Port Authority of New York and New Jersey Criteria Pollutant and Greenhouse Gas Emission Inventory – Calendar Years 2006-2008

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ABSTRACT

The Port Authority of New York and New Jersey (PANYNJ) has adopted a policy to reduce its greenhouse gas (GHG) emissions by 80 percent by the year 2050. For this project, Pechan and Southern Research Institute developed 2006, 2007, and 2008 calendar year GHG and criteria pollutant emission inventories for Port Authority facilities and operations, including the emissions of its tenants (e.g., airlines and shippers) and patrons (e.g., airport passengers, PATH riders). In addition, the consulting team developed and implemented systems that allow for annual tracking and reporting of GHG emissions.

The 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 (JFK), 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. This paper addresses the challenges associated with developing consistent GHG and criteria pollutant emission estimates for a diverse set of source types, updating these methods with time as new information and new protocols emerge, and having methods that are sensitive to the measures being adopted by the PANYNJ to reduce their emissions.

INTRODUCTION

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 (JFK), 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 has adopted a policy 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 that goal, PANYNJ sponsored an effort with Southern Research Institute and Pechan to conduct a GHG and criteria air pollutant (CAP) emission inventory of PANYNJ facilities for 2006. CAPs are inventoried to ensure GHG reduction strategies maintain and enhance CAP reduction strategies. This effort has been repeated for calendar years 2007 and 2008.

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), (2) account for the following CAPs: oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and particulate matter (PM), (3) include direct and indirect emissions, (4) maximize flexibility to prepare for future regulatory regimes, (5) ensure transparency, (6) refine the system established for the calendar year 2006 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.

Inventory Boundary

One of the first steps in developing this or any other GHG emission inventory is determining the organizational boundary for reporting emissions. The organizational boundary decisions were made so that all methods for data collection were applied consistently across all operations, facilities, and sources of the PANYNJ. An objective of this exercise was to develop an inventory that meets the criteria for submittal to a GHG registry like The Climate Registry. The Climate Registry and World Resources Institute 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 based on its share of financial ownership of an entity, operation, or source. Management control is more appropriate than equity share for an entity like the PANYNJ because it is a public organization. An important reason for choosing to report emissions based on management control is that when the PANYNJ controls how an operation or a facility is managed, the organization is able to control factors such as capital investment and technology choice, how energy is used, and the level of emissions generated.

METHODS BY SECTOR

This section describes the GHG and CAP emission estimation methods for the most prominent source categories in the PANYNJ inventory. While the methods section is limited to the most prominent source categories, the results section includes emission estimates for all sources.

Aviation – Aircraft

This source category includes emissions from all civil-commercial use of airplanes, including civil and general aviation. To date, aircraft emissions at PANYNJ facilities have been estimated using what is referred to in the IPCC Guidelines[1] as Tier 2 methods. Operations of aircraft are broken down into landing-takeoff (LTO) and cruise phases. To use the Tier 2 method, the number of LTO operations must be known for both domestic and international aviation, preferably by aircraft type. In this method, a distinction is made between emissions below and above 914 meters (3,000 feet). Emissions occurring above 3,000 feet (the mixing height), have been excluded from the inventory. This is consistent with traditional criteria pollutant emission inventory methods.

The Tier 2 method breaks the aviation emission calculation into the following steps:

1. Estimate LTO fuel consumption for domestic and international operations.
2. Estimate the cruise fuel consumption for domestic and international aviation.
3. Estimate emissions from LTO and cruise phases for domestic and international aviation.

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[1]. 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 listing the number of arrivals and departures from each airport by aircraft model for LaGuardia, JFK, Stewart, Teterboro, and Newark. The aircraft models provided by the PANYNJ were matched to the models with IPCC emission factors either directly – or approximately – using data taken from the Federal Aviation Administration's (FAA's) Emission Dispersion Modeling System (EDMS). The majority of operations were directly matched with emission factors. The information from EDMS was also used and provided the ability to match more of the aircraft types to engine types that had emission factors. In the end, about 6 percent of the operations at the PANYNJ airports did not have aircraft codes/types that matched with the IPCC emission factors, so emission factors for those aircraft were estimated using the average emission factor for the aircraft at that airport.

During 2009, the Airport Cooperative Research Program released a report[2] that is a guidebook for preparing airport GHG emission inventories. There have been some preliminary discussions about how or whether to change the PANYNJ methods according to the guidebook recommendations.

When the 2006 GHG/CAP emission inventory was developed for the PANYNJ, the FAA's EDMS model did not have the capability to estimate GHG emissions. Now that it does, more consideration is being given to use EDMS as the primary tool for estimating GHG and CAP emissions for both aircraft and ground support equipment at the airports. One of the benefits of doing so is that any resulting emission estimates can and should be able to be used by the U.S. Environmental Protection Agency (EPA) in its National Emission Inventory (NEI), and the emission estimates should also be consistent with the emission inventories used in relevant State Implementation Plans (SIPs).

Planning for developing PANYNJ aviation emission estimates for calendar year 2009 and beyond is considering using inventory methods that are more responsive to the initiatives being taken by the airlines at these airports to reduce fuel use and associated GHG and criteria pollutant emissions. Key operational factors that are important to consider include time-in-mode differences by airport and how these change with time. Default time-in-mode estimates are used in the IPCC emission factors. Auxiliary power units are now used to supply power to gated aircraft so that aircraft engines can be turned off, but the IPCC Tier 2 emission methods do not allow this change to be accounted for. In addition, it is not clear whether any specific tracking of APU use occurs at these airports.

One way to improve the emissions accounting at each airport is to track and report fuel sales by aircraft. However, this only accounts for fuel purchased at that specific airport and ignores fuel consumed or purchased for the flights prior and after PANYNJ facilities.

When the State of New Jersey was developing its statewide GHG emission inventory as part of its state climate action planning process, it was determined that the fuel sales data for New Jersey airports overestimated action aviation fuel consumed in New Jersey, as a significant portion of the fuel purchased in New Jersey is actually used for New York airports. In addition, a large portion of the flights to and from New Jersey airports are international flights. Thus, the New Jersey Department of Environmental Protection felt that only a small portion of New Jersey aviation fuel sales would be used on flights that New Jersey regulations could impact. Newark airport is the largest New Jersey airport.

Aviation – Ground Support Equipment (GSE)

For the GSE at PANYNJ airports, the calendar year 2006 and 2007 emissions were estimated by performing a survey of fuel sales by the major airlines and other identified fuel suppliers at each airport. This survey was not able to be performed for calendar year 2008, so the GSE fuel consumption in that year was estimated using the 2007 survey-based estimates multiplied by the ratio of 2008 LTOS to 2007 LTOs at each airport. Once the GSE estimates of gasoline, propane and diesel consumed were developed for each airport, GHG emissions were estimated using the emission factors from the IPCC Guidelines, Volume 2, Tables 3.3.1 for these fuels.

Because the results of the fuel survey each year had some incomplete reporting, some gap filling was needed to develop complete emission estimates for this source type. EPA's NONROAD model was used as a supplementary emissions and activity data source as well for GSE. NONROAD provided an additional data point that was used either as a quality control check on the fuel survey-based results, or as an alternative data source for estimating GHG emissions by airport. For Stewart airport, because no fuel survey data were available for calendar years 2007 or 2008, the EPA NONROAD model was used to estimate airport GSE emissions for Orange County, New York (where Stewart airport is located) and because Stewart is the only commercial airport in that county, all of the county emissions were associated with that airport.

Because the EDMS model can provide estimates of criteria pollutant emissions for airport GSE, a comparison was made of the criteria pollutant emission estimates from EDMS for 2006 with those estimated by NONROAD. GSE emissions are modeled within EDMS using EPA NONROAD model emission factors. The differences in emission estimates between the two models were generally more pronounced for GSE than for aircraft. While there were some cases where EDMS CAP emissions were lower for an airport compared with the NONROAD model-based estimates, there were more cases where EDMS estimates were higher. For example, the NONROAD model showed very little GSE activity for Bergen County, which contains Teterboro airport, while EDMS estimated higher emissions using its default assignments. Since both models use the same emission factors, emission differences are attributable to how the models simulate equipment populations and activity. EPA's NONROAD model is an attractive option for estimating GHG and CAP emissions because it has the capability to estimate carbon dioxide (CO_2) and CAP emissions. While methane and nitrous oxide (N_2O) emissions cannot be estimated using NONROAD, emission factors for these pollutants are readily available from other sources, plus the GHG emissions from these two gases are much lower than those of CO_2 for combustion sources.

Aviation – Attracted Travel

Emissions associated with vehicle trips that are attracted by the airports were computed for all of the calendar years of the inventory that have been developed to date. Vehicle types and trip types captured in this analysis include privately-owned vehicles, taxis, buses, rental cars, limousines, vans, shuttle buses, public buses, and light- and heavy-duty goods vehicles. The GHG and CAP emission estimates for all of these vehicle trips were estimated using the round trip distances to and from the airport. In estimating vehicle miles traveled (VMT), trip origin, travel distance, trip distributions, and transport mode were utilized. The VMT for limousines, private cars, chartered buses, hotel/motel shuttles, off-airport parking shuttles, and vans was estimated using the number of passengers arriving at each via that mode at each airport as a surrogate.

VMT for rental cars servicing JFK, LaGuardia, Newark, and Stewart airports was estimated based on the total number of rental vehicle transactions during 2008. The number of vehicle transactions for these facilities was allocated by trip origin based on the percentage of airport passengers by trip origin. Air cargo truck movements were estimated using a truck movement study that was performed for JFK[3].

Port Commerce – Commercial Marine Vessels (CMVs)

The Port Commerce Department of the PANYNJ includes commercial marine vessel (CMV) travel, docking and berthing, cargo handling equipment (CHE) at the Port of New York and New Jersey (Port), travel to and from the Port by trucks and rail locomotives, and buildings. The beginning methods for estimating GHG and criteria pollutant emissions for CMVs and CHE relied on the information collected during 2000 as part of a study[4] that provided SIP emission inventories for these sources to EPA and the States of New Jersey and New York. However, as this study has evolved, the PANYNJ has sponsored efforts to have combined GHG and CAP emission estimates developed for calendar year 2006[5] that have been projected to 2007 and 2008 using activity data surrogates. Truck emission estimates have been developed from a special study of port attracted travel. Rail locomotive emission estimates are based on recent activity estimates. The PANYNJ owns/operates relatively few buildings at the Port, and the GHG emissions estimates are based on electricity and natural usage in those facilities.

The boundary selected for estimating CMV emissions corresponds to the New York-Northern New Jersey-Long Island ozone nonattainment area boundary, and includes all facilities that are under

PANYNJ management control. Emissions out to the three mile demarcation line off the eastern coast of the United States are included in this boundary. Emissions from vessels calling on facilities that are not under the management control of the PANYNJ are not included in this emission inventory.

The following Port facilities are included: (1) Auto Marine Terminal, (2) Port Newark, (3) Elizabeth Marine Terminal, (4) Brooklyn/Red Hook Container Terminal, and (5) Howland Hook Terminal.

CMVs are classified into three major categories: ocean going vessels, towboats and harbor vessels. The ocean-going vessel category includes the following ship types: containerships, car carriers/roll-on/roll-off vessels, cruise ships, tankers and bulk carriers. The key harbor vessel sub-categories include assist tugs, dredging vessels, ferry-excursion vessels, and government vessels. Of these, only assist tugs and dredging vessels were deemed to be under the management control of the PANYNJ.

There are three major CMV emission sources: (1) the main engines, (2) auxiliary engines, and (3) and boilers. Each CMV type has emissions from one or more of these source types. For all vessel activity except dredging, activity information by vessel type was developed from a special study of Port activity that was sponsored by the PANYNJ for calendar year 2000. This study was updated recently to provide a best estimate of calendar year 2006 activity and GHG/CAP emissions. Estimates of 2007 and 2008 CMV emissions use annual port-wide ship call data from the PANYNJ compared with 2006 activity in order to estimate how emissions have changed during that period.

Dredging activity data for each calendar year reflect volumes dredged from the PANYNJ/U.S. Army Corps of Engineers Joint Harbor Deepening Project, as well as dredging from Port berths. All of this dredging activity is considered to be within the PANYNJ's boundary. Emission factors for dredging were derived from CAP emission factors developed by Starcrest for the engines used on dredging vessels. GHG emission factors for CO_2, methane (CH_4) and N_2O were developed from relationships between GHG and criteria pollutant emission rates for similar engine types. There have been significant year-to-year variations in dredging activity in the New York City Harbor.

Port Commerce – Cargo Handling Equipment (CHE)

Another important emissions source at New York City Port terminals are the engines used in CHE. The predominant types of equipment used at container terminals include: terminal tractors, straddle carriers, forklifts and top loaders. In addition, several other types of off-road equipment are used at these terminals, including cranes. Estimates of 2006 GHG and CAP container terminal CHE emissions were prepared by Starcrest for the Port District[5]. The 2006 CAP emissions were estimated using EPA's NONROAD model. Activity data collected for the Port District study were used in NONROAD instead of the default inputs. As noted earlier, NONROAD does not address methane and N_2O emissions, so emission factors from EPA's national GHG inventory were used for these pollutants. The change in the number of loaded and empty total energy use handled in the port between 2006 and 2008 was used as the surrogate indicator to estimate 2008 activity. The 2007 and 2008 GHG and CAP emissions were estimated by applied the total energy use ratios for 2007 and 2008 versus 2006 to the 2006 calendar year emission estimates.

Port Commerce – Rail

Emissions for Port Commerce were also estimated for the switcher locomotives that operate within the terminals as well as the line haul locomotives that serve these ports. Line haul locomotive emissions were included for the travel that occurred within the boundaries of the New York City ozone nonattainment area. Calendar year 2006 emissions for switcher and line haul locomotives were estimated by Starcrest for the Port District. The number of containers handled at Port terminals during 2007 and 2008 was used as a surrogate for estimating how these locomotive emissions would be expected to change from 2006 to 2008.

Port Commerce – Heavy-Duty Vehicles (HDVs)

HDVs (trucks) also service the Port, so emissions were estimated for truck idling within the marine terminal areas, truck travel within the marine terminal areas, and truck trips to and from the terminal areas to deliver or pick-up containers. Activity estimates for each truck travel activity type were multiplied by GHG and CAP emission factors to estimate emissions for this source type. HDV idling activity was expressed as the number of idling hours – and this was estimated 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 HDV travel within the terminal area was VMT within the terminal area, which 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 these terminals was the round trip mileage times the number of trucks making a trip of each trip length. A Vollmer terminal study[6] report provided estimates of average trip length. This report summarizes the distribution of truck origins and destinations by terminal. GHG emission factors for trucks were obtained from EPA's national GHG Inventory report. CAP emission factors for heavy-duty trucks were developed using EPA's MOBILE6 emission factor model.

Port Commerce – Landfill

There is a landfill in Elizabeth, New Jersey that is on property that is leased by a tenant, but the PANYNJ included an estimate of the methane emissions from this landfill in its inventory, although there is some uncertainty in the protocols about which organization is really responsible for these emissions. 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. LandGEM is based on the gas generated from anaerobic decomposition of landfilled waste, which has a methane content between 40 and 60 percent. The annual waste emplacement estimate was input to LandGEM for each year of operation. Because there was no detailed and accurate data available on the yearly waste deposits and the composition of waste deposited each year in the landfill, the LandGEM was used instead of the IPCC-based waste model.

Tunnels, Bridges, and Terminals

The PANYNJ's Tunnels, Bridges and Terminals Department operates four bridges and two tunnels in the New York Metro area. Emission estimates for the vehicle travel across and through these facilities were included in the GHG/CAP emission inventory. Queuing emissions at these facilities were also included in the emission inventory. The boundaries established for measuring these emissions were the bridge span roadway lengths and the average tunnel lengths. Activity data for the analysis were developed based on the annual reported traffic volumes and facility roadway lengths. VMT was estimated by multiplying annual traffic volumes for each vehicle category by the roadway length. Vehicle types in the annual traffic counts included autos, buses, small trucks and large trucks. The CH_4 and N_2O emission factors by vehicle type used in the GHG emission estimates are from EPA's GHG Inventory report. 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. Once emission estimates were computed by vehicle category and model year group, emissions were summed for all model years and vehicle categories for each GHG gas.

The queuing analysis boundary included 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. Queuing emissions were estimated as a function of the number of hours of vehicle delay at each facility. The estimated number of vehicle hours of delay was then multiplied by an estimate of idling fuel consumption to compute the amount of fuel consumed by queuing vehicles at the toll gates. The PANYNJ was able to provide electronic data on the number of hours of vehicle delay for four of its six facilities. For the other two facilities, there were aerial photographs taken twice per year that were initially used to estimate vehicle delay at those facilities. However, it was found that the queue lengths for the two sampled days (those with aerial photos) varied dramatically from year-to-year. Therefore, it was decided to use the 2006 aerial photos to establish a baseline queue length for each facility and then estimate vehicle hours of delay changes based on changes in annual traffic volumes.

RESULTS

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 equivalent (CO_2e). PANYNJ GHG direct and indirect emissions were approximately 5.89 million metric tons of CO_2e in 2007 and 5.77 million metric tons of CO_2e in 2006. A comparison of annual emissions between 2006 – the baseline year – and 2008 can be found in Table 5. Table 1 and Figure 1 show the 2008 CO_2e 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. Total (Scope 1, 2, and 3) PANYNJ CO_2 equivalent emissions in 2008.

Department	CO_2 Equivalent Emissions (metric tons)
Aviation	3,723,414
Port Commerce	867,271
Real Estate & Development	725,698
Tunnels, Bridges & Terminals	387,190
Mobile Sources	91,749
PATH	87,477
Totals	**5,882,799**

Figure 1 provides a breakdown of the sources of Scope 1 and 2 GHG emissions (under the direct management control of the PANYNJ), 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. PANYNJ 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 PANYNJ'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. GHG emissions under direct management control.

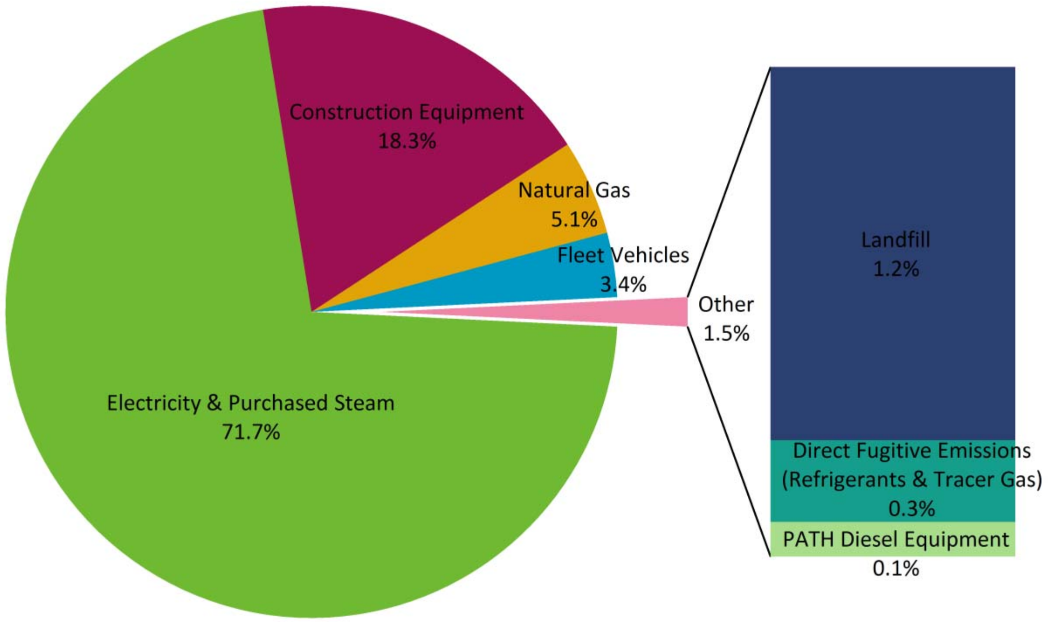

Table 2 provides Scope 1, 2, and 3 GHG emissions reported by department and broken down by sector. The table also shows how the GHG emissions from energy use in buildings is allocated among direct energy use in PANYNJ-occupied space (Scope 1 emissions), indirect electricity usage in PANYNJ-occupied space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

Table 2. 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

Department	Direct GHG Emissions Scope 1	Indirect Electricity GHG Emissions Scope 2	Other Indirect GHG Emissions Scope 3	Totals
Heavy-Duty Vehicles	0	0	469,873	469,873
Buildings	0	0	53,965	53,965
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**

COMPARISON WITH PREVIOUS STUDY YEARS

This section compares the 2008 calendar year GHG emission estimates for the PANYNJ 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 3 shows Scope 1 plus Scope 2 CO_2e 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 PANYNJ construction projects.

Table 3. Comparison of Scope 1 and 2 CO_2 equivalent emissions by department.

Department	Total CO_2e 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 4 compares the 2006, 2007, and 2008 total Scope 3 GHG emissions associated with each PANYNJ department. Overall, Scope 3 GHG emissions increased by 2.5 percent from 2006 to 2008.

Table 4. Comparison of Scope 3 CO_2 equivalent emissions by department.

Department	Total CO_2e 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 5 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 PANYNJ 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 Kennedy International Airport Cogeneration 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. CMV emission reductions are mostly attributable to reduced dredging activity in 2008.

Tunnels, bridges, and terminals 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 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 5. 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%

Department/Source	Total CO_2e Emissions (Metric Tons)				Percent Difference (2008-2006)
	2006	2007	2008	Difference (2008-2006)	
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%**

SUMMARY AND CONCLUSIONS

1) Methods have been developed that can be used to consistently track and report GHG and CAP emissions for a large organization like the PANYNJ that has a complex set of sources.
2) Some fine-tuning of these methods is needed to reflect actions being taken by the PANYNJ to reduce GHGs.
3) It should be recognized that there are actions taken by the PANYNJ that increase the organization's GHG emissions – like expanding PATH service – that serve to provide overall GHG emission reductions for the New York Metro area. New York Metro area commuters taking PATH trains emit less GHGs that those traveling in motor vehicles.
4) The emission models that were available for developing GHG and CAP emission estimates at the beginning of this project (the 2006 calendar year) did not have the capability to estimate both GHG and CAP emissions for the key PANYNJ source categories. It appears that models are becoming available – or are in the pipeline – that have at least the capability to provide CO_2 and CAP emission estimates (or emission factors). One such model is EPA's Motor Vehicle Emission Simulator (MOVES) 2010 model for onroad vehicles. Another example is FAA's EDMS model. Predecessors and

predecessor versions to these models were limited to CAP emissions. Availability of multi-pollutant model versions allows consistent inputs and outputs to be used to develop GHG and CAP emissions.

5) The bottom-up activity estimates developed for CMVs are too time-consuming and expensive to be used to develop emission estimates every year, so surrogate activity indicators are applied in this study to develop estimates for intermediate years. Using fuels sales to estimate CMV emissions was considered, but only a fraction of the ocean-going vessels in the New York City port purchase fuel in the port terminals themselves. Fuel is purchased in other nearby ports and from barges located in or around the port. Other studies in the New York City area have tried to use statewide fuel sales allocated to counties to estimate CMV fuel use, but these studies have produced emission estimates that differ widely from the bottom-up estimates, and are extremely uncertain.
6) In general, top down methods for estimating GHG emissions often focus on collecting fuel use data. Fuel use drives CO_2 emission estimates, but does not always provide the information needed to develop the best possible estimate for CH_4, N_2O, and many criteria pollutants.
7) GHG emission estimation protocols have continued to be developed and updated during the course of this project. For the 2006 calendar year emission inventory, key GHG protocols included those of the California Climate Action Registry, the World Resources Institute, and the IPCC (guidelines). Another key emission factor source has been the EPA national GHG inventory. More recently, the PANYNJ's focus has been on The Climate Registry protocols. Changing from one protocol to another can change emission factors and requires re-estimating previous year's emissions when adopted to avoid discontinuities because of method changes. For example, the California Climate Action Registry protocol diesel vehicle CO_2 emission factors were based on the properties of California reformulated diesel, while The Climate Registry protocol emission factors are for U.S. conventional diesel.
8) It has been found that significant year-to-year differences in indirect electricity CO_2e emissions can result from changes to the electricity mix by the power production facilities in New York and New Jersey. This study uses the Emissions & Generation Resource Integrated Database (eGRID) factors for these two states that serve the electricity customers in the respective states. Between 2006 and 2007, there was a substantial change in the New York State CO_2 emission factor in eGRID, which produced a significant change in the New York State indirect electricity emissions estimate, while the emissions from indirect electricity usage in New Jersey stayed about the same. This change occurred despite there not being any change in the purchasing practices by the organization.
9) For a large organization like the Port Authority, the number of facilities that are operated by the PANYNJ changes with time. This requires re-estimation of the 2006 baseline, or a recognition that a portion of the emissions increase or decrease each year is attributable to such changes and those emission changes need to be accounted for separately.

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KEY WORDS

greenhouse gases, criteria air pollutants, carbon dioxide, climate change, greenhouse gas protocols, aviation, marine vessels, traffic monitoring