions increased only by 1 percent from 2006 to 2008, which is due to the slight increase in the number of TEUs handled in the port.

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

| Category (Portwide) | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Container Terminal CHE | 130,223 | 133,905 | 131,729 | 1% |
| Auto-marine Terminal | 150 | 156 | 135 | -11% |
| **Total** | 130,373 | 134,061 | 131,864 | 1% |

## 3.3. LOCOMOTIVES

### 3.3.1. Boundary

The boundary for this category includes switch locomotives at container terminals and line haul locomotives within the boundary of the New York/New Jersey Non-Attainment Area (NYNJLINA).

### 3.3.2. Facilities Included in the Inventory

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.

### 3.3.3. Methods

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

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 emissions for 2008, the 2006 switch and line haul locomotive emissions were grown to 2008 using the number of containers handled by the switch locomotives. In 2008, the locomotives associated with the Port Authority marine terminals handled 377,827 containers, compared with 262,157 in 2006 (PANYNJ, 2009b). To estimate the CAP emissions for 2008, the 2006 switch and line-haul locomotive activity was grown to 2008 using the number of containers handled by switch locomotives. Emissions were estimated by multiplying the grown activity by locomotive CAP emission factors (EPA, 2009).

### 3.3.4. Locomotive GHG Results

Table 3-9 summarizes the GHG emission estimates for switch and line haul locomotives. Line haul locomotives are the predominant contributor to the CHE inventory.

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 $CO_2$e emissions.

**Table 3-9. Locomotive GHG Emissions by Gas and $CO_2$ Equivalent**

| Category (Portwide) | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ Equivalent |
| Switch Locomotive | 6,460 | 0.51 | 0.17 | 6,523 |
| Line Haul Locomotive | 12,586 | 0.99 | 0.33 | 12,710 |
| **Totals** | **19,046** | **2** | **1** | **19,233** |

### 3.3.5. Locomotive CAP Results

Table 3-10 summarizes the CAP emission estimates for the switch and line haul locomotives. CAP emissions are dominated by $NO_x$ emissions.

**Table 3-10. Locomotive CAP Emissions**

| Category (Portwide) | CAP Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| Switch Locomotive | 189 | 3 | 6 | 6 |
| Line Haul Locomotive | 192 | 2 | 4 | 4 |
| **Totals** | **381** | **5** | **10** | **10** |

### 3.3.6. Comparison with Estimates in Previous Studies

Table 3-11 compares 2006, 2007, and 2008 $CO_2$ equivalent emissions for switch and line haul locomotives. The 44 percent increase in emissions from 2006 to 2008 is a result of the increase in the number of containers handled by switch locomotives.

**Table 3-11. Locomotive $CO_2$ Equivalent GHG Emissions Comparison**

| Category (Portwide) | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Switch Locomotive | 4,526 | 6,181 | 6,523 | 44% |
| Line Haul Locomotive | 8,819 | 12,044 | 12,710 | 44% |
| **Total** | **13,345** | **18,226** | **19,233** | **44%** |

## 3.4. HEAVY-DUTY VEHICLES

### 3.4.1. Boundary

The boundary for heavy-duty vehicles 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.

### 3.4.2. 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; and
d. Howland Hook Marine Terminal.

### 3.4.3. 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 2008 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 2008 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 2008 was calculated from the PANYNJ Annual Reports for 2007 (PANYNJ, 2008d) and 2008 (PANYNJ, 2009d). This growth rate was applied to the 2006 total annual HDDV trips from the Starcrest emission inventory report (Starcrest, 2008b) to estimate the 2008 annual HDDV trips. The 2008 HDDV trips 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 0.23 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, 2009d).

Once the 2006 proportions of gate counts by terminal were calculated, these ratios were applied to the total 2008 annual trips to estimate the 2008 annual HDDV trips 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 3-12 summarizes the activity data used to calculate emissions from attracted travel at the marine terminals.

#### 3.4.3.1. 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 2008 annual HDDV trips 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 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. To estimate idling hours per trip for the Howland Hook Marine Terminal, the analysis used idling hours from Starcrest Container Terminals. Idling data from Starcrest Auto Terminals was used to estimate the Red Hook Container Terminal and Auto Marine Terminal annual trips, 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 2008 annual trips to determine the total number of hours that trucks spent idling at the port terminals in 2008. 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 3-12.

#### 3.4.3.2. 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 annual HDDV trips 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

**Table 3-12. Summary of Heavy-Duty Vehicle Activity Data for Port Commerce**

| Terminals | Estimated Annual 2008 HDDV Trips (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 2008 Total Truck Idling Hours in Terminal (hours) | Estimated One-Way Trip Length To or From Terminal (miles) | 2008 VMT for Trip to and from Terminal (miles) |
|---|---|---|---|---|---|---|---|
| Port Newark/Port Elizabeth | 2,943,270 | 1.08 | 3,181,700 | 1.36 | 4,013,166 | 42.7 | 251,333,741 |
| Howland Hook Marine Terminal | 462,755 | 1.13 | 520,409 | 1.40 | 647,287 | 42.7 | 39,515,911 |
| Red Hook Container Terminal/Auto Marine Terminal | 14,869 | 0.39 | 5,747 | 1.68 | 24,986 | 42.7 | 1,269,688 |

[a]SOURCE: Estimated by Pechan from data in Starcrest, 2008.

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 2008 HDDV trips 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 3-12.

#### 3.4.3.3. 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. VMT 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 3-13 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 2008 VMT to and from the terminals. Table 3-12 summarizes the estimated VMT associated with the trips to and from the terminals.

#### 3.4.3.4. Emission Factors and Emission Calculations

Emission factors for trucks were obtained from EPA's latest GHG Inventory report (EPA, 2008a). 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

**Table 3-13. 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.

gallon. Fuel economy by model year and vehicle type, were obtained from the Department of Energy's Annual Energy Outlook reports (DOE, 1996-2009). Heavy duty truck fuel efficiency is estimated to decline by 1.0 percent between 2007 and 2008, based on AEO emissions data. 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.

### 3.4.4. Results

Table 3-14 summarizes the GHG emission estimates for the Port Commerce heavy-duty vehicle activities included in this 2008 inventory. A majority of the emissions are associated with the truck travel to and from the port terminals. While the estimates of annual HDDV trips should be fairly certain, the allocations of trips by terminal have a higher degree of uncertainty.

**Table 3-14. Port Commerce Heavy-Duty Vehicle GHG Emissions by Gas and $CO_2$ Equivalent**

| | **Greenhouse Gas Emissions Totals (metric tons)** | | | |
|---|---|---|---|---|
| **Activity and Facility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| **Idling Within Terminal** | | | | |
| Port Newark/Port Elizabeth | 20,373 | 0.00 | 0.00 | 20,373 |
| Howland Hook Marine Terminal | 3,286 | 0.00 | 0.00 | 3,286 |
| Red Hook Container Terminal/Auto Marine Terminal | 127 | 0.00 | 0.00 | 127 |
| *Total* | ***23,786*** | ***0.00*** | ***0.00*** | ***23,786*** |
| **Travel Within Terminal** | | | | |
| Port Newark/Port Elizabeth | 4,793 | 0.02 | 0.02 | 4,798 |
| Howland Hook Marine Terminal | 784 | 0.00 | 0.00 | 785 |
| Red Hook Container Terminal/Auto Marine Terminal | 9 | 0.00 | 0.00 | 9 |
| *Total* | ***5,585*** | ***0.02*** | ***0.02*** | ***5,591*** |
| **Travel To and From Terminal** | | | | |
| Port Newark/Port Elizabeth | 378,593 | 1.28 | 1.21 | 378,994 |
| Howland Hook Marine Terminal | 59,524 | 0.20 | 0.19 | 59,587 |
| Red Hook Container Terminal/Auto Marine Terminal | 1,913 | 0.01 | 0.01 | 1,915 |
| ***Total*** | ***440,030*** | ***1.49*** | ***1.40*** | ***440,496*** |
| **Total Heavy-Duty Vehicle Travel** | | | | |
| Port Newark/Port Elizabeth | 403,759 | 1.30 | 1.22 | 404,165 |
| Howland Hook Marine Terminal | 63,594 | 0.20 | 0.19 | 63,658 |
| Red Hook Container Terminal/Auto Marine Terminal | 2,048 | 0.01 | 0.01 | 2,050 |
| ***Total*** | ***469,401*** | ***1.51*** | ***1.42*** | ***469,873*** |

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 $CO_2$e emissions.

In comparison with 2007 emissions from attracted travel, 2008 total $CO_2$e emissions were almost constant, decreasing only 0.3 percent. There is virtually no change because the estimate of annual trips decreased by 1.3 percent compared with last year, where the emissions from within the terminal was actually higher due to a lower fuel efficiency estimate for 2008 compared with 2007. Emissions from idling within terminals decreased 1.3 percent while emissions from both travel within and travel to and from terminals decreased by 0.3 percent.

### 3.4.5. Comparison with Estimates in Previous Studies

Table 3-15 shows the 2008 inventory in comparison to the 2006 and 2007 estimates. The attracted travel GHG emission estimates increased by 4.4 percent from 2006 to 2008.

**Table 3-15. Port Commerce Attracted Travel $CO_2$ Equivalent GHG Emissions Comparison**

| | $CO_2$ Equivalent (metric tons) | | | Percentage |
|---|---|---|---|---|
| **Facility** | **2006** | **2007** | **2008** | **Difference** |
| Idling Within Terminal | 23,239 | 24,091 | 23,786 | 2.3% |
| Travel Within Terminal | 5,350 | 5,609 | 5,591 | 4.5% |
| Travel To and From Terminal | 421,282 | 441,698 | 440,496 | 4.5% |
| **Total Attracted Travel** | 449,871 | 471,399 | 469,873 | 4.4% |

## 3.5. LANDFILL

### 3.5.1. 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 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 due to the uncontrolled nature of filling employed at the landfill during its use. However, based on information from the New Jersey Department of Environmental Protection 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 remaining portion consists of outlying portions of the landfill where fill was placed, and is owned by the Port Authority. The Port Authority property is part of the Port Commerce department, and is leased to tenants.

### 3.5.2. Facilities Included in the Inventory

Elizabeth Landfill.

### 3.5.3. 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, 2005b), 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, 2005b). LandGEM is based on the gas generated from anaerobic decomposition of landfilled waste, which has a methane content between 40 and 60 percent. Default pollutant concentrations used by LandGEM have already been corrected for air infiltration, as stated in AP-42. 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 per year.

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 landfilled 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.

### 3.5.4. Results

Table 3-16 summarizes the landfill GHG emission estimates for 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, since 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.

**Table 3-16. Landfill GHG Emissions by Gas and $CO_2$ Equivalent**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Facility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| Elizabeth Landfill – Port Commerce Department | 0 | 191 | 0 | 4,011 |

Emissions generated by the Elizabeth Landfill have been determined to be Scope 1. Neither TCR, 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.

### 3.5.5. Comparison with Estimates in Previous Studies

Table 3-17 details the expected reduction in emissions from the landfill due to continuous decay of the remaining waste in the landfill since 2006.

**Table 3-17. Landfill GHG Emissions by Gas and $CO_2$ Equivalent**

| | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| **Elizabeth Landfill** | **2006** | **2007** | **2008** | **(2006 vs. 2008)** |
| Traction | 4,224 | 3,958 | 4,011 | -5.0% |

## 3.6. BUILDINGS

### 3.6.1. Boundary

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

### 3.6.2. Facilities Included in the Inventory

All facilities listed in Table 3-18 are included in this building energy use category. For facilities in which partial or no 2008 data was available, 2007 values were substituted for the purposes of this evaluation. An asterisk identifies properties within the boundary in which 2008 data was used.

**Table 3-18. 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 |

### 3.6.3. Methods

GHG emissions associated with energy consumption in buildings that are owned, or leased, by the PANYNJ were estimated in five 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. Step four encompassed filling in missing fields with 2007 data. 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 TCR 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).

### 3.6.4. Results

Facility total $CO_2$ equivalent emissions and division of emissions by scope are included in Table 3-19, showing that all emissions come from facilities not directly under PANYNJ control.

**Table 3-19. 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 | 228 |
| Howland Hook Marine Terminal and Port Ivory | 0 | 0 | 2,364 |
| Port Newark Terminal / Elizabeth Marine Terminal | 0 | 0 | 47,859 |
| **Total** | **0** | **0** | **53,965** |

### 3.6.5. Comparison with Estimates in Previous Studies

Table 3-20 compares the 2008 GHG emission estimates from this study with baseline year 2006.

**Table 3-20. Port Commerce Buildings $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Auto Marine Terminal and Greenville Yard | 3,537 | 3,514 | 3,514 | -0.65% |
| Brooklyn PA Marine Terminal Red Hook Container Terminal | 219 | 190 | 228 | 4.11% |
| Port Newark Terminal/Elizabeth Marine Terminal | 44,424 | 47,859 | 47,859 | 7.73% |
| Howland Hook Marine Terminal/Port Ivory | 2,389 | 2,211 | 2,364 | -1.05% |
| **Total** | **50,569** | **53,774** | **53,965** | **6.72%** |

## 3.7. PORT COMMERCE DEPARTMENT GHG EMISSIONS SUMMARY

Table 3-21 summarizes the GHG 2008 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 3-21. 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** | **-** | **-** | **341,006** | **341,006** |
| Commercial Marine Vessels | - | - | 187,943 | 187,943 |
| Cargo Handling Equipment | - | - | 131,863 | 131,863 |
| Rail Locomotives | | | 19,293 | 19,293 |
| **Port Newark/ Elizabeth Terminal** | **308** | **-** | **452,024** | **452,332** |
| Heavy-Duty Vehicles | - | - | 404,165 | 404,165 |
| Buildings | - | - | 47,859 | 47,859 |
| Fleet Vehicle | 308 | - | - | 308 |
| **Howland Hook Marine Terminal/Port Ivory** | **3** | **-** | **66,022** | **66,025** |
| Heavy-Duty Vehicles | - | - | 63,658 | 63,658 |
| Buildings | - | - | 2,364 | 2,364 |

| | Scope 1 | Scope 2 | Scope 3 | Facility Emission Totals |
|---|---|---|---|---|
| Fleet Vehicle | 3 | - | - | 3 |
| **Red Hook Container Terminal and Brooklyn PA Marine Terminal (Brooklyn Piers)** | **59** | **-** | **2,278** | **2,337** |
| Heavy-Duty Vehicles | - | - | 2,050 | 2,050 |
| Buildings | - | - | 228 | 228 |
| Fleet Vehicle | 59 | - | - | 59 |
| **Auto Marine Terminal and Greenville Yard** | **13** | **-** | **3,514** | **3,527** |
| Heavy-Duty Vehicles | - | - | Included in Red Hook | |
| Buildings | - | - | 3,514 | 3,514 |
| Fleet Vehicle | 13 | - | - | 13 |
| **Elizabeth Landfill** | **4,011** | **-** | **-** | **4,011** |
| **PORT COMMERCE DEPARTMENT** | **4,394** | **0** | **862,937** | **867,331** |

## 3.8. PORT COMMERCE DEPARTMENT CAP EMISSIONS SUMMARY

Table 3-22 summarizes the 2008 CAP emissions by Port Commerce facilities, specifying the source of emissions and the amount which falls under each pollutant.

In comparing the heavy-duty vehicle 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 and 2008 compared with 2006.

**Table 3-22. Port Commerce Department CAP Emissions by Facility (metric tons)**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| **All Port Authority Marine Terminals** | **5,245** | **2,919** | **405** | **339** |
| Commercial Marine Vessels | 3,484 | 2,711 | 307 | 248 |
| Cargo Handling Equipment | 1,289 | 201 | 86 | 79 |
| Rail Locomotives | 472 | 7 | 12 | 12 |
| **Port Newark/ Elizabeth Terminal** | **2,127** | **78** | **66** | **53** |
| Heavy-Duty Vehicles | 2,045 | 10 | 59 | 48 |
| Buildings | 81 | 68 | 7 | 5 |
| Fleet Vehicle | 1 | 0 | 0 | 0 |
| **Howland Hook Marine Terminal/Port Ivory** | **323** | **2** | **9** | **8** |
| Heavy-Duty Vehicles | 322 | 2 | 9 | 8 |
| Buildings | - | - | - | - |
| Fleet Vehicle | 1 | 0 | 0 | 0 |
| **Red Hook Container Terminal and Brooklyn PA Marine Terminal (Brooklyn Piers)** | **10** | **0** | **0** | **0** |
| Heavy-Duty Vehicles | 10 | 0 | 0 | 0 |
| Buildings | - | - | - | - |
| Fleet Vehicle | 0 | 0 | 0 | 0 |
| **Auto Marine Terminal and Greenville Yard** | **0** | **0** | **0** | **0** |
| Buildings | - | - | - | - |
| Fleet Vehicle | 0 | 0 | 0 | 0 |
| **PORT COMMERCE DEPARTMENT** | **7,705** | **2,999** | **480** | **400** |

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# 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] Miles | Annual Traffic Volume[2] (one way) |
|---|---|---|---|
| Bridges | George Washington Bridge | 2.54 | 52,947,247 |
| | Bayonne Bridge | 1.88 | 3,746,483 |
| | Goethals Bridge | 1.53 | 14,107,912 |
| | Outerbridge Crossing | 2.05 | 15,116,115 |
| Tunnels | Lincoln Tunnel | 3.75 | 20,937,090 |
| | Holland Tunnel | 3.25 | 16,870,502 |

[1]DATA SOURCE: PANYNJ, 2007.
[2]DATA SOURCE: PANYNJ, 2009.

### 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; PANYNJ, 2009). $CO_2$ 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 was derived by multiplying annual traffic volumes (one-way) for each PA's vehicle category by the roadway length in miles. The result was then multiplied by a factor of two to account for round-trip travel. The PA vehicle types were categorized as auto, buses, small trucks, and large trucks.

The $CH_4$ and $N_2O$ emission factors were obtained from the EPA's latest GHG Inventory report (EPA, 2008a) and were provided based on EPA's vehicle categories. Because of this, estimated VMT were disaggregated to vehicle categories equivalent to EPA's vehicle types and fuel types. 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**

| Port Authority's Vehicle Type | EPA Vehicle Type[1] | Allocation Factors[2] |
|---|---|---|
| AUTO | LDGV | 0.4103 |
| | LDGT1 | 0.4014 |
| | LDGT2 | 0.1374 |
| | HDGV | 0.0324 |
| | LDDV | 0.0004 |
| | LDDT | 0.0020 |
| | HDDV | 0.00997 |
| | MC | 0.0060 |
| SMALL TRUCKS | HDGV | 0.2036 |
| | HDDV | 0.7964 |
| LARGE TRUCKS | HDGV | 0.0001 |
| | HDDV | 0.9999 |
| BUSES | HDGV | 0.0828 |
| | HDDV | 0.9172 |

[1] LDGV – Light-duty Gasoline Vehicles
LDGT1 – Light-duty Gasoline Trucks 1 and 2
LDGT2 – Light-duty Gasoline Trucks 3 and 4
LDDV – Light-duty Diesel Vehicles
LDDT – Light-duty Diesel Trucks
MC – Motorcycles
HDGV – Heavy-duty Gasoline Vehicles
HDDV – Heavy-duty Diesel Vehicles
[2] Estimated based on EPA's MOBILE6 default data.

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 2008 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 2008 enhanced inspection maintenance (I/M) program annual report (DEC, 2009). Vehicle age-specific distribution data (i.e., 25-year range, 1984 through 2008) were then utilized in estimating GHG emissions and were used for all facilities.

$CO_2$ emissions were estimated by dividing VMT by the average model year-specific fuel economy factors and multiplying by fuel-specific emission factors expressed in pounds per gallon. Fuel economy data were derived from a combination of EPA's MOBILE6 default values for model years 1984 to 1992 and supplemental tables to the Annual Energy Outlook (AEO) reports prepared by the U.S. Department of Energy (DOE) Energy Information Administration (EIA) (EPA, 2003; DOE, 1996-2007; DOE, 2008a; DOE, 2009). 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 vehicle type and model year-specific technology weighted emission factors (in grams/mile) by EPA's vehicle category. The technology weighted emission factors by vehicle type, pollutant, and model year combination were derived based on the VMT allocations and emission factors for all control technologies. 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 $CO_2$e 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**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Facility Name** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| **Bridges** | | | | |
| George Washington Bridge | 133,188 | 6 | 6 | 135,192 |
| Bayonne Bridge | 7,106 | 0 | 0 | 7,210 |
| Goethals Bridge | 22,082 | 1 | 1 | 22,401 |
| Outerbridge Crossing | 28,702 | 1 | 1 | 29,174 |
| **Tunnels** | | | | |
| Lincoln Tunnel | 90,455 | 3 | 3 | 91,591 |
| Holland Tunnel | 45,951 | 3 | 3 | 46,809 |
| **Total** | **327,483** | **15** | **15** | **332,377** |

In 2008, 332,377metric tons of $CO_2$e 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 $CO_2$e), and about 2 percent was from $N_2O$ (as $CO_2$e).

### 4.1.5. Comparison with Estimates in Previous Studies

This section provides a comparison of 2006, 2007, and 2008 **$CO_2$ equivalent** emissions results. Table 4-4 presents emissions results for calendar years 2006, 2007, and 2008.

**Table 4-4. $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Bridges | | | | |
| George Washington Bridge | 139,967 | 137,777 | 135,192 | -3.4% |
| Bayonne Bridge | 8,277 | 7,672 | 7,210 | -12.9% |
| Goethals Bridge | 20,503 | 22,310 | 22,401 | 9.3% |
| Outerbridge Crossing | 32,063 | 30,356 | 29,174 | -9.0% |
| Tunnels | | | | |
| Lincoln Tunnel | 94,486 | 94,093 | 91,591 | -3.1% |
| Holland Tunnel | 48,985 | 48,122 | 46,809 | -4.4% |
| **Total** | **344,281** | **340,330** | **332,377** | **-3.5%** |

The 2008 GHG emissions inventory for attracted travel crossing tunnel and bridge facilities showed an overall decrease in GHG emissions by 3.5 percent from 2006. As presented in Table 4-4, the estimated GHG emissions produced by tunnel and bridge facilities amounted to 332,377 metric tons in 2008 and 344,281 metric tons in 2006, an 11,904 metric ton decrease in emissions from 2006 to 2008. The decrease in emission values was 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 a 9.3 percent increase in emissions. The emission increase for Goethals Bridge was a result of an increase in the vehicle traffic volume for all vehicle categories (i.e., auto, buses, small trucks, and large trucks). The Port Authority tunnels and bridges annual traffic volumes showed an overall decrease of 2.6 percent from 2006 to 2008.

## 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

This section presents the methods used for estimating 2008 queuing GHG emissions. Because there were no updated information regarding queuing activity on the tunnels and bridges for 2008, the primary method used in estimating 2008 GHG emission from queuing was to grow 2006 emissions to 2008. The methodology for estimating 2006 activity data, GHG emissions, and data sources is also presented in this section.

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, 2008a). 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 |
| 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 2008 GHG emissions. This methodology is consistent with the methods applied in 2007 GHG inventory.

The 2006 $CO_2$ queuing emissions were grown to 2008 by multiplying the 2006 facility-specific queuing emissions by the ratio of 2008 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 | 7,924 | 0 | 0 | 7,924 |
| Bayonne Bridge | 1 | 0 | 0 | 1 |
| Goethals Bridge | 1,295 | 0 | 0 | 1,295 |
| Outerbridge Crossing | 168 | 0 | 0 | 168 |
| **Tunnels** | | | | |
| Lincoln Tunnel | 9,729 | 0 | 0 | 9,729 |
| Holland Tunnel | 4,348 | 0 | 0 | 4,348 |
| **Total** | **23,464** | **0** | **0** | **23,464** |

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. Scaling the 2006 emissions to 2008 is also a source of uncertainty because queuing delays are not linearly proportional to travel volumes.

### 4.2.5. Comparison with Estimates in Previous Studies

This section provides a comparison of 2008 results from the previous year. Table 4-7 provides a comparison of the 2006, 2007, and 2008 $CO_2$ equivalent results.

**Table 4-7. $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| **Bridges** | | | | |
| George Washington Bridge | 8,167 | 8,059 | 7,924 | -3.0% |
| Bayonne Bridge | 1 | 1 | 1 | -12.5% |
| Goethals Bridge | 1,180 | 1,287 | 1,295 | 9.8% |
| Outerbridge Crossing | 183 | 174 | 168 | -8.6% |
| **Tunnels** | | | | |
| Lincoln Tunnel | 9,994 | 9,975 | 9,729 | -2.6% |
| Holland Tunnel | 4,525 | 4,458 | 4,348 | -3.9% |
| **Total** | **24,050** | **23,954** | **23,464** | **-2.4%** |

GHG emissions from queuing decreased 2.4 percent from 2006 to 2008. Year-to-year changes in queuing emissions are in proportion to travel volumes at these facilities. As with the 2006 and 2007 queuing emissions results, a majority of the 2008 queuing emissions occurred at the most heavily traveled facilities: Lincoln Tunnel, George Washington Bridge, and Holland Tunnel.

## 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 TCR 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. Tunnels and Bridges Buildings GHG Emissions by Facility and by Scope**

| Facility | Scope 1 (metric tons) | Scope 2 (metric tons) | Scope 3 (metric tons) |
|---|---|---|---|
| George Washington Bridge | 557 | 2,605 | 0 |
| Holland Tunnel | 74 | 3,336 | 0 |
| Lincoln Tunnel | 38 | 3,117 | 0 |
| Bayonne Bridge | 0 | 276 | 0 |
| Goethals Bridge | 422 | 831 | 0 |
| Outerbridge Crossing | 186 | 435 | 0 |
| **Total** | **720** | **10,600** | **0** |

### 4.3.5. Comparison with Estimates in Previous Studies

Table 4-10 compares 2006 baseline data with 2008 GHG emissions for Tunnels & Bridges building utility use. Note that George Washington Bridge, Holland Tunnel, and Lincoln Tunnel had gas and NYPA power consumption figures reported, but did not have PSE&G power consumption figures reported for 2008. George Washington Bridge had no gas consumption reported in 2006 and 2007, but reported gas consumption for the first time in 2008. This made estimation of 2008 emissions questionable for all three facilities.

**Table 4-10. $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| George Washington Bridge | 3,095 | 2,959 | 2,605 | -15.83% |
| Holland Tunnel | 5,589 | 4,927 | 3,410 | -38.99% |
| Lincoln Tunnel | 7,569 | 7,574 | 3,155 | -58.32% |
| Bayonne Bridge | 268 | 232 | 276 | 2.99% |
| Goethals Bridge | 1,109 | 967 | 1,253 | 12.98% |
| Outerbridge Crossing | 566 | 505 | 621 | 9.72% |
| **Total** | **18,197** | **17,164** | **11,320** | **-37.79%** |

The CAP emissions summary for tunnels and bridges is provided in Table 5-12 in the next chapter.

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# 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. The activity for the buses is the mileage traveled within the terminals and the fuel consumed while idling in the terminals during 2008. The activity for the personal vehicles is the mileage traveled within the terminals and the vehicle starts within the terminals during 2008. 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 within the Port Authority bus terminals.

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 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 dimensions of the bus terminal. Table 5-1 summarizes the total 2008 bus movements and dimensions of both bus terminals, along with the corresponding data sources. 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). In addition to the bus travel through the terminal, this analysis also accounts for the VMT accumulated due to extra circulation on city streets currently required at the George Washington Bridge Bus Station (GWBBS) at the Lower Level as well as the extra circulation on city streets when the Port Authority Bus Terminal (PABT) congestion requires a diversion. Based on information from the Port Authority, the diversion 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 covers a distance of 2,681 feet, with 10 buses circulating at any given time from 5 p.m. to 6:45 p.m. weekdays. This results in an additional 19,000 miles of bus travel at the GWBBS and 23,000 miles at the PABT per year.

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, 2008). From the data in this report, the average time each bus spends within the terminal was calculated, and then the amount of time it would take a bus to travel the specified distance through the facility at a nominal speed of 5 miles per hour was subtracted. The remaining time was assumed to be the average bus idling time. 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 one half gallon of diesel fuel is consumed for each hour of idling (EPA, 2002) 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, 2010), applying emission factors from the heavy-duty diesel vehicle category. 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 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, but on a total fuel cycle basis, increased emissions from $CH_4$ tend to offset these $CO_2$ reductions (Cannon, 2000).

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 was estimated in the same manner as the bus VMT (twice the length plus the width of the dimensions of the bus terminal). The per-vehicle VMT was then multiplied by the total number of vehicles parked at the bus terminals during 2008, as shown in Table 5-1. The number of vehicle starts was assumed to be equal to the number of vehicles parked during 2008. Cold start emissions from buses were not calculated, as the IPCC emission factors for cold starts from diesel vehicles are all negative (IPCC, 2006).

**Table 5-1. Bus Terminal Activity Data**

| Terminal | Terminal Length (feet) | Terminal Width (feet) | Total Bus Movements[a] | Total Vehicles Parked |
|---|---|---|---|---|
| George Washington Bridge Bus Station | 400[b] | 185[b] | 324,000 | 36,500[c] |
| Port Authority Bus Terminal | 1,200[d] | 200[d] | 2,220,000 | 418,500[e] |

[a]SOURCE: PANYNJ, 2008.
[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 400 by 800 feet in 1963; expanded by 50 percent in late 1980s, so original length of 800 feet was multiplied by 1.5 to obtain current length of 1,200 feet.
[e]Leased parking at PABT from Leased Parking Stats-PABT.xls (total 2006 vehicles parked), spreadsheet provided by PANYNJ to Pechan, October 2007.

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2008), 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 was converted to annual fuel consumption to estimate $CO_2$ emissions by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy data were obtained from DOE's Annual Energy Outlook (DOE, 1998-2007). 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 and 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 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.

### 5.1.4. Results

Table 5-2 summarizes the GHG emission estimates that occur within the PANYNJ bus terminal boundaries. These emissions are broken down by facility, as well as for buses and personal vehicles. Emissions at the PABT are nearly 10 times greater than the emissions at the GWBBS. This is reasonable, given the differences in magnitude of bus operations of the two facilities, 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 $CO_2$e emissions. The amount of time the buses spend idling within the terminals and the speeds the buses travel within the terminal are relatively uncertain. Idling times were estimated based on the time buses spend within the terminals and subtracting the amount of time it would require for them to pass through the terminal at an assumed speed of 5 mph. If this assumed speed is significantly different from the actual speeds through the terminal, or if the buses generally turn their engines off while parked in the terminal, the emissions from idling could be significantly different.

**Table 5-2. George Washington Bridge Bus Station GHG Emissions by Gas and $CO_2$ Equivalent**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **George Washington Bridge Bus Station** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| In Terminal Bus Emissions | 412 | 0 | 0 | 412 |
| In Terminal Car Emissions | 2 | 0 | 0 | 3 |
| Total | 414 | 0 | 0 | 416 |

**Table 5-3. Bus Terminal CAP Emissions by Gas**

| | Criteria Pollutant Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **George Washington Bridge Bus Station** | **$NO_x$** | **$SO_x$** | **$PM_{10}$** | **$PM_{2.5}$** |
| In Terminal Bus Emissions | 36 | 0 | 0 | 0 |
| In Terminal Car Emissions | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 |

**Table 5-4. Port Authority Bus Terminal GHG Emissions by Gas and $CO_2$ Equivalent**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Port Authority Bus Terminal** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| In Terminal Bus Emissions | 4,196 | 0 | 0 | 4,198 |
| In Terminal Car Emissions | 59 | 0 | 0 | 63 |
| Total | 4,255 | 0 | 0 | 4,261 |

**Table 5-5. Port Authority Bus Terminal CAP Emissions by Gas**

| | Criteria Pollutant Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Port Authority Bus Terminal** | **$NO_x$** | **$SO_x$** | **$PM_{10}$** | **$PM_{2.5}$** |
| In Terminal Bus Emissions | 10 | 0 | 0 | 0 |
| In Terminal Car Emissions | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 |

### 5.1.5. Comparison with Estimates in Previous Studies

Tables 5-6 and 5-7 compare the George Washington Bridge and Port Authority bus terminal GHG emissions for 2006, 2007, and 2008. Overall GHG emissions from vehicle movements at these two bus terminals have declined 26 percent from 2006 to 2008.

**Table 5-6. George Washington Bridge Bus Terminal Yearly Emissions Comparison**

| George Washington Bridge Bus Station | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| In Terminal Bus Emissions | 607 | 391 | 412 | -32.1% |
| In Terminal Car Emissions | 4 | 4 | 3 | -16.3% |
| Total | 611 | 395 | 416 | -32.0% |

**Table 5-7. Port Authority Bus Terminal Yearly Emissions Comparison**

| Port Authority Bus Terminal | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| In Terminal Bus Emissions | 5,645 | 4,103 | 4,198 | -25.6% |
| In Terminal Car Emissions | 89 | 90 | 63 | -28.9% |
| Total | 5,734 | 4,193 | 4,261 | -25.7% |

## 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 5-8 are included in this building energy use category. For facilities in which partial or no 2008 data was available, 2007 values were substituted for the purposes of this evaluation. An asterisk identifies properties within the boundary in which 2008 data was used.

**Table 5-8. 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 five 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. Step four encompassed filling in missing fields with 2007 data. The final step consisted in classifying emission results according to scope. All bus terminal building energy use was 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 TCR 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 percent in accordance with TCR 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 5-9.

**Table 5-9. 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 | 12,796 |
| **Total** | **0** | **0** | **15,192** |

### 5.2.5. Comparison with Estimates in Previous Studies

Table 5-10 compares the baseline year 2006 and 2008 GHG emissions for bus terminal buildings.

**Table 5-10. $CO_2$ Equivalent GHG Emissions Comparison**

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| George Washington Bridge Bus Station | 3,417 | 2,396 | 2,396 | -29.88% |
| Port Authority Bus Terminal | 12,872 | 11,467 | 12,796 | -0.59% |
| **Total** | **16,289** | **13,863** | **15,192** | **-6.73%** |

## 5.3. TUNNELS, BRIDGES, AND TERMINALS GHG EMISSIONS SUMMARY

Table 5-11 summarizes the 2008 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 5-11. Tunnels, Bridges and Terminals Department 2008 GHG Emissions by Facility and Scope (metric tons $CO_2$ equivalent)**

| | Scope 1 | Scope 2 | Scope 3 | Facility Emission Totals |
|---|---|---|---|---|
| **George Washington Bridge** | **445** | **2,605** | **143,116** | **146,166** |
| Attracted Travel | - | - | 135,192 | 135,192 |
| Queuing | - | - | 7,924 | 7,924 |
| Buildings | - | 2,605 | - | 2,605 |
| Fleet Vehicle Emissions | 445 | - | - | 445 |
| **Staten Island Bridges (Bayonne, Goethals, & Outerbridge Crossing)** | **372** | **-** | **-** | **372** |
| Fleet Vehicle Emissions | 372 | - | - | 372 |
| **Bayonne Bridge** | **-** | **276** | **7,211** | **7,487** |
| Attracted Travel | - | - | 7,210 | 7,210 |
| Queuing | - | - | 1 | 1 |
| Buildings | - | 276 | - | 276 |
| **Goethals Bridge** | **422** | **831** | **23,696** | **24,949** |
| Attracted Travel | - | - | 22,401 | 22,401 |
| Queuing | - | - | 1,295 | 1,295 |
| Buildings | 422 | 831 | - | 1,253 |
| **Outerbridge Crossing** | **186** | **435** | **29,342** | **29,963** |
| Attracted Travel | - | - | 29,174 | 29,174 |
| Queuing | - | - | 168 | 168 |
| Buildings | 186 | 435 | - | 621 |
| **Lincoln Tunnel** | **677** | **3,117** | **101,320** | **105,114** |
| Attracted Travel | - | - | 91,591 | 91,591 |
| Queuing | - | - | 9,729 | 9,729 |
| Buildings | 38 | 3,117 | - | 3,155 |
| Fleet Vehicle Emissions | 619 | - | - | 619 |
| Direct Fugitive Emissions | 20 | - | - | 20 |
| **Holland Tunnel** | **411** | **3,336** | **51,157** | **54,904** |
| Attracted Travel | - | - | 46,809 | 46,809 |
| Queuing | - | - | 4,348 | 4,348 |
| Buildings | 74 | 3,336 | - | 3,410 |
| Fleet Vehicle Emissions | 337 | - | - | 337 |
| **George Washington Bridge Bus Station** | **-** | **-** | **1,155** | **1,155** |
| Buildings | - | - | 740 | 740 |
| In Terminal Bus Emissions | - | - | 412 | 412 |
| In Terminal Private Vehicle Emissions | - | - | 3 | 3 |
| **Port Authority Bus Terminal** | **23** | **-** | **17,057** | **17,080** |
| Buildings | - | - | 12,796 | 12,796 |
| Fleet Vehicle Emissions | 23 | - | - | 23 |
| In Terminal Bus Emissions | - | - | 4,198 | 4,198 |
| In Terminal Private Vehicle Emissions | - | - | 63 | 63 |
| **TUNNELS, BRIDGES & TERMINALS** | **2,536** | **10,600** | **374,054** | **387,190** |

## 5.4. TUNNELS, BRIDGES, AND TERMINALS CAP EMISSIONS SUMMARY

Table 5-12 shows the estimated 2008 Tunnels, Bridges, and Terminals CAP emissions by facility.

**Table 5-12. Tunnels, Bridges, and Terminals 2008 CAP Emission Estimates**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| **George Washington Bridge** | **351** | **5** | **12** | **8** |
| Attracted Travel | 338 | 3 | 12 | 8 |
| Queuing | 9 | 0 | 0 | 0 |
| Buildings | 3 | 2 | - | - |
| Fleet Vehicle Emissions | 0 | 0 | 0 | 0 |
| **Staten Island Bridges (Bayonne, Goethals, & Outerbridge Crossing)** | **1** | **0** | **0** | **0** |
| Fleet Vehicle Emissions | 1 | 0 | 0 | 0 |
| **Bayonne Bridge** | **20** | **-** | **1** | **-** |
| Attracted Travel | 20 | - | 1 | - |
| Queuing | - | - | - | - |
| Buildings | - | - | - | - |
| **Goethals Bridge** | **61** | **2** | **2** | **1** |
| Attracted Travel | 58 | 1 | 2 | 1 |
| Queuing | 2 | 0 | 0 | 0 |
| Buildings | 1 | 1 | - | - |
| **Outerbridge Crossing** | **74** | **1** | **2** | **1** |
| Attracted Travel | 73 | 1 | 2 | 1 |
| Queuing | 0 | - | - | - |
| Buildings | 1 | - | - | - |
| **Lincoln Tunnel** | **360** | **4** | **9** | **6** |
| Attracted Travel | 341 | 2 | 9 | 6 |
| Queuing | 15 | 0 | 0 | 0 |
| Buildings | 3 | 2 | - | - |
| Fleet Vehicle Emissions | 1 | 0 | 0 | 0 |
| **Holland Tunnel** | **96** | **4** | **4** | **2** |
| Attracted Travel | 89 | 1 | 4 | 2 |
| Queuing | 3 | 0 | 0 | 0 |
| Buildings | 3 | 3 | - | - |
| Fleet Vehicle Emissions | 0 | 0 | 0 | 0 |
| **George Washington Bridge Bus Station** | **2** | **-** | **-** | **-** |
| Buildings | 1 | - | - | - |
| In Terminal Bus Emissions | 1 | - | - | - |
| In Terminal Private Vehicle Emissions | - | - | - | - |
| **Port Authority Bus Terminal** | **23** | **10** | **1** | **1** |
| Buildings | 12 | 10 | 1 | 1 |
| Fleet Vehicle Emissions | 1 | 0 | 0 | 0 |
| In Terminal Bus Emissions | 10 | - | - | - |
| In Terminal Private Vehicle Emissions | - | - | - | - |
| **TUNNELS, BRIDGES & TERMINALS** | **986** | **26** | **32** | **20** |

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# 6.0 PATH

This chapter describes the GHG and CAP emission estimation methods and results for PATH trains, travel attracted to PATH stations, and PATH diesel equipment.

## 6.1. TRAINS

Because PATH trains are electric, they are responsible for indirect emissions from their power use. The greenhouse gas emissions associated with the generation of electricity used by the trains were estimated by applying an emission factor associated with the utility providing the electricity. PATH traction power is provided by a Public Service Electric & Gas Company (PSE&G) account associated with PathCorpWashSt_All. This account is primarily a traction power account, with the electricity to power the trains comprising 85 percent of the electricity used. Activity data, in the form of kWh, was estimated as being 85 percent of the total kWh from the PathCorpWashSt_All account during the year. Emission factors were taken from the Emissions & Generation Resource Integrated Database (eGRID) 2007 version 1.1 year 2005 eGRID subregion: Reliability First Corporation East (EPA, 2008a). The activity data was multiplied by the emission factors and the results were converted to $CO_2$e using the IPCC SAR GWPs. Table 6-1 sets forth these GHG emission factors for PATH electricity.

**Table 6-1. 2007 GHG Emission Factors for PATH Electricity**

| $CO_2$ (lb/MWh) | $CH_4$ (lb/GWh) | $N_2O$ (lb/GWh) |
|---|---|---|
| 1139.07 | 30.27 | 18.71 |

Indirect CAP emissions were also estimated for the electricity used by PATH trains. Activity data was the same as that used for the GHG emission estimation (the total kWh used over the course of the year for traction power). The emission factors for $NO_x$ and $SO_2$ were already in eGRID, and $PM_{2.5}$ and $PM_{10}$ emissions were calculated in proportion to the $SO_2$ emissions. This approach is valid and applicable because the electricity comes from a variety of power plant sources, and the major factor which contributes to the difference in PM emissions from one power plant source to the next is the control device being used. Since PM controls have a strong correlation to $SO_2$ reduction, the $SO_2$ would vary from plant to plant in a similar manner. In order to find the proportion to use, the 2002 NEI was analyzed, and the total emissions from all electric generating processes was totaled for plants in New York and in New Jersey for $SO_2$, $PM_{2.5}$, and $PM_{10}$. The proportion calculated for New Jersey was applied to the PATH $SO_2$ emissions, given that PATH purchases the majority of their electricity from PSE&G. Table 6-2 sets forth these CAP emission factors for PATH electricity.

**Table 6-2. CAP Emission Factors for PATH Electricity**

| $NO_x$ (lb/MWh) | $SO_2$ (lb/MWh) | $PM_{10}$ (lb/MWh) | $PM_{2.5}$ (lb/MWh) |
|---|---|---|---|
| 1.707 | 8.035 | 0.472 | 0.411 |

### 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 2008 – 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 2008. 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, 2008b). 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

The total greenhouse gas and criteria air pollutant estimates from indirect PATH utility traction power are shown in Tables 6-3 and 6-4. The increase in emissions in 2008 is the result of an increase in purchased traction power.

**Table 6-3. GHG Emission Estimates for PATH Electric Power**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **PATH Utility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| Traction | 41,956 | 1.1 | 0.7 | 42,194 |

**Table 6-4. CAP Emission Estimates for PATH Electric Power**

| PATH Utility | Criteria Pollutant Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $NO_x$ | $SO_x$ | $PM_{10}$ | $PM_{2.5}$ |
| Traction | 63 | 296 | 17 | 15 |

### 6.1.5. Comparison with Estimates in Previous Studies

Table 6-5 summarizes PATH train GHG emissions and shows that these emissions increased by about 3 percent during 2008. PATH ridership in 2008 totaled 75 million passengers – a 5 percent increase from 2007 totals.

**Table 6-5. Comparison of GHG Estimates PATH Utility Data**

| PATH Utility Power | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Traction | 40,161 | 40,206 | 42,194 | 3.24% |

## 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, as well as idling emissions at Journal Square.

### 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 and idling emissions were also calculated based on vehicle trips. VMT data was multiplied by $CH_4$ and $N_2O$ emission factors (in terms of mass per mile and mass per vehicle start) and converted to gallons of fuel consumed (based on fuel efficiency) and multiplied by emission factors for $CO_2$ (in terms of mass per gallon of fuel consumed) 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 2008 (PANYNJ, 2009a) 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 2008 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 6-6 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 33$^{rd}$ 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 estimate 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 6-6. Activity Data for Vehicle Travel To and From PATH Train Stations**

| PATH Access/Egress Mode | 2008 Total Passengers | Estimated Trip Length (miles) | Average Vehicle Occupancy | Assumed Number of Starts per Trip | 2008 Total VMT (miles) |
|---|---|---|---|---|---|
| Auto: drove | 8,257,196 | 5 | 1.49 | 1 | 27,743,449 |
| Auto: Passenger | 4,030,622 | 5 | 1.49 | 1 | 13,542,532 |
| Commuter Van | 1,184,551 | 20 | 8 | 1 | 2,961,379 |
| Taxi | 3,562,401 | 5 | 1.63 | 0 | 10,927,610 |
| **Total** | | | | | 55,174,969 |

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 6-6.

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2008c), 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, 1996-2009). The $CO_2$ emissions 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 activities associated with the bus emissions are VMT and idling. VMT was estimated by multiplying the total number of 2008 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 33$^{rd}$ 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 2008 was provided by PANYNJ (PANYNJ, 2009b). This showed that 470,976 buses departed from the Journal Square Transportation Center in 2008. 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).

Idling emissions were estimated based on survey data conducted at Journal Square in 2008. The assumption was made that buses consume one half gallon of fuel per hour (EPA, 2007) during idling. Total fuel consumed from bus idling was calculated by multiplying the average idling time per bus (2.4 minutes (PATH, 2008)) by the annual number of bus movements at Journal Square (470,976). Using this method, it is estimated that buses idled 18,939 hours at the Journal Square Station in 2008. These hours are then multiplied by the fuel consumed per hour of idling (0.5 gal/hour), to estimate a total consumption of 9,469 gallons of diesel fuel.

Emission factors were obtained from EPA's latest GHG Inventory report (EPA, 2008c), 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 buses and vehicles were then summed by bus terminal. The $CH_4$ and $N_2O$ emissions totals were multiplied by their GWP coefficients to calculate their $CO_2$ equivalents. There are no $CH_4$ and $N_2O$ emissions associated with idling.

### 6.2.4. Results

Table 6-7 summarizes the GHG emission estimates for vehicle trips to and from 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 $CO_2$e emissions.

**Table 6-7. PATH Attracted Travel GHG Emissions by Gas and $CO_2$ Equivalent**

| | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Facility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| PATH Vehicle Trips Attracted | 19,568 | 1.57 | 1.89 | 20,188 |
| Bus Trips at PATH Journal Square Station | 11,401 | 0.02 | 0.02 | 11,408 |
| ***PATH Attracted Travel Total*** | ***30,969*** | ***1.59*** | ***1.92*** | ***31,597*** |

### 6.2.5. Comparison with Estimates in Previous Studies

In comparison with 2006 emissions from PATH attracted travel, 2008 total $CO_2$e emissions increased 13.6 percent. Emissions from bus trips from Journal Square increased only 1.1 percent, while emissions from vehicle trips increased 22.2 percent between 2006 and 2008. This increase in vehicle trip emissions is congruent with the 23.3 percent increase in PATH ridership from 2006 to 2008. The number of Journal Square bus departures for 2008 was essentially the same as in 2006, which explains why there is so little change in emissions in this category from last year. The majority of the increase in Journal Square emissions comes from the inclusion of bus idling emissions, which were not included in the 2006 and 2007 analyses, although these make up only a small portion (0.8 percent) of total Journal Square $CO_2$e emissions. Table 6-8 summarizes the 2006-2008 PATH attracted travel emissions.

**Table 6-8. PATH Attracted Travel $CO_2$ Equivalent GHG Emissions Comparison**

| | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006-2008) |
|---|---|---|---|---|
| **Facility** | **2006** | **2007** | **2008** | |
| PATH Vehicle Trips Attracted | 16,526 | 19,382 | 20,188 | 22.2% |
| Bus Trips at PATH Journal Square Station | 11,279 | 11,280 | 11,408 | 1.14% |
| **Total** | **27,805** | **30,662** | **31,597** | 13.6% |

## 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 6-9 summarizes the emissions from diesel equipment.

**Table 6-9. 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** |
| 29,961 | 333 | 0.0 | 0.1 | 373 |

### 6.3.5. Comparison with Estimates in Previous Studies

Table 6-10 compares 2008 GHG emission estimates for PATH diesel equipment with those made previously for 2006 and 2007.

**Table 6-10. PATH Diesel Equipment $CO_2$ Equivalent GHG Emissions Comparison**

| | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| **Facility** | **2006** | **2007** | **2008** | |
| Diesel Equipment | 284 | 272 | 373 | 27% |

## 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 6-11 are included in this building energy use category. 2008 data was unavailable for this evaluation therefore 2007 was used for the purposes of this report.

**Table 6-11. Facilities within PATH Boundary**

| Facility |
|---|
| PATH Rapid Transit System |
| Journal Square Transportation Center |

### 6.4.3. Methods

In 2007, 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. Facility total $CO_2$ equivalent emissions and division of emissions by scope are included in Table 6-12.

**Table 6-12. PATH Buildings GHG Emissions by Facility and by Scope**

| Facility | Scope 1 (metric tons) | Scope 2 (metric tons) | Scope 3 (metric tons) |
|---|---|---|---|
| PATH Buildings | - | 7,446 | - |
| Journal Square Transportation Center | - | 5,537 | - |
| **Total** | **0** | **12,983** | **0** |

### 6.4.5. Comparison with Estimates in Previous Studies

Table 6-13 compares 2008 GHG emission estimates for PATH Buildings with those made previously for baseline year 2006.

**Table 6-13. PATH Buildings $CO_2$ Equivalent GHG Emissions Comparison**

| | $CO_2$ Equivalent (metric tons) | | | Percentage |
|---|---|---|---|---|
| Facility | 2006 | 2007 | 2008 | Difference |
| PATH Buildings | 7,205 | 7,095 | 7,446 | 3.24% |
| Journal Square Transportation Center | 5,537 | 5,537 | 5,537 | N/A |
| **Total** | **12,743** | **12,632** | **12,983** | **1.85%** |

## 6.5. PATH GHG EMISSIONS SUMMARY

Table 6-14 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 6-14. PATH Department GHG Emissions by Facility and Scope (metric tons $CO_2$ equivalent)**

| | Scope 1 | Scope 2 | Scope 3 | Facility Emission Totals |
|---|---|---|---|---|
| Attracted Travel | - | - | 31,597 | 31,597 |
| Buildings | - | 12,983 | - | 12,983 |
| Direct Fugitive Emissions | 39 | - | - | 39 |
| Vehicle Fleet | 291 | - | - | 291 |
| Indirect Emissions from Purchased Traction Power | - | 42,194 | - | 42,194 |
| Diesel Equipment | 373 | - | - | 373 |
| **PATH RAPID TRANSIT SYSTEM** | **703** | **55,177** | **31,597** | **87,477** |

## 6.6. PATH CAP EMISSIONS SUMMARY

Table 6-15 summarizes the CAPs emissions estimates for PATH trains, buildings, attracted travel, and diesel equipment within the Port Authority's PATH department.

**Table 6-15. PATH CAP Emission Estimates**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| Attracted Travel | 69 | 1 | 2 | 2 |
| Buildings | 37 | 204 | 18 | 15 |
| Vehicle Fleet | 0 | 0 | 0 | 0 |
| Indirect Emissions from Purchased Traction Power | 63 | 296 | 17 | 15 |
| Diesel Equipment | 8 | 1 | 1 | 1 |
| **PATH RAPID TRANSIT SYSTEM** | **177** | **502** | **38** | **33** |

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# 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 2008 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, 1,513 on-road and 863 non-road fleet vehicles were identified from the data provided by PANYNJ. These vehicles were estimated to travel 13.97 million miles and consume 1.22 million gallons of fuel in 2008.

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 2008; and the miles traveled in 2008. The fuel estimate also included credit card purchases of fuel purchased from vendors not in the Central Automotive Division's system, but not at a vehicle specific level. The credit card fuel data was at a departmental level and was evenly distributed among the vehicles in the department that use fuel This data set included both on-road vehicles and non-road engine and equipment data, for which emissions were calculated separately. The $CO_2$ 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. CAPs were estimated using VMT for both onroad and non-road vehicles.

For this analysis, the fuel use and fuel class data were used to estimate fleet vehicle activity during 2008. 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. This is because the no sales data for E-85 were provided and the only E-85 fueling stations available in the New York area are operated by and for the New York Department of Sanitation.

$CO_2$, $CH_4$, and $N_2O$ emission factors were assigned to each vehicle type. The $CO_2$ emission factors varied only by fuel type (gasoline, 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 $CO_2$e emissions.

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

| | GHG Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Facility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| JFK Int. Airport | 1,306 | 6.51E-02 | 6.15E-02 | 1,326 |
| LGA Airport | 741 | 1.56E-02 | 1.20E-02 | 745 |
| Newark Liberty Int. Airport | 1,087 | 3.24E-02 | 4.28E-02 | 1,101 |
| Teterboro Airport | 0 | 4.86E-04 | 4.81E-04 | 0 |
| P.A. Bus Terminal | 19 | 6.27E-04 | 6.35E-04 | 20 |
| Long Term Rental Pool | 13 | 2.87E-03 | 5.30E-03 | 14 |
| NY Motor Pool | 35 | 4.67E-03 | 2.40E-03 | 36 |
| PATH Rail Transportation | 284 | 5.04E-03 | 3.05E-03 | 285 |
| Brooklyn Piers | 57 | 1.50E-03 | 1.84E-03 | 57 |
| New Jersey Marine Terminal | 0 | 2.45E-07 | 2.30E-07 | 0 |
| New York Marine Terminal | 13 | 7.08E-04 | 1.00E-03 | 13 |
| Port Ivory | 3 | 2.59E-04 | 5.73E-04 | 3 |
| Port Newark Facilities | 25 | 1.36E-03 | 2.37E-03 | 26 |
| Port Newark Marine Terminal | 218 | 6.89E-03 | 8.81E-03 | 221 |
| New York Teleport | - | 8.68E-05 | 9.21E-05 | 0 |
| Newark Legal Center | 2 | 3.46E-04 | 6.51E-04 | 2 |
| P.A. Technical Center | 839 | 4.51E-02 | 4.13E-02 | 853 |
| P.A. Technical Center Short Term Pool | 53 | 6.51E-03 | 6.71E-03 | 55 |
| Park Avenue Offices | 15 | 5.73E-03 | 3.59E-03 | 16 |
| Rehabilitation Shop at 777 | 5 | 1.07E-04 | 1.69E-04 | 5 |
| World Trade Center | 7 | 9.70E-05 | 6.29E-05 | 7 |
| George Washington Bridge | 263 | 5.77E-03 | 7.53E-03 | 265 |
| Holland Tunnel | 235 | 4.68E-03 | 6.12E-03 | 237 |
| Lincoln Tunnel | 479 | 1.02E-02 | 1.20E-02 | 483 |
| Staten Island Bridge Facilities | 308 | 9.83E-03 | 1.30E-02 | 312 |
| Public Safety Department Total | 3,366 | 8.49E-02 | 6.85E-02 | 3,389 |
| ***On-road Fleet Vehicles Total*** | **9,373** | **0.311** | **0.302** | **9,473** |

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

| | GHG Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| **Facility** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| JFK Int. Airport | 410 | 1.97E-02 | 1.20E-01 | 448 |
| LGA Airport | 254 | 1.22E-02 | 7.35E-02 | 277 |
| Newark Liberty Int. Airport | 306 | 1.46E-02 | 9.12E-02 | 334 |
| Teterboro Airport | 2 | 9.07E-05 | 6.12E-04 | 2 |
| P.A. Bus Terminal | 3 | 1.46E-04 | 9.83E-04 | 3 |
| Long Term Rental Pool | 15 | 7.03E-04 | 4.75E-03 | 16 |
| PATH Rail Transportation | 6 | 2.91E-04 | 1.56E-03 | 7 |

| Facility | GHG Emissions Totals (metric tons) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ Equivalent |
| Brooklyn Piers | 1 | 7.18E-05 | 3.31E-04 | 2 |
| Port Newark Facilities | 23 | 1.14E-03 | 5.96E-03 | 25 |
| Port Newark Marine Terminal | 32 | 1.53E-03 | 9.89E-03 | 36 |
| P.A. Technical Center | 58 | 2.83E-03 | 1.62E-02 | 63 |
| Rehabilitation Shop at 777 | 2 | 5.34E-05 | 2.67E-05 | 2 |
| George Washington Bridge | 164 | 7.81E-03 | 5.03E-02 | 180 |
| Holland Tunnel | 91 | 4.32E-03 | 2.91E-02 | 100 |
| Lincoln Tunnel | 124 | 5.91E-03 | 3.76E-02 | 136 |
| Staten Island Bridge Facilities | 55 | 2.66E-03 | 1.49E-02 | 59 |
| Public Safety Department Total | 423 | 2.01E-02 | 1.30E-01 | 464 |
| ***Non-road Fleet Vehicles Total*** | **1,970** | **0.09** | **0.59** | **2,154** |

### 7.1.5. CAP 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 |
| 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 | 0.005 | 2.86E-05 | 1.44E-04 | 1.13E-04 |
| George Washington Bridge | 0.428 | 2.16E-03 | 1.15E-02 | 9.29E-03 |
| Holland Tunnel | 0.266 | 1.34E-03 | 7.14E-03 | 5.78E-03 |
| JFK Int. Airport | 1.211 | 6.19E-03 | 3.25E-02 | 2.62E-02 |
| LGA Airport | 0.693 | 3.49E-03 | 1.86E-02 | 1.51E-02 |
| Lincoln Tunnel | 0.205 | 1.07E-03 | 5.50E-03 | 4.39E-03 |
| Long Term Rental Pool | 0.055 | 2.76E-04 | 1.47E-03 | 1.19E-03 |
| Newark Liberty Int. Airport | 0.885 | 4.49E-03 | 2.38E-02 | 1.92E-02 |
| P.A. Bus Terminal | 0.015 | 7.31E-05 | 3.91E-04 | 3.16E-04 |
| P.A. Technical Center | 0.096 | 4.84E-04 | 2.58E-03 | 2.09E-03 |
| PATH Rail Transportation | 0.006 | 3.14E-05 | 1.62E-04 | 1.30E-04 |
| Port Newark Facilities | 0.033 | 1.86E-04 | 8.86E-04 | 6.85E-04 |
| Port Newark Marine Terminal | 0.027 | 1.37E-04 | 7.30E-04 | 5.91E-04 |
| Staten Island Bridge Facilities | 0.209 | 1.07E-03 | 5.60E-03 | 4.50E-03 |
| Teterboro Airport | 0.009 | 4.51E-05 | 2.41E-04 | 1.95E-04 |
| Public Safety Department | 1.731 | 8.73E-03 | 4.65E-02 | 3.76E-02 |
| ***Non-road Fleet Vehicles Total*** | **5.87** | **0.030** | **0.158** | **0.127** |

### 7.1.6. Comparison with Estimates in Previous Studies

Table 7-5 compares the fleet vehicle $CO_2$ equivalent emissions between 2006 and 2008. This table shows that overall GHG emissions decreased by approximately 2.5 percent between 2006 and 2008 despite an 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 2008, there were approximately 1.22 million gallons of fuel used, an increase of approximately 14 percent. However, between 2006 and 2008, all remaining diesel fleet has been converted to B-20 biodiesel. Biodiesel makes up about 19 percent of the Port Authority's fuel use, and has a lower emission factor which resulted in a small decrease in CO2 emissions. The large decrease in Public Safety department fuel use from 2007 to 2008 is due in part to a reduction in the number of emergency vehicles reported in the fleet.

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

| Department | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Aviation | 2,962 | 3,779 | 4,234 | 42.9% |
| Port Commerce | 311 | 438 | 383 | 22.9% |
| Bus Terminals | 12 | 13 | 23 | 93.5% |
| Tunnels & Bridges | 1,491 | 1,828 | 1,772 | 18.8% |
| Fleet Vehicles - NY Motor Pool & Long Term Rental Pool | 364 | 136 | 66 | -81.8% |
| PATH | 156 | 154 | 291 | 86.6% |
| Real Estate & Development | 1,370 | 1,109 | 1,004 | -26.7% |
| Public Safety Department | 5,252 | 8,259 | 3,853 | -26.6% |
| Total | 11,919 | 15,715 | 11,627 | -2.5% |

## 7.2. CONSTRUCTION EQUIPMENT

### 7.2.1. Boundary

The boundary for construction equipment includes any construction equipment used during the 2008 calendar year in Port Authority capital projects.

### 7.2.2. Facilities Included in the Inventory

PANYNJ provided 2008 construction work in progress (WIP) spending data for its facilities (PANYNJ, -2009a). The PANYNJ WIP spending data was then assigned to counties. Table 7-6 lists the facilities included in this inventory by county where construction equipment operated during 2008. 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 2008**

| 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 |

| Facility | County/State |
|---|---|
| **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 |
| Stewart Airport | Orange, NY |
| NYC Heliport | New York, NY |
| 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 |
| Goethals 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 |
| George Washington Bridge Bus Terminal | New York, NY |
| Port Newark | Essex, NJ |
| Auto Marine Terminal | Hudson, NJ |

### 7.2.3. Methods

Construction equipment emissions were estimated using information about construction spending by the PANYNJ during 2008 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 2008. Data were then obtained from McGraw-Hill on the county-level construction dollars spent during 2008. The McGraw-Hill data were used to compute the ratio of PANYNJ construction spending to total county-level construction spending.

EPA's NONROAD2008 Model (EPA, 2009) was run to estimate 2008 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 was 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, 2008 diesel fuel consumption was provided by PANYNJ (PANYNJ, 2009b). Gasoline fuel use was reported for 2008, which was less than one percent of the total fuel consumption. The total fuel consumption was used instead of NONROAD fuel estimates as the basis for the WTC facility construction activity. To estimate the GHG emissions, the total 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 2008 for the PANYNJ construction vehicle fleet. Engine specific inputs were required to run the quantifier program. These data were collected from the NONROAD2008 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 NONROAD2008 model run for year 2008. 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.
- 75 percent of the total engine population was assumed to be retrofitted. Pechan assumed that all 2006, 2007, and 2008 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, 2007, and 2008 model year construction equipment populations relative to the total construction equipment population for all model years in 2008.
- Of the 75 percent of the population to be retrofitted, 75 percent of the engines employed DPFs and the remaining 25 percent employed DOCs (PANYNJ,).

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 (56 percent); CO (57percent); and PM (55percent). 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 percentage 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 $CO_2$e 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 | 1,959 | 0 | 1 | 2,191 |
| Newark Airport* | New Jersey | Essex | 16,867 | 1 | 6 | 18,866 |
| Stewart Airport* | New York | Orange | 401 | 0 | 0 | 449 |
| Jamaica Station | New York | Queens | 0 | 0 | 0 | 0 |
| JFK Airport* | New York | Queens | 6,688 | 0 | 3 | 7,480 |
| JFK Light Rail System | New York | Queens | 51 | 0 | 0 | 57 |
| LaGuardia Airport* | New York | Queens | 8,107 | 0 | 3 | 9,068 |
| NYC Heliport* | New York | New York | 5 | 0 | 0 | 5 |
| **PATH** | | | | | | |
| PATH* | New Jersey | Hudson | 4,989 | 0 | 2 | 5,581 |
| PATH* | New York | New York | 1,055 | 0 | 0 | 1,182 |
| Battery Park Marine Terminal | New York | New York | 332 | 0 | 0 | 372 |
| **Ports** | | | | | | |
| NJ Marine Terminals* | New Jersey | Essex | 3,109 | 0 | 1 | 3,477 |
| Auto Marine Terminal* | New Jersey | Hudson | 53 | 0 | 0 | 59 |
| NJ Marine Terminals | New Jersey | Union | 2,407 | 0 | 1 | 2,692 |
| Brooklyn Piers | New York | Kings | 458 | 0 | 0 | 512 |
| Ports - Multi-Facility | New York | Kings | 160 | 0 | 0 | 179 |
| Howland Hook | New York | Richmond | 200 | 0 | 0 | 223 |
| Ports - Multi-Facility | New York | Richmond | 70 | 0 | 0 | 78 |
| **TB&T** | | | | | | |
| George Washington Bridge* | New Jersey | Bergen | 987 | 0 | 0 | 1,104 |
| Goethals Bridge* | New Jersey | Essex | 285 | 0 | 0 | 319 |
| TB&T - Multi-Facility | New Jersey | Essex | 11 | 0 | 0 | 13 |
| Bayonne Bridge* | New Jersey | Hudson | 805 | 0 | 0 | 901 |
| Holland Tunnel* | New Jersey | Hudson | 747 | 0 | 0 | 836 |
| Lincoln Tunnel* | New Jersey | Hudson | 452 | 0 | 0 | 506 |
| TB&T - Multi-Facility | New Jersey | Hudson | 3 | 0 | 0 | 3 |
| Outerbridge Crossing* | New Jersey | Union | 83 | 0 | 0 | 93 |
| Arthur Kill | New Jersey | Union | 77 | 0 | 0 | 86 |
| TB&T - Multi-Facility | New Jersey | Union | 6 | 0 | 0 | 7 |
| Port Authority Bus Terminal* | New York | New York | 1,252 | 0 | 0 | 1,403 |
| George Washington Bridge* | New York | New York | 397 | 0 | 0 | 445 |
| George Washington Bridge Bus Terminal* | New York | New York | 1 | 0 | 0 | 1 |
| Holland Tunnel* | New York | New York | 158 | 0 | 0 | 177 |
| Lincoln Tunnel* | New York | New York | 96 | 0 | 0 | 107 |
| Bayonne Bridge* | New York | Richmond | 1,070 | 0 | 0 | 1,196 |

| | | | Greenhouse Gas Emissions Totals (metric tons) | | | |
|---|---|---|---|---|---|---|
| **Facility** | **State** | **County** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
| Goethals Bridge* | New York | Richmond | 546 | 0 | 0 | 610 |
| Outerbridge Crossing* | New York | Richmond | 191 | 0 | 0 | 214 |
| Arthur Kill | New York | Richmond | 177 | 0 | 0 | 198 |
| TB&T - Multi-Facility | New York | Richmond | 39 | 0 | 0 | 44 |
| **World Trade Center** | | | | | | |
| World Trade Center* | New York | New York | 1,652 | 0 | 1 | 1,850 |
| | | **Total** | **55,946** | **2** | **21** | **62,586** |
| *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 2008. $NO_x$ 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)**

| | | | CAP Emissions Totals (metric tons) | | | |
|---|---|---|---|---|---|---|
| **Facility** | **State** | **County** | **$NO_x$** | **$SO_2$** | **$PM_{10}$** | **$PM_{2.5}$** |
| **Aviation** | | | | | | |
| Teterboro Airport* | New Jersey | Bergen | 17 | 0 | 0 | 0 |
| Newark Airport* | New Jersey | Essex | 142 | 3 | 4 | 3 |
| Stewart Airport | New York | Orange | 3 | 0 | 0 | 0 |
| Jamaica Station | New York | Queens | 0 | 0 | 0 | 0 |
| JFK Airport* | New York | Queens | 56 | 1 | 1 | 1 |
| JFK Light Rail System | New York | Queens | 0 | 0 | 0 | 0 |
| LaGuardia Airport* | New York | Queens | 68 | 2 | 2 | 2 |
| NYC Heliport* | New York | New York | 0 | 0 | 0 | 0 |
| **PATH** | | | | | | |
| PATH* | New Jersey | Hudson | 42 | 1 | 1 | 1 |
| PATH* | New York | New York | 9 | 0 | 0 | 0 |
| Battery Park Marine Terminal | New York | New York | 0 | 0 | 0 | 0 |
| **Ports** | | | | | | |
| NJ Marine Terminals* | New Jersey | Essex | 26 | 1 | 1 | 1 |
| Auto Marine Terminal* | New Jersey | Hudson | 0 | 0 | 0 | 0 |
| NJ Marine Terminals | New Jersey | Union | 20 | 0 | 1 | 0 |
| Brooklyn Piers | New York | Kings | 4 | 0 | 0 | 0 |
| Ports - Multi-Facility | New York | Kings | 1 | 0 | 0 | 0 |
| Howland Hook | New York | Richmond | 2 | 0 | 0 | 0 |
| Ports - Multi-Facility | New York | Richmond | 1 | 0 | 0 | 0 |
| **TB&T** | | | | | | |
| George Washington Bridge* | New Jersey | Bergen | 8 | 0 | 0 | 0 |
| Goethals Bridge | New Jersey | Essex | 2 | 0 | 0 | 0 |
| TB&T - Multi-Facility | New Jersey | Essex | 0 | 0 | 0 | 0 |
| Bayonne Bridge* | New Jersey | Hudson | 7 | 0 | 0 | 0 |
| Holland Tunnel* | New Jersey | Hudson | 6 | 0 | 0 | 0 |
| Lincoln Tunnel* | New Jersey | Hudson | 4 | 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 | 1 | 0 | 0 | 0 |

| Facility | State | County | CAP Emissions Totals (metric tons) | | | |
|---|---|---|---|---|---|---|
| | | | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| TB&T - Multi-Facility | New Jersey | Union | 0 | 0 | 0 | 0 |
| Port Authority Bus Terminal* | New York | New York | 11 | 0 | 0 | 0 |
| George Washington Bridge* | New York | New York | 3 | 0 | 0 | 0 |
| George Washington Bridge Bus Terminal* | New York | New York | 0 | 0 | 0 | 0 |
| Holland Tunnel* | New York | New York | 1 | 0 | 0 | 0 |
| Lincoln Tunnel* | New York | New York | 1 | 0 | 0 | 0 |
| Bayonne Bridge* | New York | Richmond | 9 | 0 | 0 | 0 |
| Goethals Bridge | New York | Richmond | 5 | 0 | 0 | 0 |
| Outerbridge Crossing* | New York | Richmond | 2 | 0 | 0 | 0 |
| Arthur Kill | New York | Richmond | 1 | 0 | 0 | 0 |
| TB&T - Multi-Facility | New York | Richmond | 8 | 0 | 0 | 0 |
| **World Trade Center** | | | | | | |
| World Trade Center* | New York | New York | 14 | 0 | 1 | 1 |
| **Total** | | | **469** | **11** | **12** | **12** |

*includes security projects.

### 7.2.6. Comparison with Estimates in Previous Studies

Table 7-9 compares the 2006, 2007, and 2008 $CO_2$ equivalent emissions. The comparison of the 2008 $CO_2$ emissions to the 2006 estimates show that three counties had dramatic increases in emissions from 2006 to 2008; Essex County, NJ, Union County, NJ, and Kings County, NY. 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. Emissions decreased in both New York and Richmond counties, but the large increases in the other counties led to a 29 percent increase of Port Authority emissions from 2006 to 2008.

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 | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| **New Jersey** | | | | |
| Bergen | 2,676 | 2,860 | 3,295 | 23% |
| Essex | 6,482 | 21,170 | 22,676 | 250% |
| Hudson | 2,687 | 3,321 | 7,886 | 193% |
| Union | 465 | 5,074 | 2,878 | 519% |
| **New York** | | | | |
| Kings | 188 | 210 | 691 | 268% |
| New York | 5,624 | 6,001 | 5,542 | -1% |

| State/County | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | 2006 | 2007 | 2008 | |
| Orange | N/A | 37 | 449 | N/A |
| Queens | 16,239 | 12,816 | 16,605 | 2% |
| Richmond | 14,075 | 2,960 | 2,564 | -82% |
| **Total** | 48,436 | 54,448 | 62,586 | 29% |

## 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 | Bayonne Bridge |
| 8 | Downtown Manhattan Heliport |
| 9 | Gateway Plaza I |
| 10 | Gateway Plaza II |
| 11 | Gateway Plaza III |
| 12 | George Washington Bridge |
| 13 | George Washington Bridge Bus Station |
| 14 | Goethals Bridge |
| 15 | Harrison Car Maintenance Facility |
| 16 | Holland Tunnel |
| 17 | Howland Hook Marine Terminal and Port Ivory |
| 18 | John F. Kennedy International Airport |
| 19 | Journal Square Transportation Center |
| 20 | KAL Building at JFK |
| 21 | LaGuardia Airport |
| 22 | Legal Center |
| 23 | Lincoln Tunnel |

| Number | Facility Name |
|---|---|
| 24 | Newark Liberty International Airport |
| 25 | 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 | Queens West |
| 33 | Stewart International Airport |
| 34 | Teleport |
| 35 | Teterboro Airport |
| 36 | Waldo Yard Buildings |
| 37 | World Trade Center |

### 7.3.3. 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 calendar year 2008 employee commuting activity, a web-based survey was developed and implemented during January 2009. 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 2008, 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 Port Authority Technical Center (PATC) and the two nearest PATH stations, Journal

Square Transportation Center (JSTC), and Hoboken. The 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, 2008). Table 7-11 shows these 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 | 25.01 |
| Diesel Mileage | 28.63 |

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 | kg $CH_4$/Gallon | kg $N_2O$/Gallon |
|---|---|---|---|
| Gasoline | 8.97 | 0.000492697 | 0.000392657 |
| Diesel | 11.11 | 0.000014315 | 0.000028630 |

### 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 WRI Aircraft and Public Transport Emission Factors calculation tools used to estimate the emissions 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) | 0.185 |
| US Transit Rail (e.g., subway, PATH) | 0.163 |
| US Commuter Rail (i.e., NJ Transit) | 0.163 |
| CNG, urban (buses) | 0.107 |

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 in a bus/van/carpool from 1-2 miles per one-way trip. In the 2009 survey, the employee shuttle was added as an explicit travel choice.

### 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) | $CH_4$ (g/mile) | $N_2O$ (g/mile) | $NO_x$ (g/mile) | $SO_2$ (g/mile) | $PM_{2.5}$ (g/mile) | $PM_{10}$ (g/mile) |
|---|---|---|---|---|---|---|---|---|
| Buses | Diesel | 11.11 | 5.10E-03 | 4.80E-03 | 10.13 | 0.14 | 0.26 | 0.31 |
| Wagons | Gasoline | 8.97 | 6.48E-02 | 6.33E-02 | 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 1,050 valid responses out of 1,091 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) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$e (metric Tons) |
| Employee Survey | 24,532 | 1.10 | 0.82 | 24,811 |
| Employee Shuttle | 138 | 7.61E-04 | 7.32E-04 | 138 |
| **Total** | **24,650** | **1.1** | **0.8** | **24,949** |

Emissions from car travel accounted for 69 percent of total emissions. 21 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) | | | |
|---|---|---|---|---|
| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| Survey | 835.5 | 48.7 | 21.1 | 19.2 |
| Shuttles | 6.57E-01 | 9.10E-03 | 1.99E-02 | 1.67E-02 |
| Total | 836.1 | 48.7 | 21.1 | 19.2 |

### 7.3.5. Comparison with Estimates in Previous Studies

The calendar year 2008 employee commuting GHG emissions estimate is based on the survey that was given to Port Authority employees in January of 2009 and the data collection was completed in February of 2009. 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. No new data was provided for year 2008, the fuel and mileage estimates are assumed to be same as in 2007. 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**

| | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| **Source** | **2006** | **2007** | **2008** | **%** |
| Survey | 27,080 | 27,074 | 24,811 | -8.38% |
| Shuttles | N/A | 124 | 138 | N/A |
| **Total** | **27,080** | **27,198** | **24,949** | **-7.87%** |

## 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 | 66 | - | - | 66 |
| Public Safety Department Fleet Vehicles | 3,853 | - | - | 3,853 |
| Direct Fugitive Emissions - Central Automotive Division | 295 | - | - | 295 |
| Construction | 62,586 | - | 0 | 62,586 |
| Employee Commuting | - | - | 24,949 | 24,949 |
| **Mobile Sources: Multiple Departments** | **66,800** | **0** | **24,949** | **91,749** |

## 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)**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| Fleet Vehicles- NY Motor Pool & Long Term Rental Pool | 1 | 0 | 0 | 0 |
| Public Safety Department Fleet Vehicles | 4 | 0 | 0 | 0 |
| Construction | 520 | 12 | 14 | 14 |
| Employee Commuting | 836 | 49 | 21 | 19 |
| **Mobile Sources: Multiple Departments** | **1,361** | **61** | **35** | **33** |

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# 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* |
| Essex County Resource Recovery Facility* |

### 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 TCR 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). TCR 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 substituted with 2007 data.

### 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. Facilities marked by a dash represent calculations in which 2007 data was used.

**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 | 348 | | 4,368 | 4,716 |
| The Legal Center | 1175 | | 5,739 | 6,914 |
| The Teleport | 198 | | 35,867 | 36,065 |
| World Trade Center (including ERP) | | | 176,369 | 176,369 |
| 115 Broadway *- | 140 | 554 | | 694 |
| 225 Park Avenue South * | 72 | 2221 | | 2,293 |
| 233 Park Avenue South * | | 466 | | 466 |
| 5 Marine View *- | 13 | 63 | | 76 |
| 777 Jersey Avenue * | 227 | 708 | | 935 |
| Gateway Plaza I *- | | 4 | | 4 |
| Gateway Plaza II * | | 677 | | 677 |
| Gateway Plaza III* | | 96 | | 96 |
| KAL Building at JFK *- | 6 | 25 | | 31 |
| One Madison Avenue * | | 416 | | 416 |
| Port Authority Technical Center * | 633 | 4407 | | 5,040 |
| **Total** | **2812** | **9637** | **222343** | **234792** |

### 8.1.5. Comparison with Estimates in Previous Studies

Table 8-3 compares the calendar year 2008 GHG emission estimates with those made previously for the baseline year (2006) and shows the percent difference. This comparison shows that buildings GHG emissions increased by 6 percent.

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

| Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| | **2006** | **2007** | **2008** | |
| Bathgate Industrial Park | 7,685 | 6,342 | 4,716 | -38.63% |
| The Legal Center | 6,914 | 5,493 | 6,914 | 0.00% |
| The Teleport | 30,148 | 28,732 | 36,065 | 19.63% |
| World Trade Center | 165,423 | 147,449 | 176,369 | 6.62% |
| **PA Leased Property** | **11,905** | **7,841** | **10,728** | **-9.89%** |
| 115 Broadway | 694 | 608 | 694 | 0.00% |
| 225 Park Avenue South | 2,390 | 1,555 | 2293 | -4.06% |
| 233 Park Avenue South | 466 | 219 | 466 | 0.00% |
| 5 Marine View | 77 | 76 | 76 | -1.30% |
| 777 Jersey Avenue | 944 | 764 | 935 | -0.95% |
| Gateway Plaza I | 4 | 4 | 4 | 0.00% |
| Gateway Plaza II | 596 | 552 | 677 | 13.59% |
| Gateway Plaza III | 92 | 75 | 96 | 4.35% |
| KAL Building at JFK | 32 | 28 | 31 | -3.13% |
| One Madison Avenue | 1,566 | 449 | 416 | -73.44% |
| Port Authority Technical Center | 5,044 | 3,511 | 5040 | -0.08% |
| **Total** | **222,075** | **195,857** | **234,792** | **5.73%** |

## 8.2. RESOURCE RECOVERY FACILITY

### 8.2.1. Boundary

The GHG and CAP emissions from the Essex County Resource Recovery Facility are associated with the municipal solid waste (MSW) combustion as well as combustion of fossil fuel for auxiliary usage. Emissions associated with hauling and tipping of waste are not included in the total emissions estimates from this 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 2008 was 830,308 metric tons. These data were provided by the facility owners. The facility does not have a reliable waste characterization study.

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. Types of waste incinerated include MSW, industrial waste, hazardous waste, clinical waste and sewage sludge.

Essex County Resource Recovery Facility (Facility) primarily incinerates MSW. It is generally defined as waste collected by municipalities or other local authorities.

Waste composition is one of the main factors influencing emissions from solid waste treatment, as different waste types contain different amount of degradable organic carbon (DOC) and fossil carbon. Waste composition data in MSW vary widely by the source. MSW typically includes:

- Food waste;
- Garden (yard) and park waste;
- Paper and cardboard;
- Wood;
- Textiles;
- Rubber and leather;
- Plastics;
- Metal;
- Glass (and pottery and china); and
- Other (e.g., ash, dirt, dust, soil, electronic waste).

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 estimating 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.

EPA’s waste characterization data for discarded solid waste were used to define the waste composition of MSW combusted (EPA, 2006) – these are provided in Table 8-4. 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 detailed 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 2007; therefore, the EPA report on national waste characteristics (EPA, 2006) was used. The method based on the total amount of waste combusted by waste composition is outlined in the following equation:

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

**Table 8-4. Assumed Waste Composition**

| MSW Component | Composition |
|---|---|
| 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 |
| 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 8-5 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 from the 2006 IPCC guidelines were used (IPCC, 2006a). Dry matter, organic content, carbon content, and fossil content were estimated using the IPCC dataset shown in Table 8-5.

**Table 8-5. IPCC Organic Content Data**

| MSW component | Dry matter content in % of wet weight | DOC content in % of wet waste | | DOC content in % of dry waste | | Total carbon content in % of dry weight | | Fossil carbon fraction in % of total carbon | |
|---|---|---|---|---|---|---|---|---|---|
| | Default | Default | Range | Default | Range | Default | Range | Default | Range |
| Paper/Cardboard | 90 | 40 | 36 – 45 | 44 | 40 -50 | 46 | 42- 50 | 1 | 0 -5 |
| Textiles | 80 | 24 | 20 - 40 | 30 | 25 -50 | 50 | 25- 50 | 20 | 0 -50 |
| Food Waste | 40 | 15 | 8 - 20 | 38 | 20 - 50 | 38 | 20 -50 | - | - |
| Wood | 85 | 43 | 39 – 46 | 50 | 46 -54 | 50 | 46- 54 | - | - |
| Garden and Park Waste | 40 | 20 | 18 – 22 | 49 | 45 -55 | 49 | 45- 55 | 0 | 0 |
| Diapers | 40 | 24 | 18 - 32 | 60 | 44 - 80 | 70 | 54- 90 | 10 | 10 |
| Rubber and Leather | 84 | (39) | (39) | (47) | (47) | 67 | 67 | 20 | 20 |
| Plastics | 100 | - | - | - | - | 75 | 67- 85 | 100 | 95 - 100 |

| MSW component | Dry matter content in % of wet weight | DOC content in % of wet waste | | DOC content in % of dry waste | | Total carbon content in % of dry weight | | Fossil carbon fraction in % of total carbon | |
|---|---|---|---|---|---|---|---|---|---|
| | Default | Default | Range | Default | Range | Default | Range | Default | Range |
| Metal | 100 | - | - | - | - | NA | NA | NA | NA |
| Glass | 100 | - | - | - | - | NA | NA | NA | NA |
| Other, inert waste | 90 | - | - | - | - | 3 | 0-5 | 100 | 50 - 100 |

$CH_4$ emissions from waste incineration depend 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 of the 2006 IPCC guidelines have been used in estimating the emissions. Emissions were estimated by multiplying tons of waste combusted by pollutant emission factors (IPCC, 2006b). $CH_4$ and $N_2O$ emission factors are shown in Table 8-6.

**Table 8-6. $CH_4$ and $N_2O$ Emission Factors**

| Type of Incineration | $CH_4$ Emission Factors (kg/Gg ) | $N_2O$ Emissions Factor g/T waste |
|---|---|---|
| Continuous Incineration | 0.2 | 50 |
| SOURCE: IPCC inventory guidelines, volume 5, chapter 5. | | |

8.2.3.2. CAP Emission Factors

Activity data in the form of the amount of waste combusted were used along with emission factors to estimate the total quantity of pollutants emitted. Emission factors were obtained from EPA AP-42, Chapter 2 Table 2.1-8 (EPA, 1996). The Facility's waste combustors use electrostatic precipitators and spray dry scrubber systems for air pollution control, mainly particulate matter. As such, the emission factors used to estimate emissions are based on the installed control equipment. $PM_{10}$ and $PM_{2.5}$ emissions are assumed to be same due to relatively small quantity of PM emissions. $SO_2$, $PM_{10}$ and $PM_{2.5}$ emission factors are show in Table 8-7.

**Table 8-7. CAP Emission Factors for Refuse-Derived Fuel-Fired Combustors**

| Pollutant | Spray Dryer/ESP Emission Factors (lbs/ton) |
|---|---|
| $SO_2$ | 1.60 |
| $PM_{10}$ | 0.10 |
| $PM_{2.5}$ | 0.10 |

For example, the total emissions from $SO_2$ are:

*1.6 (lbs/ton)*415,258 (metric tons)*1/2000 = 332 tons*

Emission factors for $NO_x$ were not available in EPA AP-42, Chapter 2 Table 2.1-8 (EPA, 1996). To estimate $NO_x$ emissions, eGRID methodology (Pechan, 2007) was used; 2008 emissions were estimated by multiplying 2006 emissions by the ratio of MSW combusted in 2008 to 2006. $NO_x$ emissions for year 2008 were estimated to be 430 tons. As such, 2008 $NO_x$ emissions from MSW combusted are estimated to be:

*2006 $NO_x$ emissions * 2008/2006(Waste Combusted in Tons)*

*841 tons*(830,308 tons combusted / 808,416 tons combusted) = 863 tons*

The 2006 $NO_x$ emissions were estimated by multiplying 2004 emissions in eGRID by the ratio of 2006 to 2004 net generation (megawatt-hour [MWh]). The 2006 net generation was obtained from the preliminary EIA-906 dataset. In 2004 the net generation was 478,514 MWh; in 2006 the net generation was 484,222 MWh. Annual adjusted 2004 $NO_x$ emissions in eGRID were 831 tons. The 2006 $NO_x$ emissions from MSW combusted were estimated to be 841 tons.

#### 8.2.3.3. Fuel Combustion

Essex County Resource Facility also combusted Type 2 fuel in plant operations in 2008 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 2008 was 179,336 gallons. The total emissions from fuel combustion were calculated by multiplying gallons of fuel consumed by each pollutant emission factor.

Emission factors for $CO_2$ provided in Table C.5: 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.6: 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 8-8.

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

**Table 8-8. Fuel Based Emission Factors (Diesel)**

| Pollutant | Emission Factor (kg/gallon) |
|---|---|
| $CO_2$ | 10.15 |
| $CH_4$ | 0.0014 |
| $N_2O$ | 0.0001 |
| SOURCE: California Climate Action Registry. | |

#### 8.2.3.4. CAP Emission Factors

CAP emission factors were obtained from EPA AP-42, Chapter 1, Table 1.3-1 (EPA, 2000), it was assumed that the boiler capacity is greater than 100 MMBtu/hr. Table 8-9 shows CAP emission factors.

**Table 8-9. CAP Emission Factors for Fuel Oil Combustion**

| Pollutant | Emission Factor (Tons/Gallon) |
|---|---|
| $NO_x$ | 0.0000108863 |
| $SO_2$ | 0.0000644108 |
| $PM_{10}$ | 0.0000010796 |
| $PM_{2.5}$ | 0.0000009662 |

For example $SO_2$ emissions were estimated by multiplying emission factor from Table 8-9 by annual fuel consumed in 2006.

*0.0000644108 (tons/gallon) * 179,336 (gallons) = 12 tons*

For $SO_2$, emission factor of 142 was used assuming 1 percent sulfur based on the errata given in AP-42 Chapter 1. In Table 1.3-1, for boilers > 100 MMBtu/hr, the $SO_2$ emission factor for No. 2 oil, is 142S, not 157S as mentioned in the table http://www.epa.gov/ttn/chief/ap42/ch01/index.html.

Also, it was assumed that the $PM_{10}$ Emission Factor is sum of $PM_{10}$ -Fil and PM CON emission factor and $PM_{2.5}$ Emission Factor is sum of $PM_{2.5}$-Fil and PM CON emission factor.

### 8.2.4. Results

Emissions estimate from the facility accounts for combustion processes only. There are minor emissions associated with trucking and hauling of waste as well as fuel use in support equipment. Emission estimates are not adjusted for the greenhouse gases that are avoided due to electricity generation, recovery of metals, and methane emissions from landfills. Emissions from waste combustion were 90 percent of total emissions.

Emissions estimated are summarized in Table 8-10. The IPCC global warming potential factors were used to convert $CH_4$ and $N_2O$ to $CO_2$ equivalent.

**Table 8-10. Essex County Resource Recovery Facility GHG Emissions by Gas and $CO_2$ Equivalent**

| Source | Greenhouse Gas Emission Totals (metric tons) | | | $CO_2e$ (metric Tons) |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | |
| MSW Combustion | 466,097 | 0.1 | 42 | 466,379 |
| Fuel Combustion | 1,820 | 0.2 | 0.01 | 2,148 |
| **Totals** | **467,917** | **0.3** | **42** | **468,527** |

CAP Emissions estimates are summarized in Table 8-11.

**Table 8-11. Essex County Resource Recovery Facility – 2008 CAP Emissions (metric tons)**

| | CAPs | | | |
|---|---|---|---|---|
| **Source** | **$NO_x$** | **$SO_2$** | **$PM_{10}$** | **$PM_{2.5}$** |
| MSW Combustion | 861 | 664 | 42 | 42 |
| Fuel Combustion | 2 | 10 | 0 | 0 |
| **Totals** | **862** | **675** | **42** | **42** |

### 8.2.5. Comparison with Estimates in Previous Studies

The 2008 anthropogenic $CO_2$ equivalent emissions due to combustion of MSW and fuel usage were 480,796 metric tons. The emissions that result from waste incineration increased by 2.7 percent when compared with 2006, while emissions from diesel combustion dropped by 15 percent. This nets a 2.6 percent increase in overall emissions from the facility.

| | $CO_2$ Equivalent (metric tons) | | | Percentage Difference |
|---|---|---|---|---|
| **Essex County Resource Recovery Facility** | **2006** | **2007** | **2008** | **(2006 vs. 2008)** |
| Waste combusted | 466,379 | 471,821 | 478,970 | 2.70% |
| Diesel fuel combusted | 2,148 | 2,847 | 1,826 | -15.01% |
| **Total** | **468,527** | **474,668** | **480,796** | 2.62% |

## 8.3. REAL ESTATE AND DEVELOPMENT GHG EMISSIONS SUMMARY

Table 8-12 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 8-12. Real Estate and Development Department GHG Emissions by Facility and Scope (tons $CO_2$ equivalent)**

| | Scope 1 | Scope 2 | Scope 3 | Facility Emission Totals |
|---|---|---|---|---|
| **Bathgate Industrial Park** | **-** | **-** | **6,299** | **6,299** |
| Buildings | - | - | 6,299 | 6,299 |
| **The Teleport** | **-** | **-** | **42,799** | **42,799** |
| Buildings | - | - | 42,799 | 42,799 |
| **The Legal Center** | **2** | **-** | **6,914** | **6,916** |
| Buildings | - | - | 6,914 | 6,914 |
| Fleet Vehicles | 2 | - | - | 2 |
| **World Trade Center (including WTC ERP)** | **7** | **-** | **176,369** | **176,376** |
| Buildings | - | - | 176,369 | 176,369 |
| Fleet Vehicles | 7 | - | - | 7 |
| **PA leased office space** | **3,096** | **9,404** | **-** | **12,500** |
| Buildings | 2,101 | 9,404 | - | 11,505 |
| Fleet Vehicles | 995 | - | - | 995 |
| **Essex County Resource Recovery Facility** | **-** | **-** | **480,796** | **480,796** |
| Mixed Solid Waste Combustion Emissions | - | - | 478,970 | 478,970 |
| Fuel Combustion Emissions | - | - | 1,826 | 1,826 |
| **REAL ESTATE & DEVELOPMENT** | **3,105** | **9,404** | **713,177** | **725,686** |

## 8.4. REAL ESTATE AND DEVELOPMENT CAP EMISSIONS SUMMARY

Table 8-13 summarizes the estimated criteria air pollutant emissions for the Real Estate and Development Department during 2008. $NO_x$ and $SO_2$ emissions for this Department are dominated by solid waste combustion at the Essex County Resource Recovery Facility.

**Table 8-13. Real Estate and Development Department CAP Emissions by Facility (tons)**

| | $NO_x$ | $SO_2$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|
| **Bathgate Industrial Park** | **7** | **34** | **3** | **3** |
| Buildings | 7 | 34 | 3 | 3 |
| **The Teleport** | **66** | **312** | **31** | **25** |
| Buildings | 66 | 312 | 31 | 25 |
| **The Legal Center** | **10** | **42** | **4** | **4** |
| Buildings | 10 | 42 | 4 | 4 |
| Fleet Vehicles | 0 | 0 | 0 | 0 |
| **World Trade Center (including WTC ERP)** | **171** | **134** | **8** | **7** |
| Buildings | 171 | 134 | 8 | 7 |
| Fleet Vehicles | 0 | 0 | 0 | 0 |
| **PA leased office space** | **15** | **39** | **4** | **3** |
| Buildings | 13 | 39 | 4 | 3 |
| Fleet Vehicles | 2 | 0 | 0 | 0 |
| **Essex County Resource Recovery Facility** | **862** | **675** | **42** | **42** |
| Mixed Solid Waste Combustion Emissions | 861 | 664 | 42 | 42 |
| Fuel Combustion Emissions | 2 | 10 | 0 | 0 |
| **REAL ESTATE & DEVELOPMENT** | **1,131** | **1,236** | **92** | **84** |

## 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.

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# 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, 2008 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 TCR. 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.

**Table 9-1. 2008 Purchased Quantities of Refrigerants**

| Facility | Freon Refrigerant R134A (lbs) |
|---|---|
| Newark Liberty International Airport | 450 |
| John F. Kennedy International Airport | 330 |
| LaGuardia Airport | 90 |
| PE01 | 600 |
| **Total** | **1,470** |
| NOTE: The purchased quantities are recorded in 30-pound cylinders. | |

In addition to refrigerant leakages, the Port Authority conducted 3 vapor monitoring operations in 2008, 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 2008 was 0.486 kg.

## 9.4. RESULTS

GHG emission estimates for refrigerants purchased by the PANYNJ during calendar year 2008 are shown in Table 9-2. These estimates are based on Freon amounts that were ordered during 2008 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 CO2 Equivalent**

| | Greenhouse Gas Emission Totals (metric tons) | | |
|---|---|---|---|
| **Department/Facility** | **HFC-134a** | **$SF_6$** | **$CO_2e$** |
| Newark Liberty International Airport | 0.204 | 0 | 265.4 |
| John F. Kennedy International Airport | 0.150 | 0 | 194.6 |
| LaGuardia Airport | 0.041 | 0 | 53.1 |
| PE01 | 0.272 | 0 | 353.8 |
| Engineering Department | 0 | 0.000486 | 11.7 |
| **Total** | **0.6668** | **0.000486** | **878.5** |

## 9.5. COMPARISON WITH ESTIMATES IN PREVIOUS STUDIES

As shown in Table 9-3, the documented facilities driving fugitive emissions changed drastically from 2007 to 2008. Overall, direct fugitive increased by 13 percent from the 2006 baseline. Note that the allocations of fugitive emissions to Departments for 2008 are particularly uncertain because the allocation information provided for 2008 was less detailed than what was provided for 2006 and 2007 calendar years. For the purpose of comparison, the emissions labeled with facility PE01 were distributed to sources in proportion to the same sources in 2007.

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

| Department/Facility | $CO_2$ Equivalent (metric tons) | | | Percentage Difference (2006 vs. 2008) |
|---|---|---|---|---|
| | **2006** | **2007** | **2008** | |
| Aviation-Newark Airport | 0 | 0 | 265.4 | N/A |
| Aviation-JFK Airport | 0 | 0 | 194.6 | N/A |
| LaGuardia Airport | 0 | 0 | 53.1 | N/A |
| PATH | 17.7 | 35.4 | 39.3 | 122% |
| Port Commerce-NJ Marine Terminals | 17.7 | 0 | 0 | -100% |
| TBT-Lincoln Tunnel | 35.4 | 17.7 | 19.7 | -44% |
| Operation Services Department-Central Automotive Division | 707.5 | 636.8 | 294.8 | -58% |
| Engineering | 0 | 7.8 | 11.7 | N/A |
| **Totals** | **778.3** | **697.7** | **878.6** | **13%** |