SCOPE 1, SCOPE 2, & SCOPE 3 (ATTRACTED TRAVEL AND MARINE TERMINALS) GREENHOUSE GAS AND CRITERIA AIR POLLUTANT EMISSIONS INVENTORY FOR THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

Calendar Year 2012

Final Report

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ACRONYMS AND ABBREVIATIONS

AC	air conditioning
B20	20 percent biodiesel
Btus	British thermal units
CAD	Central Automotive Division
CAP	criteria air pollutant
ccf	100 cubic feet
CFCs	chlorofluorocarbons
CH_4	methane
CMV	commercial marine vessels
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
conEdison	Consolidated Edison Co. of N.Y., Inc.
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
eGRID	Emissions & Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
g	gram(s)
E10	10 percent ethanol
E85	85 percent ethanol
gal	gallon
GHG	greenhouse gas
GRP	General Reporting Protocol
GWBBS	George Washington Bridge Bus Station
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HDDV	heavy-duty diesel vehicle
HFCs	hydrofluorocarbons
hr	hour
IPCC	Intergovernmental Panel on Climate Change
JFK	John F. Kennedy International Airport
kg	kilogram
KIAC	Kennedy International Airport Cogeneration
kWh	kilowatt hour
LandGEM	EPA's Landfill Gas Emissions Model
LGA	LaGuardia Airport
MARKAL	EPA's MARKet ALlocation database
MMBtu	million British thermal units
MOVES	EPA's Motor Vehicle Emissions Simulator
mph	miles per hour
MWh	megawatt hour(s)
National Grid	National Grid USA Service Company, Inc.
N_2O	nitrous oxide
NA	not applicable
NG	natural gas
NO_x	oxides of nitrogen
NPCC	Northeast Power Coordinating Council
NYC	New York City

NYMTC	New York Metropolitan Transportation Council
ODS	ozone-depleting substance
PABT	Port Authority Bus Terminal
PAS	Park Avenue South
PATC	Port Authority Technical Center
PATH	Port Authority Trans-Hudson
Pechan	former E.H. Pechan & Associates (now SC&A)
PDF	portable document format
PFCs	perfluorocarbons
PM	particulate matter
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
Port Authority	Port Authority of New York and New Jersey
PSEG	Public Service Electric and Gas
SEM	Simplified Estimation Method
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SO_x	sulfur oxides
Southern	Southern Research Institute
SWF	Stewart International Airport
TCAP	Tenant Construction and Alteration Process manual
TCR	The Climate Registry
TEB	Teterboro Airport
The Registry	The Climate Registry
TPY	tons per year of pollutant
VOCs	volatile organic compounds
VMT	Vehicle miles traveled
WTC	World Trade Center

EXECUTIVE SUMMARY

The Port Authority of New York and New Jersey (Port Authority) owns, manages, and maintains bridges, tunnels, bus terminals, airports, the 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. The Port Authority has set ambitious goals to conserve and enhance the region's natural resources for future generations. It is committed to conducting operations in a manner that would minimize environmental impacts while enhancing regional transportation and goods movement.

In June 1993, the Port Authority formally issued its environmental policy affirming its long-standing commitment to provide transportation, terminal, and other facilities of commerce within its jurisdiction, to the greatest extent practicable, in an environmentally sound manner and consistent with applicable environmental laws and regulations. On March 27, 2008, the Board of Commissioners expanded the Port Authority's environmental policy to include a sustainability component that explicitly addresses the problem of climate change and ensures that the agency maintains an aggressive posture in its efforts to reduce greenhouse gas (GHG) emissions. The cornerstone of the policy is a goal to reduce GHG emissions stemming from Port Authority facilities, tenants, and customers by 80 percent by 2050 (using 2006 as the baseline year) (Port Authority, 2008a). Accordingly, the Port Authority prepares annual emissions inventories and seeks to decrease emissions by promoting energy efficiency and renewable energy options, instituting advanced technology, reducing waste and water use, and developing sustainable design and construction guidelines. The inventory also tracks Port Authority criteria air pollutant (CAP) emissions to ensure that GHG reduction measures maintain and enhance CAP reduction strategies.

To establish the initial baseline required to monitor progress, the Port Authority conducted a GHG emissions inventory of Port Authority operations (scope 1 and 2 emissions) and tenant and customer activities (scope 3 emissions) for calendar year 2006, documented in *Greenhouse Gas Emission Inventory for the Port Authority of New York & New Jersey, Calendar Year 2006* (Port Authority, 2009). The 2006 inventory was followed by updates for emission years 2007, 2008, 2010, and 2011.

The completion of the 2012 inventory documented in this report represents an important milestone for the Port Authority. This report describes the development and results of the scope 1 and 2 GHG emissions estimates for 2012 being reported to The Climate Registry. The use of a consistent and high-quality protocol for the 2010, 2011 and 2012 inventories provides intended users with a high level of confidence that emissions levels asserted by the Port Authority are complete and accurate, and that emissions trends are reliable and verifiable.

This report estimates that the Port Authority's organizational GHG emissions in 2012 were 266,661 metric tons of carbon dioxide equivalent (CO_2e) gases. This compares with estimates of 281,368 metric tons CO_2e for 2011 and 295,223 metric tons CO2e in 2010. The Port Authority's total scope 1 and 2 GHG emissions declined by 5.2 percent from 2011 to 2012 and by 10.6 percent from 2010 to 2012. In 2012, electricity usage in Port Authority occupied buildings, PATH trains, and AirTrain JFK and AirTrain Newark accounted for 69.9 percent of the GHG emissions total. Other important Port Authority activities in terms of GHG emissions were fuel combustion for heating buildings (11.8 percent of GHGs) and motor vehicle fuel combustion (4.7 percent of GHGs).

The final portion of this report describes the development and results of the GHG emissions estimates for Scope 3 attracted travel and maritime terminal emissions for calendar year 2012. Attracted travel is a category that encompasses all ground access vehicles entering Port Authority facilities through public roadways. Typical ground access vehicles include private vehicles transporting passengers to and from terminals, shuttle buses, cargo roadway travel, taxis and airport-owned vehicles operated by contractors. Marine terminal emissions encompass the movement of commercial marine vessels, operation of cargo handling equipment, rail locomotives, and cross-harbor barge activity that occurs at, or in proximity of, Port Authority marine terminals.

1.0 INTRODUCTION

1.1. BACKGROUND

The Port Authority of New York and New Jersey (Port Authority) owns, manages, and maintains bridges, tunnels, bus terminals, airports, the 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 Port Authority include John F. Kennedy International Airport (JFK), Newark Liberty International Airport (EWR), LaGuardia Airport (LGA), Stewart International Airport (SWF) and Teterboro Airport (TEB); the George Washington Bridge; the Lincoln and Holland tunnels; Port Newark; Howland Hook Marine Terminal; the Port Authority Bus Terminal (PABT); and the 16-acre World Trade Center (WTC) site in lower Manhattan.

As a cornerstone of its broader sustainability program, the Port Authority implemented a program to reduce greenhouse gas (GHG) emissions by 80 percent from 2006 levels by 2050. Emissions to be reduced include both those under its operational control (Scope 1 and Scope 2[1]) and those produced by its tenants and customers (Scope 3[2]). The Port Authority used the services of Southern Research Institute (Southern) and SC&A, Inc. (formerly TranSystems|E.H. Pechan & Associates) to conduct a GHG and criteria air pollutant (CAP) emissions inventory of Port Authority facilities and operations for calendar year 2006 to establish the initial baseline required for monitoring progress toward this goal (Port Authority, 2009). The same consulting team later developed GHG and CAP emissions inventories for 2007, 2008, 2010, and 2011. The 2010 and 2011 emission inventories did not include Scope 3 emissions from attracted travel.

The GHG emissions in this report were developed in conformance with The Climate Registry's (The Registry's) "General Reporting Protocol – Version 2.0" (GRP) (TCR, 2013a). The Registry requires members to report Scope 1 and 2 emissions using its standardized methods for calculating emissions from typical emitting activities based on objective and verifiable evidence. When systems are not in place to determine emissions based on complete and

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[1] Scope 1 emissions encompass an organization's direct GHG emissions from stationary and mobile fuel combustion, as well as fugitive emissions from air conditioning units. Scope 2 emissions account for energy acquisitions, such as purchased electricity, steam, heating, or cooling.

[2] Scope 3 emissions come from emitting activities that occur outside the operational boundaries of an organization. Typical Scope 3 emitting activities at the Port Authority include tenant energy consumption, employee commuting, and attracted travel to Port Authority installations.

accurate records, The Registry permits the use of Simplified Estimation Methods (SEMs), provided that SEM emissions do not exceed five percent of total emissions.

This report also documents the development of a 2012 emission inventory of Scope 3 attracted travel and marine terminal emissions. The attracted travel category encompasses all ground access vehicles entering Port Authority facilities through public roadways. Typical ground access vehicles include private vehicles transporting passengers to and from terminals, shuttle buses, cargo roadway travel, taxis, and airport-owned vehicles operated by contractors. Marine terminal emissions encompass the movement of commercial marine vessels, operation of cargo handling equipment, rail locomotives, and cross-harbor barge activity that occurs at or interacts directly with Port Authority marine terminals.

1.2. ORGANIZATION OF THE INVENTORY

1.2.1. Scope 1 and 2 Boundary

The Registry's mission is to assist the world's leading organizations with assembling the highest quality carbon data by setting consistent and transparent standards to calculate, verify, and publicly report GHG emissions into a single registry. The Registry is the only voluntary carbon reporting program that is backed by State governments and that generates high-quality, consistent, and credible data to help organizations become more efficient, sustainable, and competitive. The 2012 GHG inventory was developed according to the following specifications:

- **<u>Scope</u>**

Emission Year:	2012
Geographic Boundary:	North America
Organizational Boundary:	Management Control – Operational Criterion
Reported Type:	Complete
Reported Gases:	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6)

- **<u>Criteria</u>**

  The GHG emissions estimates for 2012 were developed using The Registry's GRP Version 2.0 and "2013 Climate Registry Default Emission Factors," released April 2, 2013 (TCR, 2013b).

- **Materiality**

  The inventory was developed to avoid material discrepancies. Discrepancies are considered to be material if the collective magnitude of conformance and reporting errors in the Port Authority's GHG assertions alters the calculation of its direct or indirect emissions by plus or minus five percent.

- **Level of Assurance**

  The Port Authority has retained the services of an accredited verification body to verify with a reasonable level of assurance that the 2012 GHG emissions inventory is complete, accurate, and in conformance with the voluntary reporting requirements of The Registry. The Scope 3 GHG emissions estimates are not verified by a third party.

Table 1-1 lists the types of emitting activities per department that fall inside the Port Authority's organizational boundary and is organized first by Port Authority department, then by facility. Note that 'Electricity Usage' includes all uses of electricity; major uses are lighting and heating, ventilation, and air conditioning (AC). This inventory structure applied to both GHG and CAP emissions estimates. Note also that the Port Authority leases a great deal of space. GHG and CAP emissions associated with tenant energy usage are outside of Port Authority operational control and are not counted as Scope 1 or Scope 2 emissions. Emissions from sources not expressly affiliated with one department, such as emissions from electricity and heating at the Port Authority's Park Avenue offices (which house the Port Authority's Senior Management, Law, Human Resources, Media and Marketing, Planning, Government Affairs, Finance, and Environmental and Energy Program departments, along with support staff from the Port Authority's Engineering, Port Commerce, Aviation, and Real Estate groups) or fleet vehicles in the New York motor pool, are assigned to "Central Administration," in lieu of a department. Buildings and properties that the Port Authority manages and leases as property manager are assigned to "Real Estate."

Table 1-1: Scope 1 & 2 Emitting Activities by Facility and Department

Facility	Emitting Activity	Scope 1	Scope 2
Central Administration Functions			
Central Administration Buildings[a]	Electricity Usage	✓	✓
Central Automotive Department	Fleet Vehicles	✓	
Aviation			
John F. Kennedy International Airport (JFK)	Electricity Usage	✓	✓
	Refrigerants	✓	
AirTrain JFK	Terminal and Trains	✓	✓
LaGuardia Airport (LGA)	Electricity Usage	✓	✓
	Refrigerants	✓	
Newark Liberty International Airport (EWR)	Electricity Usage	✓	✓
	Refrigerants	✓	

Facility	Emitting Activity	Scope 1	Scope 2
AirTrain EWR	Terminals and Trains		✓
Stewart International Airport (SWF)	Electricity Usage	✓	✓
	Refrigerants	✓	
Teterboro Airport (TEB)	Electricity Usage	✓	✓
	Refrigerants	✓	
Port Commerce			
Brooklyn Marine Terminal	Electricity Usage	✓	✓
Port Jersey	Electricity Usage	✓	✓
Port Newark	Electricity Usage	✓	✓
Elizabeth Port Authority Marine	Electricity Usage		✓
Elizabeth Landfill	Fugitive Emissions	✓	
Howland Hook Marine Terminal	Electricity Usage	✓	✓
Tunnels and Bridges			
Holland Tunnel	Electricity Usage	✓	✓
Lincoln Tunnel	Electricity Usage	✓	✓
George Washington Bridge	Electricity Usage	✓	✓
Bayonne Bridge	Electricity Usage		✓
Goethals Bridge	Electricity Usage	✓	✓
Outerbridge Crossing	Electricity Usage	✓	✓
Bus Terminals			
Port Authority Bus Terminal	Electricity Usage	✓	✓
George Washington Bridge Bus Station	Electricity Usage	✓	✓
PATH			
PATH Rail Transit System	Trains		✓
	Utility Track Vehicles	✓	
	Maintenance Vehicles	✓	
	Electricity Usage	✓	✓
Journal Square Transportation Center	Electricity Usage		✓
Real Estate			
Bathgate Industrial Park	Electricity Usage	✓	✓
The Teleport	Electricity Usage	✓	✓
	Fleet Vehicles	✓	
The Legal Center	Fleet Vehicles	✓	
World Trade Center	Fleet Vehicles	✓	
Multi-Department			
Various facilities	Emergency Generators and Fire Pumps	✓	
	Welding Gases	✓	

[a] Central Administration Buildings include 225/223 Park Avenue South (PAS), Gateway Newark, Port Authority Technical Center (PATC), 5 Marine View, 115 Broadway, 96/100 Broadway, 116 Nassau Street, and 777 Jersey Avenue.

1.2.2. Scope 3 Attracted Travel Boundary

Decisions on the Scope 3 boundary by facility type for attracted travel emissions were made during the development of the initial 2006 Port Authority GHG and CAP emission inventory (Port Authority, 2009). These same boundaries are used in this report, thus facilitating emission comparisons across inventory years. Table 1-2 summarizes the boundaries that this study applied for the departments and facilities included in the 2012 Scope 3 attracted travel emission inventory.

Table 1-2: Scope 3 Attracted Travel Emission Inventory Departmental Boundaries

Department	Boundary
Aviation	• Vehicle trips attracted by the airport, including those of private vehicles, taxis, and buses • Vehicles owned by the Port Authority and operated by contractors (also known as the "Shadow Fleet")
Port Commerce	• Drayage trucks/rail freight to the first point of rest • Movement of new vehicles at Auto Marine Terminals
Tunnels, Bridges & Terminals	• Emissions based on vehicle volume, the roadway length of each facility, and the vehicle hours of delay in toll lane queues • For terminals, all vehicle travel within the terminal property
PATH	• Commuters' vehicle trips to PATH stations

1.2.3. Scope 3 Marine Terminals Boundary

The Scope 3 Marine Terminal boundary encompasses activities listed in Table 1-3 associated with marine terminal activity linked to facilities maintained by the Port Authority and leased to private terminal operators. The geographical area covered by commercial marine vessels (CMV) includes the counties within the New York New Jersey Long Island Non-Attainment Area (NYNJLINA) and is bounded on the ocean side by the three nautical mile demarcation line off the eastern coast of the U.S.

Table 1-3: Scope 3 Marine Terminals Emission Inventory Boundary

Department	Boundary
Port Commerce	• Movement of commercial marine vessels • Operation of cargo-handling equipment • Operation of rail locomotives • Cross-harbor barging

1.2.4. Global Warming Potential Factors

For non-CO_2 GHGs, the mass estimates of these gases are converted to CO_2 equivalent (CO_2e) by multiplying the non-CO_2 GHG emissions in units of mass by their global warming potentials (GWPs). The Intergovernmental Panel on Climate Change (IPCC) developed GWPs 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 (IPCC, 1996). In 2001, the IPCC published its Third Assessment

Report (IPCC, 2001), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of CO_2. The IPCC adjusted these GWPs again during 2007 in its Fourth Assessment Report (IPCC, 2007). However, Second Assessment Report GWPs are still used by international convention to maintain consistency with international practices, including by the United States and Canada when reporting under the United Nations Framework Convention on Climate Change. Consistent with international practice, The Registry requires its reporting members to use GWP values from the Second Assessment Report. These values are presented in Table 1-4.

In addition to GHGs, the Scope 3 analysis assesses emissions of the following CAPs: oxides of nitrogen (NO_x), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), and particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$).

Table 1-4: Global Warming Potential Factors for Reportable GHGs

Common Name	Formula	Chemical Name	GWP
Carbon dioxide	CO_2	Not Applicable (NA)	1
Methane	CH_4	NA	21
Nitrous oxide	N_2O	NA	310
Sulfur hexafluoride	SF_6	NA	23,900
Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	trifluoromethane	11,700
HFC-32	CH_2F_2	difluoromethane	650
HFC-41	CH_3F	fluoromethane	150
HFC-43-10mee	$C_5H_2F_{10}$	1,1,1,2,3,4,4,5,5,5-decafluoropentane	1,300
HFC-125	C_2HF_5	pentafluoroethane	2,800
HFC-134	$C_2H_2F_4$	1,1,2,2-tetrafluoroethane	1,000
HFC134a	$C_2H_2F_4$	1,1,1,2-tetrafluoroethane	1,300
HFC-143	$C_2H_3F_3$	1,1,2-trifluoroethane	300
HFC-143a	$C_2H_3F_3$	1,1,1-trifluoroethane	3,800
HFC-152	$C_2H_4F_2$	1,2-difluoroethane	43
HFC-152a	$C_2H_4F_2$	1,1-difluoroethane	140
HFC-161	C_2H_5F	fluorothane	12
HFC-227ea	C_3HF_7	1,1,1,2,3,3,3-heptafluoropropane	2,900
HFC-236cb	$C_3H_2F_6$	1,1,1,2,2,3-hexafluoropropane	1,300
HFC-236ea	$C_3H_2F_6$	1,1,1,2,3,3-hexafluoropropane	1,200
HFC-236fa	$C_3H_2F_6$	1,1,1,3,3,3-hexafluoropropane	6,300
HFC-245ca	$C_3H_3F_5$	1,1,2,2,3-pentafluoropropane	560
HFC-245fa	$C_3H_3F_5$	1,1,1,3,3-pentafluoropropane	950
HFC-365mfc	$C_4H_5F_5$	1,1,1,3,3-pentafluoropropane	890
Perfluorocarbons (PFCs)			
Perfluoromethane	CF_4	tetrafluoromethane	6,500
Perfluoroethane	C_2F_6	hexafluoroethane	9,200
Perfluoropropane	C_3F_8	octafluoropropane	7,000
Perfluorobutane	C_4F_{10}	decafluorobutane	7,000
Perfluorocyclobutane	c-C_4F_8	octafluorocyclobutane	8,700
Perfluoropentane	C_5F_{12}	dodecafluoropentane	7,500
Perfluorohexane	C_6F_{14}	tetradecafluorohexane	7,400

Source: IPCC, 1996

1.3. SUMMARY OF 2012 GREENHOUSE GAS EMISSIONS RESULTS

1.3.1. Scope 1 and 2 Summary Results

Total Scope 1 and Scope 2 emissions for 2012 are presented in Table 1-5 where results are summarized at the department level. Emissions from sources not expressly affiliated with one department are assigned to “Central Administration” in lieu of a department. Emission sources grouped under “Central Administration” include, but are not limited to, electricity purchases at the Port Authority’s Park Avenue offices, and fleet vehicles in the New York motor pool. Additionally, electricity consumption and natural consumption at properties not owned but leased by the Port Authority and occupied by Port Authority were assigned to the “Real Estate” category.

Table 1-5: Port Authority 2012 Scope 1 & 2 GHG Emissions

Department	Metric Tons CO_2e	Contribution
Aviation	151,182	56.70%
PATH	53,590	20.10%
Tunnels, Bridges and Terminals	28,204	10.50%
Central Administration	21,488	8.10%
Port Commerce	9,805	3.70%
Real Estate	1,588	0.60%
Multi-Department	802	0.30%
Total	**266,661**	**100.00%**

As Table 1-5 shows, reportable emissions for facilities under operational control of the Aviation department account for a majority of Port Authority emissions (56.7 percent). Although the Port Commerce department also administers large maritime properties, most of the maritime terminal facilities are leased to and operated by tenants. Emissions from PATH are the second highest at 20.1 percent, primarily from electricity used as traction power for the rail system (see Section 3.2.1). Central Administration functions contribute another 8.1 percent, primarily due to fuel combustion by the Port Authority fleet. Tunnels and Bridges contribute 5.9 percent as a result of indirect emissions from purchased electricity and steam.

In 2012, 77.9 percent of the Port Authority’s total emissions were Scope 2 and 22.1 percent were Scope 1. Figure 1-1 breaks down emissions by scope per department. For Aviation and PATH, scope 2 emissions are substantially larger than scope 1. These Scope 2 emissions are primarily from electricity and steam purchases that serve large public spaces (i.e., airport terminals, PATH stations).

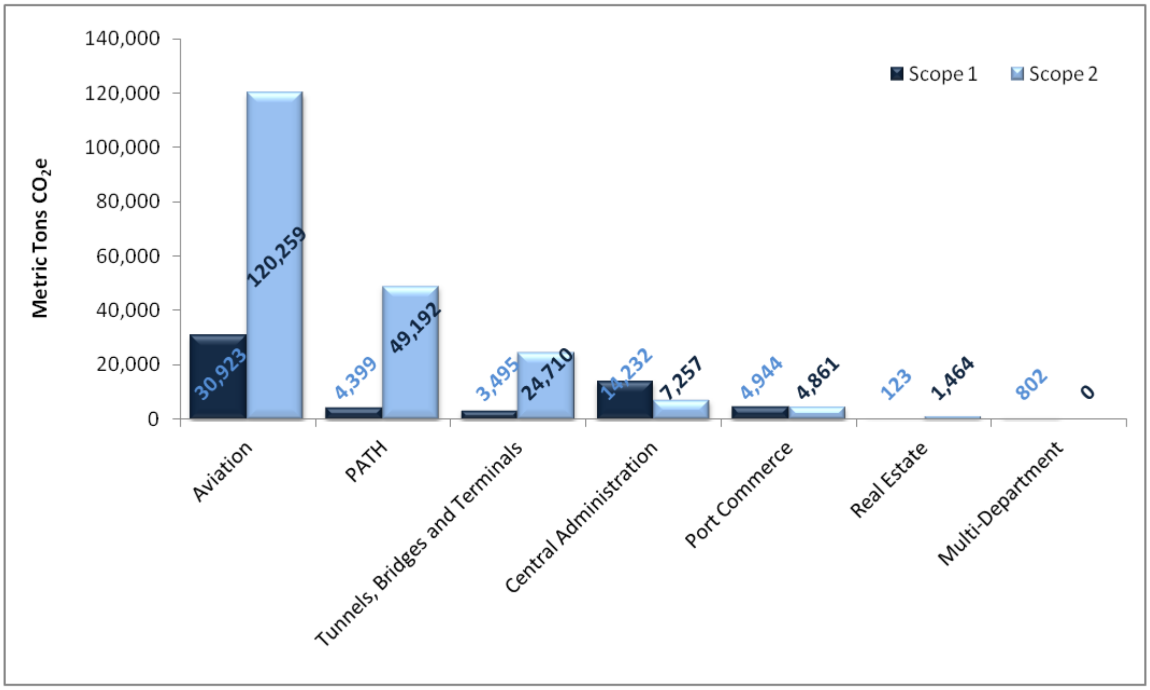

Figure 1-1: 2012 Scope 1 & 2 GHG Emissions by Department and Scope

Figure 1-2 shows which emitting activities make the largest contributions to Port Authority GHG emissions. Purchased electricity contributes 73.8 percent of total emissions, followed by fuel combustion (used for heating facilities) at 12.4 percent, and vehicle fleet fuel combustion, at 4.9 percent. Emissions caused by leaks in AC systems (e.g., refrigeration) and discharges from specialized fire suppression systems contribute 2.8 percent of Port Authority emissions.

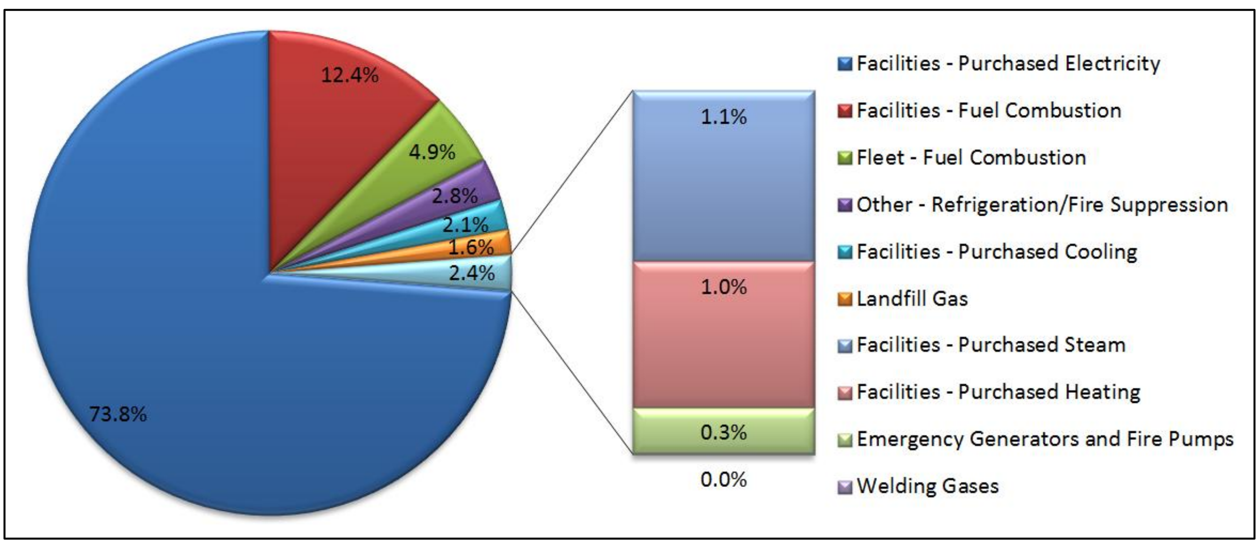

Figure 1-2: Distribution of 2012 Scope 1 & 2 GHG Emissions by Emitting Activity

Table 1-6 shows a detailed summary of the Scope 1 and 2 GHG emissions by department and emitting activity. In general, indirect emissions from electricity purchases comprise the majority of GHG emissions in each department, with a few notable exceptions. For Central Administration functions, the largest emitting activity is motor vehicle fuel combustion. At Port Commerce, landfill gas emissions contribute about half of that department's combined Scope 1 and 2 emissions. Some emitting activities were denoted as "Multi-Department"; these represent small and dispersed emission sources across various Department, but belonging to the same class of emissions (e.g., emergency generators).

Table 1-6: Port Authority 2012 Scope 1 & 2 GHG Emissions by Department and Emitting Activity

Department – Emitting Activity	**Scope 1** (metric tons CO_2e)	**Scope 2** (metric tons CO_2e)	**Total** (metric tons CO_2e)
Aviation	**30,923**	**120,259**	**151,182**
Facilities – Fuel Combustion	26,158	–	26,158
Facilities – Purchased Cooling	–	5,537	5,537
Facilities – Purchased Electricity	0.01	112,167	112,167
Facilities – Purchased Heating	–	2,555	2,555
Other – Refrigeration/Fire Suppression	4,765	–	4,765
PATH	**4,399**	**49,192**	**53,590**
Facilities – Fuel Combustion	2,538	–	2,538
Facilities – Purchased Electricity	–	49,192	49,192
Fleet – Fuel Combustion	267	–	267
Other – Refrigeration/Fire Suppression	1,594	–	1,594
Tunnels, Bridges and Terminals	**3,495**	**24,710**	**28,205**
Facilities – Fuel Combustion	2,898	–	2,898
Facilities – Purchased Electricity	–	21,737	21,737
Facilities – Purchased Steam	–	2,973	2,973
Other – Refrigeration/Fire Suppression	596	–	596
Central Administration	**14,232**	**7,257**	**21,488**
Facilities – Fuel Combustion	1,096	–	1,096
Facilities – Purchased Electricity	–	7,257	7,257
Fleet – Fuel Combustion	12,872	–	12,872
Other - Refrigeration/Fire Suppression	263	–	263
Port Commerce	**4,944**	**4,861**	**9,805**
Facilities – Fuel Combustion	298	–	298
Facilities – Purchased Electricity	–	4,861	4,861
Landfill Gas	4,384	–	4,384
Other – Refrigeration/Fire Suppression	262	–	262

Department – Emitting Activity	**Scope 1** (metric tons CO_2e)	**Scope 2** (metric tons CO_2e)	**Total** (metric tons CO_2e)
Real Estate	**123**	**1,464**	**1,588**
Facilities – Fuel Combustion	123	–	123
Facilities – Purchased Electricity	–	1,464	1,464
Multi-Department	**802**	–	**802**
Emergency Generators and Fire Pumps	802	–	802
Welding Gases	0.54	–	0.54
Grand Total	**58,918***	**207,743**	**266,661**

*This number includes total direct emissions plus the total biogenic emissions.

A number of emitting activities were calculated using SEMs, such as refrigerant losses from AC units, fuel usage by emergency generators, and electricity purchases interpolated from available billing statements. Emissions estimates using SEMs amounted to 4.2 percent of total Port Authority emissions. Table 1-7 presents a department-level summary of emissions estimated using SEMs.

Table 1-7: Port Authority 2012 Scope 1 & 2 GHG Emissions Using SEM

Department	**Emitting Activity**	**Metric Tons CO_2e**
Aviation	Facilities – Fuel Combustion	114
	Facilities – Purchased Electricity	194
	Other – Refrigeration/Fire Suppression	4,765
	Facilities – Purchased Electricity	45.3
	Fleet – Fuel Combustion	289
	Other - Refrigeration/Fire Suppression	263
PATH	Facilities – Fuel Combustion	541
	Facilities – Purchased Electricity	85.9
	Fleet – Fuel Combustion	267
	Other – Refrigeration/Fire Suppression	1,594
Port Commerce	Facilities – Fuel Combustion	6.08
	Facilities – Purchased Electricity	1,193
	Other – Refrigeration/Fire Suppression	262
Tunnels and Bridges	Facilities – Fuel Combustion	163
	Facilities – Purchased Electricity	3.36
	Other – Refrigeration/Fire Suppression	596
Multi-Department	Emergency Generators and Fire Pumps	802
	Welding Gases	0.54
Total		**11,183**

1.3.2. Scope 3 Attracted Travel Summary Results

EPA's Motor Vehicle Emission Simulator (MOVES), version MOVES 2010b (EPA, 2012b) was used to develop both the GHG and CAP emission estimates from attracted travel activities. The New York Metropolitan Transportation Council (NYMTC) provided detailed county-level MOVES inputs for the 10 New York counties in the metropolitan area (NYMTC, 2013). These inputs were developed by New York State Department of Environmental Conservation and NYMTC for use in transportation conformity analyses for the New York City metropolitan area for a 2011 calendar year. SC&A adjusted these inputs, where necessary, to a 2012 calendar year for use in estimating emission rates for this analysis. The same inputs were used to estimate both GHG emission rates and CAP emission rates.

Table 1-8 presents total attracted travel GHG emissions from the Port Authority for 2012 at the Port Authority department level. The GHG emissions inventory for calendar year 2012 estimates that Port Authority GHG attracted travel emissions totaling over 3 million metric tons of CO_2e. Nearly half of these emissions came from attracted travel at the Port Authority airports, as illustrated in Figure 1-3. Port Commerce accounts for an additional 31.8 percent of the GHG emissions, followed by Tunnels, Bridges & Terminals at 17.9 percent, and PATH at 2 percent.

Table 1-8: Summary of Port Authority 2012 Scope 3 Attracted Travel Emissions

Department	Metric Tons CO_2e
Aviation	1,479,449
Port Commerce	972,020
Tunnels, Bridges & Terminals	546,025
PATH	60,064
Totals	**3,057,558**

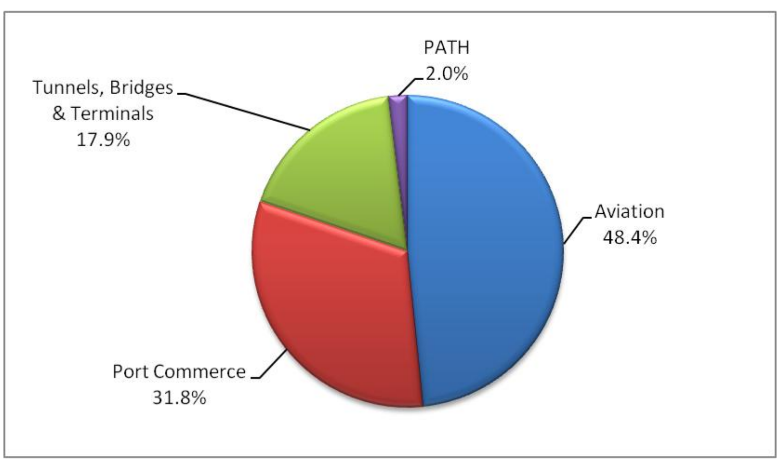

Figure 1-3: Distribution of 2012 Attracted Travel CO_2e Emissions by Department

Table 1-9 presents the Port Authority's attracted travel GHG emissions in more detail, by facility. Note that for Port Commerce results are aggregated at the Department level. Chapters 7, 8, 10, 11 and 12 provide details on the attracted travel analysis and further breakdown of emissions by facility and source.

Table 1-9: Port Authority 2012 Scope 3 Attracted Travel GHG Emissions by Department and Facility

Department/Facility	Metric Tons CO_2e
Aviation	**1,479,449**
John F. Kennedy	*758,567*
La Guardia	*221,965*
Newark	*491,688*
Teterboro	*1,353*
Stewart	*5,876*
Port Commerce	**972,020**
Tunnels, Bridges, and Terminals	**546,025**
George Washington Bridge	170,965
Bayonne Bridge	12,183
Goethals Bridge	25,400
Outerbridge Crossing	53,235
Lincoln Tunnel	207,817
Holland Tunnel	71,237
George Washington Bridge Bus Station	531
Port Authority Bus Terminal	4,657
PATH	**60,064**
Journal Square (bus emissions)	54,583
PATH (vehicle attracted travel)	5,481
Total	**3,057,558**

As with the GHG emissions, all of the CAP emissions were calculated for the first time in 2012 using EPA's MOVES model (EPA, 2012b). The CAP emissions were estimated using the same inputs as those used to estimate the GHG emissions in MOVES. The use of this model can result in significant changes to CAP emission factors, in terms of mass of pollutant per mile of vehicle travel, when compared to emission factors calculated using EPA's MOBILE6 model. In this Port Authority analysis, NO_x and particular matter (PM) emission rates for the most attracted travel categories were higher than those that would have been estimated using EPA's MOBILE6 model (EPA, 2003), which was used to calculate the previous Port Authority CAP emission inventories. Table 1-10 summarizes the Port Authority CAP emission estimates by department and facility for 2012.

Table 1-10: Port Authority 2012 Scope 3 Attracted Travel CAP Emissions

Department/Facility	Metric Tons			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Aviation	1,639	25.9	84.7	170.0
John F. Kennedy	828	13.5	43.4	87.3
La Guardia	257	3.8	13.1	25.8
Newark	546	8.5	27.8	56.1
Teterboro	1	0.0	0.1	0.1
Stewart	7	0.1	0.3	0.7
Port Commerce	6,254	29	427	510
Tunnels, Bridges, and Terminals	1,746	9	87	118
George Washington Bridge	359	2.8	21.6	29.9
Bayonne Bridge	19	0.2	1.2	2.0
Goethals Bridge	44	0.4	2.3	3.1
Outerbridge Crossing	72	0.9	4.6	7.9
Lincoln Tunnel	1,003	3.8	47.4	61.5
Holland Tunnel	114	1.0	6.5	9.5
George Washington Bridge Bus Station	15	0.0	0.4	0.4
Port Authority Bus Terminal	119	0.1	3.2	3.4
PATH	132	1.1	7.0	10.5
Journal Square (bus emissions)	81	0.2	4.6	5.0
PATH (vehicle attracted travel)	51	0.9	2.4	5.5
Total	**9,771**	**65**	**606**	**808**

NO_x emissions are the largest of the CAPs. NO_x is probably the most important of these pollutants because it is an ozone precursor and the New York City area continues to be an ozone nonattainment area. The Port Authority's attracted travel NO_x emissions are dominated by Port Commerce emission sources, primarily from heavy-duty vehicle travel to and from the Port Newark/Port Elizabeth terminal. Other key sources include emissions from travel through the Lincoln Tunnel and aviation emissions.

1.3.3. Scope 3 Marine Terminals Summary Results

The Port Authority commissioned the development of the *Port Commerce Department 2012 Multi-Facility Emissions Inventory* (Starcrest, 2014). Marine terminal inventory description and methodologies are not covered in this report; however, pertinent results are presented in this section. Table 1-11 presents GHG emissions by source category, and Table 1-12 shows CAP emissions by source category.

Table 1-11: Port Authority 2012 Scope 3 Marine Terminal GHG Emissions

Department	Emitting Activity	Metric Tons			
		CO_2	CH_4	N_2O	CO_2e
Port Commerce	Commercial Marine Vessels	147,757	8.9	9.7	151,114
	Cargo Handling Equipment	119,856	6.8	3	120,943
	Vehicle Handling at Auto Marine Terminals	401	0.002	0.003	402
	Railroad Locomotives	16,591	1.2	0.4	16,738
Total		**284,605**	**17**	**13**	**289,197**

Source: Starcrest, 2014

Table 1-12: Port Authority 2012 Scope 3 Marine Terminal CAP Emissions

Department	Emitting Activity	Metric Tons			
		NO_x	SO_2	$PM_{2.5}$	PM_{10}
Port Commerce	Commercial Marine Vessels	2,645	1,569	246.8	198.7
	Cargo Handling Equipment	1,137	1.12	71.7	69.8
	Vehicle Handling at Auto Marine Terminals	0.016	0.008	0.067	0.01
	Railroad Locomotives	241	1.18	8.53	8.07
Total		**4,023**	**1,571**	**327**	**277**

Source: Starcrest, 2014

1.4. COMPARISON WITH PREVIOUS INVENTORIES

1.4.1. Scope 1 and 2 Comparison with Previous Inventories

The Port Authority adopted 2006 as its base year in its most recent environmental sustainability policy (Port Authority, 2008a). The 2006 inventory was the first effort of its kind at the Port Authority and was instrumental in tracing the initial inventory boundary for Port Authority operations (Scope 1 and 2 emissions) as well as key tenant and customer activities (Scope 3 emissions). The Port Authority commissioned additional GHG studies, culminating with the 2010 inventory (Port Authority, 2011), 2011 inventory (Port Authority, 2014), and this 2012 inventory, all of which were developed in conformance with The Registry's guidelines and verified by an independent third party.

Figure 1-4 compares 2010, 2011, and 2012 emissions with the base year (2006). Because the 2010, 2011, and 2012 inventories were developed under the same protocol and verified by an independent third party, the downward trend in annual emissions from 2010 through 2012 represents real and verifiable GHG reductions. As the 2006 inventory was conducted on the basis of best available data and methodology, 2006 results are not expected to meet the same standard of accuracy as the 2010, 2011, and 2012 inventories. For that reason, comparison of recent inventory results with the 2006 base year should be conducted only to infer the general direction of emission trends prior to 2010.

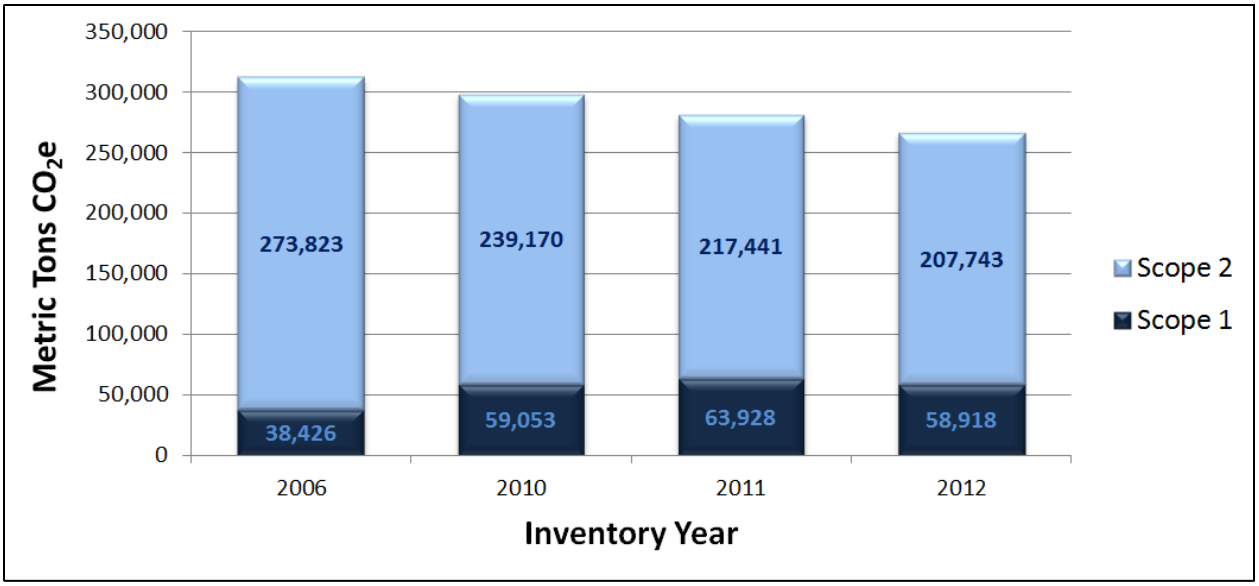

Figure 1-4: Comparison of 2010, 2011, and 2012 Emissions with Base Year 2006 (metric tons CO_2e)

Table 1-13 compares 2011 and 2012 direct (Scope 1) emissions by emitting activity and department. Overall, the Port Authority reduced Scope 1 GHG emissions by over 5,000 metric tons of CO_2e (7.8 percent) between 2011 and 2012. Nearly every department's facilities decreased their fuel combustion (used for heating facilities), reducing GHG emissions by over 5,500 metric tons of CO_2e between 2011 and 2012. However, the Port Authority fleet increased fossil fuel consumption that in turn increased GHG emissions by almost 800 metric tons of CO_2e between 2011 and 2012. Additionally, an increase of GHG emissions equal to 436 metric tons of CO_2e (119 percent) was also observed between 2011 and 2012 due to increased emergency generators usage associated with power outages caused by Hurricane Sandy.

Table 1-13: Comparison of 2011 and 2012 Port Authority Scope 1 GHG Emissions

Emitting Activity/Department	2011	2012	Difference (metric tons CO_2e)	Difference (%)
Facilities – Fuel Combustion	**38,683**	**33,112**	**-5,571**	**-14%**
Aviation	31,282	26,158	-5,124	-16%
Bus Terminals	683	573	-110	-16%
Port Commerce	449	298	-151	-34%
Real Estate	145	123	-22	-15%
Tunnels and Bridges	2,610	2,325	-285	-11%

Emitting Activity/Department	2011	2012	Difference (metric tons CO_2e)	Difference (%)
PATH	2,561	2,538	-24	-0.9%
Central Administration	952	1,096	144	15%
Fleet – Fuel Combustion	**12,344**	**13,139**	**795**	**6.4%**
PATH	267	267	-	0.0%
Central Administration	12,077	12,872	795	6.6%
Landfill Gas	**4,642**	**4,384**	**-258**	**-5.6%**
Port Commerce	4,642	4,384	-258	-5.6%
Other – Refrigeration/Fire Suppression	**7,892**	**7,480**	**-412**	**-5.2%**
Aviation	5,391	4,765	-626	-12%
Bus Terminals	573	596	23	4.1%
Port Commerce	109	262	153	140%
Tunnels and Bridges	0.20	0.24	0.04	22%
PATH	1,550	1,594	44	2.8%
Central Administration	270	263	-6.8	-2.5%
Emergency Generators and Fire Pumps	**366**	**802**	**436**	**119%**
Multi-Department	366	802	436	119%
Welding Gases	**0.47**	**0.54**	**0.08**	**17%**
Multi-Department	0.47	0.54	0.08	17%
Total	**63,928***	**58,918***	**-5,010**	**-7.8%**

*This number includes total direct emissions plus the total biogenic emissions.

Table 1-14 compares 2011 and 2012 indirect (Scope 2) emissions by emitting activity and department. Overall, the Port Authority reduced Scope 2 emissions by over 9,600 metric tons of CO_2e (4.5 percent) between 2011 and 2012. The majority of this reduction can be accounted for in the over 8,500 metric tons of CO_2e (4.3 percent) decrease of Port Authority GHG emissions associated with purchased electricity from 2011 to 2012. Additionally, a decrease of GHG emissions equal to 918 metric tons of CO_2e (24 percent) associated with purchased steam was also observed between 2011 and 2012.

Table 1-14: Comparison of 2011 and 2012 Port Authority Scope 2 GHG Emissions

Emitting Activity/Department	2011	2012	Difference (metric tons CO_2e)	Difference (%)
Facilities – Purchased Electricity	**205,411**	**196,677**	**-8,734**	**-4.3%**
Aviation	117,917	112,167	-5,750	-4.9%
Bus Terminals	10,358	8,204	-2,154	-21%
Port Commerce	3,019	4,861	1,842	61%
Real Estate	877	1,464	588	67%
Tunnels and Bridges	13,628	13,533	-95	-0.7%
PATH	53,844	49,192	-4,653	-8.6%
Central Administration	5,769	7,257	1,488	26%
Facilities – Purchased Cooling	**5,397**	**5,537**	**140**	**2.6%**
Aviation	5,397	5,537	140	2.6%

Emitting Activity/Department	2011	2012	Difference (metric tons CO_2e)	Difference (%)
Facilities – Purchased Steam	**3,891**	**2,973**	**-918**	**-24%**
Bus Terminals	3,891	2,973	-918	-24%
Facilities – Purchased Heating	**2,742**	**2,555**	**-187**	**-6.8%**
Aviation	2,742	2,555	-187	-6.8%
Grand Total	**217,441**	**207,743**	**-9,698**	**-4.5%**

Because the carbon intensity of electricity purchases varies annually depending on the primary fuel mix used by power plants and the extent of clean energy supplied to the grid,, it is good practice to compare year-to-year electricity purchases in terms of energy units [i.e., megawatt hours (MWh)], as presented in Table 1-15. The data in Table 1-15 indicate that Port Authority electricity consumption has decreased by 3.3 percent between 2011 (514,446 MWh) and 2012 (497,352 MWh). Comparisons with the base year should note that the 2006 inventory made more extensive use of surrogate data and engineering calculations than later inventories because GHG data tracking and management systems were still being built at that time. Since then, the Port Authority has implemented an account-level tracking system for electricity and natural gas purchases that captured energy acquisitions and distributions more accurately for 2010, 2011, and 2012 than was possible with the systems in place in 2006. It is important to note that there are some accounts that toggle between Port Authority (Scope 2) and tenant (Scope 3 usage). When under Port Authority control, these tenant spaces are unoccupied and electricity usage is considered minimal. Future inventories may investigate the significance of this issue.

Table 1-15: Electricity Consumption by Department, 2006, 2010, 2011, and 2012 (MWh)

Department	2006	2010	2011	2012
Aviation	419,208	310,856	289,801	281,573
Bus Terminals	30,552	30,848	37,310	29,543
Central Administration	9,940	18,065	15,180	18,536
PATH	106,394	119,667	124,613	113,812
Port Commerce	0	6,204	7,415	11,567
Real Estate	22,821	2,969	3,159	5,274
Tunnels and Bridges	54,435	37,873	36,968	37,048
Total	**643,350**	**526,483**	**514,446**	**497,352**

1.4.2. Scope 3 Attracted Travel Comparison with Previous Inventories

This section compares the 2012 calendar year Scope 3 GHG emission estimates for the Port Authority with those developed previously for calendar years 2006, 2007, and 2008. Table 1-16 compares 2012 with the 2006, 2007, and 2008 attracted travel GHG emissions associated with each Port Authority department. The overall estimate of CO_2e emissions increased from 2,047,249 metric tons in 2008 to 3,057,558 metric tons in 2012, a 51 percent increase.

Table 1-16: Comparison of Scope 3 Attracted Travel GHG Emissions, 2006-2008, and 2012

Department	Total CO_2e Emissions (Metric Tons)				Percent Difference (2008–2012)
	2006[a]	2007[a]	2008[a]	2012[b]	
Aviation	1,169,468	1,196,694	1,185,261	1,479,449	27%
Port Commerce	449,871	471,399	469,873	972,020	116%
Tunnels, Bridges & Terminals	374,676	368,872	360,518	546,025	46%
PATH	27,805	30,662	31,597	60,064	116%
Total	**2,021,820**	**2,067,627**	**2,047,249**	**3,057,558**	**51%**

[a] Estimates developed using MOBILE 6 emission rates.
[b] Estimates developed using MOVES emission rates.

The primary reason for increased emissions in 2012 pertains to a methodological enhancement in this study. In all previous inventories, national average fuel economy values used in calculating CO_2 emissions were obtained from EPA's MOBILE 6 model (EPA, 2003) by vehicle class for model years 1984 through 1992 as well as from the U.S. Department of Energy's (DOE's) *Annual Energy Outlook* for model years 1993 through 2008. For the 2012 inventory, MOVES (EPA, 2012b) was used to develop CO_2 emissions. MOVES also uses national average fuel economy factors by model year and vehicle class but also accounts for speed and driving behavior such as idling, acceleration, and sudden stops. Emissions calculations using MOVES are more representative of actual in-use fuel consumption because fuel consumption and CO_2 emission rates are generally highest at low speeds and very high speeds, while lower emission rates occur when a vehicle is operated in cruise mode at a moderate speed.

To enable a more direct comparison to the attracted travel GHG emissions from the earlier calendar years, a simplified emission estimate was made for 2012 by scaling the 2008 GHG emissions by the change in activity from 2008 to 2012. In addition, CO_2 emissions in this simplified estimate were also scaled by an adjustment factor to account for the national change in fleet-wide fuel economy from 2008 to 2012. Based on national vehicle-miles traveled (VMT) and fuel consumption for all vehicle types combined from data in DOE's *Annual Energy Outlook 2009***,** the average fuel economy in 2008 was 17.01 miles per gallon (DOE, 2009). This improved to 17.28 miles per gallon in 2012 (DOE, 2013). Figure 1-5 shows a facility-level comparison of the 2008 and 2012 CO_2e emissions from 2006 through 2012, with the 2012 estimates simulating modeling with MOBILE 6.

Where possible, Chapters 7 through 12 summarize activity for 2008 and 2012 at the individual facilities to provide a better indicator of how GHG emissions are actually changing over time at the Port Authority facilities. Although comparisons to previous years should not be made with the 2012 GHG emission estimates, the 2012 GHG inventory can be used to evaluate which of the Port Authority facilities present the greatest opportunities for future GHG emissions reductions. Emissions can by compared by department, by facility, and by activity, and the Port Authority can then determine whether it has the ability to influence activities and emissions within each of these departments, facilities, and activities.

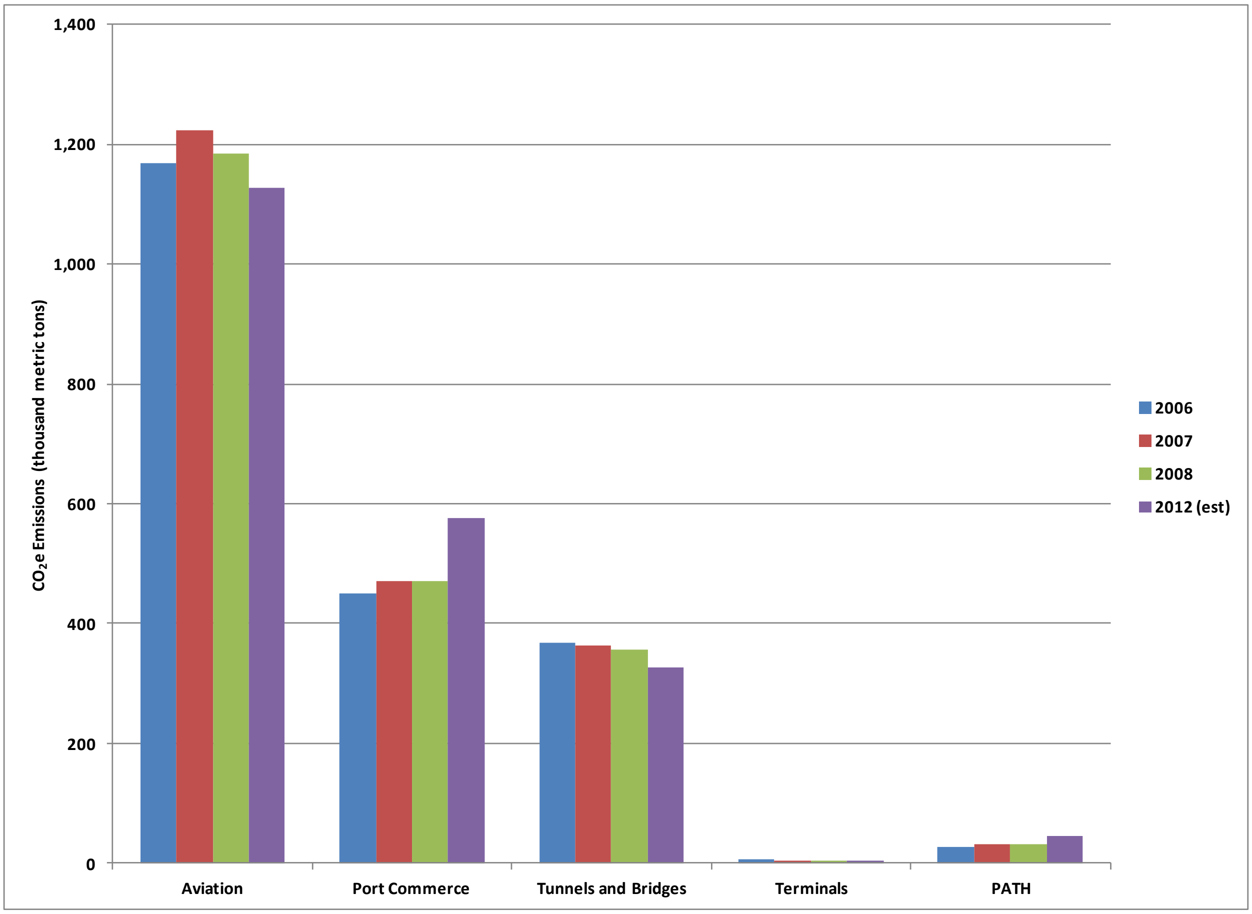

Figure 1-5: Attracted Travel Comparison Based on MOBILE 6 Methodology, 2006, 2007, 2008, and 2012

2.0 STATIONARY COMBUSTION (SCOPE 1)

2.1. BUILDINGS

The 2012 inventory considered buildings (including, but not limited to, Port Authority Central Administration Buildings) where fuel was combusted in a fixed location primarily for heating purposes. Natural gas fuel was the sole fuel combusted. Not all buildings within the Port Authority's boundaries combust fuel; therefore, not all buildings were included in the inventory. Table 2-1 lists Port Authority facilities where fuel was combusted during 2012.

Table 2-1: Port Authority Facilities with Stationary Combustion

Facility	Utility Service Provider
225 PAS	Consolidated Edison Co. of N.Y., Inc. (ConEdison)
777 Jersey Ave	Public Service Electric and Gas (PSEG)
AirTrain JFK	National Grid USA Service Company, Inc. (National Grid)
Bayonne Bridge	National Grid
Brooklyn Marine Terminal	National Grid
EWR	PSEG
George Washington Bridge	PSEG and ConEdison
George Washington Bridge Terminal	PSEG and ConEdison
Goethals Bridge	National Grid
Holland Tunnel	PSEG and ConEdison
JFK	National Grid
LGA	National Grid
Lincoln Tunnel	ConEdison
Outerbridge Crossing	National Grid
PATC	Hess Corporation and PSEG
PATH Buildings	PSEG
PCNJ	PSEG
Port Authority Bus Terminal	ConEdison
SWF	Central Hudson Energy Group
TEB	PSEG
The Teleport	National Grid

Note: Many facilities include multiple buildings. Utility service provider in parenthesis.

2.1.1. Activity Data

For natural gas combustion, the Port Authority provided natural gas consumption data by month for each building in therms or hundreds of cubic feet (ccf). It transcribed some of the data directly from the utility's website into a Microsoft Excel workbook and provided additional data in the form of copies of bills from the utility or landlord. In some cases, data were not immediately available, so Southern downloaded data from the provider's website in the form of screen shots converted to portable document format (PDF) or transcribed data from the website into an Excel workbook.

2.1.2. Emission Factors and Other Parameters

The GHG emission factors used to calculate the GHGs associated with stationary fuel combustion in buildings are shown in Table 2-2. The values in Table 2-2 are representative of U.S. pipeline-grade natural gas, which has an average high heating value of 1,028 British thermal units (Btus) per standard cubic foot as taken from GRP Table 12.1 (TCR, 2013a). The emission factors for CO_2 were taken from GRP Table 12.1, and the emission factors for CH_4 and N_2O were taken from GRP Table 12.9 (TCR, 2013a).

Table 2-2: Stationary Combustion GHG Emission Factors

Units	CO_2	CH_4	N_2O
Kilograms (kg)/ccf of natural gas (NG)	5.45	5.14×10^{-4}	1.03×10^{-5}
kg/therm of NG	5.30	5.00×10^{-4}	1.00×10^{-5}

Source: TCR, 2013a.

The CAP emission factors are based on values recommended by the U.S. Environmental Protection Agency's (EPA's) "AP-42 Compilation of Air Pollutant Emission Factors," Chapter 1.4, "Natural Gas Combustion" (EPA, 1995). The SO_2 emission factor is based on assuming a 100 percent fuel sulfur conversion. The NO_x and PM emission factors are based on the assumption that the natural gas was combusted in a small [<100 million Btus (MMBtu)/hour (hr)] uncontrolled boiler. These values are presented in Table 2-3.

Table 2-3: Stationary Combustion CAP Emission Factors

Units	SO_2	NO_x	PM total
g/ccf of NG	2.72×10^{-5}	4.54×10^{-3}	3.45×10^{-4}
kg/therm of NG	2.65×10^{-5}	4.41×10^{-3}	3.35×10^{-4}

2.1.3. Emissions Estimates

Emissions estimates were developed in accordance with GRP Chapter 12, "Direct Emissions from Stationary Combustion" (TCR, 2013a) using the emission factors presented in Section 2.1.2. In a small number of cases, stationary combustion data were not available from the energy provider as natural gas bills, meter readings, or purchase records. For example, if no records existed for a given month, the natural gas consumption was estimated by averaging the consumption for the previous and subsequent months. Additionally, if no records existed for a period of several months, natural gas consumption was estimated using historical data from 2011. The Registry requires that emissions developed from engineering calculations be reported separately as SEM and aggregated with the estimates from all other emission sources. Stationary combustion emissions assessed using SEM are presented in Table 1-7.

Table 2-4 summarizes stationary combustion emissions by department, and Figure 2-1 breaks down the percentage of these emissions by department. The Aviation department is the primary emitter of CO_2e related to stationary combustion because the Port Authority assumes responsibility for heating large portions of terminal space.

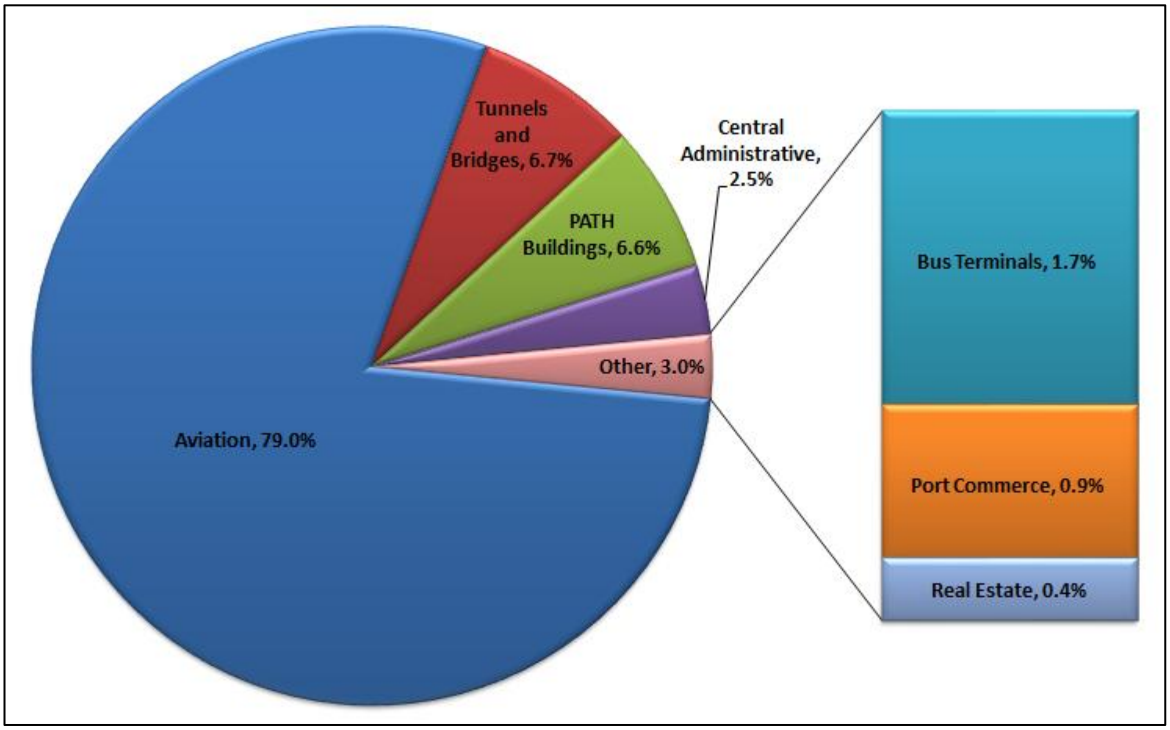

Figure 2-1: 2012 GHG Emissions Distribution from Stationary Combustion by Department

Table 2-5 further breaks down stationary combustion emissions by facility. CAP emissions totals are given by department and facility in Table 2-6**Error! Reference source not found.** and Table 2-7, respectively.

Table 2-4: 2012 GHG Emissions from Stationary Combustion by Department (metric tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	26,091	2.4605	0.0492	26,158
PATH Buildings	2,531	0.2387	0.0048	2,538
Tunnels and Bridges	2,319	0.2187	0.0044	2,325
Central Administrative	1,093	0.1031	0.0021	1,096
Bus Terminals	572	0.0539	0.0011	573
Port Commerce	297	0.0280	0.0006	298
Real Estate	123	0.0116	0.0002	123
Totals	**33,027**	**3.1146**	**0.0623**	**33,112**

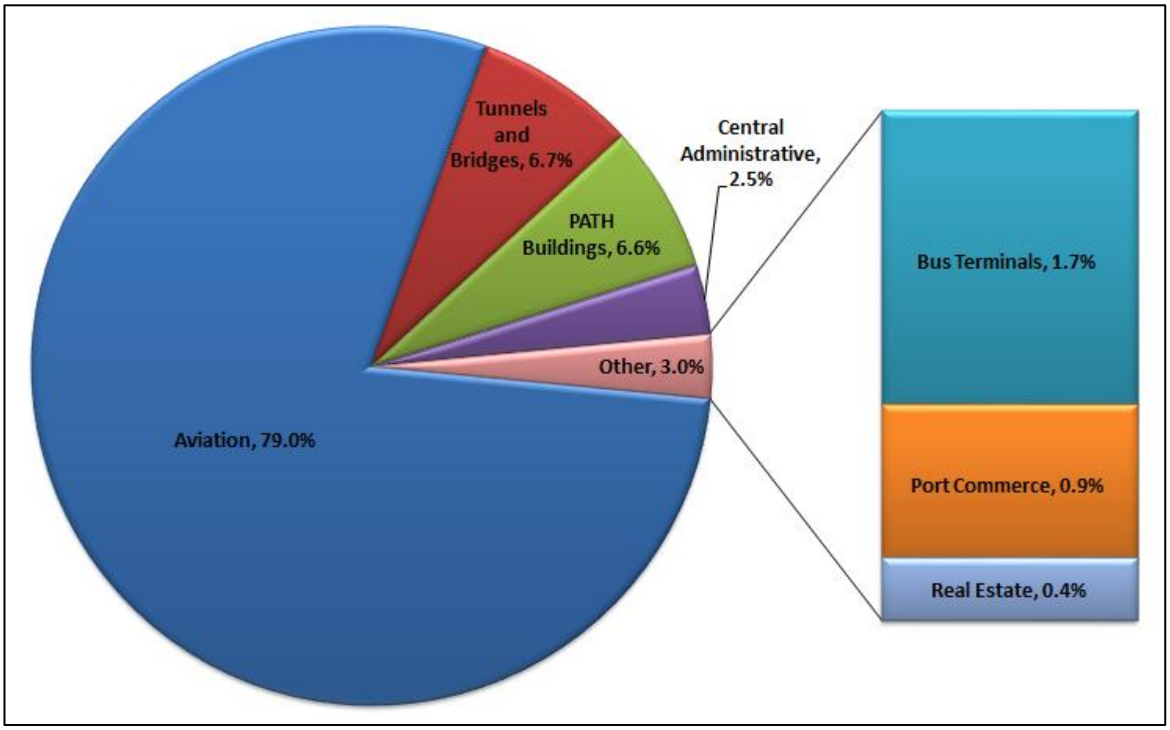

Figure 2-1: 2012 GHG Emissions Distribution from Stationary Combustion by Department

Table 2-5: 2012 GHG Emissions from Stationary Combustion by Facility (metric tons)

Facility	CO_2	CH_4	N_2O	CO_2e
JFK	11,107	1.0475	0.0209	11,136
EWR	10,897	1.0277	0.0206	10,925
LGA	3,336	0.3146	0.0063	3,345
PATH Buildings	2,531	0.2387	0.0048	2,538
PATC	854	0.0805	0.0016	856
George Washington Bridge	688	0.0649	0.0013	690
Lincoln Tunnel	656	0.0619	0.0012	658
George Washington Bridge Terminal	558	0.0526	0.0011	560
Holland Tunnel	421	0.0397	0.0008	422
TEB	379	0.0358	0.0007	380
Goethals Bridge	361	0.0341	0.0007	362
AirTrain JFK	251	0.0236	0.0005	251
777 Jersey	206	0.0194	0.0004	206
Port Commerce – New Jersey	193	0.0182	0.0004	194
Outerbridge Crossing	142	0.0134	0.0003	143
The Teleport	123	0.0116	0.0002	123

SWF	121	0.0114	0.0002	121
Brooklyn Marine Terminal	104	0.0098	0.0002	105
Bayonne Bridge	51	0.0048	0.0001	51
225 PAS	34	0.0032	0.0001	34
Port Authority Bus Terminal	14	0.0013	0.0000	14
Totals	**33,027**	**3.1146**	**0.0623**	**33,112**

Table 2-6: 2012 CAP Emissions from Stationary Combustion by Department (metric tons)

Department	SO_2	NO_x	PM
Aviation	0.1303	21.7135	1.6502
PATH Buildings	0.0126	2.1064	0.1601
Tunnels and Bridges	0.0116	1.9301	0.1467
Central Administrative	0.0055	0.9099	0.0692
Bus Terminals	0.0029	0.4758	0.0362
Port Commerce	0.0015	0.2475	0.0188
Real Estate	0.0006	0.1024	0.0078
Totals	**0.1649**	**27.4857**	**2.0889**

Table 2-7: 2012 CAP Emissions from Stationary Combustion by Facility (metric tons)

Facility	SO_2	NO_x	PM
JFK	0.0555	9.2438	0.7025
EWR	0.0544	9.0690	0.6892
LGA	0.0167	2.7763	0.2110
PATH Buildings	0.0126	2.1064	0.1601
PATC	0.0043	0.7106	0.0540
George Washington Bridge	0.0034	0.5725	0.0435
Lincoln Tunnel	0.0033	0.5463	0.0415
George Washington Bridge Terminal	0.0028	0.4645	0.0353
Holland Tunnel	0.0021	0.3503	0.0266
TEB	0.0019	0.3155	0.0240
Goethals Bridge	0.0018	0.3006	0.0228
AirTrain JFK	0.0013	0.2085	0.0158
777 Jersey	0.0010	0.1711	0.0130
PCNJ	0.0010	0.1606	0.0122
Outerbridge Crossing	0.0007	0.1183	0.0090
The Teleport	0.0006	0.1024	0.0078
SWF	0.0006	0.1005	0.0076
Brooklyn Marine Terminal	0.0005	0.0869	0.0066
Bayonne Bridge	0.0003	0.0421	0.0032
225 PAS	0.0002	0.0282	0.0021
Port Authority Bus Terminal	0.0001	0.0113	0.0009
Totals	**0.1649**	**27.4857**	**2.0889**

2.2. EMERGENCY GENERATORS AND FIRE PUMPS

All facilities under Port Authority control have stationary engine generators for use in emergency situations. These emergency generators and fire pumps are typically diesel-fired, but the Port Authority does have some gasoline- and natural gas-fired generators.

2.2.1. Activity Data

The Port Authority provided Southern with Microsoft Excel spreadsheets containing actual annual runtime and/or fuel usage data for emergency generators and fire pumps. Information on typical fuel consumption (in terms of gallons per hour of operation) was determined for the specific engine/generator make and model and used to estimate the total annual fuel consumption for the equipment. Based on these data and using the emission factors from GRP Chapter 12, “Direct Emissions from Stationary Combustion” (TCR, 2013a) and EPA AP-42, Section 3.3, “Gasoline and Diesel Industrial Engines” (EPA, 1995), surrogate GHG and CAP emission factors were developed based on each facility’s electricity usage (in tons per year of pollutant (TPY) per MWh). However, actual annual runtime or fuel usage data for emergency generators and fire pumps were not available for all facilities. For these facilities, estimated emissions were calculated using the surrogate emission factors described above and applying them against the electricity usages for each facility. Because these methodologies are based on engineering estimates as opposed to calibrated measurements, all of the emissions associated with emergency generators and fire pumps are reported as SEM (see Table 1-9).

2.2.2. Emission Factors

Table 2-8 provides the emission factors developed for emergency generators during this exercise.

Table 2-8: Emergency Generator and Fire Pump GHG and CAP Emissions Factors

Pollutant	Emergency Generator (TPY/MWh)	Fire Pump (TPY/MWh)
CO_2	1.53×10^{-3}	1.44×10^{-4}
CH_4	2.26×10^{-7}	2.14×10^{-8}
N_2O	1.23×10^{-8}	1.17×10^{-9}
NO_x	4.12×10^{-5}	3.89×10^{-6}
SO_x	2.69×10^{-6}	2.56×10^{-7}
PM	2.88×10^{-6}	2.73×10^{-7}

2.2.3. GHG Emissions Estimates

Total emergency generator GHG emissions estimates are shown in Table 2-9

Table 2-9: 2012 GHG Emissions from Emergency Generators and Fire Pumps (metric tons)

Pollutant	Emergency Generators	Fire Pumps
CO_2	746.40	37.896
CH_4	0.1106	0.0056
N_2O	0.0060	0.0003
CO_2e	750.59	38.110

2.2.4. CAP Emissions Estimates

Total emergency generator CAP emissions estimates are shown in Table 2-10.

Table 2-10: 2012 CAP Emissions from Emergency Generators (metric tons)

Pollutant	Emergency Generators	Fire Pumps
NO_x	10.853	1.0250
SO_x	0.7084	0.0674
PM	0.7593	0.0720

2.3. WELDING GASES

Limited welding activity takes place within the boundary for the Port Authority inventory, and its impact on Port Authority emissions is negligible. An engineering estimate was developed to quantify the level of welding gas emissions, correlating the emitting activity to the dollar amount of welding gas purchased. When surveyed for the 2010 inventory, LGA reported spending $866 on welding gas (Port Authority, 2012c). Typically, acetylene costs $1.24 per standard cubic foot (WeldingWeb, 2012). Assuming that all purchased welding gas was acetylene and that all purchased gas was used, it was determined by stoichiometry that 77.8 kg of CO_2 were emitted at LGA. Furthermore, assuming that the same level of welding activity occurred at all five airports and at the two marine terminals, total welding gas emissions at the Port Authority were estimated to be 0.5 metric tons of CO_2 in 2010. The same engineering emission estimate (or SEM, in Climate Registry terminology) was ascribed to calendar year 2012.

3.0 MOBILE COMBUSTION (SCOPE 1)

The Port Authority maintains operational control of a large fleet of vehicles, including passenger vehicles, police vehicles, firefighting equipment, and construction equipment. The majority of these vehicles are tracked and serviced by the Port Authority's Central Automotive Division (CAD). CAD relies on fuel cards to track fuel use for individual vehicles. CAD also directly dispenses alternative fuels such as compressed natural gas (CNG), gasoline with a 10 percent ethanol blend (E10), gasoline with a 85 percent ethanol blend (E85), and B20 (20 percent bio-diesel) to some vehicles. CNG fuel purchases are not tracked at the vehicle level. In addition, PATH owns and operates some of its own diesel equipment.

3.1. CENTRAL AUTOMOTIVE DIVISION FLEET

CAD is in charge of purchasing and maintaining the Port Authority's fleet of vehicles. CAD also handles bulk fuel purchasing and fueling for all of the fleet except for a small contingent of vehicles. Fuel purchases for the latter are administered by the Office of the Treasury.

3.1.1. Activity Data for GHG Analysis

CAD is responsible for various fleets, as shown in Figure 3-1. The Main Fleet of approximately 2,500 vehicles refuels either on site at Port Authority service stations or at Sprague retail sites. Every month, Sprague invoices the Port Authority for the volume of fuel dispensed on site and at Sprague retail sites. Table 3-1 presents the Main Fleet's fuel consumption by fuel type.

Fuel consumption for the smaller fleets is tracked by the Port Authority Office of the Treasury. This includes 25 vehicles designated as the Executive Fleet, 35 security vehicles associated with the Port Authority's Inspector General's office, and two vehicles used in association with training activities in Morris County, New Jersey. These fuel purchases are for vehicles within CAD's Main Fleet but are not tracked by Sprague records; instead, their fuel use is tracked by the Office of the Treasury through invoicing of branded fuel cards (e.g., Shell Fuel Card).

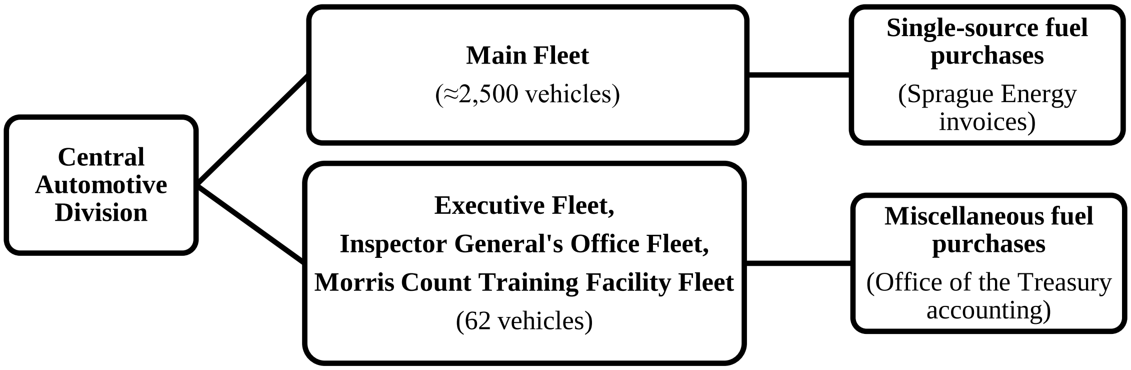

Figure 3-1: Recordkeeping for CAD Fleets

Table 3-1: Main Fleet Fuel Consumption in 2012

Fuel	Consumption	Units
Gasoline (E10)	1,034,998	Gallons
#2 Diesel	13,186	Gallons
Biodiesel (B20)	266,315	Gallons
E85	80,807	Gallons
CNG	67,967	CCF
Propane	1,095	Gallons

3.1.2. GHG Emission Factors and Other Parameters

GHG emissions were calculated as the product of fuel use and fuel-GHG specific emissions factors. CO_2 emissions were estimated by multiplying the fuel use by the appropriate emission factor from GRP Table 13.1 (TCR, 2013a). The majority of fuel consumed by the Port Authority contains some biofuel (either E10 or B20). For these biofuel blends, the emissions were calculated by multiplying the gallons (gal) of fuel used by the gasoline and diesel emission factors and by the percentage of gasoline in the fuel. For example, CO_2 emissions from E10 gasoline would equal gallons of fuel used × 90 percent × 8.78 kg CO_2/gal.

Biogenic CO_2 emissions (i.e., those generated during the combustion or decomposition of biologically based material such as biodiesel or ethanol) are calculated in a similar fashion, by multiplying the gallons used by the percentage of biofuel and by the ethanol or biodiesel emission factor. Therefore, the biogenic CO_2 emissions from E10 would equal the gallons of fuel used × 10 percent × 5.75 kg CO_2/gal.

For all fuel types, CH_4 and N_2O emissions were estimated using SEM, based on the ratio of CO_2 to CH_4 and N_2O emissions taken from GRP Table 13.9 (TCR, 2013a). The emission factors used are presented in Table 3-2.

Table 3-2: Transportation Fuel Emission Factors

Fuel Type	Percentage Biofuels	CO_2 (kg/gal or kg/ccf)	Biogenic CO_2 (kg/gal)	CH_4 (kg/kg of CO_2)	N_2O (kg/kg of CO_2)
Gasoline (E10)	10%	8.78	5.75	0.000062	0.000070
#2 Diesel	0%	10.21	9.45	0.000062	0.000070
Biodiesel (B20)	20%	10.21	9.45	0.000062	0.000070
E85	85%	8.78	5.75	0.000062	0.000070
CNG	0%	5.4	0	0.000062	0.000070
Propane	0%	5.59	0	0.000062	0.000070

3.1.3. GHG Emissions Estimates

The estimate of GHG emissions for the CAD main fleet is displayed in Table 3-3. Both anthropogenic and biogenic CO_2 emissions use the standard methodology, while the CH_4 and N_2O emissions use SEM.

Table 3-3: 2012 GHG Emissions from Main Fleet (metric tons)

Fuel Type	CO_2	Biogenic CO_2	CH_4	N_2O
Gasoline (E10)	8,087.0	588.5	5.4E-01	6.0E-01
#2 Diesel	133.0	0.0	8.3E-03	9.3E-03
Biodiesel (B20)	2,146.4	496.6	1.6E-01	1.8E-01
E85	105.3	390.7	3.1E-02	3.5E-02
CNG	363.9	0.0	2.3E-02	2.5E-02
Propane	6.1	0.0	3.8E-04	4.2E-04
Total	**10,841.7**	**1,475.8**	**7.7E-01**	**8.6E-01**

Table 3-4 shows the emissions estimated from the rest of the fleet, tracked by the Office of the Treasury. Table 3-5 shows the total CAD emissions estimated for each pollutant based on calculation methodology.

Table 3-4: 2012 GHG Emissions from Executive Fleet, Security, and Training Vehicles (metric tons)

Department	CO_2	Biogenic CO_2	CH_4	N_2O
Gasoline (E10)	248.2	18.1	0.017	0.019
#2 Diesel	0.4	0.0	0.000	0.000
Total	**248.5**	**18.1**	**0.017**	**0.019**

Table 3-5: 2012 GHG Emissions from the CAD Fleet (metric tons)

Emission Method	CO_2	CH_4	N_2O	CO_2e
Standard Estimation Method	11,090	0.0	0.0	11,090
SEM	0	0.8	0.9	289
Biogenic Emissions	1,494	0.0	0.0	1,494
Total	**12,584**	**0.8**	**0.9**	**12,872**

3.1.4. Activity Data for CAP Analysis

Vehicle mileage data maintained by CAD served as input to the CAP analysis. Vehicle mileage was divided into two categories: highway and non-highway.

3.1.5. CAP Emission Factors

CAP emission factors for highway vehicles were calculated based on the emission factors from the EPA Motor Vehicle Emissions Simulator (MOVES) (EPA, 2012b). These emission factors are expressed as grams per mile based on model year and vehicle type for the 2012 inventory. CAP emissions from vehicles using B20 fuel were assumed to be the same as for diesel vehicles; similarly, CAP emissions from vehicles using E10 fuel were assumed to be the same as for gasoline vehicles. These emission factors were then multiplied by the 2012 estimates of mileage per vehicle provided by the CAD to calculate total CAP emissions per vehicle.

The CAP estimates for the Executive Fleet and the security and training vehicles were estimated based on the per-gallon emission factors from EPA's MARKet ALlocation (MARKAL) model database (Pechan, 2010), because no information on mileage per vehicle was available. Non-highway emissions were calculated by multiplying total per-vehicle fuel consumption by the national average emission factors from the MARKAL database.

3.1.6. CAP Emissions Estimates

Table 3-6 shows the CAP emissions estimates for the entire CAD fleet.

Table 3-6: 2012 CAP Emissions from the CAD Fleet (metric tons)

Vehicle Type	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Highway Vehicles	6.57	0.08	0.64	0.37
Non-highway Vehicles	0.41	0.01	0.04	0.04
Zero Fuel Recorded	3.93	0.01	0.28	0.23
Bulk CNG	0.06	0.01	0.06	0.06
Propane	0.02	0.00	0.00	0.00
Executive/Security Fleet	0.38	0.01	0.03	0.03
Total	**11.37**	**0.11**	**1.06**	**0.73**

3.2. PATH DIESEL EQUIPMENT

3.2.1. Activity Data

PATH owns and operates certain track maintenance vehicles that are not accounted for by CAD. Emissions from PATH vehicles are calculated as part of the fleet vehicles' bulk fuel total. PATH uses diesel fuel exclusively for maintenance vehicles and generators (the PATH is powered by traction).

3.2.2. GHG Emission Factors and Other Parameters

CO_2 emissions from PATH vehicles are estimated based on the gallons of diesel fuel multiplied by the appropriate emission factor from GRP Table 13.1 (TCR, 2013a). CH_4 and N_2O emissions are calculated based on the per-gallon diesel emission factor for non-highway equipment, from GRP Tables 13.7 and 13.8, respectively (TCR, 2013a).

3.2.3. GHG Emissions Estimates

Total GHG emissions for PATH diesel equipment are shown in Table 3-7.

Table 3-7: 2012 GHG Emissions from PATH Diesel Equipment (metric tons)

CO_2	CH_4	N_2O	CO_2e
266.43	1.51×10^{-2}	9.41×10^{-4}	267.04

4.0 FUGITIVE EMISSIONS (SCOPE 1)

Fugitive emissions are intentional and unintentional releases of GHGs from joints, seals, gaskets, and similar points. Equipment or activities responsible for fugitive emissions controlled by the Port Authority are included in this inventory as Scope 1. Such sources include the use of substitutes for ozone-depleting substances (ODSs), generally found in refrigerants and fire suppressants, as well as gas emanating from a closed landfill.

4.1. USE OF REFRIGERANTS

ODS substitutes are used at the Port Authority as refrigerants in stationary and mobile AC equipment. For the 2010 inventory, the project team estimated the usage of ODS substitutes based on survey responses completed by Port Authority facility managers; however, survey participation was not universal and some data gaps were identified. Therefore, the 2011 inventory effort started by revising and supplementing the list of AC equipment that was initiated with the 2010 inventory. The 2012 inventory continues this inventory effort to get survey information wherever possible. Although most of the information was eventually gathered using a survey, in some cases surrogate data were used to develop a rough and conservative emissions estimate. The decision tree for the selection of methods to quantify fugitive emissions from AC equipment (both stationary and mobile) is shown in Figure 4-1.

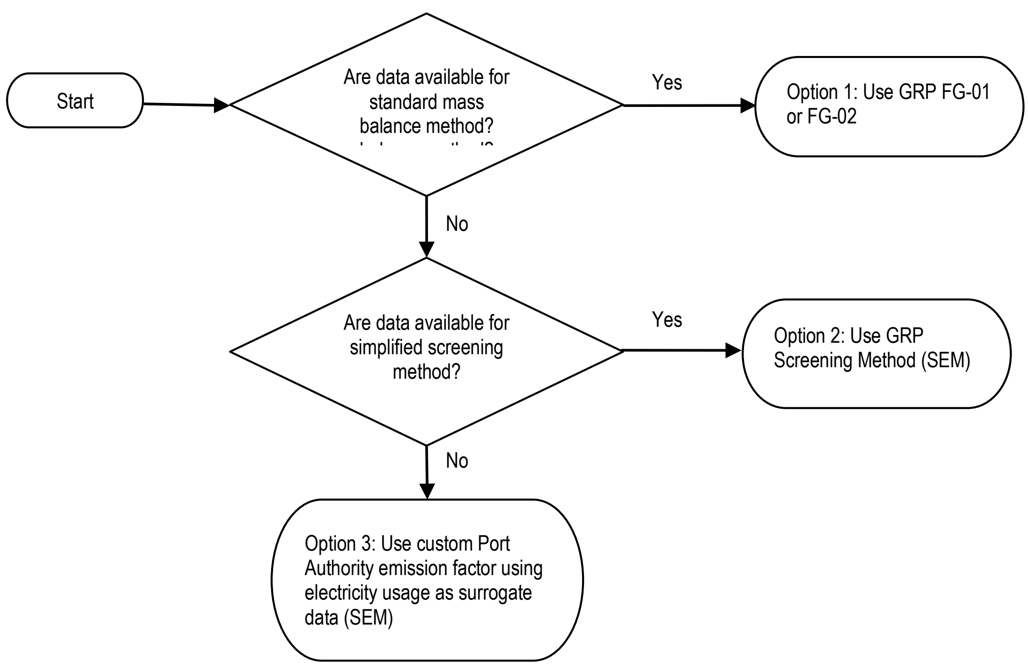

Figure 4-1: Selection of Method to Quantify Fugitive Emissions from AC Equipment

Option 1

This option is not feasible unless a disciplined refrigerant monitoring plan is implemented at the facility level. The methodology relies on a mass balance approach to account for changes in refrigerant inventory levels (additions as well as subtractions) and net increases in nameplate capacity. Because the Port Authority does not have a comprehensive refrigerant monitoring plan, the implementation of Option 1 was not feasible for the 2012 inventory.

Option 2

This simplified method estimates emissions from refrigerant leaks based on equipment type, cooling capacity, and assumed operating factors. This method requires the development of an inventory of discrete emitting sources within the facility. Once the initial equipment list is created, it is maintained by tracking changes (i.e., additions, removals) to the baseline equipment list. This method is incorporated in the GRP as an approved SEM (TCR, 2013a).

Option 3

In the absence of data for application of the simplified method, refrigerant emissions are estimated using an emissions metric expressed as the mass of refrigerant in terms of CO_2e per unit of electricity consumption. For example, the average emissions metric for Port Authority airports was determined as the average ratio of refrigerant emissions to electricity purchases at SWF and EWR. Emissions estimates developed using this option are categorized as SEM (TCR, 2013a, p. 128).

4.1.1. Activity Data

Each Port Authority facility received a pre-populated refrigerant use survey requesting the count, charge, refrigerant type, and cooling capacity of each AC unit. Responses to these surveys were compiled, and the compiled data were processed using Option 2 (the GRP screening method). Option 3 was applied for those facilities that only reported electricity consumption. Table 4-1 presents the methodology option selected for each facility based on the available activity data.

Table 4-1: Selection of Refrigerant Methodology Option by Facility

Facility Description		Method
Fleet (CAD)	CAD	Option 2
JFK	JFK	Option 3
LGA	LGA	Option 3
SWF	SWF	Option 2
EWR	EWR	Option 2
TEB	TEB	Option 3
Port Commerce Facilities NY	Brooklyn Cruise Terminal	Option 2
	Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)	Option 2
	Howland Hook Marine Terminal	Option 2
Port Commerce Facilities NJ	Elizabeth Port Authority Marine Terminal	Option 3
	Port Jersey	Option 3
	Port Newark Marine Terminal	Option 3
Tunnels & Bridges	George Washington Bridge	Option 2
	Holland Tunnel	Option 2
	Lincoln Tunnel	Option 2
Bus Terminals NY	George Washington Bridge Bus Terminal	Option 3
	PABT	Option 2
AirTrain JFK	AirTrain JFK	Option 3
AirTrain EWR	AirTrain EWR	Option 3
PATH	PATH	Option 2
PATH Buildings	PATH Buildings	Option 2
	PATH Buildings (54 window units)	Option 3

4.1.2. Emission Factors and Other Parameters

Emissions of HFCs and PFCs from refrigeration and AC equipment result from the manufacturing process, leakage over the operational life of the equipment, and disposal at the end of the useful life of the equipment. Common refrigerants such as R-22, R-12, and R-11 are not part of the GHGs required to be reported to The Climate Registry because they are either hydrochlorofluorocarbons (HCFCs) or chlorofluorocarbons (CFCs). The production of HCFCs and CFCs is being phased out under the Montreal Protocol; as a result, HCFCs and CFCs are not defined as GHGs under the Kyoto Protocol. Emissions of non-Kyoto-defined GHGs are not reported as emission sources to The Registry, regardless of the gas's GWP.

To estimate emissions using Option 2, the project team estimated the types and quantities of refrigerants used and applied default emission factors by equipment type (e.g., chiller or residential/commercial AC, including heat pump). Then, the emissions estimates for each HFC and PFC were converted to units of CO_2e using the GWP factors listed in Table 4-2 to determine total HFC and PFC emissions.

To estimate emissions using Option 3, facilities were grouped into three types (airports, bus terminals, and trains), and associated refrigerant emissions metrics were developed based on data from those Port Authority facilities for which a complete refrigerant survey was received. Table 4-2 presents the facilities for which Option 3 method was applied and the corresponding Port Authority derived emissions metric. These metrics use electricity consumption as a surrogate for AC usage in order estimate total refrigerant emissions. This assumes that the refrigerant use (and corresponding emissions) is proportional to facility electricity use.

Table 4-2: Assignment of Refrigerant Emissions Metrics Under Method Option 3

Facility Description	Representative Emissions Metric	Metric, (g CO_2e/kWh)
John F. Kennedy International Airport	Airport Facilities	15.6
LaGuardia Airport	Airport Facilities	15.6
Teterboro Airport	Airport Facilities	15.6
Port Commerce Facilities NJ	Airport Facilities	15.6
GW Bridge Bus Terminal	Port Authority Bus Terminal	20.2
AirTrain JFK	PATH Trains	11.5
AirTrain Newark	PATH Trains	11.5
PATH Buildings	Airport Facilities	15.6

4.1.3. GHG Emissions Estimates

GHG emissions estimates for refrigerants used by the Port Authority during 2012 are shown in Table 4-3. This table excludes non-reportable GHGs such as R-22. Note that GHG emissions values in the column labeled “Unknown” are emissions estimates developed using Option 3.

Table 4-3: 2012 Refrigerant Emissions by Facility and Reportable GHG (metric tons CO_2e)

Facility Description	HFC-134a	HFC-227ea	R-407C	R-10A	R-500	Unknown	Total
CAD			275.1				275.1
JFK						1,426.0	1,426.0
LGA						760.5	760.5
SWF	36.1			2.0			38.1
EWR	1,705.5	7.2			168.3		1,881.0
TEB						34.7	34.7
Brooklyn Cruise Terminal						0.0	0.0
Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)				2.8			2.8
Howland Hook Marine Terminal				2.9			2.9
Elizabeth Port Authority						51.4	51.4

Facility Description	HFC-134a	HFC-227ea	R-407C	R-10A	R-500	Unknown	Total
Marine Terminal							
Port Jersey						5.0	5.0
Port Newark Marine Terminal						109.7	109.7
George Washington Bridge	0.1						0.1
Holland Tunnel	0.0						0.0
Lincoln Tunnel	0.2						0.2
George Washington Bridge Bus Terminal						110.8	110.8
PABT	485.2						485.2
AirTrain JFK						453.1	453.1
AirTrain EWR						171.5	171.5
PATH			1,104.6				1,104.6
PATH Buildings	322.5					167.1	489.6
Total	**2,549.5**	**7.2**	**1,379.7**	**7.7**	**168.3**	**3,289.8**	**7,402.2**

Central Automotive Division

Emissions from CAD were estimated based on a default AC refrigerant leakage estimate for vehicles. According to GRP Table 16.2 (TCR, 2013a), the default capacity of mobile AC units was conservatively estimated to be 1.5 kg. This figure was multiplied by the average leakage per year (also from GRP Table 16.2) and the total number of vehicles in the CAD fleet. The CAD fleet included 2,511 vehicles in the Main Fleet in 2012 (1,323 highway vehicles, 151 non-highway vehicles, and 975 "other" vehicles), as well as 62 vehicles in the executive/security fleet for a total of 2,511 vehicles. "Other" vehicles include 647 vehicles with no fuel consumption reported and 328 non-fossil fuel vehicles. It is highly likely that a significant portion of the non-highway and "other" vehicles do not operate with an AC unit, but it was decided to calculate such emissions from all vehicles in order to produce a conservative estimate. The leakage calculation assumed mobile AC equipment usage of 21 percent (i.e., 6 days a week, 12 hours a day, 6 months a year), which is considered a conservative estimate since very few vehicles are expected to be used so heavily each year.

Airports

ODS substitutes were estimated for the five airport facilities based on the data available. SWF and EWR reported their equipment inventories with sufficient detail to estimate refrigerant leaks at the equipment level. JFK, LGA, and TEB did not report. Therefore, the project team calculated an average emission factor of 15.6 grams of CO_2e per kilowatt hour (g CO_2e/kWh) based on the CO_2e emissions from SWF and EWR divided by the electricity consumption for these two airports. This emission factor was applied to the electricity consumption at JFK, LGA, and TEB to estimate overall CO_2e emissions from ODS substitutes. The electricity consumption used in this estimate did not include tenant electricity use if that electricity usage could be identified and removed. The analysis conservatively assumed that chillers and other AC units were used 50 percent of the time in 2012, which is likely an overestimate.

Other Facilities

Tunnels and Bridges reported information on refrigerant equipment, and emissions were estimated from these equipment inventories based on default use and leakage. Sufficient equipment-level information was available to estimate emissions from Real Estate – NY. There was also equipment-level information available for the New Jersey Bridges and Tunnels, as well as PABT and some equipment in PATH buildings. The Option 2 methodology was used wherever possible to estimate emissions from ODS substitute refrigerants. As for airports, the annual usage of chillers and other AC units was conservatively estimated at 50 percent.

4.2. USE OF FIRE SUPPRESSANTS

The first step for quantifying potential emissions from fire suppressants was to identify the set of facilities that use potentially reportable GHGs as fire suppressants. A survey was distributed to facilities managers requesting a list of fire protection equipment (e.g., centralized system, hand-held devices), the nature of the fire suppressant used to charge such equipment, and the amount of fire suppressant purchased for equipment recharge (as a proxy for GHG releases). Based on the survey responses, CO_2 and FM-200 are the latent GHGs to be reported in the event of equipment discharge. According to the GRP (TCR, 2013a), FM-200 fire suppression systems in communication rooms for the transit sector may be disclosed as excluded minuscule sources without the need to quantify actual fire suppressant releases. Facility use of latent GHGs in fire protection equipment is summarized in Table 4-4.

Table 4-4: Fire Protection Equipment by Facility and Suppressant Type

Facility Description	Type of Fire Suppressant			
	CO_2	FM-200	No GHG	Unknown
JFK			X	
LGA		X		
SWF	X		X	
EWR				X
TEB			X	
Brooklyn Cruise Terminal			X	
Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)			X	
Howland Hook Marine Terminal			X	
Elizabeth Port Authority Marine Terminal				X
Port Jersey				X
Port Newark Marine Terminal				X
George Washington Bridge				X
Holland Tunnel				X

Facility Description	Type of Fire Suppressant			
Lincoln Tunnel				X
Staten Island Bridges				X
George Washington Bridge Bus Terminal				X
PABT			X	
PATH Buildings	X	X	X	
Bathgate Industrial Park			X	
The Teleport			X	

As noted above, Port Authority facility managers were asked about purchases of fire suppressants. The majority of facility managers responded that either no fire suppressants were purchased in 2012 or no reportable fire suppression occurred. Fire protection systems charged with reportable ODS substitutes often service areas with specialized equipment, such as high-value electronics, including server and communication rooms. The relative low utilization of these systems and infrequent occurrence of fire are factors that may explain why the inventory shows no reportable activity related to fire suppressants in 2012.

4.3. HISTORIC ELIZABETH LANDFILL

The Port Authority property known as "Port Elizabeth" in Elizabeth, New Jersey, is part of the Port Commerce department. The Port Elizabeth property sits atop a former landfill site where household and industrial waste was dumped until the landfill closed in 1970. It is believed that dumping began at the Elizabeth Landfill (a.k.a. the Kapkowski Road Landfill) site sometime in the 1940s (Wiley, 2002). Although the historic landfill boundary cannot be determined with certainty, the current landfill boundary based on land ownership is known and defined as the area south of Bay Avenue between the Conrail railroad tracks to the west and McLester Street to the east.

Although the Port Elizabeth property is leased to tenants; the Port Authority maintains shared operational control of property improvement activities. These activities are governed by the Tenant Construction and Alteration Process, which requires close coordination between the Port Authority and its business partners (i.e., tenants) when making "alterations and minor works at existing [Port Authority] facilities in addition to all new construction" (TCAP, 2010, p. 1). Therefore, fugitive landfill gas emissions are reported as Scope 1 emissions.

4.3.1. Activity Data

Air emissions from landfills come from landfill gas generated by the decomposition of waste in the landfill. The composition of landfill gas is roughly 50 percent CH_4 and 50 percent CO_2 by volume, with additional relatively low concentrations of other air pollutants, including volatile organic compounds (VOCs). Activity data in the form of total solid waste deposited (short tons) in the historic Elizabeth Landfill was used to estimate the CH_4 emissions from the landfill using the first-order decay model prescribed by The Registry (TCR, 2013a). A similar model, EPA's Landfill Gas Emissions Model (LandGEM) (EPA, 2005a), was used to estimate VOC emissions.

Because of a lack of waste emplacement records, the annual mass of waste received at the site was calculated as the product of the average refuse depth of 8.33 feet as measured by a geological survey (Port Authority, 1974), refuse density of 0.58 tons (EPA, 1997), and the area of the historical landfill under current Port Authority operational control of 178 acres.[3] Thus, waste emplaced was estimated to be on the order of 1.38 million short tons. Assuming that the landfill operated from 1940 through 1970, the annual rate of waste emplacement was determined to be 44,735 tons per year.

4.3.2. Emission Factors and Other Parameters

Emissions estimates were developed in accordance with Local Government Operations Protocol Chapter 9, "Solid Waste Management," as prescribed by The Registry (TCR, 2010). The project team used the default values from the model for the percentage of waste that is anaerobically degradable organic carbon, as no specific information was available on the waste disposal rates. The model was also run with the assumption that the CH_4 fraction of the landfill gas is 50 percent, and that 10 percent of the CH_4 is oxidized prior to being emitted into the atmosphere. The decay constant (i.e., k-value) was set at 0.057, which corresponds to areas that regularly receive more than 40 inches of annual rainfall. CO_2 emissions that are calculated by the model are reported, but they are classified as biogenic and not included in the CO_2e emissions total for the site.

4.3.3. Emissions Estimates

The 2012 GHG emissions estimates for the historic Elizabeth Landfill are shown in Table 4-5. The GHG emissions estimates are just for the landfill portion that is under the operational control of the Port Authority.

Table 4-5: 2012 GHG Emissions from the Historic Elizabeth Landfill

Biogenic CO_2 (metric tons)	CH_4 (metric tons)	CH_4 (metric tons CO_2e)
700	208.8	4,384

The historic Elizabeth Landfill also emits a precursor to CAP: 0.881 metric tons of VOC emissions.

[3] This value was measured in an ArcGIS environment from maps provided by Port Authority staff titled "PNPEFacMap2007draft5-07.pdf" and "Refuse_fill_rev.pdf."

5.0 PURCHASED ELECTRICITY (SCOPE 2)

The combustion of fossil fuels for the purpose of electricity generation will yield the GHGs CO_2, N_2O, and CH_4. Therefore, through a transitive relationship, the consumption of electricity generated from fossil fuel will result in the release of a certain quantity of GHGs. Because the Port Authority is not combusting the fossil fuel directly, the indirect emissions associated with electricity consumption are considered Scope 2 emissions. Table 5-1 lists the facilities and rail systems where electricity was consumed by the Port Authority.

Table 5-1: Port Authority Facilities with Electricity Consumption

96/100 Broadway	Brooklyn Marine Terminal	Lincoln Tunnel
115 Broadway	EWR	Outerbridge Crossing
116 Nassau St.	Gateway Newark	PATC
223 PAS	George Washington Bridge	PATH Buildings
225 PAS	George Washington Bridge Terminal	PATH
777 Jersey	Goethals Bridge	PCNJ
AirTrain JFK	Holland Tunnel	Port Authority Bus Terminal
AirTrain Newark	Howland Hook	SWF
Bathgate Industrial Park	JFK	TEB
Bayonne Bridge	LGA	The Teleport

Note: Facilities may include multiple buildings.

5.1. BUILDINGS

All buildings where electricity was consumed by the Port Authority are considered in this inventory. For a total of five facilities (JFK, LGA, SWF, PABT, and Teleport), total electricity consumption was shared by the Port Authority and its tenants; therefore, the total electricity consumption was split between the Port Authority and the tenant. For facilities where total dollars spent on electricity through lease agreements were not available, consumption was divided based upon each consumer’s share of square footage. All GHGs associated with the consumption of electricity in common areas maintained or provided as a service to the tenant by the Port Authority, such as street lights and lobby cooling, are considered Scope 2 emissions for the Port Authority.

5.1.1. Activity Data

The Port Authority provided data on electricity consumption by month for each building in kWh. It transcribed some of the data directly from the utility’s website into a Microsoft Excel workbook and provided additional data in the form of bill copies from the utility or landlord. In some cases, data were not immediately available, so Southern downloaded data from the provider's website in the form of screen shots converted to PDF or transcribed data from the website into an Excel workbook.

5.1.2. Emission Factors and Other Parameters

The GHG emission factors used to calculate the GHGs associated with electricity consumption are shown in Table 5-2.

Table 5-2: Electricity Consumption GHG Emission Factors

Emissions & Generation Resource Integrated Database (eGRID) 2012 Subregion/Provider	CO_2 (kg/kWh)	CH_4 (kg/kWh)	N_2O (kg/kWh)
NYCW – NPCC NYC/Westchester	0.277	1.08×10^{-5}	1.27×10^{-6}
NYUP – NPCC Upstate NY	0.226	7.23×10^{-6}	3.07×10^{-6}
Reliable First Corporation East	0.430	1.22×10^{-5}	6.79×10^{-6}
Kennedy International Airport Cogeneration (KIAC) Plant	0.421	3.02×10^{-5}	7.15×10^{-6}

For facilities located in New York, the emission factors for the Northeast Power Coordinating Council (NPCC) – New York City (NYC)/Westchester eGRID subregion were used (with one exception; SWF is in the NPCC – Upstate New York eGRID subregion). For facilities located in New Jersey, the emission factors for the Reliable First Corporation East subregion were used. These emission factors were extracted from the "2013 Climate Registry Default Emission Factors" (TCR, 2013b), and the boundaries were determined using the eGRID subregion map (EPA, 2010).

The eGRID emission factors include operational data such as emissions, different types of emission rates, generation, resource mix, and heat input within a specific region. For example, within NPCC-- NYC/Westchester, 56 percent of electricity is generated from natural gas combustion and 40 percent is generated through nuclear means, with the balance from oil and biomass combustion. In Reliable First Corporation East, 35 percent of electricity is generated from coal combustion and 43 percent through nuclear means, with the balance from oil, biomass, and hydro power (EPA, 2012a). Because more GHGs are associated with coal combustion than with natural gas combustion, the emission factors in the Reliable First Corporation East subregion are higher than those in NPCC – NYC/Westchester.

The electricity metrics for KIAC were determined as the ratio of distributed emissions over net electricity generation. Energy inputs (natural gas) and net electricity generation were provided by Calpine Corporation

(Calpine, 2013). KIAC GHG emissions were determined based on natural gas consumption by the plant and GRP emission factors (TCR, 2013a). Similarly, emissions of PM_{10} and $PM_{2.5}$ were determined on the basis of fuel consumption using AP-42 emission factors (EPA, 1995). Plant emissions of NO_x and SO_2 were taken from EPA's Air Markets Program Data (EPA, 2013b). Emissions were then distributed to electricity generation using the efficiency method as described in GRP Equation 12k (TCR, 2013a). The resulting KIAC electricity metrics are presented in Table 5-2 for GHGs and Table 5-3 for CAPs. Note that electricity purchases from KIAC are limited to two service locations, namely JFK and AirTrain JFK.

For CAP emission factors associated with eGRID regions, SO_2 and NO_x emission factors were obtained from the EPA eGRID for each subregion (EPA, 2012a). Emission factors for PM were calculated in proportion to the SO_2 emissions based on values derived from the 2008 EPA National Emissions Inventory (EPA, 2013a). This is a valid approach because the electricity comes from a variety of power plant sources, and the major factor that contributes to the difference in PM emissions is the control device(s) used. In order to find the proportion to use, total emissions from all electric generating processes were summed for plants in each State for SO_2, $PM_{2.5}$, and PM_{10}. These proportions were different because the breakdown of plant types is different in the two States. PM emission factors were calculated as the product of statewide PM emissions and SO_2 emission factor divided by the sum of statewide SO_2 emissions according to the following equation:

$$Ef_{PM} = Ef_{SO_2} x \frac{\sum_{State} PM}{\sum_{State} SO_2}$$

where:

Ef_{PM} = emission factor for either $PM_{2.5}$ or PM_{10},

Ef_{SO2} = emission factor for SO_2 provided by eGRID,

PM = value of particulate matter State emissions for either $PM_{2.5}$ or PM_{10}, and

SO_2 = value of sulfur dioxide State emissions.

Table 5-3 shows the CAP emission factors used for the 2012 electricity emissions estimates.

Table 5-3: Electricity Consumption CAP Emission Factors

eGRID 2012 Subregion/Provider	SO_2 (kg/kWh)	NO_x (kg/kWh)	$PM_{2.5}$ (kg/kWh)	PM_{10} (kg/kWh)
NPCC NYC/Westchester	4.67×10^{-5}	1.27×10^{-4}	2.00×10^{-6}	3.05×10^{-6}
NPCC Upstate NY	4.47×10^{-4}	1.79×10^{-4}	1.91×10^{-5}	2.91×10^{-5}
Reliable First Corporation East	2.09×10^{-3}	3.69×10^{-4}	3.52×10^{-4}	3.55×10^{-4}
KIAC	2.60×10^{-6}	7.96×10^{-5}	2.69×10^{-5}	2.69×10^{-5}

5.1.3. Emissions Estimates

Emissions estimates were developed in accordance with GRP Chapter 14, "Indirect Emissions from Electricity" (TCR, 2013a). In a small number of cases, when electricity consumption measurements were not available, engineering estimates were developed. For example, if no records existed for a given month, the electricity consumption was estimated by averaging the consumption for the previous and subsequent months. Additionally, if no records existed for a period of several months, electricity consumption was estimated using historical data from 2011. The Registry requires that emissions developed from engineering calculations be reported separately as SEM and aggregated with the estimates from all other emission sources. Indirect emissions from electricity purchases that were assessed using SEM are presented in Table 1-9.

Table 5-4 lists the GHG emissions for each department, excluding emissions associated with electricity consumption on the PATH, AirTrain JFK, and AirTrain EWR which are presented in Table 5-8.

Table 5-4: 2012 GHG Emissions from Electricity Consumption in Buildings by Department (metric tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	89,201	4.345	1.302	89,696
Tunnels and Bridges	13,473	0.429	0.163	13,533
Bus Terminals	8,186	0.318	0.038	8,204
PATH Buildings	7,455	0.211	0.118	7,496
Central Administrative	7,221	0.219	0.099	7,257
Port Commerce	4,836	0.140	0.074	4,861
Real Estate	1,461	0.057	0.007	1,464
Totals	**131,833**	**5.718**	**1.800**	**132,511**

The distribution of indirect emissions from purchased electricity is shown in Figure 5-1, where Aviation is the department with the largest share of CO_2e emissions from electricity consumption. This is primarily due to the electricity demand associated with the operation of common areas at its terminals.

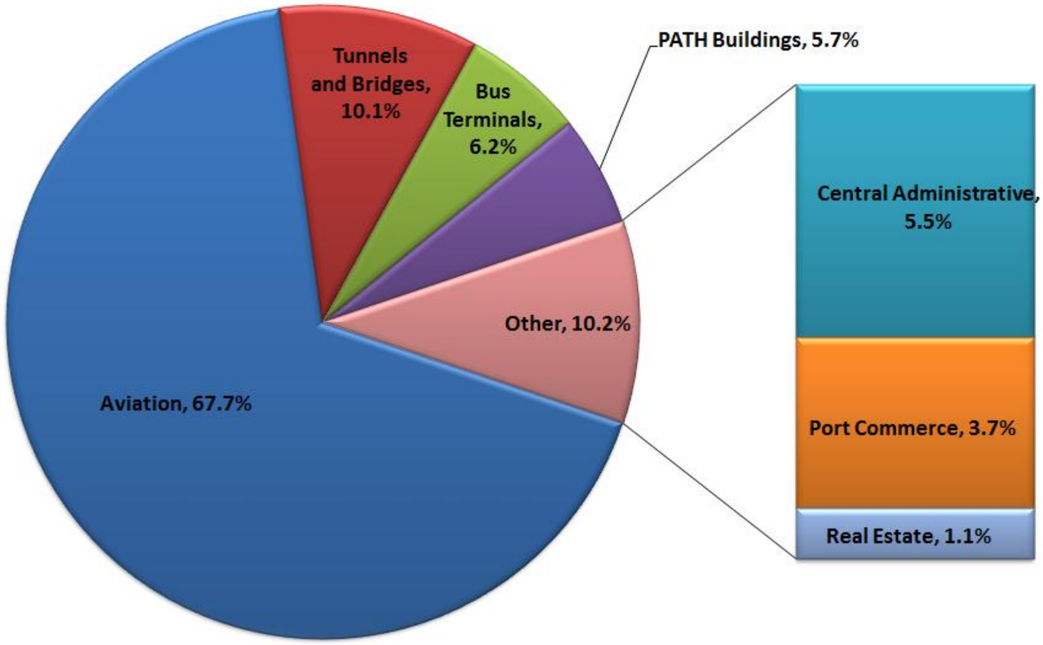

Figure 5-1: 2012 CO_2e Emissions from Electricity Consumption by Department

Table 5-5 shows the emissions estimates broken down by facility. Electricity consumed in New Jersey has higher emission factors, resulting in higher levels of CO_2e when compared to a similar quantity of electricity consumed in New York.

Table 5-5: 2012 GHG Emissions from Electricity Consumption in Buildings by Facility (metric tons)

Facility	CO_2	CH_4	N_2O	CO_2e
JFK	38,621	2.768	0.656	38,882
EWR	35,909	1.017	0.567	36,106
LGA	13,540	0.527	0.062	13,570
PATH Buildings	7,455	0.211	0.118	7,496
Port Authority Bus Terminal	6,663	0.259	0.031	6,678
Lincoln Tunnel	5,838	0.185	0.071	5,864
PATC	4,740	0.134	0.075	4,766
PCNJ	4,588	0.130	0.072	4,613
Holland Tunnel	3,849	0.126	0.043	3,865
George Washington Bridge	2,458	0.070	0.039	2,471
George Washington Bridge Terminal	1,522	0.059	0.007	1,526
The Teleport	1,371	0.053	0.006	1,374
TEB	959	0.027	0.015	964
225 PAS	726	0.028	0.003	727
Goethals Bridge	666	0.026	0.003	667
777 Jersey	569	0.016	0.009	572
Gateway Newark	559	0.016	0.009	562
Outerbridge Crossing	405	0.015	0.003	407
Bayonne Bridge	257	0.007	0.004	258
223 PAS	241	0.009	0.001	242
96/100 Broadway	203	0.008	0.001	204
SWF	172	0.005	0.002	173
Brooklyn Marine Terminal	140	0.005	0.001	141
115 Broadway	139	0.005	0.001	139
Howland Hook	108	0.004	0.000	108
Bathgate Industrial Park	91	0.004	0.000	91
116 Nassau St	45	0.002	0.000	45
Totals	**131,833**	**5.718**	**1.800**	**132,511**

CAP emissions totals are presented in a similar manner as GHGs, by department and by facility in Table 5-6 and Table 5-7, respectively.

Table 5-6: 2012 CAP Emissions for Electricity Consumption in Buildings by Department (metric tons)

Department	SO_2	NO_x	$PM_{2.5}$	PM_{10}
Aviation	182.054	45.261	32.770	33.076
Tunnels and Bridges	44.619	9.779	7.424	7.502
PATH Buildings	36.229	6.397	6.105	6.155
Central Administrative	28.746	5.654	4.815	4.860
Port Commerce	22.339	4.050	3.759	3.791
Bus Terminals	1.381	3.742	0.059	0.090
Real Estate	0.246	0.668	0.011	0.016
Totals	**315.6**	**75.6**	**54.9**	**55.5**

Table 5-7: 2012 CAP Emissions for Electricity Consumption in Buildings by Facility (metric tons)

Facility	SO_2	NO_x	$PM_{2.5}$	PM_{10}
EWR	174.53	30.81	29.41	29.65
PATH Buildings	36.229	6.397	6.105	6.155
PATC	23.036	4.067	3.882	3.914
PCNJ	22.297	3.937	3.757	3.788
Lincoln Tunnel	19.513	4.252	3.248	3.282
George Washington Bridge	11.926	2.107	2.010	2.026
Holland Tunnel	11.233	2.664	1.859	1.880
TEB	4.661	0.823	0.785	0.792
777 Jersey	2.766	0.488	0.466	0.470
Gateway Newark	2.715	0.479	0.458	0.461
LGA	2.284	6.191	0.098	0.149
Bayonne Bridge	1.249	0.221	0.211	0.212
Port Authority Bus Terminal	1.124	3.047	0.048	0.073
Outerbridge Crossing	0.584	0.229	0.092	0.094
SWF	0.340	0.136	0.015	0.022
George Washington Bridge Terminal	0.257	0.696	0.011	0.017
JFK	0.239	7.297	2.462	2.462
The Teleport	0.231	0.627	0.010	0.015
225 PAS	0.122	0.332	0.005	0.008
Goethals Bridge	0.112	0.304	0.005	0.007
223 PAS	0.041	0.110	0.002	0.003
96/100 Broadway	0.034	0.093	0.001	0.002
Brooklyn Marine Terminal	0.024	0.064	0.001	0.002
115 Broadway	0.023	0.063	0.001	0.002
Howland Hook	0.018	0.049	0.001	0.001
Bathgate Industrial Park	0.015	0.041	0.001	0.001
116 Nassau St	0.008	0.020	0.000	0.000
Totals	**315.6**	**75.6**	**54.9**	**55.5**

5.2. RAIL SYSTEMS

The three separate train systems under the jurisdiction of the Port Authority are primarily powered by electricity. Two of these train systems are airport monorail systems. One operates with service between JFK and two passenger stations in Queens, and the other operates with service between EWR and the Northeast Corridor transfer station. The PATH is a commuter subway system connecting New Jersey and New York.

5.2.1. Activity Data

For electricity consumption for the PATH, AirTrain EWR, and AirTrain JFK, the Port Authority provided consumption data by month for each building in kWh. It transcribed some of the data directly from the utility's website into a Microsoft Excel workbook and provided additional data in the form of copies of bills from the utility.

In some cases, data were not immediately available, so Southern downloaded data from the provider's website in the form of screen shots converted to PDF or transcribed data from the website into an Excel workbook.

Although The Registry requires that electricity from a combined heat and power plant such as KIAC be reported separately, this inventory includes all emissions from trains, including those associated with the electricity supplied by KIAC and consumed by AirTrain JFK.

5.2.2. Emission Factors and Other Parameters

As described in Section 5.1.2, emissions estimates are developed in accordance with GRP Chapter 14, "Indirect Emissions from Electricity" (TCR, 2013a). The GHG emission factors used to calculate the GHGs associated with electricity consumption are shown in Table 5-2**Error! Reference source not found.**.

For AirTrain JFK, two separate sets of emission factors were applied. For electricity purchased from KIAC, the emission factors were applied as described in Section 5.1.2. For the remaining electricity purchases, the NPCC – NYC/Westchester emission factors were used.

For the PATH Rail System and AirTrain EWR, the emission factors for the Reliable First Corporation East subregion were applied.

5.2.3. Emissions Estimates

GHG emissions estimates were developed from records of electricity consumption (i.e., utility statements).
Table 5-8 provides specific quantities of GHG emissions associated with train electricity usage for each system. As expected, the PATH is the largest emitting source because it is the network with the largest ridership and rail-miles. Additionally, the PATH runs on electricity supplied by the Reliable First Corporation East eGRID region, where emission factors are higher per kWh when compared to the NPCC – NYC/Westchester eGRID region (see Table 5-2). CAP emissions from electricity consumption for the train systems are given in Table 5-9.

Table 5-8: 2012 GHG Emissions from Electricity Consumption by Train System (metric tons)

Train	CO_2	CH_4	N_2O	CO_2e
PATH	41,468	1.17	0.65	41,696
AirTrain JFK	15,895	1.09	0.25	15,996
AirTrain Newark	6,440	0.18	0.10	6,475
Totals	**63,803**	**2.45**	**1.01**	**64,167**

Table 5-9: 2012 CAP Emissions from Electricity Consumption by Train System (metric tons)

Train	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PATH	201.55	35.58	33.96	34.24
AirTrain Newark	31.30	5.53	5.27	5.32
AirTrain JFK	0.342	3.405	0.928	0.934
Totals	**233.2**	**44.5**	**40.2**	**40.5**

6.0 PURCHASED STEAM, HEATING, AND COOLING (SCOPE 2)

This section discusses emissions associated with energy purchases in the form of steam, heating, and cooling from the KIAC plant and Con Edison. Emissions associated with purchased steam, heating, and cooling are considered to be indirect or Scope 2 emissions.

6.1. JFK/AIRTRAIN JFK

The Port Authority purchases thermal energy in the form of heating and cooling from KIAC to service JFK and AirTrain JFK. While the KIAC facility is owned by the Port Authority and sits within Port Authority property, emissions from the plant do not fall within The Registry's definition of the operational control inventory boundary because the facility is operated by Calpine Corporation. On the other hand, the Port Authority reports emissions associated with thermal energy purchases. These are calculated as a function of energy purchases multiplied by a KIAC-specific emissions metric.

6.1.1. Activity Data

The Port Authority provided separate monthly energy purchase data for JFK and AirTrain JFK for cooling and heating. Energy consumption for JFK and AirTrain JFK was billed separately, thus enabling more granular quantification of emissions.

6.1.2. Emission Factors and Other Parameters

The heating and cooling metrics for KIAC were determined as the ratio of distributed emissions over the output for each energy stream. Energy inputs (natural gas) and outputs (thermal energy and electricity) were provided by Calpine Corporation (Calpine, 2013). KIAC GHG emissions were determined based on natural gas consumption by the plant and GRP emission factors (TCR, 2013a); similarly, PM_{10} and $PM_{2.5}$ emissions were determined on the basis of fuel consumption using AP-42 emission factors (EPA, 1995). Plant emissions of NO_x and SO_2 were taken from EPA's Air Markets Program Data (EPA, 2013b). Emissions were then distributed to heating and cooling using the efficiency method as described in GRP Equation 12k (TCR, 2013a). The resulting heating and cooling emission factors are presented in Table 6-1 for GHGs and Table 6-2 for CAPs.

Table 6-1: KIAC GHG Emission Factors

Product	CO_2	CH_4	N_2O
Heating (kg/MMBtu)	61.698	4.42×10^{-3}	1.05×10^{-3}
Cooling (kg/MMBtu)	61.698	4.42×10^{-3}	1.05×10^{-3}

Table 6-2: KIAC CAP Emission Factors

Product	SO_2	NO_x	$PM_{2.5}$	PM_{10}
Heating (kg/MMBtu)	3.81×10^{-4}	1.17×10^{-2}	3.93×10^{-3}	3.93×10^{-3}
Cooling (kg/MMBtu)	3.81×10^{-4}	1.17×10^{-2}	3.93×10^{-3}	3.93×10^{-3}

6.1.3. Emissions Estimates

Table 6-3 provides GHG emissions estimates for the heating and cooling purchased from KIAC by the Port Authority to service JFK and AirTrain JFK. Table 6-4 presents CAP emissions estimates.

Table 6-3: 2012 GHG Emissions from KIAC Energy Purchases (metric tons)

Energy Use	CO_2	CH_4	N_2O	CO_2e
JFK Heating	2,000	0.143	0.034	2,013
JFK Cooling	4,725	0.339	0.080	4,757
JFK Total	**6,724**	**0.482**	**0.114**	**6,770**
AirTrain Heating	538	0.039	0.009	542
AirTrain Cooling	775	0.056	0.013	780
AirTrain Total	**1,313**	**0.094**	**0.022**	**1,322**

Table 6-4: 2012 CAP Emissions from KIAC Energy Purchases (metric tons)

Energy Use	SO_2	NO_x	$PM_{2.5}$	PM_{10}
JFK Heating	0.0124	0.3778	0.1275	0.1275
JFK Cooling	0.0292	0.8926	0.3012	0.3012
JFK Total	**0.0415**	**1.2705**	**0.4286**	**0.4286**
AirTrain Heating	0.0033	0.1017	0.0343	0.0343
AirTrain Cooling	0.0048	0.1465	0.0494	0.0494
AirTrain Total	**0.0081**	**0.2482**	**0.0837**	**0.0837**

6.2. PORT AUTHORITY BUS TERMINAL

The PABT reported some steam usage for heating in 2012. Scope 2 indirect emissions for this heating were calculated by assuming a total generation and delivery efficiency of 75 percent, in accordance with the GRP (TCR, 2013a). The steam was assumed to be generated by natural gas combustion with an energy content of 1,013 Btu per pound.

6.2.1. Activity Data

For steam, the Port Authority provided consumption data by month in thousands of pounds. The Port Authority transcribed some of the data from the ConEdison website into a Microsoft Excel workbook. For data that were not immediately available, Southern transcribed the data from the Con Edison website into an Excel workbook.

6.2.2. Emission Factors and Other Parameters

Since the emission factors for the purchased steam were not available from Con Edison, they had to be estimated indirectly based on boiler efficiency, fuel mix, and fuel-specific emission factors in accordance with GRP Chapter 15, “Indirect Emissions from Imported Steam, District Heating, Cooling, and Electricity from a CHP Plant” (TCR, 2013a). The steam purchased from Con Edison was generated by burning natural gas, and the project team assumed that the total efficiency factor was 93 percent. The emission factors for purchased steam are listed in Table 6-5.

Table 6-5: ConEdison GHG and CAP Emission Factors

GHG/CAP	CO_2	CH_4	N_2O	SO_2	NO_x	PM
Emission Factor (kg/thousand pounds of steam)	66.15	7.47×10^{-3}	3.11×10^{-4}	3.78×10^{-2}	6.22×10^{-2}	6.95×10^{-3}

6.2.3. Emissions Estimates

Since the GHG emissions estimates related to purchased steam were derived from data obtained from copies of bills, no simplified methods were necessary for calculation. Table 6-6 provides specific quantities of GHG emissions associated with purchased steam for the PABT.

Table 6-6: 2012 PABT GHG Emissions from Con Edison Steam Purchases (metric tons)

Building	CO_2	CH_4	N_2O	CO_2e
PABT	2,962	0.3342	0.0139	2,973.12

CAP emissions totals of purchased steam for PABT are given in Table 6-7.

Table 6-7: 2012 PABT CAP Emissions from Con Edison Steam Purchases (metric tons)

Building	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PABT	1.673	2.751	0.143	0.153

7.0 AVIATION ATTRACTED TRAVEL (SCOPE 3)

7.1. BOUNDARY

For attracted travel related to airports (excluding cargo-related vehicles), the established boundary includes the trip to or from the airport up to a maximum of 100 miles. This boundary was developed based on the trip origin data received from the Port Authority's Aviation Department (Sheu, 2013). These data showed that some of the passengers surveyed traveled from as far as Nassau, NY; New London, CT; and Philadelphia, PA. Cargo-related data were only available for JFK. Therefore, the established boundary for cargo-related vehicles was based on JFK and includes routes used to access and egress this facility. Aviation attracted travel also encompasses emissions from the operation of the Shadow Fleet, that is, vehicles owned by the Port Authority and circulating within airport property but operated on a day-to-day basis by contractors.

The facilities included in this inventory are the following:

- John F. Kennedy International Airport (JFK)
- Newark International Airport (EWR)
- LaGuardia Airport (LGA)
- Teterboro Airport (TEB)
- Stewart International Airport (SWF)

7.2. 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. VMTs for the airport facilities were calculated by mode and for the round-trip to and from the airport. Emissions from employee trips to and from the airport and the Port Authority airport shuttle buses are not included in this attracted travel inventory.

The VMT estimates used data on trip origin, travel distance, trip distributions to each passenger origin, and transport mode. Percentages of trip distributions to each passenger origin by travel mode for each airport facility were obtained from the Port Authority's Aviation Department (Sheu, 2013). Table 7-1 lists the trip origins for airport attracted travel with the corresponding estimated one-way travel distances by airport, except for TEB. Trip origin and travel mode data were not available for TEB, so vehicle travel to and from that airport were calculated based on scaling the VMT data from LGA according to the ratio of the total number of passengers at TEB to the total number of passengers at LGA. Distances reported in Table 7-1 were estimated using Google Maps roadway trip lengths and lists average travel party size by travel mode for all facilities. The surrogate location associated with each origin/destination represents the most populous locality within the county or jurisdiction. This approach represents an enhancement over previous inventories, in which the centroid of the county/jurisdiction was used to determine one-way travel distances.

Table 7-1: One-Way Travel Distances Associated with Airport Facilities

Origin/Destination		Miles to/from			
County/Jurisdiction	**Surrogate Location**	**JFK**	**LGA**	**EWR**	**SWF**
New York City					
Bronx	Bronx	17	10	27	
Brooklyn	Brooklyn	11	16	20	
Manhattan above 14th St.	E. 10th St., NYC	18	10	14	
Manhattan 14^{th}–96^{th} Sts.	E. 50th St., NYC	17	9	17	
Manhattan below 96^{th} St.	E. 110th St., NYC	18	7	20	
Nassau	Mineola	13	17	45	
Queens	Queens	8	7	26	
Staten Island	Staten Island	28	26	13	84
Suffolk	Hauppauge	42	40	59	
Westchester	Yonkers	27	17	29	54
Other New York Counties					
Albany	Albany	100			
Clinton	Plattsburgh	100			
Columbia	Hudson	100	100		67
Dutchess	Poughkeepsie	89	82	87	26
Erie	Buffalo	100			
Essex	North Elba	100	100	100	
Franklin	Malone	100			
Greene	Catskill				62
Jefferson	Watertown		100		
Lewis	Lowville		100		
Livingston	Geneseo	100			
Madison	Wampsville	100	100		
Monroe	Rochester	100		72	
Niagara	Niagara Falls		100		
Oneida	Utica	100			
Onondaga	Syracuse	100	100		
Orange	Newburgh	76	65	71	6
Otsego	Oneonta				100
Putnam	Carmel	63			35
Rockland	Nanuet	42	31		38
Saratoga	Saratoga Springs	100			100
Schenectady	Schenectady	100			
Sullivan	Monticello		94	97	39
Ulster	Kingston		98	100	40
Other NY[a]		100		100	50
New Jersey Counties					
Atlantic	Egg Harbor Township	100		100	
Bergen	Hackensack	29	18	20	55

Origin/Destination		Miles to/from			
County/Jurisdiction	**Surrogate Location**	**JFK**	**LGA**	**EWR**	**SWF**
Burlington	Evesham Township	100		76	
Camden	Camden	100		85	
Cape May	Lower Township			100	
Hudson	Union City	22	15	13	
Hunterdon	Raritan Township	75		49	
Mercer	Hamilton Township	76	71	50	
Middlesex	Edison	46	44	20	
Monmouth	Middletown	57	55	32	100
Morris	Parsippany-Troy Hills	51	40	24	62
Ocean	Lakewood Township	72		48	
Passaic	Paterson	36	25	20	
Salem	Pennsville Township		100		
Somerset	Franklin Township	53	52	27	
Sussex	Vernon Township	67	60	59	40
Union	Elizabeth	32	24	4	
Warren	Philipsburg			60	
Other NJ[a]		50	50	50	
Connecticut Counties					
Fairfield	Bridgeport	62	55	76	76
Hartford	Hartford	100	100		
Litchfield	Torrington	100	100		72
New Haven	New Haven	80	73	95	81
New London	Norwich	100			
Windham	Windham	100			
Other CT[a]		100	100		75
Pennsylvania Counties					
Allegheny	Pittsburgh		100	100	
Berks	Reading	100			
Bucks	Bensalem	92		67	
Centre	Bellefonte	100		100	
Chester	West Chester	100		100	100
Cumberland	Carlisle	100			
Dauphin	Harrisburg	100			
Delaware	Chester			98	14
Lackawanna	Scranton				94
Lancaster	Lancaster	100		100	
Lehigh	Allentown	100		82	
Montgomery	Lower Merion	100		91	100
Northampton	Bethlehem			72	
Northumberland	Sunbury			100	
Philadelphia	Philadelphia	100	100	83	
Pike	Matamoros				37
Schuylkill	Pottsville			100	
Susquehanna	Forest City	100			
Wayne	Honesdale			100	
Westmoreland	Greensburg	100			
York	York			100	
Other PA[a]		100		100	50
Other U.S.[a]		100	100	100	100

[a] These are cases where no county information was provided by survey respondent, and, consequently, a default distance was assigned.

Data presented in Tables 7-1 and 7-2, along with the trip distribution data, were applied in allocating number of passengers to number of vehicles. 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 and data sources were used to estimate the travel patterns of taxis and cargo transport vehicles. These methods are summarized by vehicle type in the following subsections.

Table 7-2: Average Travel Party Size by Travel Mode and Facility

Travel Mode	Average Travel Party Size by Facility				
	JFK	LGA	EWR	SWF	TEB
Personal Car[a]	2.42	2.77	2.06	2.42	2.77
Rental Car[a]	2.42	2.77	2.06	2.42	2.77
Taxi	2.97	2.39	3.30	2.76	2.39
Limo/Towncar[a]	2.42	2.77	2.06	2.42	2.77
Shared-Ride Van[c]	10.8	10.8	10.8	10.8	10.8
Airport/Charter/Tour Bus[b]	45.86	45.86	45.86	45.86	45.86
Public/City Bus[b]	45.86	45.86	45.86	45.86	45.86
Hotel/Motel Shuttle Van[c]	10.8	10.8	10.8	10.8	10.8
Off-Airport Parking[c]	10.8	10.8	10.8	10.8	10.8

[a] Parsons Brinckerhoff et al., 2006.
[b] Excellent et al., 2008.
[c] Airlink et al., 2008.

7.2.1. Private Cars, Rental Cars, Limousines, Chartered Buses, Public/City Buses, Hotel/Motel Shuttles, and Off-Airport Parking Shuttles

For each airport, except TEB, the number of passengers was allocated by travel mode and trip origin to obtain the number of vehicles. The number of vehicles by travel mode and trip origin was estimated using number of passengers, 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 the Port Authority's Aviation Department (Sheu, 2013). Information on distance traveled and average travel party size are listed in Tables 7-1 and 7-2, respectively.

For example, there were 49,293,587 JFK passengers in 2012. Of that total, 3.4 percent of them had trips originating in the Bronx, or 1,675,894 passengers. Another 54.5 percent of these passengers used a private car for the trip to JFK airport, with a one-way distance of 17 miles and an average travel party size of 2.42 persons. Therefore, the total VMT accounting for trips made in private cars between JFK and the Bronx is estimated as follows:

$$\textit{Private Car VMT} = ((\textit{Number of Passengers} \times \textit{Percent Distribution by trip origin and travel mode}) / \textit{Travel Party Size}) \times \textit{Trip Length} \times 2 \textit{ to account for both directions})$$

$$= (1{,}675{,}894 \times (54.5 / 100) / 2.42) \times 17 \times 2$$

$$= 12{,}832{,}361 \textit{ miles (round-trip)}$$

7.2.2. Taxi Party Size

For taxis servicing JFK, LGA, EWR, and SWF, taxi party size was estimated using the number of taxis dispatched (Sheu, 2013). The number of taxis dispatched was allocated by trip origin utilizing the percentage of airport passengers by trip origin (Sheu, 2013). The total passengers who used taxis was divided by total taxis dispatched to estimate overall party size (see Table 7-2).

7.2.3. Cargo VMT

Data detailing cargo trips by route and vehicle type were available from a 2002 air cargo truck movement study for JFK (URS, 2002). JFK VMT for cargo-related travel was derived by multiplying the number of cargo trips 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 was estimated using Google Maps (see Table 7-3). The number of cargo trips at JFK in 2012 was estimated by scaling the number of trips estimated from the 2002 study by vehicle type based on the ratio of 2012 to 2002 freight cargo at JFK (Port Authority, 2006; Port Authority, 2013a). The resulting 2012 cargo VMT for JFK by vehicle type was then scaled to LGA, EWR, and SWF airports using the 2012 ratio of cargo tons from JFK to the cargo tons at LGA, EWR, and SWF airports (Port Authority, 2013a).

Table 7-3: One-Way Travel Distance Associated with JFK Airport for Cargo Travel

Origin/Destination	Miles to/from
Van Wyck	5.10
On Airport	6.70
Rockway Blvd.	2.80
Belt Parkway/Southern State	8.20
Other Routes[a]	5.70

Source: Google Maps
[a] Average distance based on Van Wyck, On Airport, Rockaway Blvd., and Belt Parkway/Southern State trip length.

7.2.4. Emission Calculations from VMT Activity

Once VMT estimates were developed for all attracted travel, VMT was summed by facility and mode. Emission factors for attracted travel at airports were calculated using EPA's MOVES model (EPA, 2012b) based on input data for the 10 New York metropolitan counties. For personal vehicle travel (personal car, rental car, taxi, limo/town car, shared-ride van, hotel/motel shuttle van, and off-airport parking), the emission factors were based on the weighted average of the MOVES passenger car, passenger truck, and motorcycle vehicle types over the 10 counties. Emission factors for public/city bus and airport/charter/tour bus were based on the 10-county weighted average transit bus emission factors. Cargo emission factors from MOVES were assigned based on the cargo vehicle category.

Emissions estimates for CO_2, CH_4, and N_2O were developed by multiplying VMT by the corresponding emission factors (in grams per mile). Emissions for CO_2e were calculated by multiplying the CO_2, CH_4, and N_2O emissions by their corresponding GWP.

Cold-start emission factors for CO_2, CH_4, and N_2O associated with the startup of a cooled vehicle engine were applied to all personal vehicle trips. Vehicle emissions for this category were calculated by multiplying the number of vehicle trips with the corresponding weighted cold-start emission factor for each vehicle type. Total vehicle trips were estimated by dividing the total VMT for each vehicle type by the average trip distance for each airport/vehicle type combination. The cold-start emission factors (in grams per start) by vehicle type and technology type were derived from the EPA MOVES model (EPA, 2012b).

7.2.5. Teterboro Airport

Because no vehicle travel attraction statistics were available for TEB, the analysis derived this airport's emissions estimates using LGA airport emissions by passenger origin and travel type as a surrogate. Estimated LGA emissions (per passenger origin, per vehicle type) were multiplied by TEB's total number of 2012 passengers (Sheu, 2013).

7.2.6. Shadow Fleet

Data on the Port Authority Shadow Fleet vary for each airport. LGA has a shadow fleet consisting of seven buses. JFK provided only bulk fuel consumption for its shadow fleet. Mileage and fuel consumption were reported for 23 airport buses at EWR, as well as bulk diesel fuel consumption from non-highway vehicles. For SWF, 2012 data for both highway and non-highway vehicles was provided. TEB provided vehicle-level information for the 22 highway and 1 non-highway vehicle shadow fleet.

Emissions for all highway vehicles were estimated based on the CO_2 per gallon emission factor for each vehicle from GRP Table 13.1, and on the CH_4 and N_2O emissions per mile from GRP Table 13.4 (TCR, 2013a). For all non-highway vehicles, CO_2 emissions were calculated based on per-gallon emissions from GRP Table 13.1 (TCR, 2013a).

CH_4 and N_2O emissions were calculated using the construction vehicle gram-per-gallon emission factors from GRP Table 13.6 (TCR, 2013a). Biogenic CO_2 emissions are calculated using the ethanol and biodiesel emission factors from GRP Table 13.1 (TCR, 2013a). These emission factors are then multiplied by the percentage of biofuel in each gallon (typically 10 percent for gasoline and 20 percent for biodiesel) in order to calculate total emissions.

CAP emission factors for highway vehicles were calculated based on the emission factors generated in MOVES (EPA, 2012a) for a given county in 2012. These emission factors are expressed in terms of grams per mile and are specific to a model year and vehicle type. CAP emissions from B20 vehicles were assumed to be the same as for diesel vehicles. Non-highway vehicle emissions were calculated based on the national average emission factors from the MARKAL database (Pechan, 2010).

7.3. RESULTS

This section reports attracted travel GHG emissions from airport facilities. Table 7-4 summarizes the GHG emission estimates for highway vehicles for the facilities included in this inventory.

Table 7-4: Airport Facilities 2012 Attracted Travel GHG Emissions by Gas

Facility	Metric Tons			
	CO_2	CH_4	N_2O	CO_2e
John F. Kennedy (JFK)	755,232	12.4	9.9	758,567
La Guardia (LGA)	220,944	3.6	3.1	221,965
Newark (EWR)	489,535	7.9	6.4	491,688
Teterboro (TEB)	1,346	0.0	0.0	1,353
Stewart International Airport (SWF)	5,849	0.1	0.1	5,876
Total	**1,472,906**	**24.1**	**19.5**	**1,479,448**

For 2012, airport attracted travel was estimated to produce 1.5 million metric tons of CO_2e emissions. As shown in Table 7-4, more than 99 percent of these were emissions of CO_2. CH_4 and N_2O (both as CO_2e) account for less than 1 percent.

Table 7-5 provides estimated VMT by travel mode, and Table 7-6 shows the CO_2e emissions by travel mode. Personal cars make up the majority of VMT and emissions for all airports, although taxi emissions are proportionally much higher at LGA than other airports.

Table 7-5: 2012 Aviation Attracted Travel VMT by Travel Mode (miles/year)

Travel Mode[a]	2012 VMT				
	JFK	LGA	EWR	SWF	TEB[b]
Personal Car	947,117,385	154,800,512	519,415,925	8,314,083	2,360,178
Rental Car	45,243,489	36,509,177	166,474,241	1,072,977	
Taxi	189,977,143	153,129,091	80,168,030	0	
Limo/Towncar	119,376,987	54,616,075	79,945,728	61,100	
Mass Transit to AirTrain	0	0	0	0	0
Shared-Ride Van	15,949,603	4,617,896	6,313,444	0	0
Airport/Charter/Tour Bus	2,195,048	1,131,910	2,922,927	0	0
Public/City Bus	1,989,988	1,755,829	541,041	0	0
Hotel/Motel Shuttle Van	22,296,480	1,040,578	6,956,020	33,782	0
Off-Airport Parking	337,027	1,533,076	8,983,769	0	0
Cargo Light Vehicles	27,261,088	144,869	15,321,410	394,736	0
Cargo Small Trucks	12,296,053	65,343	6,910,688	178,045	0
Cargo Large Trucks	2,425,497	12,889	1,363,190	35,121	0
Total	**1,386,465,787**	**409,357,244**	**895,316,414**	**10,089,844**	**2,360,178**

[a] Shadow Fleet VMT is excluded from Table 8.5 because emission estimates were developed in function of fuel usage.
[b] The distribution of the TEB attracted travel VMT among the various means of personal transportation was unknown. All of the TEB attracted travel VMT was treated as personal car VMT.

Table 7-6: 2012 Aviation CO_2e Emissions by Travel Mode (metric tons)

Travel Mode	Airport				
	JFK	LGA	EWR	SWF	TEB
Personal Car	504,161	82,582	276,634	4,431	1,263
Rental Car	24,061	19,408	88,488	571	0
Taxi	101,299	81,805	42,743	0	0
Limo/Towncar	63,558	29,196	42,638	33	0
Mass Transit to AirTrain	0	0	0	0	0
Shared-Ride Van	8,468	2,452	3,352	0	0
Airport/Charter/Tour Bus	3,424	1,766	4,559	0	0
Public/City Bus	3,104	2,739	844	0	0
Hotel/Motel Shuttle Van	11,837	552	3,693	18	0
Off-Airport Parking	181	817	4,781	0	0
Cargo Light Vehicles	15,719	84	8,834	228	0
Cargo Small Trucks	14,552	77	8,179	211	0
Cargo Large Trucks	4,829	26	2,714	70	0
Shadow Fleet	3,376	462	4,229	0.57	90
Total	**758,567**	**221,965**	**491,688**	**5,562**	**1,353**

Figure 7-1 shows the breakdown of aviation CO_2e emissions by travel mode and emission sources as a percentage of the overall total. Emissions from personal cars are the largest category for all five airports. Taxi emissions are very high for LGA, but there are no taxi emissions estimated for SWF (based on survey results). LGA was used as the surrogate for TEB because there was no mode-specific information available for TEB.

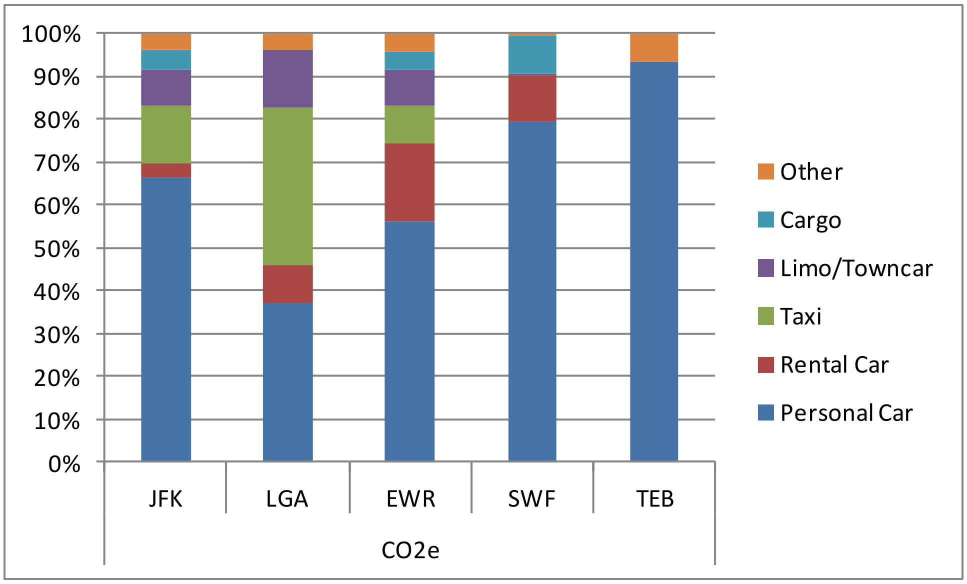

Figure 7-1: Distribution of Aviation 2012 Attracted Travel CO_2e Emissions by Travel Mode and Airport

To the extent that vehicles accessing Port Authority airports use the Port Authority's tunnels and bridges, the methods used to estimate Port Authority-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.

7.3.1. Comparison with Estimates in Previous Studies

This section compares 2006, 2007, 2008, and 2012 GHG emissions results. As presented in Table 7-7, estimated GHG emissions produced by airport facilities amounted to 1.5 million metric tons in 2012, up from 1.2 million metric tons in 2008. Overall emissions increased by 293,579 tons between 2008 and 2012. This increase in emissions is almost entirely from attracted travel activities at JFK (282,635 tons).

Table 7-7: Airport Facilities Attracted Travel GHG Emissions Comparison, 2006–2008, 2012

Facility	CO_2 Equivalent (metric tons)			
	2006	**2007**	**2008**	**2012[b]**
John F. Kennedy (JFK)	444,651	476,132	472,965	755,191
La Guardia (LGA)	209,553	199,437	192,833	221,503
Newark (EWR)	515,014	517,926	505,967	487,459
Teterboro (TEB)	250	254	210	1,263
Stewart International Airport (SWF)	Not Estimated	2,945[a]	13,286	5,561
Total	**1,169,468**	**1,208,804**	**1,185,261**	**1,470,977**

[a] 2007 emissions for SWF are based on Port Authority operation of this airport limited to November and December.
[b] Emissions in 2012 do not include shadow fleet emissions as these were not included in the aviation emissions for prior years.

Table 7-8 helps to illustrate why the increase in emissions at each airport between 2008 and 2012 is primarily due to the change in methodology used to calculate emissions. This table shows total passengers, estimated VMT, and CO_2e emissions at the airports for 2008 and 2012. The VMT and CO_2e estimates include cargo attracted travel, which is not included in the passenger total. However, cargo trips make up less than 5 percent of total VMT and CO_2e emissions. Total CO_2e emissions increased by 24.1 percent between 2008 and 2012, but the number of passengers increased only slightly by 2 percent and VMT decreased by 2 percent. Therefore, increased airport use is not likely to be the cause of the increase in emissions; instead, the increase is most likely due to the change in emissions factor methodology, as discussed in Section 1.4.2.

Table 7-8: 2008 and 2012 Comparison of Passengers, VMT, and CO_2e Airport Emissions

Airport	Passengers (thousands)[a]		Pct. Change	VMT (million miles)		Pct. Change	CO_2 Equivalent (metric tons)		Pct. Change
	2008	2012		2008	2012		2008	2012	
JFK	47,808	49,294	3.1%	1,108	1,386	25.1%	472,965	755,191	59.7%
LGA	23,073	26,041	12.9%	466	409	-12.1%	192,833	221,503	14.9%
ER	35,361	34,014	-3.8%	1,195	895	-25.1%	505,967	487,459	-3.7%
TEB	25	73	190%	N/A	2.4	N/A	210	1,263	501%
SWF	789	365	-53.8%	32	10	-68.2%	13,286	5,561	-58.1%
TOTAL	**107,056**	**109,786**	**2.6%**	**2,801**	**2,704**	**-3.5%**	**1,185,261**	**1,470,977**	**24.1%**

[a] The passenger data do not include cargo amounts; however, cargo VMT and CO2e emissions are included.
Source: Port Authority, 2013a (for JFK, LGA, EWR, and SWR) and Sheu, 2013 (for TEB).

Table 7-9 shows how the average vehicle occupancy and trip length have changed from 2008 to 2012. Vehicle occupancy values by mode were shown in Table 7-2 and, in most cases, are the same as the values used in 2008. However, the weighted average occupancy values shown in Table 7-9 show the impact of the change in travel modes from 2008 to 2012. The decreasing occupancy for JFK in Table 7-9 indicates that more passengers are traveling in modes with lower occupancies in 2012 compared with 2008, while the data for the other airports indicate that passengers are selecting modes with higher occupancies, such as buses or AirTrain, in 2012 compared with 2008. The average one-way trip lengths shown in Table 7-9 reflect the changes in trip destinations, as provided by the Port Authority (Sheu, 2013).

Table 7-9: 2008 and 2012 Comparison of Vehicle Occupancy and Trip Length at Airports

Airport	Average Occupancy (passengers/vehicle)[a]		Pct. Change[c]	Average 1-way Trip Length (miles)[b]		Pct. Change
	2008	2012		2008	2012	
JFK	3.4	3.2	7.7%	38.1	40.0	4.9%
LGA	2.9	3.0	-3.8%	28.9	24.1	-16.5%
EWR	2.4	3.0	-20.4%	39.8	35.4	-11.1%
TEB	N/A	3.0	N/A	N/A	16.2	N/A
SWF	2.4	2.5	-0.9%	48.0	28.4	-40.8%

[a] Average occupancy calculated as total airport passengers divided by total airport vehicle trips.
[b] Average 1-way trip length calculated as total airport VMT divided by total 1-way airport trips divided by 2.
[c] The number of passengers is divided by the vehicle occupancy in calculating VMT. Therefore, the percent change shown here for average vehicle occupancy is the percent change of 1/vehicle occupancy from 2008 to 2012.

7.3.2. Airport Attracted Travel CAP Emissions Summary

Table 7-10 summarizes 2012 CAP emissions by facility for the Aviation Department. Criteria pollutant emission factors come from the EPA MOVES model and are calculated on a grams per mile and grams per start basis in the same manner as the GHG emission factors. These emissions factors are then multiplied by VMT/vehicle type and starts/vehicle type to estimate total CAP emissions.

Table 7-10: Aviation Department 2012 Attracted Travel CAP Emissions by Facility

Facility Name	Metric Tons			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
JFK	827.7	13.5	43.4	87.3
LGA	257.4	3.8	13.1	25.8
EWR	546.0	8.5	27.8	56.1
TEB	1.1	0.0	0.1	0.1
SWF	6.6	0.1	0.3	0.7
Total	**1,638.8**	**25.9**	**84.7**	**170.0**

8.0 PORT COMMERCE HEAVY DUTY DIESEL VEHICLES (SCOPE 3)

8.1. BOUNDARY

This section estimates heavy-duty diesel vehicles (HDDV) emissions associated with the movement of goods to and from Port Commerce marine terminals. More specifically, HDDV activity contemplated in the assessment includes:

- On-road HDDV travel to and from Port Authority marine terminals (i.e., drayage) to the first point of rest, up to 400 miles.
- On-terminal HDDV idling
- On-terminal HDDV travel

Table 8-1 provides a list of facilities that comprise Port Commerce marine terminals. These facilities are grouped by the type of operation, namely auto terminal, container terminal or warehouse.

Table 8-1: Facilities included in 2012 Port Commerce Attracted Travel Emission Inventory

Type of Operation	Facility
Auto Terminals	Toyota Logistics at Port Newark
	Foreign Auto Preparation Services at Port Newark
	BMW at the Port Jersey Port Authority Auto Marine Terminal
Container Terminals	Port Newark Container Terminal at Port Newark
	Maher Terminal at the Elizabeth Port Authority Marine Terminal
	APM Terminal at Elizabeth Port Authority Marine Terminal
	New York Container Terminal at Howland Hook Marine Terminal
	Red Hook Container Terminal, LLC secondary barge depot at Port Newark
	Global Marine Terminal at the Port Jersey Port Authority Marine Terminal
Warehouses	Phoenix Beverage
	Harbor Freight Transport
	Eastern Warehouse
	Export Transport Co.
	ASA Apple Inc.
	Van Brunt Port Jersey Warehouse Inc.
	TRT International Ltd.
	East Coast Warehouse & Distribution Corp.
	P. Judge and Sons

Source: Starcrest, 2014.

8.2. METHODS

The methodology for on-road truck travel to and from Port Authority marine terminals was designed in this study to capture emissions to the first point rest (regardless of whether it is within or beyond the non-attainment area), to a maximum distance of 400 miles, which is about the distance travelled on a full tank of gas by a drayage truck in a day. The first point boundary was adopted as an industry good-practice (WPCI, 2010). The boundary for on-road HDDV activity compliments the results of the Port Commerce Department 2012 Multi-Facility Emission Inventory (Starcrest, 2014) by estimating incremental emissions from the 16-county NYNJLINA boundary to the first point of rest. The Starcrest report, however, only used the non-attainment area as the boundary. It did not include anything beyond that. The boundaries are visualized in Figure 8-1, where the NYNJLINA boundary is represented in light green and the maximum distance for the first point of rest is represented by a dashed perimeter with a radius of 400 miles. As measured in VMT, 32 percent of on-road travel occurs within the NYNJLINA, 40 percent occurs within a 100-mile radius, and 61 percent occurs within a 200-mile radius. Moreover, 78 percent of all VMT corresponds to trips of less than the 400 miles.

Figure 8-1: On-Road HDDV Boundaries

8.2.1. Activity Data

8.2.1.1. On-Road HDDV Activity

The activity used for on-road HDDV 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 number of trips by estimates of the average trip length both to and from the terminal.

In the Starcrest analysis, this trip starts and/or ends at the boundary of the NYNJLINA (Starcrest, 2014). For the incremental analysis of the entire trip beyond the nonattainment area, the average length of the entire HDDV trip was first estimated and multiplied by the total number of trips. The VMT within the nonattainment area was then subtracted from the total trip VMT.

For consistency with the Starcrest analysis, only trips and VMT associated with the container terminals were included in this incremental on-road HDDV analysis. The data used to estimate the trip length were obtained from a truck origin-destination survey (Vollmer, 2006). This report summarized the distribution of truck origins and destinations by county, state, or region in 2005. A weighted average trip length was estimated by multiplying the distribution percentage by the distance from the terminals. Given the close proximity of terminals to each other, one-way travel distances were assessed using the Port Elizabeth Terminal as the end point. For cases in which the origin or destination was 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, which is equivalent to the distance a truck could travel in an eight-hour day at 50 miles per hour (mph). Table 8-2 shows the distribution of origin and destination trips, the surrogate counties used, and the mileage from the terminals to each origin or destination. The surrogate location used for estimating travel distance represents the most populous locality within the county or jurisdiction. This approach represents an enhancement over previous inventories where the centroid of the county/jurisdiction was used to determine one-way travel distances. This calculation resulted in an average origin trip length of 48.6 miles and an average destination trip length of 44.3 miles, or an average one-way trip length of 46.4 miles. The resulting total VMT is shown in Table 8-3..

Table 8-2: One-Way Travel Distances Associated with Port Commerce Terminals

Origin/Destination					Miles to/from Terminal
State/Jurisdiction	**County**	**Surrogate Location**	**Truck Origins Percent of Total**	**Truck Destinations Percent of Total**	
NJ	Bergen	Hackensack	2.3	2.4	20.4
	Essex	East Orange	23.3	23.3	13.9
	Hudson	Union City	21.9	22.7	13.8
	Mercer	Hamilton Township	0.5	0.5	52.3
	Middlesex	Edison	9.3	9.8	44.1
	Monmouth	Middletown	0.7	0.4	34.9
	Morris	Parsippany-Troy Hills	0.7	0.9	27.7
	Ocean	Lakewood Township	0.1	0.1	49.8
	Passaic	Paterson	0.9	1.1	24.3
	Somerset	Franklin Township	0.8	0.9	31.3
	Union	Elizabeth	12.4	14.4	7.7
	Other	Atlantic City	2.5	2.8	118.0
NY	Bronx	Bronx	1.1	0.6	27.6
	Kings	Brooklyn	3.5	3.0	19.8
	New York	E. 50th St., New York	0.9	0.5	17.5
	Queens	Queens	0.8	0.9	25.8
	Richmond	Staten Island	0.9	1.2	14.5
	Dutchess	Poughkeepsie	0.2	0.2	87.2

Origin/Destination					Miles to/from Terminal
State/Jurisdiction	County	Surrogate Location	Truck Origins Percent of Total	Truck Destinations Percent of Total	
	Nassau	Mineola	1.4	1.0	44.2
	Orange	Newburgh	0.3	0.4	71.2
	Putnam	Carmel	0.0	0.0	73.4
	Rockland	Nanuet	0.1	0.1	37.5
	Suffolk	Hauppauge	0.2	0.2	67.7
	Westchester	Yonkers	0.4	0.5	30.4
	Upstate	Syracuse	1.5	1.4	246.0
CT	Fairfield	Bridgeport	0.3	0.1	76.3
	New Haven	New Haven	0.4	0.3	94.4
	Other	Hartford	0.4	0.2	130.0
Western MA		Springfield	0.2	0.0	155.0
Eastern MA & RI		Boston	1.4	1.1	229.0
Northern New England		Manchester, NH	0.1	0.1	262.0
NE Pennsylvania		Scranton	2.2	1.8	120.0
SE Pennsylvania		Philadelphia	2.6	2.5	87.6
Central Pennsylvania		Harrisburg	1.5	1.4	162.0
Western Pennsylvania		Pittsburgh	0.4	0.3	362.0
DE		Wilmington	0.2	0.1	117.0
MD and DC		Baltimore	0.8	0.4	178.0
Midwest		Kansas City	0.9	0.9	400.0
Pacific Northwest		Snohomish County, WA	0.1	0.0	400.0
Pacific Southwest		Boulder County, CO	0.1	0.0	400.0
Canada			1.6	1.5	400.0
Weighted Average Origin Trip Length (highway miles)					48.6
Weighted Average Destination Trip Length (highway miles)					44.3
Average One-Way Trip Length (highway miles)					**46.4**

Source: SC&A with information from Vollmer, 2006, Table VI-1; CTA, 2008.

Table 8-3: 2012 VMT from On-Road HDDV Trips to/from Port Commerce Terminals

Boundary	VMT (thousand miles)
To NYNJLINA	113,339
Incremental to the First Point of Rest	244,973
Total	**358,312**

8.2.1.2. On-Terminal HDDV Activity

Activity data were collected by Starcrest from the marine terminal facility operators (Starcrest, 2014). While the data were collected at the facility level listed in Table 8-1, the activity data are summarized by facility type in Table 8-4. Data were not reported by facility in the Starcrest report due to confidentiality concerns. Thus, emissions for this sector are reported by terminal type and state, but not by individual facility.

Table 8-4: Summary of 2012 Port Commerce On-Terminal Operating Characteristics

Facility Type	Annual Trips	On-Terminal VMT	Average Speed (mph)	Average Distance Traveled on Terminal (miles/trip)	Average Idling Time (hours/trip)	Total Idling Time (hours)

Warehouses	208,020	142,078	12	0.68	0.6	126,059
Auto-Handling Facilities	77,212	73,941	5	0.96	1.4	104,570
Container Terminals	3,857,400	4,480,318	15	1.16	0.5	1,740,307
Total	**4,142,632**	**4,696,337**				**1,970,936**

Source: Starcrest, 2014.

The activity used in estimating HDDV idling emissions was the number of hours of idling. This was calculated by multiplying the number of annual truck trips to the facilities listed in Table 8-1 during 2012 by an estimate of the average amount of time spent idling at each marine facility per trip. Total idling hours by terminal type are shown in Table 8-4.

The activity indicator used for HDDV travel within the terminal area was the VMT within the terminal area. This was calculated by multiplying the 2012 annual truck trips by an estimate of the average VMT per trip within the boundaries of each marine facility. The 2012 on-terminal VMT is summarized in Table 8-4.

8.2.2. Emission Factors and Emission Calculations

Activity data for each attracted travel category were multiplied by the relevant emission factors to estimate total GHG emissions. GHG emission factors for the off-port roads were obtained from EPA's MOVES2010b model. Starcrest estimated the emission factors for idling and the low-speed on-terminal travel by applying MOBILE6-based ratios to the off-port roads (35 mph) emission factors. These emission factors are summarized in Table 8-5. The extended idling emission factors were applied to the idling hours at the auto marine terminals, while the short-term idling emission factors were applied to the idling activity at the container and warehouse terminals.

Table 8-5: 2012 Emission Factors used in Port Commerce HDDV Attracted Travel Analysis

	HDDV Emission Factors		
Component of Operation	**CO_2**	**N_2O**	**CH_4**
Short-Term Idle[1] (g/hr)	5,340	0.0084	0.0000
Extended Idle[1](g/hr)	5,340	0.0144	0.0134
On-Terminal (15 mph avg. speed)[1] (g/mi)	2,136	0.0028	0.0000
Off-Port Roads (35 mph avg. speed)[1] (g/mi)	2,136	0.0028	0.0000
Off-Port Roads (NY metro area speeds)[2] (g/mi)	2,653	0.0047	0.0316

[1]Source: Starcrest, 2014.
[2]Source: Calculated by SC&A using MOVES2010b, average of 10-county NY metropolitan area emission factors for short-haul combination trucks with 2012 age distribution from Starcrest 2014.

The emission factors shown in Table 8-5 for off-port roads (NY metro area speeds) were calculated by SC&A using MOVES 2010b and were used in calculating the off-terminal emissions. These emission factors represent travel by short-haul combination trucks with the fleet mix and travel patterns, including speeds, representing the weighted average data over the 10-county New York metropolitan region, as provided by the NYMTC (NYMTC, 2013). The age distribution of the short-haul combination trucks was based on the model year distribution presented in the Starcrest report for the drayage trucks used on the Port Authority container terminals. These emission factors were multiplied by the total VMT shown in Table 8-3. After the total off-terminal trip emissions were calculated for each pollutant, the off-terminal portion of the Starcrest emissions was subtracted to obtain the incremental portion of the emissions expected to be attributed to areas outside of the NYNJLINA. The CO_2, CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate CO_2e emissions.

8.3. RESULTS

Table 8-6 summarizes the GHG emission estimates for the Port Commerce HDDV activities included in this 2012 inventory. A majority of these emissions are associated with on-road HDDV travel to and from the Port Commerce marine terminals. Emissions from HDDV travel outside of the NYNJLINA is shown as incremental to the emissions that occur within the nonattainment area. All emissions within the NYNJLINA are those reported by Starcrest.

Table 8-6: 2012 Port Commerce HDDV GHG Emissions Summary

Activity	Metric Tons			
	CO_2	**CH_4**	**N_2O**	**CO_2e**
On-Road HDDV Travel	950,691	11.3	1.7	951,455
to the NYNJLINA boundary	266,411	0	0	266,518
to the First Point of Rest	684,280	11.3	1.4	684,937
On-Terminal HDDV Idling	10,525	0.0	0.0	10,530
Auto Marine Terminals	558	0.0	0.0	559
Container Terminals	9,293	0.0	0.0	9,298
Warehouse Terminals	673	0.0	0.0	673
On-Terminal HDDV Travel	10,031	0.0	0.0	10,035
Auto Marine Terminals	158	0.0	0.0	158
Container Terminals	9,570	0.0	0.0	9,574
Warehouse Terminals	303	0.0	0.0	304
Total	**971,247**	**11.3**	**1.7**	**972,020**

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 Port Commerce CO_2e emissions.

8.3.1. Comparison with Estimates in Previous Studies

Table 8-7 shows the 2012 CO2 equivalent emissions from Port Commerce attracted travel activities in comparison to the 2006, 2007, and 2008 estimates. The 2012 total estimated CO_2e emissions are more than double the 2008 emissions from attracted travel. A portion of this is due to increased activity, as all activity other than idling increased by 21 to 27 percent between 2008 and 2012. The remaining increase in emissions is primarily the result of the change in emission factors and methodology as the result of switching to the MOVES model as discussed in section 1.4.2. Idling activity decreased from 2008 to 2012, leading to a comparable reduction in emissions from this activity.

Table 8-7: Port Commerce HDDV GHG Emissions Comparison, 2006-2008, 2012

Activity	CO2 Equivalent Emissions (metric tons)			
	2006	2007	2008	2012
On-Road HDDV Travel	421,282	441,698	440,496	951,455
On-Terminal HDDV Idling	23,239	24,091	23,786	10,530
On-Terminal HDDV Travel	5,350	5,609	5,591	10,035
Total Attracted Travel	**449,871**	**471,398**	**469,873**	**972,020**

Table 8-8 shows the changes in attracted travel activity between 2006 and 2012 related to Port Commerce. This table indicates that idling activity has decreased significantly at the ports, while the travel both within and to and from the ports has increased. The percent change in activity provides a rough estimation of the change in emissions that would result if the same methodology had been used to calculate emission factors in all inventory years.

Table 8-8: Port Commerce Comparison of Activity, 2006-2008, 2012

Activity	2006	2007	2008	2012	2008 to 2012	2006 to 2012
Number of Trips (one-way)	3,343,982	3,464,366	3,420,894	4,142,632	21%	24%
Idling Hours	4,580,494	4,745,493	4,685,439	1,970,936	-58%	-57%
On-Terminal VMT	3,626,624	3,756,958	3,707,856	4,696,337	27%	29%
On-Road VMT	285,551,652	295,831,511	292,119,340	358,312,340	23%	25%

8.3.2. Port Commerce CAP Emissions

Table 8-9 summarizes 2012 attracted travel CAP emissions at Port Commerce facilities. Criteria pollutant emission factors come from the EPA MOVES model, and are calculated on a g/mi and g/hour idling basis in the same manner as the GHG emission factors. CAP emissions are calculated for idling that occurs in the terminal, travel within the terminal and travel to and from the terminal. As with the GHG emissions, the travel emissions to and from the terminals are broken down to show the portion within the NYNJLINA, as reported by Starcrest, as well as the incremental portion of emissions from travel outside of the NYNJLINA. More than half of the emissions for all pollutants occur on the portion of travel outside of the nonattainment area.

Table 8-9: 2012 Port Commerce HDDV CAP Emissions Summary

Activity	Metric Tons			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
On-Road HDDV Travel	5,991	29.1	418.1	501
to the NYNJLINA boundary	2,154	2	115	119
to the First Point of Rest	3,838	27.0	303.0	382
On-Terminal HDDV Idling	162	0	5	5
Auto Marine Terminals	14	0	0	0
Container Terminals	138	0	4	4
Warehouse Terminals	10	0	0	0
On-Terminal HDDV Travel	101	0	4	4
Auto Marine Terminals	2	0	0	0
Container Terminals	96	0	4	4
Warehouse Terminals	3	0	0	0
Total	**6,254**	**29**	**427**	**510**

9.0 PORT COMMERCE MARINE TERMINALS (SCOPE 3)

9.1. BOUNDARY

9.1.1. Commercial Marine Vessels

The geographical area covered by commercial marine vessels (CMV) includes the counties within the New York New Jersey Long Island Non-Attainment Area (NYNJLINA) and is bounded on the ocean side by the three nautical mile demarcation line off the eastern coast of the U.S. The CMV category encompasses ocean-going vessels as wells as harbor crafts.

9.1.2. Cargo Handling Equipment

The boundary for cargo handling equipment (CHE) includes cargo-handling diesel equipment used in six privately operated Port Authority container terminals:

- Red Hook Container Terminal, LLC at the Brooklyn Port Authority Marine Terminal, along with the secondary barge depot at Port Newark;
- New York Container Terminal (NYCT), at Howland Hook Marine Terminal on
- Staten Island;
- APM Terminal, at the Elizabeth Port Authority Marine Terminal;
- Maher Terminal, at the Elizabeth Port Authority Marine Terminal
- Port Newark Container Terminal (PNCT), at Port Newark; and
- Global Marine Terminal at the Port Jersey Port Authority Marine Terminal.

9.1.3. Vehicle Handling at Auto Marine Terminals

The marine terminals where the handling of vehicles for shipping occurs include:

- Toyota Logistics at Port Newark
- Foreign Auto Preparation Services at Port Newark
- BMW at the Port Jersey Port Authority Auto Marine Terminal

9.1.4. Locomotives

The boundary for locomotives includes switch locomotives at container terminals and travel by line haul locomotives within the boundary of the New York/New Jersey Non-Attainment Area (NYNJLINA) moving cargo to or from the Port Authority's marine terminals. Switch locomotive activity includes all locomotive activity related to movement of cargo within the boundaries of the Port Authority's marine terminals. Line haul locomotive activity includes all activity related to the movement of cargo to or from the Port Authority facilities to or from destinations outside the boundary of the Port Authority facilities, but within the NYNJLINA.

9.2. METHODS

9.2.1. Commercial Marine Vessels

A 2012 GHG and CAP emission inventory for CMVs was prepared for the PANYNJ (Starcrest, 2014). The 2012 GHG and CAP emission estimates from that analysis are summarized at the end of this chapter. A brief summary of the methodology used in the Starcrest inventory is provided here. Further details on the procedures and emission factors used to develop these locomotive emissions can be found in the Starcrest inventory report (Starcrest, 2014).

CMVs are classified into two major categories: ocean going vessels (OGVs) and harbor craft (HC). Activity for the OGVs was based on Automatic Identification System (AIS) data provided to Starcrest by the U.S. Coast Guard. This data source provided information on the position, course, and speed of port arrivals, shifts, and departures. The IAS data for CMVs were supplemented by data from HIS-Fairplay (also referred to as “Lloyd’s data”) to provide vessel profiles including engine type, propulsion horsepower, onboard auxiliary horsepower, and other parameters. Table 9-1 summarizes the vessel calls included in the 2012 CMV inventory for OGVs.

Table 9-1: 2012 Vessel Movements for the Port Authority Marine Terminals

Vessel Type	Number of Calls
Auto Carrier	266
Bulk Carrier	59
Containership	2,033
Cruise Ship	97
General Cargo	30
Reefer	46
RoRo	90
Tanker	76
Total	**2,697**

Source: Starcrest, 2014.

Within HC, different activity data were used for assist tugs and for towboats/pushboats. The number of assist tugs was based on the number and type of OGVs. The relationships developed previously by Starcrest for the 2008 emission inventory effort between OGV type and number of assist tugs was applied in this 2012 inventory to the 2012 OGVs. For towboats and pushboats, the Port Authority marine terminals provided records of towboat/pushboat arrivals and departures. Operating characteristics of the HC, including engine horsepower and average load factors, were based on data from previous Starcrest inventories.

Emissions for both OGVs and HC were calculated using equations that included such parameters as power, load factor, hours operated, emission factor, and fuel correction factor. The Starcrest report (Starcrest, 2014) provides further detail on the emission calculations and the emission factors used.

9.2.2. Cargo Handling Equipment

A 2012 GHG and CAP emission inventory for cargo handling equipment (CHE) was prepared for the PANYNJ (Starcrest, 2014). The 2012 GHG and CAP emission estimates from that analysis are summarized at the end of this chapter. A brief summary of the methodology used in the Starcrest inventory is provided here. Further details on the procedures and emission factors used to develop these locomotive emissions can be found in the Starcrest inventory report (Starcrest, 2014).

Activity needed for the CHE sector includes a listing of equipment, along with the fuel type, hours of use, model year of manufacture, and average horsepower for each piece of equipment or averages of these values for each category of equipment type. Starcrest gathered the needed equipment data from the container terminal operators at the ports.

2012 CO_2 emissions were estimated using EPA's NONROAD2008a model (EPA, 2009). The activity data collected replaced the default model inputs. Table 9-2 summarizes the number of each type of CHE used and shows the NONROAD model category and Source Classification Code (SCC) to which each equipment type was assigned. Table 9-2 also shows the NONROAD model load factor, or average percentage of an engine's rated power output needed to perform its operating tasks, for each category of equipment.

Table 9-2: Summary of Port Commerce 2012 CHE Equipment Inventory

Equipment Type	NONROAD Category	Source Category Code (SCC)	Load Factor	2012 Count
Portable light set	Signal board/light plant	2270002027	0.43	12
Wharf crane	Crane	2270002045	0.43	4
Non-road vehicle	Off-road truck	2270002051	0.59	6
Front end loader	Front end loader	2270002060	0.59	4
Aerial platform	Aerial lift	2270003010	0.21	11
Diesel fork lift	Forklift	2270003020	0.59	105
Propane fork lift	LPG forklift	2267003020	0.30	83
Sweeper	Sweeper/scrubber	2270003030	0.43	9
Chassis rotator	Other industrial equipment	2270003040	0.43	187
Container top loader				
Empty container handler				

Equipment Type	NONROAD Category	Source Category Code (SCC)	Load Factor	2012 Count
Rubber tired gantry crane	Other material handling equipment	2270003050	0.21	303
Straddle carrier				
Terminal tractor	Terminal tractor	2270003070	0.59	465
Total				**1,189**

Source: Starcrest, 2014.

The NONROAD model does not estimate emissions of N_2O or CH_4. Therefore, emission factors for these two GHGs were developed using emission factors obtained from EPA (EPA, 2014). The emission factors were in terms of grams/kg of fuel. The amount of fuel was calculated from the NONROAD estimate of CO_2 emissions since the CO_2 emissions are directly proportional to fuel consumption.

9.2.3. Vehicle Handling at Auto Marine Terminals

In the CHE category, this study accounts for emissions associated with vehicle loading and unloading at the auto marine terminals. Such emissions were quantified for 2002 in a Starcrest emissions inventory report (Starcrest, 2003), but were not assessed in the 2012 Starcrest inventory. This 2002 report includes the average terminal driving distance and the number of vehicles by type (car or light truck) by terminal for the vehicles processed at the auto marine terminals. The total 2002 VMT on-terminal VMT was divided by the total number of vehicles to obtain an average distance traveled by each vehicle of 0.49 miles. This VMT was multiplied by the number of number of vehicles handled at the auto marine terminals in 2012 of 707,416. The resulting VMT was allocated to passenger cars and passenger trucks in the same proportion as the passenger car and truck VMT included in the 2002 inventory report (91.6 percent passenger cars, 8.4 percent passenger trucks).

The vehicles handled at these terminals were primarily expected to be new vehicles. Therefore, emission factors were estimated for model year 2011 using EPA's MOVES model. Emission factors were modeled at a speed of 5 mph, the average on-terminal speed for the auto marine terminals as listed in the 2012 inventory (Starcrest, 2014). All emission factors are based on gasoline-fueled vehicles. Although a small portion of these vehicles may be diesel-fueled, which would increase emissions slightly, overall results would change negligibly since the auto marine emissions represent a very small portion of the Port Commerce emissions inventory. Table 9-3 summarizes the VMT and emission factors used to calculate emissions from the vehicles handled at the auto marine terminals.

Table 9-3: Vehicles Handled at Auto Marine Terminal VMT and Emission Factors

Vehicle Type	2012 VMT	2012 Emission Factors for Model Year 2011 Vehicles		
		CO2	CH4	N2O
Passenger Car	320,035	1,136	0.0051	0.0080
Passenger Truck	29,345	1,296	0.0055	0.0092
Total	**349,380**			

9.2.4. Locomotives

A 2012 GHG and CAP emission inventory for switch and line haul locomotives was prepared for the PANYNJ (Starcrest, 2014). The 2012 GHG and CAP emission estimates from that analysis are presented here. A brief summary of the methodology used in the Starcrest inventory is provided below. Further details on the procedures and emission factors used to develop these locomotive emissions can be found in the Starcrest inventory report (Starcrest, 2014).

9.2.4.1. Line Haul Locomotives

Emission factors used to develop the line haul emission estimates are shown in Table 9-4. Emission factors for CO2 were developed by Starcrest using a mass balance approach. The CH4 and N2O emission factors were obtained from EPA's GHG emission inventory report (EPA, 2011) and the remaining CAP emission factors are from an EPA locomotive rulemaking document (EPA, 2009). The EPA-based emission factors were provided in units of grams per horsepower-hour and were converted to gram per gallon emission factors using a conversion factor of 20.8 horsepower-hours per gallon of fuel (EPA, 2009).

Table 9-4: Line-Haul Locomotive Emission Factors

Units	CO_2	CH_4	N_2O
g/gal	10,186	0.79	0.25
g/hp-hr	489	0.038	0.012

Line haul locomotive activity was developed as the gallons of fuel consumed by line haul locomotives in 2012. This fuel consumption estimate was based on the train schedules, destinations, length, capacity, and average density of .the trains with containers to estimate the total miles traveled by the line-haul locomotives. The average weight of each railcar is then used to estimate the total ton-miles carried in 2012. The ton-miles were then multiplied by a factor of 1.15 gallons of fuel per thousand gross ton-miles. Table 9-5 summarizes the 2012 line-haul locomotive activity.

Table 9-5: 2012 Line-Haul Locomotive Activity

Total Track Mileage	Gross Ton-Miles (thousands)	Gallons Fuel Consumed
80	717,290,834	821,725

9.2.4.2. Switchyard Locomotives

The emission factors used for switching locomotives are shown in Table 9-6. These emission factors were derived from the same sources as the line-haul emission factors (EPA, 2009 and 2011). The Tier 1 emission rates in Table 9-6 apply to locomotives built between 2002 and 2004 while the Tier 0 emission rates apply to locomotives built prior to this time period.

The activity data used in the switching locomotive emission estimates was developed based on growing 2010 activity to 2012. The 2012 data were grown based on the change in containers moved by rail between these two years, yielding a 15 percent growth rate in activity. The activity was separated by emission tier prior to applying the emission rates shown in Table 9-6.

Table 9-6: Switching Locomotive Emission Factors

Units	CO_2	CH_4	N_2O
Tier 0 Emission Factors			
g/gal	10,182	1.52	0.00
g/hp-hr	672	0.10	0.00
Tier 1 Emission Factors			
g/gal	10,182	0.76	0.26
g/hp-hr	672	0.05	0.017

9.3. RESULTS

Table 9-7 shows the GHG emissions from CMVs. Emissions are shown by vessel type and activity. CMV GHG emissions are dominated by CO2 emissions (98 percent), with methane and nitrous oxide contributing significantly less. This table also indicates that CMV emissions are dominated by emissions from OGVs, accounting for approximately 86 percent of CMV GHG emissions.

Table 9-7: 2012 CMV GHG Emissions by Gas and Activity (metric tons)

CMV Category	Activity	CO_2	CH_4	N_2O	CO_2e
OGV	Transit	46,424	2.0	3.0	47,394
OGV	Dwelling	81,505	0.5	4.9	83,035
OGV	Subtotal	127,929	2.5	7.9	130,429
Harbor Craft	Towboats/Pushboats	10,795	3.6	0.9	11,152
Harbor Craft	Assist Tugs	9,034	2.7	0.9	9,372
Harbor Craft	Subtotal	19,828	6.4	1.8	20,524
Total CMV		**147,757**	**8.9**	**9.7**	**150,953**

Table 9-8 summarizes the GHG emission estimates for the CHE categories included in the port commerce inventory. Terminal tractors and straddle carriers combine to account for about 68 percent of the CHE GHG inventory. GHG emissions are dominated by CO2 emissions, accounting for approximately 99 percent of the CO2e emissions.

Table 9-8: 2012 CHE GHG Emissions by Gas and Equipment Type (metric tons)

Equipment Type	CO_2	CH_4	N_2O	CO_2e
Terminal Tractor	45,055	2.55	1.14	45,463
Straddle Carrier	36,050	2.04	0.92	36,376
Fork Lift	2,677	0.15	0.06	2,700
Empty Container Handler	5,652	0.32	0.15	5,703
Laded Container Handler	11,292	0.64	0.29	11,395
Rubber Tired Gantry Crane	8,064	0.45	0.21	8,138
Other Primary Equipment	9,273	0.53	0.24	9,357
Ancillary Equipment	1,793	0.10	0.05	1,810
Total	**119,856**	**6.78**	**3.05**	**120,943**

Table 9-9 provides a summary of the GHG emission estimates from the vehicles handled at the auto marine terminals. These emissions are dominated by passenger cars.

Table 9-9: 2012 GHG Emissions from Vehicles Handled at Auto Marine Terminals (metric tons)

Vehicle Type	CO_2	CH_4	N_2O	CO_2e
Passenger Car	363	0.002	0.003	364
Passenger Truck	38	0.000	0.000	38
Total	**401**	**0.002**	**0.003**	**402**

Table 9-10 summarizes the GHG emission estimates for switch and line haul locomotives. Emissions from line haul locomotive activity are slightly greater than the emissions contributed by switching activity in 2012. GHG emissions are dominated by CO2 emissions, accounting for approximately 99 percent of the CO2e emissions.

Table 9-10: 2012 Locomotive GHG Emissions by Gas (metric tons)

Vehicle Type	CO_2	CH_4	N_2O	CO_2e
Line Haul	8,370	0.66	0.20	8,445
Switching	8,222	0.57	0.19	8,293
Total	**16,591**	**1.23**	**0.39**	**16,738**

Table 9-11 summarizes the Port Commerce 2012 GHG emission inventory by the primary source categories (CMV, CHE, auto marine vehicles, and locomotives) and state. The Port Commerce inventory can no longer be summarized by terminal due to confidentiality concerns. This table indicates that CMV activities account for over half (52 percent) of the GHG emission from port commerce activities in 2012, followed by CHE emissions at 42 percent of the port commerce GHG emissions total. Table 9-11 also shows that for each of these three source categories, GHG emissions from activities at New Jersey terminals and in New Jersey waters account for 3 to 5 times more emissions than the comparable emissions from New York-based activities.

Table 9-11: 2012 Marine Terminals GHG Emissions by Gas, State, and Source Category (metric tons)

Source Category	State	CO_2	CH_4	N_2O	CO_2e
CMV		147,757	8.9	9.7	151,114
	New Jersey	109,331	6.0	7.1	111,774
	New York	38,426	2.8	2.6	39,340
CHE		119,856	6.8	3.0	120,943
	New Jersey	98,554	5.6	2.5	99,448
	New York	21,302	1.2	0.5	21,495
Auto Marine Vehicles		401	0.002	0.003	402
	New Jersey	401	0.002	0.003	402
	New York	N/A	N/A	N/A	N/A
Locomotives		16,591	1.2	0.4	16,738
	New Jersey	12,592	0.9	0.3	12,704
	New York	3,999	0.3	0.1	4,034
Total Marine Terminals		284,606	16.9	13.1	289,197
	New Jersey	220,879	13	10	224,328
	New York	63,726	4.3	3.2	64,869

9.3.1. Comparison with Estimates in Previous Studies

Table 9-12 compares the current 2012 GHG emission estimate for CMVs to the comparable estimates for 2006, 2007, and 2008 from previous inventory efforts for the Port Authority. This table shows a steady decline in GHG emissions from CMV activity over this period, with total CO2e emissions from CMVs decreasing by 34 percent from 2006 to 2012.

Table 9-12: CMV CO_2 Equivalent GHG Emissions Comparison, 2006-208, 2012

CMV Category	CO2 Equivalent Emissions (metric tons)				Percent Difference 2008 to 2012	Percent Difference 2006 to 2012
	2006	2007	2008	2012		
OGV	179,318	177,595	161,326	130,434	-19.1%	-27.3%
Harbor Craft	48,796	34,564	26,617	20,679	-22.3%	-57.6%
Total	**228,114**	**212,159**	**187,943**	**151,114**	-19.6%	-33.8%

Table 9-13 compares the 2012 estimate of CO2 equivalent emissions from CHE activity with comparable estimates for 2006, 2007, and 2008. These emissions peaked in 2007 and have been declining since then. From 2006 to 2012, GHG emissions from CHE activity have decreased by 7 percent.

Table 9-13: CHE GHG Emissions Comparison, 2006-2008, 2012

CO2 Equivalent Emissions (metric tons)				Percent Difference 2008 to 2012	Percent Difference 2006 to 2012
2006	2007	2008	2012		
130,223	133,905	131,729	120,943	-8.2%	-7.1%

Table 9-14 displays the 2012 estimate of GHG emissions from vehicles handled at the auto marine terminals along with emissions from this activity in 2006, 2007, and 2008. Note that due to the change in methodology, the 2012 emissions should not be directly compared with the estimates from the earlier years. The primary change is to MOVES-based emission factors at a speed of 5 mph for the 2012 estimate compared to a fuel-based emission factor in conjunction with a new vehicle fuel economy estimate which does not take into consideration the change in fuel economy that occurs during different driving operation modes. The MOVES-based emission factors for 5 mph is roughly 3 times greater than a MOVES-based emission factor calculated in the same manner, but at 35 mph. Activity, in terms of the number of vehicles handled at the auto marine terminals, is lower in 2012 than in any of the other inventory years, and about 17 percent lower than the 2006 activity.

Table 9-14: Vehicle Handling at Auto Marine Terminals GHG Emissions Comparison, 2006-2008, 2012

CO_2 Equivalent Emissions (metric tons)			
2006	2007	2008	2012[1]
150	156	134	402

[1]Due to the change in methodology between the 2008 and 2012 estimates, the 2012 emissions should not be directly compared with the emissions from earlier years.

Table 9-15 compares 2006, 2007, 2008, and 2012 CO2 equivalent emissions for switch and line haul locomotives. This table also shows the percentage change in emissions from 2008 to 2012 and from 2006 to 2012. Table 9-16 shows the number of containers moved by rail for each of these years. The change in activity from 2006 to 2012 matches reasonably well with the change in CO2 equivalent emissions total from locomotives from 2006 to 2012.

Table 9-15: Locomotive GHG Emissions Comparison, 2006-2008, 2012

Activity	CO_2 Equivalent Emissions (metric tons)				Percent Difference 2008 to 2012	Percent Difference 2006 to 2012
	2006	2007	2008	2012		
Line Haul	8,819	12,044	12,710	8,445	-34%	-4%
Switching	4,526	6,181	6,523	8,293	27%	83%
Total	**13,345**	**18,225**	**19,233**	**16,738**	**-13%**	25%

Table 9-16: Comparison of Containers Moved by Rail 2006 to 2012

Number of Containers Moved by Rail				Percent Difference 2008 to 2012	Percent Difference 2006 to 2012
2006	2007	2008	2012		
338,884	358,403	377,827	433,481	15%	28%

Source: Port Authority, 2014b.

9.3.2. Port Commerce CAP Emission Estimates

The 2012 CAP emission estimates for Port Commerce activities are shown in Tables 9-17, 9-18, 9-19, and 9-20 for CMVs, CHE, auto marine vehicles, and locomotives, respectively. For all of the emission categories other than the auto marine vehicles, NOx emissions are dominant. However, for CMVs, the SO2 emissions are more than half of the NOx emission total with almost all of these emissions contributed by OGVs, while for CHE and locomotives, SO2 emissions are only about 1 metric ton in 2012. Table 9-21 summarizes the 2012 Port Commerce CAP emissions by source category and state. As with GHGs, a majority of the CAP emissions are associated with activity based in New Jersey, and emissions of all the CAP pollutants are dominated by CMVs.

Table 9-17: 2012 CMV CAP Emissions by Activity (metric tons)

CMV Category	Activity	NO_x	SO_2	$PM_{2.5}$	PM_{10}
OGV	Transit	1,336	575.2	124.3	98.0
OGV	Dwelling	943	992.5	102.5	80.7
OGV	Subtotal	2,280	1,568	226.8	178.7
Harbor Craft	Towboats/Pushboats	200	0.8	10.9	10.9
Harbor Craft	Assist Tugs	166	0.8	9.1	9.1
Harbor Craft	Subtotal	366	1.6	20.0	20.0
Total CMV		**2,645**	**1,569**	**246.8**	**198.7**

Table 9-18: 2012 CHE CAP Emissions by Equipment Type (metric tons)

Equipment Type	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Terminal Tractor	420	0.41	30.0	29.2
Straddle Carrier	365	0.34	23.5	22.8
Fork Lift	25	0.03	1.6	1.6
Empty Container Handler	59	0.05	2.5	2.5
Laded Container Handler	94	0.10	3.7	3.6
Rubber Tired Gantry Crane	80	0.07	4.2	4.0
Other Primary Equipment	76	0.10	4.4	4.4
Ancillary Equipment	17	0.02	1.6	1.6
Total	**1,137**	**1.12**	**71.7**	**69.8**

Table 9-19: 2012 Vehicle Handling CAP Emissions by Vehicle Type (metric tons)

Vehicle Type	NO_x	SO_2	$PM_{2.5}$	PM_{10}
Passenger Car	0.014	0.007	0.059	0.009
Passenger Truck	0.002	0.001	0.009	0.001
Total	**0.016**	**0.008**	**0.067**	**0.010**

Table 9-20: 2012 Locomotive CAP Emissions (metric tons)

Activity	NO_x	SO_2	PM_{10}	$PM_{2.5}$
Line Haul	119	0.64	3.27	3.18
Switching	122	0.54	5.26	4.90
Total	**241**	**1.18**	**8.53**	**8.07**

Table 9-21: 2012 Marine Terminals CAP Emissions by State and Source Category (metric tons)

Source Category	State	NO_x	SO_2	PM_{10}	$PM_{2.5}$
CMV		2,645	1,570	247	199
	New Jersey	1,790	1,189	171	138
	New York	855	382	76	61
CHE		1,135	1	72	70
	New Jersey	954	1	60	58
	New York	181	0	12	12
Vehicle Handling at Auto Marine Terminals		0.016	0.008	0.067	0.010
	New Jersey	0.016	0.008	0.067	0.010
	New York	N/A	N/A	N/A	N/A
Locomotives		241	1	9	8
	New Jersey	183	1	7	6
	New York	58	0	2	2
Total		4,021	1,573	327	277
	New Jersey	2,927	1,190	237	202
	New York	1,094	382	89	75

10.0 TUNNELS, BRIDGES, AND TERMINALS ATTRACTED TRAVEL (SCOPE 3)

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

10.1. BOUNDARY

The established boundaries for vehicle travel are the length of each bridge and the average length of each tunnel (Port Authority, 2007c). Table 10-1 provides the roadway length and 2012 traffic volume for each facility.

Table 10-1: Tunnels and Bridges Roadway Length and 2012 Traffic Volume by Facility

Facility Type	Facility Name	Roadway Length[a] (miles)	2012 Annual Traffic Volume[b] (one way)
Bridges	George Washington Bridge	2.54	49,110,921
	Bayonne Bridge	1.88	3,498,502
	Goethals Bridge	1.53	14,003,620
	Outerbridge Crossing	2.05	14,506,663
Tunnels	Lincoln Tunnel	3.75	19,015,035
	Holland Tunnel	3.25	16,117,533

[a] Port Authority, 2007c.
[b] Port Authority, 2013c.

For the analysis of GHG emissions associated with the Port Authority 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.

Two bus terminals are included in this analysis: George Washington Bridge Bus Station (GWBBS) and PABT.

10.2. METHODS

10.2.1. Tunnels and Bridges

This section summarizes the procedures applied for developing the GHG emissions inventory for highway vehicles traveling via the Port Authority's tunnels and bridges. Activity data were developed based on the annual traffic volume and roadway length of the facility (see Table 10-1) received from the Port Authority (Port Authority, 2007c; Port Authority, 2013c). Emissions estimates for CO_2, 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) by the roadway length in miles, as shown in Table 10-1. The result was then multiplied by a factor of two to account for round-trip travel. This was done separately for each of the four Port Authority vehicle types—autos, buses, small trucks, and large trucks—for which the Port Authority had provided 2012 travel volumes on each of the bridges and tunnels listed in Table 10-1 (Port Authority, 2013c).

The CO_2, CH_4, and N_2O emission factors were derived from runs of EPA's MOVES (2010b) model, based on local inputs for the New York counties in which each facility is located as well as the road type associated with each facility. Local inputs included vehicle age-specific distribution data, speed distribution data, fuel properties, meteorological data, and the mix of vehicle types crossing each facility.

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

10.2.2. Bus Terminals

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 2012. The activity for the personal vehicles is the mileage traveled within the terminals and the vehicle starts within the terminals during 2012. Bus activity data come from the Port Authority 2012 Annual Report, which provides the number of bus movements at GWBBS and PABT (Port Authority, 2013b). These activity data were then multiplied by emission factors for CO_2, CH_4, and N_2O from EPA's MOVES model 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 bus movement 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 10-2 summarizes the total 2012 bus movements and dimensions of both bus terminals, along with the corresponding data sources. 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 GWBBS lower level as well as the extra circulation on city streets when the 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 Port Authority report that surveyed and analyzed bus movements within the PABT (Port Authority, 2007d). 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.

Emission factors for buses were obtained from EPA's MOVES model, specifically, emission factors from the transit buses vehicle category. The CO_2, CH_4, and N_2O emission factors are expressed in units of mass per VMT. The CO_2, CH_4, and N_2O emission factors were multiplied by the total bus VMT within the bus terminals. Bus start emissions were also calculated in terms of grams per start, with one start assumed per bus trip. It should be noted that 60 buses fueled on CNG and 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 2012, as shown in Table 10-2. The number of vehicle starts was assumed to be equal to the number of vehicles parked during 2012.

Emission factors for vehicles were obtained from EPA's MOVES model, based on the weighted 10-county New York averages. The bus emission rates used diesel transit bus emission factors, and the vehicle emission factors were based on a weighted average of passenger cars, passenger trucks, and motorcycles. Running emission factors were multiplied by VMT, start-up emission factors were multiplied by the number of vehicle starts, and idling emission factors were multiplied by the number of hours of bus idling.

The resulting emissions from the buses and vehicles were then totaled by bus terminal. The CO_2, CH_4, and N_2O emissions totals were multiplied by their GWP coefficients to calculate total CO_2e emissions.

Table 10-2: 2012 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]	327,000	36,500[c]
Port Authority Bus Terminal	1,200[d]	200[d]	2,555,000	418,500[e]

[a] Source: Port Authority, 2013b.
[b] Source: http://www.panynj.gov/CommutingTravel/bus/html/gabout.html.
[c] Estimated as 100 vehicles parked per day multiplied by 365 days per year.
[d] Terminal size was 400 by 800 feet in 1963 and was expanded by 50% in the late 1980s, so the original length of 800 feet was multiplied by 1.5 to obtain the current length of 1,200 feet.
[e] Source: Port Authority, 2007e.

10.3. RESULTS

10.3.1. Tunnels and Bridges

Table 10-3 summarizes the transportation-related GHG emission estimates for the facilities included in this inventory.

Table 10-3: 2012 Tunnels and Bridges Attracted Travel GHG Emissions by Gas

Facility Name	Metric Tons			
	CO_2	CH_4	N_2O	CO_2e
Bridges				
George Washington Bridge	133,754	1	108	167,380
Bayonne Bridge	10,248	0	6	12,183
Goethals Bridge	20,553	0	16	25,380
Outerbridge Crossing	44,452	0	28	53,223
Tunnels				
Lincoln Tunnel	165,997	2	99	196,601
Holland Tunnel	49,820	0	46	63,964
Total[a]	**424,825**	**5**	**303**	**518,731**

[a] Totals may not add up due to rounding

In 2012, 518,731 metric tons of CO_2e GHG emissions were associated with travel across Port Authority 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.

10.3.1.1. Comparison with Estimates in Previous Studies

Table 10-4 provides a comparison of the 2012 GHG emission results for attracted travel on Port Authority tunnels and bridges with the 2008 emissions calculated for these same facilities, in terms of CO_2e emissions. The estimated attracted travel CO_2e emissions from tunnels and bridges increased by 56 percent from 2008 to 2012, with emissions from the Lincoln Tunnel more than doubling over that time. In contrast, estimated emissions on the Goethals Bridge increased by 13 percent.

Table 10-4: Tunnels and Bridges Attracted Travel GHG Emissions Comparison, 2008 and 2012

Facility	CO_2 Equivalent (metric tons) 2008	2012	Percentage Difference (2008 vs. 2012)
Bridges			
George Washington Bridge	135,192	167,380	24%
Bayonne Bridge	7,210	12,183	69%
Goethals Bridge	22,401	25,380	13%
Outerbridge Crossing	29,174	53,223	82%
Tunnels			
Lincoln Tunnel	91,591	196,601	115%
Holland Tunnel	46,809	63,964	37%
Total	**332,377**	**518,731**	**56%**

Although emissions from attracted travel show an increase on all tunnels and bridges, the activity across the tunnels and bridges, expressed as either one-way vehicle volumes or total VMT, decreased at all facilities over this same time period, with an overall decrease in VMT across all facilities of 6.5 percent, as shown in Table 10-5. Because activity decreased in all cases, the increases in emissions are the result of the change in emission factors caused by switching to the MOVES model to calculate 2012 emissions, as discussed in Section 1.4.2.

Table 10-5: Comparison of Attracted Travel Activity on Tunnels and Bridges, 2008 and 2012

Facility	One-Way Travel Volumes 2008	One-Way Travel Volumes 2012	VMT (Two Ways) 2008	VMT (Two Ways) 2012	Percentage Change in VMT (2008 vs. 2012)
Bridges					
George Washington Bridge	52,947,247	49,110,921	134,263,388	124,535,250	-7.2%
Bayonne Bridge	3,746,483	3,498,502	7,024,656	6,559,691	-6.6%
Goethals Bridge	14,107,912	14,003,620	21,514,566	21,355,521	-0.7%
Outerbridge Crossing	15,116,115	14,506,663	30,988,036	29,738,659	-4.0%
Tunnels					
Lincoln Tunnel	20,937,090	19,015,035	78,514,088	71,306,381	-9.2%
Holland Tunnel	16,870,502	16,117,533	54,829,132	52,381,982	-4.5%
Total	**123,725,349**	**116,252,274**	**327,133,864**	**305,877,485**	**-6.5%**

Figure 10-1 illustrates the change in activity expressed as average daily one-way vehicle volumes from all of the tunnels and bridges for each year from 2006 through 2012, including the average daily volumes each month in 2012. The effects of Hurricane Sandy can be seen in the October and November 2012 average daily volumes. This figure also shows a general downward trend in vehicle volumes crossing these bridges and tunnels since 2007.

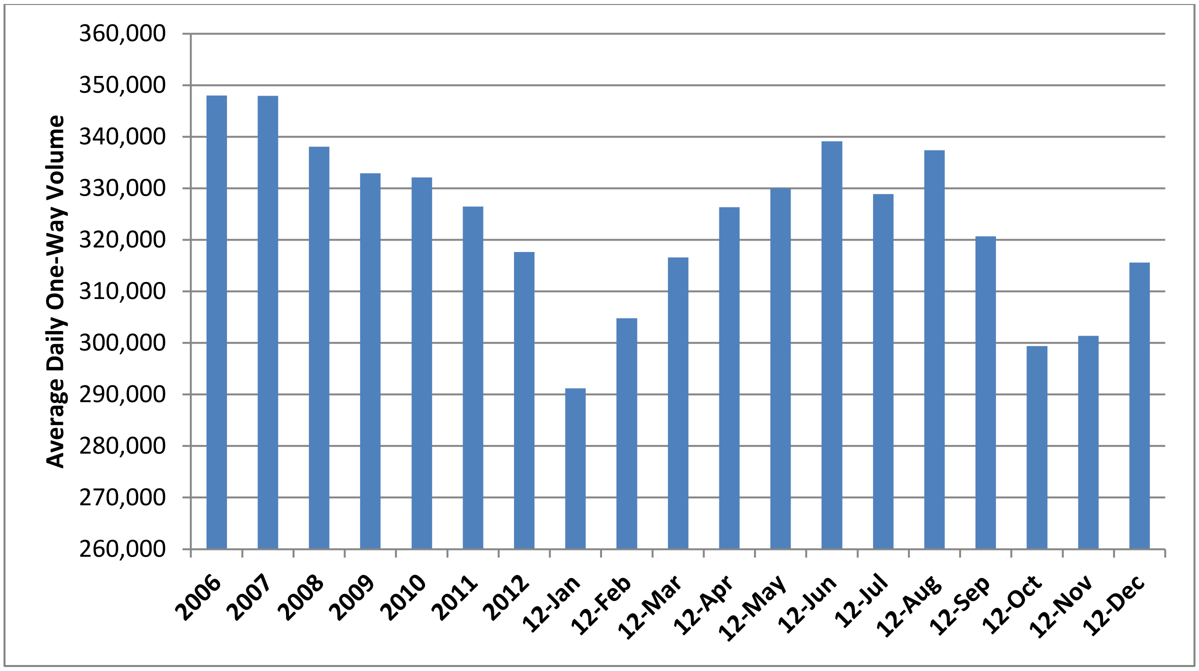

Figure 10-1: Average Daily One-Way Volume on Port Authority Tunnels and Bridges, 2006–2012

In summary, the increase in attracted travel emissions for the Port Authority tunnels and bridges from 2008 to 2012 is due exclusively to the change to MOVES-based CO_2 emission rates. Travel volumes across the tunnels and bridges decreased by more than 6 percent, leading to a corresponding decline in VMT. Thus, if emission factors for the earlier years were calculated in a manner consistent with the 2012 estimates, the GHG emissions from attracted travel on the Port Authority tunnels and bridges would likely have decreased by more than 6 percent from 2008 to 2012 as a result of improved fleet-wide fuel economy in combination with the decreased travel volumes observed over this time period. No other methodological changes were made for this category.

10.3.1.2. Tunnels and Bridges Attracted Travel CAP Emissions Summary

Table 10-6 summarizes annual CAP emissions for the Port Authority bridges and tunnels. For each of these pollutants, the emission totals are dominated by the emissions from the Lincoln Tunnel. These emissions were calculated in the same manner as the GHG pollutants, using the MOVES models for the affected counties and roadway types.

Table 10-6: 2012 Tunnels and Bridges Attracted Travel CAP Emissions

Facility Name	Metric Tons			
	NO_x	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Bridges				
George Washington Bridge	348	2.7	29.4	21.1
Bayonne Bridge	19	0.2	2.0	1.2
Goethals Bridge	44	0.4	3.1	2.3
Outerbridge Crossing	72	0.9	7.9	4.6
Tunnels				
Lincoln Tunnel	932	3.5	59.4	45.3
Holland Tunnel	101	0.9	9.0	5.9
Total	**1,516**	**8.6**	**110.9**	**80.5**

10.3.2. Bus Terminals

Table 10-7 summarizes the GHG emission estimates that occur within GWBBS and PABT boundaries. These emissions are displayed by facility and for buses and personal vehicles within each facility. Emissions at the PABT are more than five times greater than emissions at the GWBBS. This is reasonable, given the differences in magnitude of bus operations of the two facilities. 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 nearly 99 percent of the CO_2e emissions. The amount of time the buses spend idling within the terminals and the speeds the buses travel within the 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 typically turn their engines off while parked in the terminal, the emissions from idling could be significantly different.

Table 10-7: 2012 Bus Terminal Attracted Travel GHG Emissions by Gas

Facility/Activity	Metric Tons			
	CO_2	**CH_4**	**N_2O**	**CO_2e**
George Washington Bridge Bus Station	**525**	**0.0**	**0.0**	**531**
In-Terminal Bus Emissions	517	0.0	0.0	522
In-Terminal Car Emissions	8	0.0	0.0	9
Port Authority Bus Terminal	**4,613**	**0.3**	**0.1**	**4,657**
In-Terminal Bus Emissions	4,457	0.2	0.1	4,491
In-Terminal Car Emissions	156	0.0	0.0	166
Total	**5,138**	**0.3**	**0.1**	**5,188**
In-Terminal Bus Emissions	4,975	0	0	5,013
In-Terminal Car Emissions	163	0	0	174

10.3.2.1. Comparison with Estimates in Previous Studies

Table 10-8 compares the GWBBS and PABT bus terminal GHG emissions for 2006, 2007, 2008, and 2012. Between 2008 and 2012, GHG emissions from vehicle movements at GWBBS have increased, whereas emissions at PABT have declined. Overall, bus movements declined by 3 percent at GWBBS and by 40 percent at PABT between 2008 and 2012. Emissions have gone down by less than this amount at PABT (and increased at GWBBS) due to the change in methodology resulting from switching to the MOVES model as discussed in Section 1.4.2. Other than the change to the MOVES model, no methodology changes were made to the bus terminal activity and emission calculations.

Table 10-8: Bus Terminal GHG Emissions Comparison, 2006–2008, 2012

Facility/Activity	CO_2 Equivalent (metric tons)			
	2006	2007	2008	2012
George Washington Bridge Bus Station	**611**	**395**	**416**	**531**
In-Terminal Bus Emissions	607	391	412	522
In-Terminal Car Emissions	4	4	3	9
Port Authority Bus Terminal	**5,734**	**4,193**	**4,261**	**4,657**
In-Terminal Bus Emissions	5,645	4,103	4,198	4,491
In-Terminal Car Emissions	89	90	63	166
Total	**6,345**	**4,588**	**4,677**	**5,188**
In-Terminal Bus Emissions	6,252	4,494	4,610	5,013
In-Terminal Car Emissions	93	94	66	174

10.3.2.2. Bus Terminal Attracted Travel CAP Emission Summary

Table 10-9 summarizes the CAP emissions resulting from attracted travel at the Port Authority bus terminals. As with the GHG emissions, the CAP emissions from the PABT are much greater than those from the GWBBS.

Table 10-9: 2012 Bus Terminal Attracted Travel CAP Emissions by Pollutant

Facility/Activity	Metric Tons			
	NO_x	SO_x	PM_{10}	$PM_{2.5}$
George Washington Bridge Bus Station	**15.2**	**0.0**	**0.4**	**0.4**
In-Terminal Bus Emissions	15.1	0.0	0.4	0.4
In-Terminal Car Emissions	0.0	0.0	0.0	0.0
Port Authority Bus Terminal	**119.2**	**0.1**	**3.2**	**3.4**
In-Terminal Bus Emissions	118.7	0.1	3.2	3.4
In-Terminal Car Emissions	0.5	0.0	0.0	0.0
Total	**134.4**	**0.2**	**3.6**	**3.8**
In-Terminal Bus Emissions	133.9	0.2	3.6	3.8
In-Terminal Car Emissions	0.6	0.0	0.0	0.0

11.0 TUNNELS, BRIDGES & TERMINALS QUEUING (SCOPE 3)

11.1. 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. The following facilities are included in this analysis:

- George Washington Bridge
- Bayonne Bridge
- Goethals Bridge
- Outerbridge Crossing
- Lincoln Tunnel
- Holland Tunnel

11.2. METHODS

Activity data for queuing activity on the tunnels and bridges, in terms of vehicle-hours of delay, were multiplied by CO_2 emission factors, in terms of mass per hour of idling activity, to estimate GHG emissions. The activity used for queuing was the number of hours of vehicle delay estimated for 2012 (Skycomp, 2013). The estimated number of vehicle hours of delay was then multiplied by emission factors (mass emissions per hour) to calculate the emissions resulting from queuing at the toll facilities.

The data on vehicle queuing times for the tunnels and bridges were based on a Skycomp study conducted in 2012 for the Port Authority (Skycomp, 2013). This study presented data on volumes and queue travel times based on aerial photos of the surveyed facilities. Two spring and two fall survey flights were conducted on weekdays 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 weekday flights. The spring flights occurred in May 2012 and the fall flights took place in October and December 2012. (Due to Hurricane Sandy, the December flights replaced flights originally scheduled for November 2012.)

For each facility, season, and peak period, the Skycomp survey data presented hourly volumes and the average hourly queue travel time. The 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. No information specific to delays on weekends during 2012 were available. However, based on Skycomp data from weekend flights for 2006, the average daily hours of vehicle delay on weekends is often as high as or higher than the average weekday hours of delay. Therefore, the total annual vehicle hours of delay were calculated by multiplying these weekday estimates by 366 days. Table 11-1 summarizes the 2012 average daily vehicle-hours of delay by facility.

Table 11-1: 2012 Estimated Daily Average Vehicle-Hours of Delay by Tunnel and Bridge Facility

Facility	Average Daily Vehicle-Hours of Delay, Weekday 2012
George Washington Bridge	2,293
Bayonne Bridge	0
Goethals Bridge	13
Outerbridge Crossing	7
Lincoln Tunnel	6,778
Holland Tunnel	4,826
Total	**13,918**

Once the 2012 annual vehicle hours of delay were estimated for each facility, 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. The idling emission factors vary by vehicle type.

Emission factors for idling were calculated using the MOVES model. To obtain emission factors for idling, the analysts developed operating mode distributions, with 100 percent of the hours of vehicle operation occurring in the idling mode. MOVES runs were modeled using these operating mode distributions along with the county-specific inputs for New York County and Richmond County, New York (the two New York counties where these facilities are located). The resulting emissions from idling were divided by the corresponding hours of vehicle operation to obtain MOVES emission factors in terms of grams of emissions per vehicle-hour of idling.

The resulting MOVES idling emission factors by Port Authority vehicle type were multiplied by the annual vehicle hours of delay for the corresponding vehicle type to obtain queuing emissions for 2012.

11.3. RESULTS

Table 11-2 summarizes the GHG emission estimates from queuing at the Port Authority’s tunnels and bridges. About half of the queuing emissions occurred on the Lincoln Tunnel. GHG emission estimates for queuing at the

George Washington Bridge and the Holland Tunnel combined accounted for 49 percent of the total CO_2e emissions. Queuing emissions from the Bayonne Bridge, Goethals Bridge, and Outerbridge Crossing are negligible.

Table 11-2: 2012 Tunnels and Bridges Queuing GHG Emissions by Gas

Facility Name	Metric Tons			
	CO_2	CH_4	N_2O	CO_2e
Bridges				
George Washington Bridge	3,538	0.11	0.14	3,585
Bayonne Bridge	0	0.00	0.00	0
Goethals Bridge	20	0.00	0.00	21
Outerbridge Crossing	11	0.00	0.00	11
Tunnels				
Lincoln Tunnel	11,083	0.35	0.41	11,217
Holland Tunnel	7,173	0.23	0.31	7,273
Total	**21,826**	**0.70**	**0.86**	**22,106**

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. The 2012 survey samples only eight weekdays out of the entire year. Therefore, observed data may not provide a representative sample of conditions during the entire year. Additionally, for this analysis, weekend delays were assumed to be the same as weekday delays. As no survey flights were conducted on weekends in 2012, the amount of queuing from weekend traffic includes a significant amount of uncertainty.

11.3.1. Comparison with Estimates in Previous Studies

Table 11-3 compares the 2008 and 2012 CO_2e results. Table 11-4 compares estimated activity for these two years in terms of annual vehicle-hours of delay. Using the MOVES-based emission factors had minimal or no impact on the change in emissions from 2008 to 2012 because the modeling emissions is not sensitive to driving behavior such as idling, acceleration, and sudden stops. For this reason, estimates of idling emissions correspond much better to changes in activity than emissions related to vehicle travel.

Table 11-3: Tunnels and Bridges Queuing GHG Emissions Comparison, 2008 and 2012

Facility	CO_2 Equivalent Emissions (metric tons)		Percentage Difference (2008 vs. 2012)
	2008	2012	
Bridges			
George Washington Bridge	7,924	3,585	-55%
Bayonne Bridge	1	0	-100%
Goethals Bridge	1,295	21	-98%
Outerbridge Crossing	168	11	-93%
Tunnels			
Lincoln Tunnel	9,729	11,217	15%
Holland Tunnel	4,348	7,273	67%
Total	**23,464**	**22,106**	**-6%**

Table 11-4: Comparison of Annual Queuing Delay on Tunnels and Bridges, 2008 and 2012

Facility	Annual Vehicle-Hours of Delay		Percentage Difference (2008 vs. 2012)
	2008	2012	
Bridges			
George Washington Bridge	1,758,862	839,279	-52.3%
Bayonne Bridge	128	0	-100.0%
Goethals Bridge	287,213	4,750	-98.3%
Outerbridge Crossing	37,343	2,717	-92.7%
Tunnels			
Lincoln Tunnel	2,150,530	2,480,765	15.4%
Holland Tunnel	973,996	1,766,379	81.4%
Total	**5,208,072**	**5,093,890**	**-2.2%**

While the overall change in activity from all tunnels and bridges combined is relatively small, there were significant changes at the individual facility level. These changes in activity result in part from a change in methodology. The 2008 hours of delay for the Holland Tunnel and the George Washington Bridge are based on 2006 Skycomp survey data while the 2008 data for the remaining facilities were based on 2006 Transcom data (Port Authority, 2008b). The 2006 Skycomp and Transcom hours of delay were grown to 2008 based on the change in vehicle volumes from 2006 to 2008 for each facility. In addition, the 2006 data included estimates of both weekday and weekend day hours of delay, while in the 2012 analysis, the weekday estimates of delay were applied on weekends as well.

11.3.2. Tunnels and Bridges Queuing CAP Emissions Summary

Table 11-5 summarizes the CAP emissions that result from queuing on the Port Authority tunnels and bridges in 2012. More than half of the NO_x and PM_{10} queuing emissions resulted from buses idling on the Lincoln Tunnel.

Table 11-5: 2012 Tunnels and Bridges Queuing CAP Emissions from Queuing

Facility	Metric Tons			
	NO_x	SO_2	PM_{10}	$PM_{2.5}$
Bridges				
George Washington Bridge	10.6	0.1	0.5	0.4
Bayonne Bridge	0.0	0.0	0.0	0.0
Goethals Bridge	0.1	0.0	0.0	0.0
Outerbridge Crossing	0.0	0.0	0.0	0.0
Tunnels				
Lincoln Tunnel	71.7	0.2	2.1	2.0
Holland Tunnel	13.1	0.1	0.6	0.5
Total	**95.4**	**0.4**	**3.2**	**3.0**

12.0 PATH ATTRACTED TRAVEL (SCOPE 3)

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

12.1. 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 (hereafter referred to as "Journal Square") 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.

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

12.2. 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. The activity indicator for both modes of travel is VMT. Cold-start emissions were also calculated based on vehicle trips. Idling emissions were calculated for the Journal Square bus stations. VMT data were multiplied by emission factors from MOVES to estimate emissions associated with attracted travel at PATH train stations.

12.2.1. Vehicle Access to PATH Train Stations

Activity for vehicles bringing passengers to the PATH train stations was estimated based on the average number of PATH passengers on a weekday and a weekend in 2012 (Port Authority, 2012b). This survey also assigned travel modes to PATH passengers; the PATH access and egress modes associated with personal vehicles included the following: Auto: Drove; Auto: Passenger; Commuter Van; and Taxi. Other modes of travel were included in the survey, such as walking, NJ Transit, and Amtrak, but these modes of travel do not have any emissions estimated for them. The total number of 2012 PATH passengers was multiplied by the fraction of PATH commuters using one of these listed modes. This calculation was performed separately for weekdays and weekends/holidays. Once the number of passengers using personal vehicles to travel to the PATH stations was calculated, estimates of vehicle occupancy were used to determine the number of vehicles traveling to and from the PATH stations. Average vehicle occupancy for the Auto: Drove, Auto: Passenger, and Taxi categories comes from a 2009 National Household Travel Survey of average vehicle occupancy based on trip types (DOT, 2009). The assumption of eight passengers per commuter van is based on an EPA report on vanpool benefits (EPA, 2005b). Table 12-1 displays the occupancy used for weekends and weekdays.

Table 12-1: Average Vehicle Occupancy for Weekdays and Weekends/Holidays

Travel Mode	Assumed Vehicle Occupancy – Weekdays	Assumed Vehicle Occupancy – Weekends, Holidays
Auto: Drove	1.00	1.00
Auto: Passenger	1.13	1.67
Commuter Van	8.00	8.00
Taxi	1.13	1.67

Table 12-2 shows the number of passengers estimated by access/egress mode, the vehicle occupancy assumed for each type of vehicle mode, and the estimated number of vehicle trips by mode. For Auto: Drove, Commuter Van, and Taxi, the number of passengers divided by vehicle occupancy is used to estimate total vehicle trips. For Auto: Passengers, this accounts for both people driving in vehicles that were already heading to the PATH station (hereafter referred to as "passenger trips") and passengers who are dropped off ("drop-off trips") by vehicles that otherwise would not be driving to a PATH station. Only the emissions from those drop-off trips are calculated for Auto: Passenger (passenger trips are already included in the Auto: Drove category, so including them would be double counting). The portion of Auto: Passenger trips that were drop-offs were calculated by subtracting the passenger trips from the total Auto: Passenger trips. The passenger trips were estimated by multiplying the assumed vehicle occupancy minus 1 by the number of Auto: Drove trips. For example, there were 4,494,704 Auto: Drove trips, which was multiplied by vehicle occupancy from Table 12-1 to get a total of 516,211 passengers who arrived with drivers in the Auto: Drove portion of the total estimate:

4,494,704 Auto: Drove × (1.13 – 1) = 516,211 passengers

These passengers were subtracted from the Weekday Auto: Passengers total (1,100,523) to get an estimate of 516,211 weekday passengers dropped off. This figure was then divided by assumed vehicle occupancy (1.13) to get the Auto: Passenger weekday vehicle trips of 456,824.

Table 12-2: 2012 Passengers, Vehicle Occupancy, and Estimated Vehicle Trips

Travel Mode	2012 Total Passengers		Assumed Vehicle Occupancy		Estimated Vehicle Trips	
	Weekdays	Weekends and Holiday	Weekday	Weekend and Holiday	Weekdays	Weekend and Holiday
Auto: Drove	4,494,704	943,630	1.00	1.00	4,494,704	943,630
Auto: Passenger	1,100,523	296,972	1.13	1.67	456,824	0
Commuter Van	373,863	33,702	8.00	8.00	46,733	4,213
Taxi	697,176	399,901	1.13	1.67	616,969	239,462
Total	**6,666,265**	**1,674,206**			**5,615,230**	**1,187,305**

Average trip length was estimated based on information provided by the Port Authority on passenger origin by access mode (Port Authority, 2012b). This study included a survey of where each passenger arrived from and the travel mode they used to get to their PATH station. To estimate the distances travelled, the PATH stations were divided into three categories: Outer Jersey (Harrison and Newark Penn Station), Inner Jersey (Journal Square, Grove Street, Exchange Place, Newport, and Hoboken), and New York City (World Trade Center, Christopher Street, 9th Street, 14th Street, 23rd Street, and 33rd Street). For each of these categories, a single station (9th street for New York City, Journal Square for Inner Jersey, and Newark Penn Station for Outer Jersey) was used as the surrogate for distances traveled. Table 12-3 shows the driving distances travelled for each station, which were estimated using Google Maps. The surrogate location used for estimating travel distance represents the most populous locality within the county or jurisdiction. This approach represents an enhancement over previous inventories, in which the centroid of the county/jurisdiction was used to determine one-way travel distances. These distances travelled were multiplied by the percentage of passengers at each station that came from each location to get an average trip length. Table 12-3 does not include distances for some locations because some location/station combinations were not included in the PATH origin/destination survey results (Port Authority, 2012b).

Table 12-3: One-Way Travel Distances Associated with PATH Stations

Origin/Destination		Miles to/from		
County/Jurisdiction	**Surrogate Location**	**Outer Jersey**	**Inner Jersey**	**New York**
Essex County	East Orange	5	10	
Bergen County	Hackensack	16	13	
Middlesex County	Edison	26	31	
Newark	Newark	1		
Hudson County (not Hoboken and Not Jersey City)	Union City	10	5	
Union County	Elizabeth	6	11	
Morris County	Parsippany-Troy Hills	20	25	
Monmouth County	Middletown	35	40	
Somerset County	Franklin Township	32	37	
Mercer County	Hamilton Township	53	58	
Passaic County	Paterson	15	18	
Sussex County	Vernon Township	46	49	
Burlington County	Evesham Township	79		
Warren County	Philipsburg	59		
Gloucester County	Washington Township	92		
Jersey City	Jersey City		2	
Manhattan	Manhattan			2
Brooklyn	Brooklyn			9
Queens	Queens			13
Bronx	Bronx			14
Staten Island	Staten Island			18
Other NY State	Yonkers			15
Connecticut	Stamford			38
New Jersey Other		50	50	
Pennsylvania		70	70	
New York	Nanuet		31	
Other		75		

As indicated in Table 12-4, total vehicle trips by travel mode were multiplied by average trip length to estimate total VMT.

Table 12-4: 2012 VMT by Travel Mode

Travel Mode	Estimated Vehicle Trips		Average Trip Length (Miles)		Total VMT (Miles)
	Weekday	Weekend and Holiday	Weekday	Weekend and Holiday	
Auto: Drove	4,494,704	943,630	16.7	16.0	89,999,714
Auto: Passenger	456,824	0	9.4	11.4	4,312,178
Commuter Van	46,733	4,213	12.7	6.0	620,289
Taxi	616,969	239,462	8.3	5.4	6,425,208
Total	**5,615,230**	**1,187,305**			**101,357,390**

Once VMT estimates were developed for all vehicle attracted travel to PATH stations, annual VMT was calculated by mode by multiplying the VMT from weekday trips by 253 and the weekend/holiday daily VMT by 52. Emission factors for attracted travel at the PATH stations were calculated using EPA's MOVES model (EPA, 2012b) based on input data for the 10 New York metropolitan counties. For personal vehicle travel, the emission factors were based on the weighted average of the MOVES passenger car, passenger truck, and motorcycle vehicle types over the 10 counties. Running emission factors (grams/mile) were multiplied by VMT, and start-up emission factors were multiplied by the number of trips, except taxi trips, for which no start-up emissions were estimated.

12.2.2. 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 2012 bus departures from Journal Square by an estimated trip length of 5 miles from Journal Square. The 5-mile commuting distance to Journal Square was estimated by taking the national average one-way commuting distance of 12 miles (Pisarski, 2006) and subtracting the estimated average PATH train ride distance of seven miles (from Journal Square to 33rd Street). The resulting VMT was multiplied by two to account for both the trip to and the trip from Journal Square. Annual bus departure data for 2012 provided by the Port Authority (Panepinto, 2013) indicated that 344,303 buses departed from Journal Square in 2012. CO_2, CH_4, and N_2O emission factors for diesel transit buses from MOVES, representing the 10-county New York weighted average data, were multiplied by VMT to estimate total emissions.

Idling emissions were estimated based on data from a survey conducted at Journal Square in 2008 (PATH, 2008). Total emissions from bus idling were calculated by multiplying the average idling time per bus (2.413 minutes) (PATH, 2008) by the annual number of bus movements at Journal Square in 2012 (344,303) (Panepinto, 2013). Using this method, this report estimated that buses idled 13,845 hours at Journal Square in 2012. These hours were then multiplied by the idling emissions factor for diesel transit buses from MOVES to estimate total idling emissions.

The resulting emissions from both buses and vehicles were summed by bus terminal. The CO_2, CH_4, and N_2O emissions were multiplied by their GWP coefficients to calculate total CO_2e emissions.

12.3. RESULTS

Table 12-5 summarizes the GHG emission estimates for vehicle trips to and from the PATH stations, as well as for the bus trips to and from Journal Square. 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 (more than 99 percent of total CO_2e emissions), with emissions of CH_4 and N_2O contributing much less.

Table 12-5: 2012 PATH Attracted Travel GHG Emissions by Gas

Facility	Metric Tons			
	CO_2	CH_4	N_2O	CO_2e
PATH Vehicle Trips Attracted	54,245	1.22	1.01	54,583
Bus Trips at Journal Square	5,471	0.10	0.03	5,481
PATH Attracted Travel Total	**59,716**	**1.32**	**1.04**	**60,064**

12.3.1. Comparison with Estimates in Previous Studies

In comparison with 2008 emissions from PATH attracted travel, 2012 total estimated CO_2e emissions increased significantly. Emissions from bus trips from Journal Square decreased, primarily due to the decrease in bus activity. In contrast, emissions from vehicle trips increased 170 percent between 2008 and 2012. This is primarily to the result of two major changes in emissions-calculating methodology between the 2008 and 2012 analyses. The most important change was the use of actual origin and destination data for PATH attracted travel trips for 2012, for which data had not been available in prior years. This increased overall VMT from PATH trips from 60 million miles to 105 million miles, an increase of 75 percent. The other major methodology change was the switch to the MOVES model and use of MOVES emission factors, which also led to some higher emissions estimates as discussed in previous sections of this report. These two changes combined to significantly increase the estimated emissions from PATH vehicle trips. Table 12-6 summarizes PATH attracted travel emissions in 2006, 2007, 2008, and 2012.

Table 12-6: PATH Attracted Travel GHG Emissions Comparison, 2006–2008, 2012

Facility	CO_2 Equivalent Metric Tons			
	2006	2007	2008	2012
PATH Vehicle Trips Attracted	16,526	19,382	20,188	54,583
Bus Trips at Journal Square	11,279	11,280	11,408	5,481
Total	**27,805**	**30,662**	**31,597**	**60,064**

12.3.2. PATH CAP Emissions Summary

Table 12-7 summarizes the CAP emissions estimates for PATH attracted travel.

Table 12-7: 2012 PATH Attracted Travel CAP Emissions

Facility	Metric Tons			
	NO_x	SO_2	$PM_{2.5}$	PM_{10}
PATH Vehicle Trips Attracted	50.6	0.9	2.4	5.5
Bus Trips at Journal Square	81.0	0.2	4.6	5.0
PATH Attracted Travel Total	**131.6**	**1.1**	**7.0**	**10.5**

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