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

Calendar Year 2011

Final Report

Prepared for:

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

Prepared by:

Southern Research Institute
Durham, NC

and

SC&A, Inc.
Vienna, VA

January 2014

(This page intentionally left blank)

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AC	air conditioning
B20	20-percent biodiesel
Btus	British thermal units
CAD	Central Automotive Department
CAP	criteria air pollutant
ccf	100 cubic feet
CFCs	chlorofluorocarbons
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
eGRID	Emissions & Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
EWR	Newark Liberty International Airport
g	gram(s)
E10	10-percent ethanol
E85	85-percent ethanol
EY	emission year
g/hp-hr	grams per horsepower-hour
gal	gallon
GHG	greenhouse gas
GRP	General Reporting Protocol
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFCs	hydrofluorocarbons
hr	hour
HVAC	heating, ventilation, and air conditioning
IPCC	Intergovernmental Panel on Climate Change
JFK	John F. Kennedy International Airport
kg	kilogram
KIAC	Kennedy International Airport Cogeneration
kWh	kilowatt hours
LandGEM	EPA’s Landfill Gas Emissions Model
LGA	LaGuardia Airport
LPG	liquefied petroleum gas
MARKAL	EPA’s MARKet ALlocation database
MMBtu	million British thermal units
MOVES	EPA’s Motor Vehicle Emissions Simulator
MWh	megawatt hour(s)
N_2O	nitrous oxide
NA	not applicable
NG	natural gas
NO_x	oxides of nitrogen
NPCC	Northeast Power Coordinating Council
N.Q.	not quantified
NYC	New York City
NYNJR	New York New Jersey Rail
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
SEM	Simplified Estimation Method
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
Southern	Southern Research Institute
SWF	Stewart International Airport
TEB	Teterboro Airport
The Registry	The Climate Registry
tpy	ton(s) per year
VOCs	volatile organic compounds
WIP	work-in-place
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, 2008). 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, and 2010.

The completion of the 2011 inventory documented in this report represents an important milestone for the Port Authority. This report describes the development and results of the GHG emissions estimates for 2011 being reported to The Climate Registry. This includes all scope 1 and 2 emissions, as well as the emissions estimates for some optional scope 3 emission sources (construction equipment, the Cross-Harbor Freight Program, and airport fleet vehicles) that are services performed by Port Authority contractors. The use of a consistent and high-quality protocol for the 2010 and 2011 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 2011 were 281,368 metric tons of carbon dioxide equivalent (CO_2e) gases. This compares with a 2010 estimate of 298,223.4 metric tons CO_2e. In 2011, electricity usage in Port Authority occupied buildings, PATH trains, and AirTrain JFK and AirTrain Newark accounted for 73 percent of the GHG emissions total. Other important Port Authority activities in terms of GHG emissions were fuel combustion for heating buildings (13.7 percent of GHGs) and motor vehicle fuel combustion (4.4 percent of GHGs). The Port Authority's electricity consumption declined by 2.3 percent from 2010 to 2011 which is equivalent to 22,088 metric tons CO_2e; on the other hand, increases in natural gas fuel consumption and motor vehicle fuel usage increased by 6.9 percent or 3,215 metric tons CO_2e in the same time period.

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), and LaGuardia Airport (LGA); 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, and 2010.

The sections of the 2011 inventory pertaining to scope 1 and scope 2 GHG emissions were developed in conformance with The Climate Registry's (The Registry's) "General Reporting Protocol – Version 2.0" (GRP) (TCR, 2013). 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 accurate records, The Registry permits the use of Simplified Estimation Methods (SEMs), provided that SEM emissions do not exceed five percent of total emissions. Additionally, the consulting team developed scope 3 emissions estimates for emitting activities associated with the Shadow Fleet[3], the Cross-Harbor Freight Program[4], and construction activities associated with capital projects.

[1] Scope 1 emissions encompass an organization's direct GHG emissions from stationary and mobile fuel combustion, as well 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 organizational and 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.
[3] The Shadow Fleet comprises vehicles owned by the Port Authority and stationed at the airports that are operated by contractors.
[4] The Cross-Harbor Freight Program targets more efficient ways to move freight across New York Harbor to the east-of-Hudson region by floating railcars on barges.

1.2. VOLUNTARY REPORTING WITH THE CLIMATE REGISTRY

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 2011 GHG inventory was developed according to the following specifications.

Scope

Emission Year:	2011
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)

Criteria

The GHG emissions estimates for 2011 were developed using The Registry's GRP Version 2.0 and "2013 Climate Registry Default Emission Factors," released April 2, 2013 (TCR EF, 2013).

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 2011 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.

1.2.1. Organizational Boundary

Table 1-1 lists the types of emitting activity per department that fall inside the Port Authority's organizational boundary and is organized first by Port Authority department, then by facility. This inventory structure applied to both GHG and CAP emissions estimates.

Table 1-1: Emitting Activities by Facility and Department in the 2011 Emissions Inventory				
Facility	**Emitting Activity**	**Scope 1**	**Scope 2**	**Scope 3**
Central Administration Functions				
Buildings[1]	Lighting and HVAC	✓	✓	
Central Automotive Department	Fleet Vehicles	✓		
Aviation				
John F. Kennedy International Airport (JFK)	Lighting and HVAC	✓	✓	
	Shadow Fleet			✓
	Refrigerants	✓		
AirTrain JFK	Terminal and Trains	✓	✓	
LaGuardia Airport (LGA)	Lighting and HVAC	✓	✓	
	Shadow Fleet			✓
Newark Liberty International Airport (EWR)	Lighting and HVAC	✓	✓	
	Shadow Fleet			✓
	Refrigerants	✓		
AirTrain EWR	Terminals and Trains		✓	
Stewart International Airport (SWF)	Lighting and HVAC	✓	✓	
	Shadow Fleet			✓
	Refrigerants	✓		
Teterboro Airport (TEB)	Lighting and HVAC	✓	✓	
	Shadow Fleet			✓
Port Commerce				
Brooklyn Marine Terminal	Lighting and HVAC	✓	✓	
Port Jersey	Lighting and HVAC	✓	✓	
Port Newark	Lighting and HVAC	✓	✓	
Elizabeth Port Authority Marine Terminal	Lighting and HVAC		✓	
Elizabeth Landfill	Fugitive Emissions	✓		
Howland Hook Marine Terminal	Lighting and HVAC	✓	✓	
Cross-Harbor Freight Program	Tug Vessel Operations			✓
	Rail Locomotives			✓
Tunnels and Bridges				
Holland Tunnel	Lighting and HVAC	✓	✓	
Lincoln Tunnel	Lighting and HVAC	✓	✓	
George Washington Bridge	Lighting and HVAC	✓	✓	
Bayonne Bridge	Lighting and HVAC		✓	
Goethals Bridge	Lighting and HVAC	✓	✓	
Outerbridge Crossing	Lighting and HVAC	✓	✓	
Bus Terminals				
Port Authority Bus Terminal	Lighting and HVAC	✓	✓	
George Washington Bridge Bus Station	Lighting and HVAC	✓	✓	
PATH				
PATH Rail Transit System	Trains		✓	
	Utility Track Vehicles	✓		
	Maintenance Vehicles	✓		
	Lighting and HVAC	✓	✓	
Journal Square Transportation Center	Lighting and HVAC		✓	
Real Estate				
Bathgate Industrial Park	Lighting and HVAC	✓	✓	

Table 1-1: Emitting Activities by Facility and Department in the 2011 Emissions Inventory				
Facility	**Emitting Activity**	**Scope 1**	**Scope 2**	**Scope 3**
The Teleport	Lighting and HVAC	✓	✓	
	Fleet Vehicles	✓		
The Legal Center	Fleet Vehicles	✓		
World Trade Center	Fleet Vehicles	✓		
Multi-Department				
Various facilities	Emergency Generators and Fire	✓		
	Welding Gases	✓		
Various sites	Construction Equipment			✓
[1]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. 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 (e.g. the Port Authority) to use GWP values from the Second Assessment Report. These values are presented in Table **1-2**.

Table 1-2: Global Warming Potential Factors for Reportable GHGs			
Common Name	**Formula**	**Chemical Name**	**GWP**
Carbon dioxide	CO_2	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

Table 1-2: Global Warming Potential Factors for Reportable GHGs			
Common Name	**Formula**	**Chemical Name**	**GWP**
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 2011 GREENHOUSE GAS EMISSIONS RESULTS

The chapters that follow detail the emissions calculations by source type and specify which facilities were responsible for each emissions source. Total emissions (i.e., scope 1 and 2) from the Port Authority for 2011 are presented in Table 1-3. For the purposes of Port Authority staff, Table 1-3 presents total emissions at the department level. 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 were assigned to "Real Estate."

As Table 1-3 shows, the Aviation department accounts for a majority of Port Authority emissions (57.8 percent of reportable emissions), largely because of the quantity of electricity and fuel used to power and heat large airport terminals. Although the Port Commerce department also administers large maritime properties, most of the maritime terminal facilities are leased to and operated directly by tenants. Emissions from PATH are the second highest at 20.7 percent, primarily from electricity used as traction power for the rail system (see Section 3.2.1). Central Administration functions contribute another 6.8 percent primarily due to fuel combustion by the Port Authority fleet. Tunnels and Bridges contribute 5.8 percent as a result of indirect emissions from purchased electricity and steam.

Table 1-3: Summary of Port Authority 2011 CO_2e Emissions (Metric Tons)		
Department	**Total Emissions**	**Contribution**
Aviation	162,728	57.8%
PATH	58,223	20.7%
Tunnels and Bridges	19,068	6.8%
Central Administration	16,238	5.8%
Bus Terminals	15,504	5.5%
Port Commerce	8,220	2.9%
Real Estate	1,022	0.4%
Multi-Department	366	0.1%
Total	**281,368**	**100.0%**

In 2011, 77.2 percent of the Port Authority's total emissions were scope 2 and 22.8 percent were scope 1. Figure 1-1 breaks down emissions by scope per department. For each of the four departments with the largest shares of the Port Authority's scope 1 and 2 GHG emissions (Aviation, PATH, Bus Terminals, and Tunnels and Bridges), scope 2 emissions comprise the vast majority of their total emissions contributions. These scope 2 emissions are primarily from electricity and steam purchases.

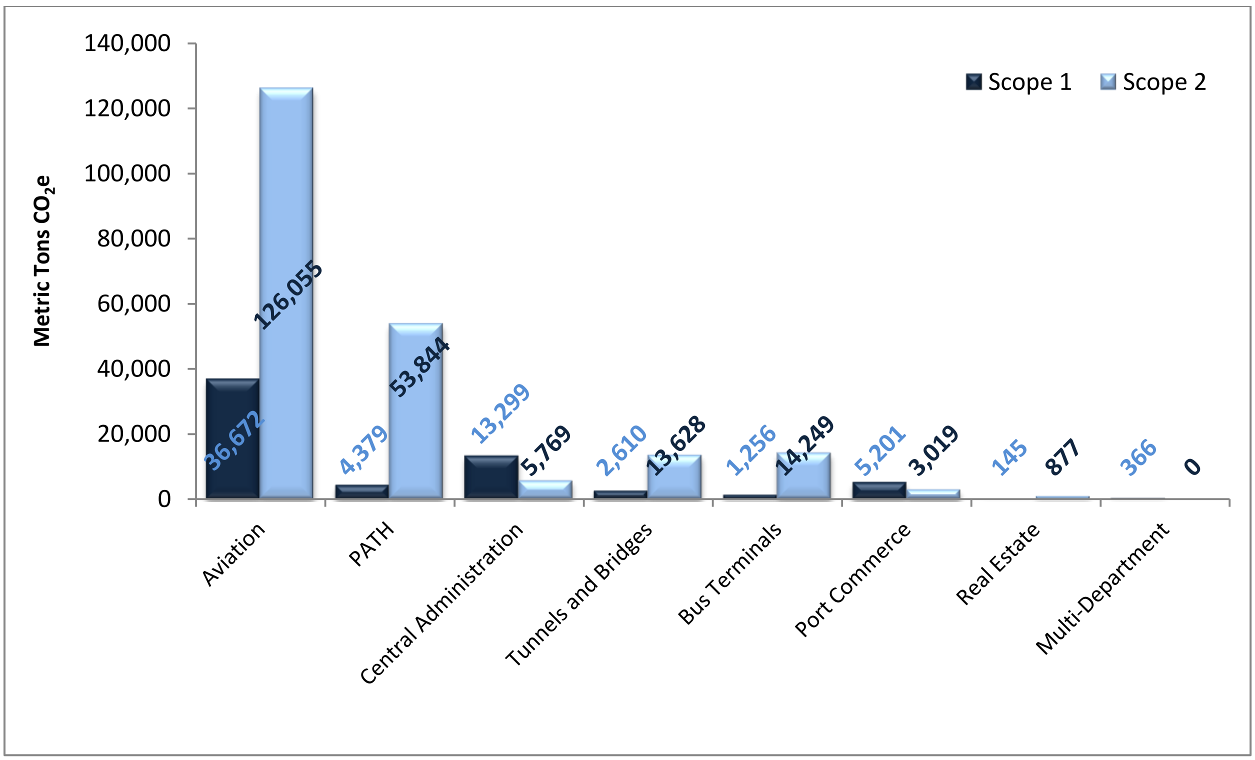

Figure 1-1: 2011 GHG Emissions by Department and Scope

Figure 1-2 shows which emitting activities make the largest contributions to Port Authority GHG emissions. Purchased electricity contributes 73.0 percent of total emissions, followed by fuel combustion (used for heating facilities) at 13.7 percent, and vehicle fleet fuel combustion, at 4.4 percent. Emissions caused by leaks in air conditioning (AC) systems (e.g., refrigeration) and discharges from specialized fire suppression systems contribute 2.8 percent of Port Authority emissions.

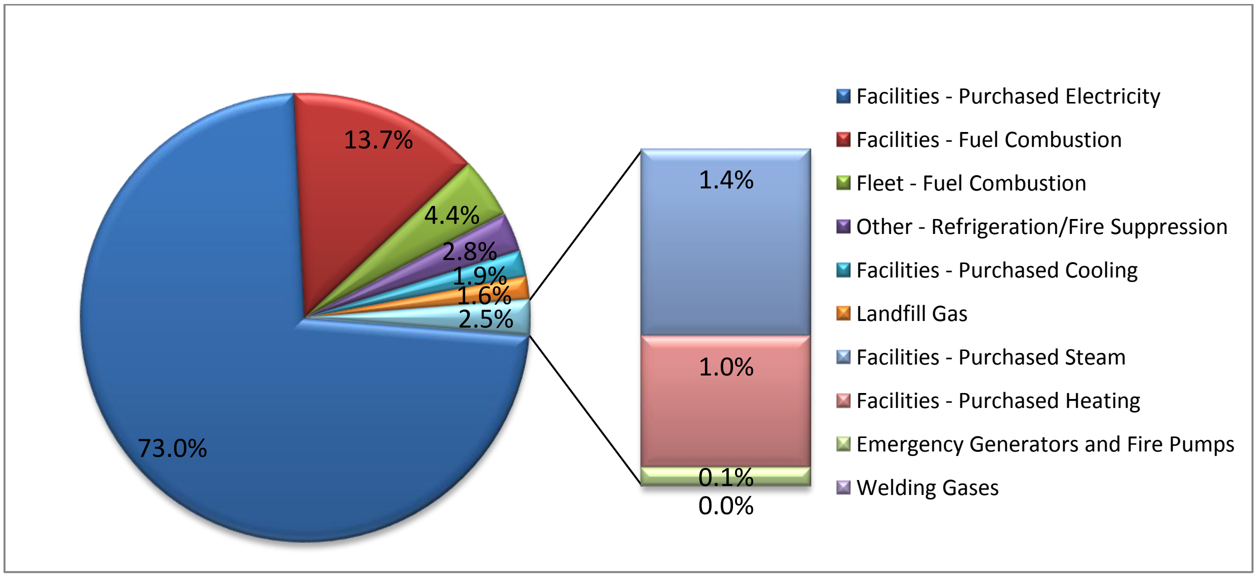

Figure 1-2: 2011 GHG Emissions by Emitting Activity

Table 1-4 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. Fuel combustion by emergency generators and emissions from welding are examples of emitting activities that occur in all departments. However, these emitting activities are small contributors to Port Authority emissions and were consolidated into the "Multi-Department" group.

Table 1-4: Port Authority 2011 Emissions by Department and Emitting Activity (Metric Tons CO_2e)

Department - Emitting Activity	Scope 1	Scope 2	Total
Aviation	**36,672.3**	**126,055.4**	**162,727.7**
Facilities - Fuel Combustion	31,281.8	0	31,281.8
Facilities - Purchased Cooling	0	5,396.9	5,396.9
Facilities - Purchased Electricity	0	117,916.6	117,916.6
Facilities - Purchased Heating	0	2,741.9	2,741.9
Other - Refrigeration/Fire Suppression	5,390.5	0	5,390.5
Bus Terminals	**1,255.7**	**14,248.6**	**15,504.3**
Facilities - Fuel Combustion	683.1	0	683.1
Facilities - Purchased Electricity	0	10,357.9	10,357.9
Facilities - Purchased Steam	0	3,890.7	3,890.7
Other - Refrigeration/Fire Suppression	572.6	0	572.6
Central Administration	**13,299.1**	**5,768.6**	**19,067.7**
Facilities - Fuel Combustion	952.3		952.3

Table 1-4: Port Authority 2011 Emissions by Department and Emitting Activity (Metric Tons CO_2e)			
Department - Emitting Activity	**Scope 1**	**Scope 2**	**Total**
Facilities - Purchased Electricity	0	5,768.6	5,768.6
Fleet - Fuel Combustion	12,077.1	0	12,077.1
Other - Refrigeration/Fire Suppression	269.7	0	269.7
Port Commerce	**5,200.5**	**3,019.2**	**8,219.7**
Facilities - Fuel Combustion	449.3	0	449.3
Facilities - Purchased Electricity	0	3,019.2	3,019.2
Landfill Gas	4,642.0	0	4,642.0
Other - Refrigeration/Fire Suppression	109.2	0	109.2
Real Estate	**145.2**	**876.9**	**1,022.1**
Facilities - Fuel Combustion	145.2	0	145.2
Facilities - Purchased Electricity	0	876.9	876.9
Tunnels and Bridges	**2,610.0**	**13,627.6**	**16,237.6**
Facilities - Fuel Combustion	2,609.8	0	2,609.8
Facilities - Purchased Electricity	0	13,627.6	13,627.6
Other - Refrigeration/Fire Suppression	0.2	0	0.2
PATH	**4,378.6**	**53,844.4**	**58,223.0**
Facilities - Fuel Combustion	2,561.2	0	2,561.2
Facilities - Purchased Electricity	0	53,844.4	53,844.4
Fleet - Fuel Combustion	267.0	0	267.0
Other - Refrigeration/Fire Suppression	1,550.3	0	1,550.3
Multi-Department	**366.3**	**0**	**366.3**
Emergency Generators and Fire Pumps	365.8	0	365.8
Welding Gases	0.5	0	0.5
Grand Total	**63,927.7***	**217,440.7**	**281,368.4**

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

A number of emitting activities were calculated using SEMs, such as refrigerant leaks from AC units, fuel usage by emergency generators, and electricity purchases interpolated from available billing statements. Emissions estimates using SEMs amounted to 4.3 percent of total Port Authority emissions. Table 1-5 presents a department-level summary of emissions estimated using SEMs.

Table 1-5: Port Authority 2011 SEM Emissions by Department and Emitting Activity (Metric Tons CO_2e)		
Department	**Emitting activity**	**Total**
Aviation	Facilities - Fuel Combustion	510.5
	Facilities - Purchased Electricity	1.2
	Other - Refrigeration/Fire Suppression	5,390.5
Bus Terminals	Facilities - Purchased Steam	358.9
	Other - Refrigeration/Fire Suppression	572.6
Central Administration	Facilities - Fuel Combustion	681.9
	Facilities - Purchased Electricity	86.6
	Fleet - Fuel Combustion	270.6
	Other - Refrigeration/Fire Suppression	269.7

Table 1-5: Port Authority 2011 SEM Emissions by Department and Emitting Activity (Metric Tons CO_2e)		
Department	**Emitting activity**	**Total**
PATH	Facilities - Fuel Combustion	1,122.1
	Facilities - Purchased Electricity	75.3
	Fleet - Fuel Combustion	267.0
	Other - Refrigeration/Fire Suppression	1,550.3
Port Commerce	Facilities - Fuel Combustion	131.1
	Facilities - Purchased Electricity	83.7
Real Estate	Other - Refrigeration/Fire Suppression	109.2
Tunnels and Bridges	Facilities - Fuel Combustion	13.7
	Facilities - Purchased Electricity	207.0
	Other - Refrigeration/Fire Suppression	0.1
Multi-Department	Emergency Generators and Fire Pumps	0.2
	Welding Gases	365.8
Total		**12,068.6**

1.4. COMPARISON WITH PREVIOUS INVENTORIES

The Port Authority adopted 2006 as its base year in its most recent environmental sustainability policy (Port Authority, 2008). 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 in 2007, 2008, 2010 and 2011, with the 2010 inventory (Port Authority, 2011) and this 2011 inventory developed in conformance with The Registry's guidelines. The adoption of a consistent and high-quality protocol for the 2010 and 2011 inventories provides intended users a high level of confidence that Port Authority emissions assessments are complete, accurate, transparent, and verifiable.

Figure 1-3 compares 2011 and 2010 emissions with the base year (2006). Comparisons between inventories need to take changes in methodology into account. First, the 2010 and 2011 inventories made limited use of surrogate data and engineering estimates; emissions estimates derived from these techniques account for less than five percent of Port Authority emissions. On the other hand, the 2006 inventory made more extensive use of surrogate data and engineering calculations because GHG data tracking and management systems were still being built at that time. For example, the Port Authority instituted an account-level tracking system for all energy consumption (natural gas and electricity) starting with 2010 activity data. Second, the effort for the 2006 inventory focused on all key emission sources across the organization. As the inventory program matured, contributions from very small and dispersed emission sources (i.e., emergency generators and fire pumps, welding gases) were quantified starting with the 2010 inventory. Third, expansion and contraction of Port Authority operations contribute to year-to-year fluctuation of emissions. For example, the Port Authority assumed operation of SWF in 2007 and stopped operating the Manhattan heliport in 2011.

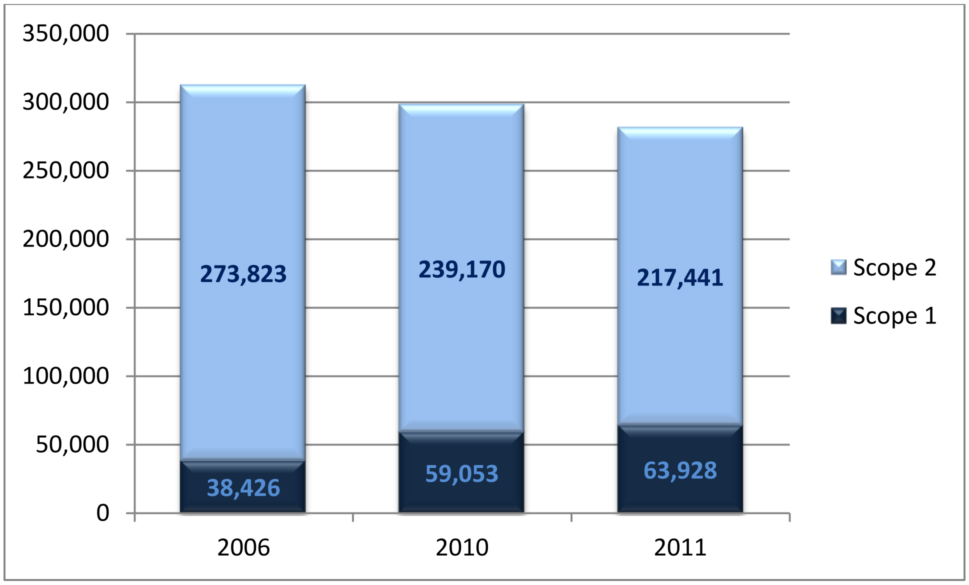

Figure 1-3: Comparison of 2010 and 2011 Emissions with Base Year 2006 (Metric Tons CO_2e)

Table 1-6 compares 2010 and 2011 direct (scope 1) emissions by emitting activity and department. The Port Authority fleet decreased fossil fuel consumption that in turn reduced GHG emissions by more than 500 metric tons of CO_2e between 2010 and 2011; this reduction also serves to decrease CAP emissions with--attendant air quality benefits. Other emissions reductions are the result of methodological changes; most notably, these include emissions from emergency generators and fire pumps. The 2010 inventory assumed that emergency generators and fire pumps operated up to their maximum hourly allowance; however, in 2011, the Port Authority collected actual run times and concluded that emergency generators operated well below their maximum operating time allowance. Overall, direct (scope 1) emissions increased by 8 percent between 2010 and 2011. An increase in the number of natural gas accounts under the operational control of the Port Authority accounts for 41 percent of the increase (1,966 metric tons CO_2e). Another quarter of the emissions increase can be attributed to enhancements in the way HFC and PFC emission sources were identified and quantified (HFC and PFC sources are included in the "Other – Refrigeration/Fire Suppression" line item in Table 1-6).

Table 1-6: Comparison of 2010 and 2011 Port Authority Scope 1 GHG Emissions (Metric Tons CO_2e)

Emitting Activity/Department	2010	2011	Diff.	Diff. %
Facilities - Fuel Combustion	**34,854.8**	**38,682.8**	**3,828.0**	**11.0%**
Aviation	30,687.4	31,281.8	594.4	1.9%
Bus Terminals	674.8	683.1	8.4	1.2%
Port Commerce	199.0	449.3	250.4	125.8%
Real Estate	162.1	145.2	-16.9	-10.4%
Tunnels and Bridges	638.7	2,609.8	1,971.2	308.6%
PATH	1,538.8	2,561.2	1,022.4	66.4%

Table 1-6: Comparison of 2010 and 2011 Port Authority Scope 1 GHG Emissions (Metric Tons CO_2e)				
Emitting Activity/Department	**2010**	**2011**	**Diff.**	**Diff. %**
Central Administration	954.1	952.3	-1.8	-0.2%
Fleet - Fuel Combustion	**12,617.4**	**12,344.2**	**-273.3**	**-2.2%**
PATH	0[5]	267.0	267.0	100%
Central Administration	12,617.4	12,077.1	-540.3	-4.3%
Landfill Gas	**4,044.6**	**4,642.0**	**597.4**	**14.8%**
Port Commerce	4,044.6	4,642.0	597.4	14.8%
Other - Refrigeration/Fire Suppression	**6,881.3**	**7,892.5**	**1,011.2**	**14.7%**
Aviation	3,678.6	5,390.5	1,711.9	46.5%
Bus Terminals	413.6	572.6	159.0	38.4%
Port Commerce	N.Q.	109.2	109.2	100%
Tunnels and Bridges	2.1	0.2	-1.9	-90.4%
PATH	2,787.0	1,550.3	-1,236.7	-44.4%
Central Administration	N.Q.	269.7	269.7	100%
Emergency Generators and Fire Pumps	**654.7**	**365.8**	**-288.9**	**-44.1%**
Multi-Department	654.7	365.8	-288.9	-44.1%
Welding Gases	**0.5**	**0.5**	**0.0**	**0.0%**
Multi-Department	0.5	0.5	0.0	0.0%
Total	**59,053.3**	**63,927.7***	**4,874.5**	**8.3%**

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

Table 1-7 compares 2010 and 2011 indirect (scope 2) emissions by emitting activity and department. Table 1-7 shows that Port Authority GHG emissions associated with purchased electricity declined by 9.7 percent from 2010 to 2011. However, only 2.3 percent of this decline resulted from decreased electricity purchases (see Port Authority electricity consumption trends shown in Table 1-8) while the remaining percentage was from reductions in the GHG annual emission rates by the power producers that operate in the three subregions identified in the EPA Emissions & Generation Resource Integrated Database (eGRID) (EPA, 2010) that supply electricity to the Port Authority. Again, comparisons between years need to consider certain factors. First, metrics that convert electricity purchases to GHG emissions vary annually depending on the fuel mix and operating practices of the energy supplier. Second, electricity metrics are published with a lag. For example, the 2011 inventory was developed using electricity metrics from eGRID 2012, which is based on electricity generation data from 2009. The 2010 inventory used electricity metrics from eGRID 2010, which is based on electricity generation data from 2007. Third, the proportion of Port Authority electricity purchases that serve tenant consumption is dynamic and variable from year to year. Given these factors, it is helpful to analyze GHG scope 2 emissions in conjunction with energy consumption trends.

[5] In 2010, PATH diesel equipment was categorized as stationary combustion. Because these pieces of equipment are portable or movable along rail tracks, associated emissions were categorized as Fleet – Fuel Combustion in 2011.

Table 1-7: Comparison of 2010 and 2011 Port Authority Scope 2 GHG Emissions (Metric Tons CO_2e)				
Emitting Activity/Department	**2010**	**2011**	**Diff.**	**Diff. %**
Facilities - Purchased Electricity	**227,499.2**	**205,411.2**	**-22,088.0**	**-9.7%**
Aviation	132,781.6	117,916.6	-14,865.0	-11.2%
Bus Terminals	9,884.1	10,357.9	473.8	4.8%
Port Commerce	2,858.5	3,019.2	160.7	5.6%
Real Estate	875.4	876.9	1.5	0.2%
Tunnels and Bridges	15,656.6	13,627.6	-2,029.0	-13.0%
PATH	57,817.3	53,844.4	-3,972.9	-6.9%
Central Administration	7,625.7	5,768.6	-1,857.1	-24.4%
Facilities - Purchased Cooling	**5,405.5**	**5,396.9**	**-8.6**	**-0.2%**
Aviation	5,405.5	5,396.9	-8.6	-0.2%
Facilities - Purchased Steam	**3,594.4**	**3,890.7**	**296.3**	**8.2%**
Bus Terminals	3,594.4	3,890.7	296.3	8.2%
Facilities - Purchased Heating	**2,671.1**	**2,741.9**	**70.8**	**2.7%**
Aviation	2,671.1	2,741.9	70.8	2.7%
Grand Total	**239,170.1**	**217,440.7**	**-21,729.5**	**-9.1%**

As noted above, 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. For that reason, 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 1-8. The data in Table 1-8 indicate that Port Authority electricity consumption has decreased by 2.3 percent between 2010 (526 GWh) and 2011 (514 GWh). 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 and 2011 than was possible with the systems in place in 2006.

Table 1-8. Scope 2 Electricity Consumption by Department, 2006, 2010, and 2011 (MWh)				
Department	**2006**	**2010**	**2011**	**2011 vs. 2010 Diff. %**
Aviation	419,208	310,856	289,801	-6.8%
Bus Terminals	30,552	30,848	37,310	20.9%
Central Administration	9,940	18,065	15,180	-16.0%
PATH	106,394	119,667	124,613	4.1%
Port Commerce	0	6,204	7,415	19.5%
Real Estate	22,821	2,969	3,159	6.4%
Tunnels and Bridges	54,435	37,873	36,968	-2.4%
Total	**643,350**	**526,483**	**514,446**	**-2.3%**

2.0 STATIONARY COMBUSTION (SCOPE 1)

2.1. BUILDINGS

The 2011 inventory considered buildings where fuel was combusted to produce electricity, heat, or motive power using equipment in a fixed location. 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 2011.

Table 2-1: Port Authority Facilities with Stationary Combustion	
225 PAS	JFK
777 Jersey	LGA
AirTrain JFK	Lincoln Tunnel
Bathgate Industrial Park	Outerbridge Crossing
Bayonne Bridge	PATC
Brooklyn Marine Terminal	PATH Buildings
EWR	Port Authority Bus Terminal
George Washington Bridge	Elizabeth Port Authority Marine Terminal
George Washington Bridge Terminal	Port Newark
Goethals Bridge	SWF
Holland Tunnel	TEB
Howland Hook	The Teleport
Note: Many facilities include multiple buildings.	

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 per GRP Table 12.1 (TCR, 2013). The emission factors for CO_2 were derived from GRP Table 12.1, and the emission factors for CH_4 and N_2O were derived from GRP Table 12.9 (TCR, 2013).

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, 2013.

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 sulfur dioxide (SO_2) emission factor is based on assuming a 100-percent fuel sulfur conversion. The oxides of nitrogen (NO_x) and particulate matter (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
kg/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, 2013) using the emission factors presented in section 2.1.2. In a small number of cases, stationary combustion data were not available from energy provider such 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 2010. 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 1-5.

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. Table 2-5 further breaks down stationary combustion emissions by facility.

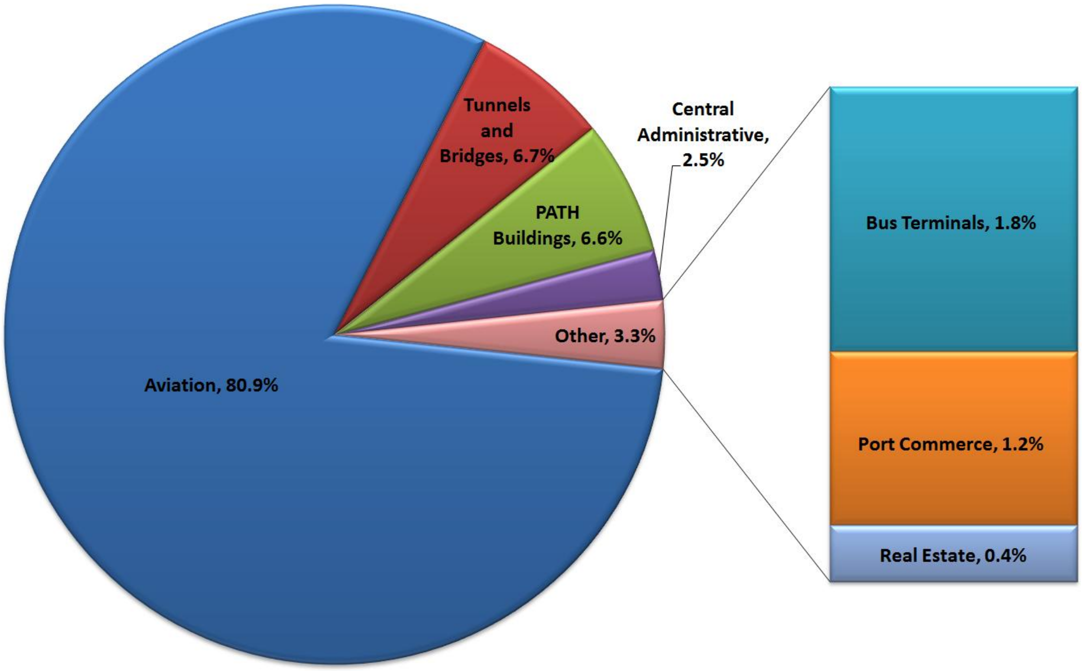

Figure 2-1: 2011 CO_2e Emissions Distribution from Stationary Combustion by Department

.

Table 2-4: 2011 GHG Emissions from Stationary Combustion by Department (Metric Tons)				
Department	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Aviation	31,202	2.9425	0.0588	31,282
Tunnels and Bridges	2,603	0.2455	0.0049	2,610
PATH Buildings	2,555	0.2409	0.0048	2,561
Central Administration	950	0.0896	0.0018	952
Bus Terminals	681	0.0643	0.0013	683
Port Commerce	448	0.0423	0.0008	449
Real Estate	145	0.0137	0.0003	145
Total	**38,584**	**3.6386**	**0.0728**	**38,683**

Table 2-5: 2011 GHG Emissions from Stationary Combustion by Facility (Metric Tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
JFK	13,943	1.3149	0.0263	13,979
EWR	12,605	1.1887	0.0238	12,638
LGA	3,637	0.3430	0.0069	3,646
PATH Buildings	2,555	0.2409	0.0048	2,561
Holland Tunnel	849	0.0801	0.0016	852
George Washington Bridge	777	0.0732	0.0015	779
George Washington Bridge Terminal	674	0.0635	0.0013	675
PATC	635	0.0599	0.0012	637
TEB	613	0.0578	0.0012	615
Lincoln Tunnel	421	0.0397	0.0008	422
Goethals Bridge	345	0.0326	0.0007	346
AirTrain JFK	287	0.0271	0.0005	288
777 Jersey	265	0.0250	0.0005	266
Port Newark	214	0.0201	0.0004	214
Outerbridge Crossing	155	0.0146	0.0003	156
SWF	116	0.0110	0.0002	117
Brooklyn Marine Terminal	101	0.0095	0.0002	101
Elizabeth Port Authority Marine Terminal	91	0.0086	0.0002	91
The Teleport	80	0.0076	0.0002	80
Bathgate Industrial Park	65	0.0061	0.0001	65
Bayonne Bridge	56	0.0053	0.0001	56
225 PAS	49	0.0046	0.0001	49
Howland Hook	43	0.0040	0.0001	43
Port Authority Bus Terminal	8	0.0007	0.0000	8
Totals	**38,584**	**3.6386**	**0.0728**	**38,683**

CAP emissions totals are given by department and facility in Table 2-6 and Table 2-7, respectively.

Table 2-6: 2011 CAP Emissions from Stationary Combustion by Department (Metric Tons)			
Department	**SO_2**	**NO**	**PM**
Aviation	1.56×10^{-1}	2.60×10^{1}	1.97×10^{-0}
Tunnels and Bridges	1.30×10^{-2}	2.17×10^{-0}	1.65×10^{-1}
PATH Buildings	1.28×10^{-2}	2.13×10^{-0}	1.62×10^{-1}
Central Administration	4.74×10^{-3}	7.90×10^{-1}	6.01×10^{-2}
Bus Terminals	3.40×10^{-3}	5.67×10^{-1}	4.31×10^{-2}
Port Commerce	2.24×10^{-3}	3.73×10^{-1}	2.83×10^{-2}
Real Estate	7.23×10^{-4}	1.21×10^{-1}	9.16×10^{-3}
Total	**1.93×10^{-1}**	**3.21×10^{1}**	**2.44×10^{-0}**

Table 2-7: 2011 CAP Emissions from Stationary Combustion by Facility (Metric Tons)			
Facility	**SO_2**	**NO_x**	**PM**
JFK	6.96×10^{-2}	1.16×10^{1}	8.82×10^{-1}
EWR	6.29×10^{-2}	1.05×10^{1}	7.97×10^{-1}
LGA	1.82×10^{-2}	3.03×10^{0}	2.30×10^{-1}
PATH Buildings	1.28×10^{-2}	2.13×10^{0}	1.62×10^{-1}
Holland Tunnel	4.24×10^{-3}	7.07×10^{-1}	5.37×10^{-2}
George Washington Bridge	3.88×10^{-3}	6.46×10^{-1}	4.91×10^{-2}
George Washington Bridge Terminal	3.36×10^{-3}	5.61×10^{-1}	4.26×10^{-2}
PATC	3.17×10^{-3}	5.29×10^{-1}	4.02×10^{-2}
TEB	3.06×10^{-3}	5.10×10^{-1}	3.88×10^{-2}
Lincoln Tunnel	2.10×10^{-3}	3.50×10^{-1}	2.66×10^{-2}
Goethals Bridge	1.73×10^{-3}	2.88×10^{-1}	2.19×10^{-2}
AirTrain JFK	1.43×10^{-3}	2.39×10^{-1}	1.82×10^{-2}
777 Jersey Avenue	1.33×10^{-3}	2.21×10^{-1}	1.68×10^{-2}
Port Newark	1.07×10^{-3}	1.78×10^{-1}	1.35×10^{-2}
Outerbridge Crossing	7.76×10^{-4}	1.29×10^{-1}	9.82×10^{-3}
SWF	5.81×10^{-4}	9.68×10^{-2}	7.36×10^{-3}
Brooklyn Marine Terminal	5.04×10^{-4}	8.39×10^{-2}	6.38×10^{-3}
Elizabeth Port Authority Marine Terminal	4.55×10^{-4}	7.59×10^{-2}	5.77×10^{-3}
The Teleport	4.00×10^{-4}	6.67×10^{-2}	5.07×10^{-3}
Bathgate Industrial Park	3.23×10^{-4}	5.39×10^{-2}	4.09×10^{-3}
Bayonne Bridge	2.78×10^{-4}	4.63×10^{-2}	3.52×10^{-3}
225 PAS	2.45×10^{-4}	4.08×10^{-2}	3.10×10^{-3}
Howland Hook Marine Terminal	2.13×10^{-4}	3.55×10^{-2}	2.70×10^{-3}
PABT	3.93×10^{-5}	6.55×10^{-3}	4.98×10^{-4}
Total	$\mathbf{1.93 \times 10^{-1}}$	$\mathbf{3.21 \times 10^{-1}}$	$\mathbf{2.44 \times 10^{0}}$

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 MS 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, 2013) 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 1-5).

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	3.79×10^{-5}	3.77×10^{-4}
CH_4	5.64×10^{-9}	5.57×10^{-8}
N_2O	3.08×10^{-10}	3.02×10^{-9}
NO_x	1.03×10^{-6}	1.01×10^{-5}
SO_x	6.74×10^{-8}	6.58×10^{-7}
PM	7.21×10^{-8}	7.07×10^{-7}

2.2.3. GHG Emissions Estimates

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

Table 2-9: 2011 GHG Emissions from Emergency Generators and Fire Pumps (Metric Tons)

Pollutant	Emergency Generators	Fire Pumps
CO_2	336.17	27.66
CH_4	0.0496	0.0041
N_2O	0.0027	0.0002
CO_2e	338.05	27.81

2.2.4. CAP Emissions Estimates

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

Table 2-10: 2011 CAP Emissions from Emergency Generators (Metric Tons)

Pollutant	Emergency Generators	Fire Pumps
NO_x	9.0416	0.7480
SO_x	0.5870	0.0492
PM	0.6302	0.0526

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, 2012a). 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 and the same emission level was estimated for 2011 in conformance with The Registry requirements (see Table 1-5).

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. Most of these vehicles are tracked and serviced by the Port Authority's Central Automotive Division (CAD). The CAD relies on fuel cards to track fuel use for individual vehicles. CAD also directly dispenses alternative fuels such as compressed natural gas (CNG) and gasoline with a 15 percent ethanol blend (E85) to some vehicles, and these bulk fuel purchases are not tracked at the vehicle level. In addition, PATH owns and operates some of its own diesel equipment.

In addition, the Port Authority owns vehicles stationed at the airports and operated by or on behalf of the individual facility by contractors. The contracted operators, not the CAD, track fuel and mileage records for these vehicles, known as the Shadow Fleet. Because the Port Authority does not have operational control over the Shadow Fleet, this report includes Shadow Fleet emissions as optional scope 3 emissions (see Section 7.1).

3.1. CENTRAL AUTOMOTIVE FLEET

The 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

The CAD is responsible for two distinct fleets, as shown in Figure 3-1. The main fleet of approximately 2,400 vehicles refuels at Port Authority service stations, where fuel consumption is tracked by means of bulk fuel invoices from supplier Sprague Energy. The Port Authority Office of the Treasury maintains records of fuel purchases at commercial gas stations for a small subset of the fleet. 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.

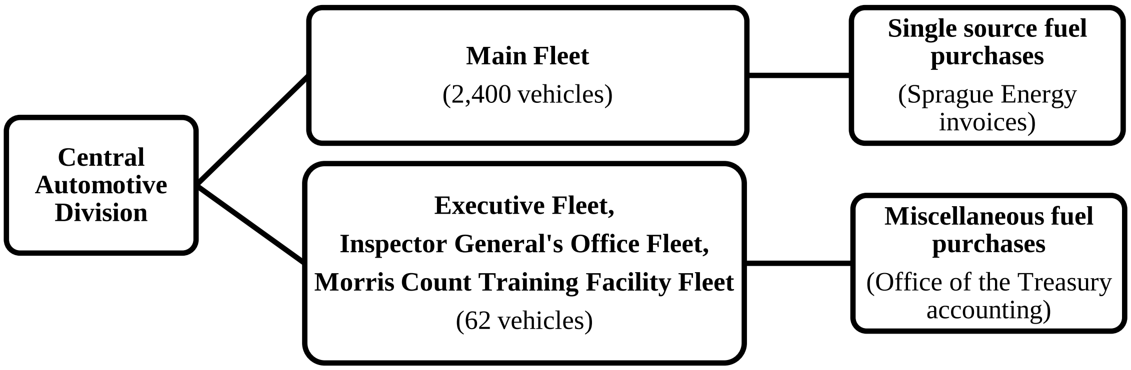

Figure 3-1: Recordkeeping for CAD Fleets

Fuel consumption by the main fleet is determined based on bulk fuel purchase records. Because the Port Authority buys fuel primarily for the purpose of consumption (as opposed to long-term storage), the volume of fuel tracked by purchasing closely matches the volume of fuel consumed. However, it is plausible that a small amount of fuel consumption is unaccounted for when the physical inventory is high at the beginning of the year and low at the end of the year. In order to quantify the volume of fuel consumption that could be overlooked by the purchasing accounting system, an engineering calculation was performed. This calculation assumed that the maximum annual physical inventory difference was three times the average daily delivery volume. Table 3-1 presents the volume of purchased fuel, the volume of fuel attributable to differences in physical inventory, and the sum of these two, which represent total fuel consumption.

Table 3-1: Main Fleet Fuel Consumption in 2011

Fuel	Purchases	Max. Physical Inventory Difference	Total Consumption	Units
Gasoline (E10)	965,129	11,235	976,364	gallons
#2 Diesel	15,358	287	15,645	gallons
Biodiesel (B20)	283,480	6,004	289,484	gallons
E85	25,958	421	26,379	gallons
CNG	6,200,641	69,403	62,700	ccf

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, 2013). The majority of fuel consumed by Port Authority contains some biofuel (either E10 or B20). For these biofuel blends, the emissions were calculated by multiplying the gallons of fuel used by the gasoline and diesel emission factors and by the percentage of gasoline in the fuel. For instance, CO_2 emissions from E10 gasoline would equal gallons (gal) of fuel used * 90% * 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% * 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, 2013).

The emission factors used to calculate the emissions are presented in Table 3-2.

Table 3-2: Emission Factors Applied to the CAD Fleet

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

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: 2011 GHG Emissions for Main Fleet (Metric Tons)

Fuel Type	CO_2	Biogenic CO_2	CH_4	N_2O
Gasoline (E10)	7,626.4	554.9	5.10×10^{-1}	5.70×10^{-1}
#2 Diesel	156.8	0.0	1.00×10^{-2}	1.10×10^{-2}
Biodiesel (B20)	2,315.5	535.8	1.78×10^{-1}	1.99×10^{-1}
E85	34.2	126.9	1.00×10^{-2}	1.10×10^{-2}
CNG	334.8	0.0	2.10×10^{-2}	2.30×10^{-2}
Total	10,467.7	1,217.6	7.29×10^{-1}	8.14×10^{-1}

Table 3-4 shows the emissions estimated from the rest of the fleet, tracked by the Office of the Treasury.

Table 3-4: 2011 GHG Emissions for Executive Fleet, Security, and Training Vehicles (Metric Tons)				
Department	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
Gasoline (E10)	108.9	7.9	0.007	0.008
#2 Diesel	4.4	0.0	0.000	0.000
Total	113.3	7.9	0.007	0.008

Table 3-5 shows the total CAD emissions estimated for each pollutant based on calculation methodology.

Table 3-5: 2011 GHG Emissions from the CAD Fleet (Metric Tons)				
Emission Method	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Standard Estimation Method	10,581	0.0	0.0	10,581
SEM	0	0.7	0.8	275
Biogenic Emissions	1,226	0.0	0.0	1,226
Total	**11,807**	**0.7**	**0.8**	**12,077**

3.1.4. CAP Activity Data

The vehicle data provided by the CAD is 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 in an estimate of grams per mile based on model year and vehicle type for the 2011 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 2011 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: 2011 CAP Emissions for the CAD Fleet (Metric Tons)				
Vehicle Type	**NO_x**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**
Highway Vehicles	7.82	9.5×10^{-2}	6.4×10^{-1}	3.9×10^{-1}
Non-highway Vehicles	4.5×10^{-1}	7.0×10^{-3}	4.1×10^{-2}	4.0×10^{-2}
No Fuel/Bad Reading	2.82	2.0×10^{-2}	1.9×10^{-1}	1.3×10^{-1}
Bulk CNG	3.91	1.0×10^{-2}	5.7×10^{-2}	5.7×10^{-2}
Executive/Security Fleet	1.8×10^{-1}	3.0×10^{-3}	1.9×10^{-2}	1.8×10^{-2}
Total	**15.18**	**1.4×10^{-1}**	**9.5×10^{-1}**	**6.3×10^{-1}**

3.2. PATH DIESEL EQUIPMENT

3.2.1. Activity Data

PATH owns and operates track maintenance equipment that is not accounted for by the CAD. PATH provided the total fuel consumption for all equipment in total gallons. Emissions from PATH equipment are calculated as part of the fleet vehicles bulk fuel total. PATH uses diesel fuel exclusively for maintenance equipment (the PATH Rail System 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, 2013). CH_4 and N_2O emissions are calculated based on the per-gallon diesel emission factor for non-highway equipment, from GRP Table 13.7 and 13.8, respectively (TCR, 2013).

3.2.3. GHG Emissions Estimates

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

Table 3-7. 2011 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. 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.

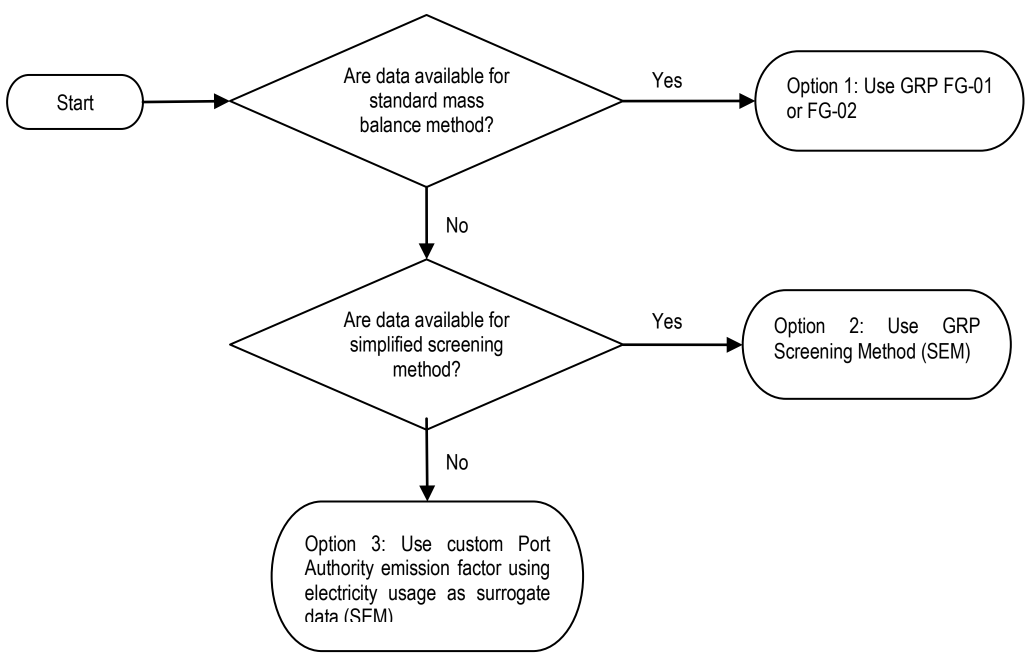

Figure 4-1: Selection of Method to Quantify Fugitive Emissions from AC Equipment

<u>Option 1</u>

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 2011 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, 2013).

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, 2013, 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 3
	Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)	Option 3
	Howland Hook Marine Terminal	Option 3
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

Table 4-1: Selection of Refrigerant Methodology Option by Facility		
Facility Description		Method
	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 Rail System	PATH Rail System	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 1-2 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	Emissions Metric (g CO_2e/kWh)
JFK	Airport Facilities	17.7
LGA	Airport Facilities	17.7
TEB	Airport Facilities	17.7
Port Commerce Facilities NY	Airport Facilities	17.7
Port Commerce Facilities NJ	Airport Facilities	17.7

Table 4-2: Assignment of Refrigerant Emissions Metrics Under Method Option 3		
Facility Description	Representative Emissions Metric	Emissions Metric (g CO_2e/kWh)
George Washington Bridge Bus Terminal	PABT	15.3
AirTrain JFK	PATH Rail System	10.3
AirTrain EWR	PATH Rail System	10.3
PATH Buildings	Airport Facilities	17.7

4.1.3. GHG Emissions Estimates

GHG emissions estimates for refrigerants used by the Port Authority during 2011 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: 2011 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			269.7				269.7
JFK						2,188.6	2,188.6
LGA						645.9	645.9
SWF	36.1			2.0			38.1
EWR	1,705.5	7.2			168.3		1,881.0
TEB						34.5	34.5
Brooklyn Cruise Terminal						9.8	9.8
Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)						9.2	9.2
Howland Hook Marine Terminal						10.3	10.3
Elizabeth Port Authority Marine Terminal						2.4	2.4
Port Jersey						24.8	24.8
Port Newark Marine Terminal						52.8	52.8
George Washington Bridge	0.1						0.1
Holland Tunnel	0.0						0.0
Lincoln Tunnel	0.2						0.2
George Washington Bridge Bus Terminal						87.4	87.4
PABT	485.2						485.2
AirTrain JFK						416.1	416.1
AirTrain EWR						186.3	186.3
PATH Rail System			1,104.6				1,104.6
PATH Buildings	322.5						322.5
						123.2	123.2
Total	**2,549.5**	**7.2**	**1,374.3**	**2.0**	**168.3**	**3,791.3**	**7,892.5**

Central Automotive Division

Emissions from the CAD were estimated based on a default AC refrigerant leakage estimate for vehicles. According to GRP Table 16.2 (TCR, 2013), 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 2,400 vehicles in the primary fleet in 2011 (1,368 highway vehicles, 459 non-highway vehicles, and 573 “other” vehicles), as well as 62 vehicles in the executive/security fleet for a total of 2,462 vehicles. “Other” vehicles include 406 vehicles with no fuel consumption reported and 167 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 17.7 grams of CO_2e (g CO_2e) per kilowatt hour (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 2011, 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 PABT and some equipment in PATH buildings, and 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 GRP (TCR, 2013), 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: Identification 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
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 2011 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 2011.

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, 2013). A similar model, EPA's Landfill Gas Emissions Model (LandGEM) (EPA, 2005), 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 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[6]. 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 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 that 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.

---

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

4.3.3. Emissions Estimates

The 2011 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: 2011 GHG Emissions from the Historic Elizabeth Landfill

Biogenic CO_2 (metric tons)	CH_4 (metric tons)	CH_4 (metric tons CO_2e)
741	221.0	4,642

The historic Elizabeth Landfill also emits a precursor to CAP, that is VOC emissions which are shown in Table 4-6.

Table 4-6: 2011 VOC Emissions from the Historic Elizabeth Landfill (Metric Tons)
0.932

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[a] with Electricity Consumption

225 PAS	LGA	Lincoln Tunnel
223 PAS	EWR	George Washington Bridge
Gateway Newark	AirTrain EWR	Bayonne Bridge
PATC	SWF	Goethals Bridge
5 Marine View	TEB	Outerbridge Crossing
115 Broadway	Brooklyn Marine Terminal	PABT
96/100 Broadway	Port Jersey	George Washington Bridge Terminal
116 Nassau Street	Port Newark	PATH Rail System
777 Jersey Avenue	Elizabeth Port Authority Marine Terminal	PATH Buildings
JFK	Howland Hook Marine Terminal	The Teleport
AirTrain JFK	Holland Tunnel	

[a] 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 was 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

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	0.425	3.05×10^{-5}	7.21×10^{-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 EF, 2013), 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 is 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, 2013). Similarly, emissions of particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) and 2.5 microns or less ($PM_{2.5}$) 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, 2013). The resulting KIAC electricity metrics are presented in Tables 5-2 for GHGs and 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 summary tables for 2009 for each subregion (EPA, 2012a). Emission factors for PM were calculated based on values derived from the 2008 EPA National Emissions Inventory (EPA, 2013a). The eGRID SO_2 totals by state were used to determine the split between $PM_{2.5}$ and PM_{10}. As with GHG emissions, the CAP emission factors vary by eGRID region and electricity source. Table 5-3 shows the CAP emission factors used for the 2011 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	8.40×10^{-5}	2.37×10^{-6}	2.71×10^{-5}	2.71×10^{-5}

5.1.3. Emissions Estimates

Emissions estimates were developed in accordance with GRP Chapter 14, “Indirect Emissions from Electricity” (TCR, 2013). 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 2010. 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 1-5.

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

Table 5-4: 2011 GHG Emissions from Electricity Consumption in Buildings by Department (Metric Tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	93,076	5.020	1.418	93,621
Tunnels and Bridges	13,567	0.429	0.167	13,628
Bus Terminals	10,335	0.402	0.048	10,358
PATH Buildings	7,473	0.212	0.118	7,514
Central Administrative	5,742	0.178	0.075	5,769
Port Commerce	3,004	0.089	0.044	3,020
Real Estate	875	0.034	0.004	877
Totals	**134,072**	**6.363**	**1.874**	**134,786**

The distribution of indirect emissions from purchased electricity is shown in Figure 5-1, 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 of the operation of common areas within its terminals.

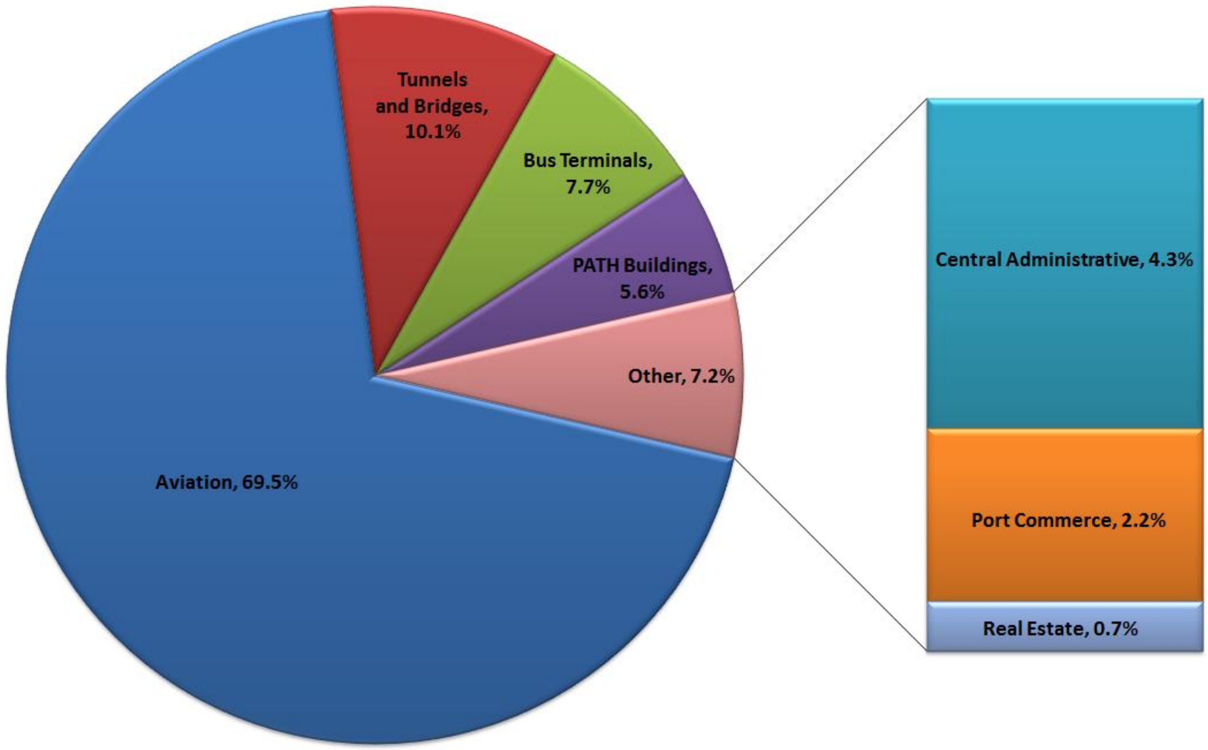

Figure 5-1: 2011 CO_2e Emissions from Electricity Consumption by Department

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: 2011 GHG Emissions from Electricity Consumption in Buildings by Facility (Metric Tons)

Facility	CO_2	CH_4	N_2O	CO_2e
JFK	52,508	3.763	0.891	52,864
EWR	29,437	0.834	0.465	29,599
LGA	10,100	0.393	0.046	10,123
Port Authority Bus Terminal	8,757	0.341	0.040	8,776
PATH Buildings	7,473	0.212	0.118	7,514
Lincoln Tunnel	5,935	0.188	0.073	5,962
Holland Tunnel	3,737	0.120	0.044	3,753
PATC	3,158	0.089	0.050	3,176
George Washington Bridge	2,508	0.071	0.040	2,522
Port Newark	2,015	0.057	0.032	2,026
George Washington Bridge Terminal	1,578	0.061	0.007	1,581
The Teleport	875	0.034	0.004	877
TEB	836	0.024	0.013	841
225 PAS	775	0.030	0.004	777

Table 5-5: 2011 GHG Emissions from Electricity Consumption in Buildings by Facility (Metric Tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Goethals Bridge	728	0.028	0.003	730
Gateway Newark	650	0.018	0.010	653
Elizabeth Port Authority Marine Terminal	601	0.017	0.009	604
777 Jersey	476	0.013	0.008	478
Outerbridge Crossing	386	0.014	0.003	387
Bayonne Bridge	272	0.008	0.004	274
223 PAS	268	0.010	0.001	268
SWF	194	0.006	0.003	195
96/100 Broadway	195	0.008	0.001	195
Brooklyn Marine Terminal	169	0.007	0.001	169
Howland Hook	162	0.006	0.001	162
115 Broadway	127	0.005	0.001	128
Port Jersey	58	0.002	0.001	58
116 Nassau St	53	0.002	0.000	53
5 Marine View	40	0.001	0.001	40
Totals	**134,072**	**6.363**	**1.874**	**134,786**

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

Table 5-6: 2011 CAP Emissions for Electricity Consumption in Buildings by Department (Metric Tons)				
Department	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Aviation	149.521	41.127	28.231	28.481
Tunnels and Bridges	46.200	9.955	7.696	7.775
PATH Buildings	36.316	6.412	6.120	6.170
Central Administrative	21.254	4.359	3.551	5.445
Port Commerce	13.050	2.445	2.192	2.211
Bus Terminals	1.743	4.725	0.074	0.114
Real Estate	0.148	0.400	0.006	0.010
Totals	**268.2**	**69.4**	**47.9**	**50.2**

Table 5-7: 2011 CAP Emissions for Electricity Consumption in Buildings by Facility (Metric Tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
EWR	143.076	25.261	24.110	24.307
PATH Buildings	36.316	6.412	6.120	6.170
PATC	15.351	2.710	2.587	4.467
Lincoln Tunnel	20.215	4.356	3.367	3.402
JFK	0.293	10.377	3.347	3.347
George Washington Bridge	12.171	2.151	2.051	2.068
Holland Tunnel	11.850	2.667	1.968	1.989
Port Newark	9.792	1.729	1.650	1.664
TEB	4.064	0.718	0.685	0.690
Gateway Newark	3.157	0.557	0.532	0.536
Elizabeth Port Authority Marine Terminal	2.920	0.515	0.492	0.496
777 Jersey	2.311	0.408	0.389	0.393
Bayonne Bridge	1.324	0.234	0.223	0.225
LGA	1.704	4.618	0.073	0.111

Table 5-7: 2011 CAP Emissions for Electricity Consumption in Buildings by Facility (Metric Tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Port Authority Bus Terminal	1.477	4.004	0.063	0.096
Outerbridge Crossing	0.518	0.215	0.081	0.083
Port Jersey	0.282	0.050	0.048	0.048
5 Marine View	0.196	0.035	0.033	0.033
SWF	0.384	0.154	0.016	0.025
George Washington Bridge Terminal	0.266	0.721	0.011	0.017
The Teleport	0.148	0.400	0.006	0.010
225 PAS	0.131	0.354	0.006	0.009
Goethals Bridge	0.123	0.333	0.005	0.008
223 PAS	0.045	0.122	0.002	0.003
96/100 Broadway	0.033	0.089	0.001	0.002
Brooklyn Marine Terminal	0.029	0.077	0.001	0.002
Howland Hook	0.027	0.074	0.001	0.002
115 Broadway	0.021	0.058	0.001	0.001
116 Nassau St	0.01	0.02	0.00	0.00
Totals	**268.2**	**69.4**	**47.9**	**50.2**

5.2. RAIL SYSTEMS

The three separate rail systems under the jurisdiction of the Port Authority are primarily powered by electricity. Two of these rail 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 Rail System is a commuter subway system connecting New Jersey and New York.

5.2.1. Activity Data

For electricity consumption for the PATH Rail System, 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, 2013). The GHG emission factors used to calculate the GHGs associated with electricity consumption are shown in Table 5-2.

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 6.1.2. 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 Rail System is the largest emitting source because it is the network with the largest ridership, and rail-miles. Additionally, the PATH Rail System runs on electricity supplied by the Reliable First Corporation East eGRID region, where emission rates are higher per kWh when compared to the NPCC - NYC/Westchester eGRID region (see Table 5.2).

Table 5-8. 2011 GHG Emissions from Electricity Consumption by Rail System (Metric Tons)

Rail System	CO_2	CH_4	N_2O	CO_2e
PATH Rail System	46,078	1.305	0.728	46,331
AirTrain JFK	16,376	1.125	0.260	16,480
AirTrain EWR	7,773	0.220	0.123	7,816
Total	**70,226**	**2.65**	**1.11**	**70,626**

CAP emissions from electricity consumption for the rail systems are given in Table 5-9.

Table 5-9: 2011 CAP Emissions from Electricity Consumption by Rail System (Metric Tons)

Rail System	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PATH Rail System	223.95	39.54	37.74	38.05
AirTrain EWR	37.78	6.67	6.37	6.42
AirTrain JFK	0.333	3.62	0.96	0.97
Total	**262.1**	**49.8**	**45.1**	**45.4**

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 Kennedy International Airport Cogeneration (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, 2013); 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, 2013). 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)	60.8	4.36×10^{-3}	1.03×10^{-3}
Cooling (kg/MMBtu)	60.8	4.36×10^{-3}	1.03×10^{-3}

Table 6-2: KIAC CAP Emission Factors				
Product	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Heating (kg/MMBtu)	3.39×10^{-4}	1.20×10^{-2}	3.87×10^{-3}	3.87×10^{-3}
Cooling (kg/MMBtu)	3.39×10^{-4}	1.20×10^{-2}	3.87×10^{-3}	3.87×10^{-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: 2011 GHG Emissions from KIAC Energy Purchases (Metric Tons)				
Energy Use	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
JFK Heating	2119	0.152	0.036	2133
JFK Cooling	4499	0.322	0.076	4530
JFK Total	**6618**	**0.474**	**0.112**	**6663**
AirTrain Heating	605	0.043	0.01	609
AirTrain Cooling	862	0.062	0.015	867
AirTrain Total	**1467**	**0.105**	**0.025**	**1476**

Table 6-4: 2011 CAP Emissions from KIAC Energy Purchases (Metric Tons)				
Energy Use	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK Heating	0.0118	0.4187	0.1351	0.1351
JFK Cooling	0.0251	0.8891	0.2868	0.2868
JFK Total	**0.0369**	**1.3078**	**0.4219**	**0.4219**
AirTrain Heating	0.0034	0.1195	0.0385	0.0385
AirTrain Cooling	0.0048	0.1703	0.0549	0.0549
AirTrain Total	**0.0082**	**0.2898**	**0.0934**	**0.0934**

6.2. PORT AUTHORITY BUS TERMINAL

The PABT reported some steam usage for heating in 2011. 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, 2013). 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 Con Edison 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, 2013). 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: Con Edison 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: 2011 PABT GHG Emissions from Con Edison Steam Purchases (Metric Tons)

Building	CO_2	CH_4	N_2O	CO_2e
PABT	3,875	0.4610	0.0182	3,890.67

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

Table 6-7: 2011 PABT CAP Emissions from Con Edison Steam Purchases (Metric Tons)

Building	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PABT	2.216	3.335	0.218	0.189

7.0 OPTIONAL EMISSIONS CATEGORIES (SCOPE 3)

This chapter covers emissions estimates for sources that are within the geographical boundary of the Port Authority but that fall outside of the operational control of the Port Authority. It includes emissions from the Shadow Fleet, the Cross-Harbor Freight Program, and use of construction equipment.

7.1. SHADOW FLEET

The Shadow Fleet is the set of vehicles owned by the Port Authority that circulate with Port Authority license plates but are operated on a day-to-day basis by contractors.

7.1.1. Activity Data

Data on the Port Authority Shadow Fleet vary for each airport. LGA has a shadow fleet consisting of seven buses and 10 non-highway vehicles. JFK provided information on fuel consumption and mileage for each vehicle in its shadow fleet, which consisted of 40 buses. Mileage and fuel consumption were reported for 23 airport buses at EWR. For SWF, the data provided for 2011 were incomplete. Therefore, data from 2012 were used for both highway and non-highway vehicles for this inventory. TEB provided vehicle-level information for the highway vehicle shadow fleet of 28 vehicles. The non-highway information for TEB included a vehicle list, but all information on fuel consumption was in a single bulk fuel figure.

7.1.2. Emission Factors and Other Parameters

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, 2013). For all non-highway vehicles, CO_2 emissions were calculated based on per-gallon emissions from GRP Table 13.1 (TCR, 2013). CH_4 and N_2O emissions were calculated using the construction vehicle gram-per-gallon emission factors from GRP Table 13.6 (TCR, 2013). Biogenic CO_2 emissions are calculated using the ethanol and biodiesel emission factors from GRP Table 13.1 (TCR, 2013). 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.

Because a complete fuel consumption estimate for SWF was not available for 2011, emissions for SWF were calculated differently. Fuel consumption in 2011 was estimated for highway and non-highway vehicles based on 2012 fuel consumption data, multiplied by the change in Air Traffic Activity System operations at SWF between 2011 and 2012 (FAA, 2013). There were 46,169 operations at SWF in 2011, compared to 47,080 operations in 2012; therefore, 2011 Shadow Fleet fuel consumption was assumed to have declined by 1.97 percent from the 2012 levels. This decline was applied to the highway and non-highway totals for gasoline and diesel, as shown in Table 7-1.

Table 7-1: 2011 Shadow Fleet Fuel Consumption at SWF (Gallons)			
Vehicle Type	**Fuel Type**	**2012**	**2011**
Highway	Gasoline	9,553	9,368
	Diesel	6,349	6,226
Non-Highway	Gasoline	0	0
	Diesel	16,696	16,373

CO_2 emissions were estimated based on total fuel consumption multiplied by the appropriate emission factor from GRP Table 13.1 (TCR, 2013). For highway vehicles, CH_4 and N_2O emissions were estimated using an SEM based on the ratio of CO_2 to CH_4 and N_2O emissions from GRP Table 13.9 (TCR, 2013). SWF non-highway vehicle CH_4 and N_2O emissions were calculated using the construction vehicle gram-per-gallon emission factors from GRP Table 13.6 (TCR, 2013).

CAP emission factors for highway vehicles were calculated based on the emission factors generated in MOVES (EPA, 2012b) for a given county. 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).

7.1.3. Emissions Estimates

GHG emissions results for the Shadow Fleet are shown in Table 7-2. Biogenic emissions are those CO_2 emissions that come from biofuels such as ethanol and biodiesel and are not included in the CO_2 emissions total.

Table 7-2: 2011 GHG Emissions from the Shadow Fleet (Metric Tons)					
Metric Tons	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**	**CO_2e**
EWR	2,282	0	0	0	2,284
JFK	1,453	336	0	0	1,454
LGA	957	88	0	0	962
SWF	313	0	0	0	318
TEB	197	0	0	0	198
Total	**5,202**	**425**	**0**	**0**	**5,215**

CAP emissions estimates for the Shadow Fleet are shown in Table 7-3.

Table 7-3: 2011 CAP Emissions from the Shadow Fleet (Metric Tons)				
Facility	**NO_x**	**SO_x**	**PM10**	**PM25**
EWR	5.16	0.01	0.15	0.07
JFK	2.77	0.01	0.07	0.03
LGA	1.66	0.01	0.08	0.07
SWF	0.69	0.03	0.14	0.13
TEB	0.25	0.01	0.04	0.03
Total	**10.54**	**0.07**	**0.48**	**0.32**

7.2. CROSS-HARBOR FREIGHT PROGRAM

The Cross-Harbor Freight Program has two main components. First, switch locomotives at New York New Jersey Rail (NYNJR) facilities in Brooklyn (Bush Terminal Rail Yard) or in Jersey City (Greenville Rail Yard) load cargo train cars onto a special rail barge. Then, a contracted tugboat tows the barge across the harbor, where it is then unloaded by a switch locomotive. During 2011, tug operations were carried out by two towing companies: McAllister Towing and Transportation Co., Inc., and Thomas J. Brown and Sons. Both of these operations are considered as non-highway vehicle mobile combustion.

7.2.1. Activity Data

The relevant activity data for this source type is annual fuel use. For the tug operations, NYNJR was unable to obtain 2011 fuel records from either towing company, so a SEM was used to estimate the gallons of marine diesel used. The two companies supply NYNJR with invoices that detail the hours of use in various modes and the vessel used. Using the horsepower of the vessel and a load factor typical of tug vessels, the hours of operation were converted into horsepower-hours of work. A brake-specific fuel consumption estimate was applied to this number to determine the mass of fuel consumed. The result was divided by the typical density of marine diesel to determine gallons of fuel use. The formula used to estimate fuel use was:

$$F = t \times HP \times LF \times Bsfc \div d$$

where:

F=fuel use in gallons,

t=time in hours,

HP=main engine horsepower,

LF=load factor,

Bsfc=brake-specific fuel consumption in grams per horsepower hour, and

d=density of marine diesel in grams per gallon.

For the switch locomotives, NYNJR was not able to provide the gallons of diesel used in the locomotives during 2011. Instead, the information for 2010 was used to create the rail estimate. Diesel locomotive fuel consumption was estimated based on 2010 Locomotive Fuel Consumption * (2011 Tug Fuel Consumption / 2010 Tug Consumption). Therefore, 2011 Locomotive Diesel Consumption = (19,900 gal) * (24,809 gal/19,743 gal) = 25,006 gal of Diesel Fuel.

7.2.2. Emission Factors and Other Parameters

Emissions estimates were developed in accordance with GRP Chapter 13, "Direct Emissions from Mobile Combustion" (TCR, 2013). The GHG emission factors used to calculate the GHG emissions associated with mobile fuel combustion in the switch locomotives and the tugboat are shown in Table 7-4.

Table 7-4: GHG Emission Factors for Diesel Switching Locomotives and Tugboats			
Emission Source	**CO_2 (kg/gallon)**	**CH_4 (g/gallon)**	**N_2O (g/gallon)**
Locomotives	10.21	0.80	0.26
Ships and Boats	10.21	0.74	0.26
Source	GRP Table 13.1	GRP Table 13.6	GRP Table 13.6

Because activity data in terms of fuel use could not be obtained, and the emission factors were in terms of gallons of diesel, a number of other parameters were used to determine the fuel use in the tug operations, as described above. These parameters (main engine horsepower, load factor, brake-specific fuel consumption, and density of marine diesel) were taken from a number of different sources, as described below.

The main engine horsepower was determined by examining the vessel specifications of the tugboats named on the invoices from McAllister. For the majority of trips, the tug vessel was the Charles D. McAllister, which has two 2,800-HP CAT 3512 engines (McAllister, 2013). For the trips made by Thomas J. Brown and Sons, the vessel uses a 2,520-HP engine, based on information from NYNJR (Port Authority, 2012c).

The load factor of 31 percent, corresponding to tugboats, was taken from EPA's "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories," Table 3-4, "Load Factors for Harbor Craft (Port of Los Angeles and Long Beach)" (EPA, 2009a). This factor was based on a Starcrest Consulting Group, LLC, study of the Port of Long Beach, where researchers measured actual vessel load readings (EPA, 2009a).

The brake-specific fuel consumption was taken from Appendix D of the "New York, Northern New Jersey, Long Island Non-attainment Area Commercial Marine Vessel Emissions Inventory" (Starcrest, 2003). The value of 227 g/kWh for medium-speed diesel engines was obtained from Table D.5, "Brake Specific Fuel Consumption," and was applied to both vessels. Finally, the fuel density of the marine diesel was taken from AP-42 (EPA, 1995), which lists the weight of distillate oil as 845 g/liter or 3,198 g/gallon.

The CAP emission factors used to calculate CAP emissions associated with mobile fuel combustion in the switch locomotives and the tugboat are shown in Table 7-5. The emission factors for tug vessels came from EPA's "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" (EPA, 2009a). Based on the specification sheets provided by the Port Authority, tug engines were considered to be Tier 1 Category 2. No specific data on fuel sulfur content were available from the Port Authority, so the project team used the default emission factor, which is based on a sulfur content of 1.5 percent (EPA, 2009a).

Table 7-5: CAP Emission Factors for Switching Locomotives and Tugboats				
Emission Source	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Switch Locomotive (g/gallon)	274.0	18.0	19.3	19.3
Tug Vessel (g/kWh)	9.8	1.3	1.1	1.1

7.2.3. Emissions Estimates

The 2011 GHG emissions estimates for the Cross-Harbor Freight Program are shown in Table 7-6.

Table 7-6: 2011 GHG Emissions Estimates for Cross-Harbor Freight Program (Metric Tons)			
Emission Source	**CO_2**	**CH_4**	**N_2O**
Switch Locomotives	255.3	0.020	0.007
Tug Operations	253.3	0.0184	0.0065

The CAP emissions estimates for the Cross-Harbor Freight Program are shown in Table 7-7 by emissions source to provide an idea of the relative magnitudes of the emissions. $PM_{2.5}$ and PM_{10} emissions are equal because diesel engine emissions are all less than 2.5 microns.

Table 7-7: CAP Emissions Estimates for Cross-Harbor Freight Program (Metric Tons)				
Emission Source	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Switch Locomotive	6.85	0.45	0.48	0.48
Tug Vessel	3.43	0.45	0.38	0.38

7.3. CONSTRUCTION EQUIPMENT

This category represents combustion emissions from construction equipment used during 2011 in Port Authority capital projects. Construction equipment includes stationary combustion emissions from generators and air compressors. In a few cases, mobile combustion emissions from the use of excavators and crawlers are also included. Construction equipment activity and associated emissions were estimated for construction for both WTC and non-WTC projects.

The reporting of this emission category to The Registry is optional under The Registry's protocols because the Port Authority is not operationally or financially liable for the equipment used by contractors. However, the Port Authority exerts some influence on construction activities by setting contracting requirements and specifications, such as the exclusive operation of clean diesel equipment and adherence to sustainable construction guidelines. Because the building and maintenance of major infrastructure is a core function of the Port Authority, estimates of GHG and CAP emissions from the operation of construction equipment have been included in this report.

7.3.1. Activity Data

WTC Projects

For the WTC facility, data on 2011 diesel fuel consumption was provided by the Port Authority (Port Authority, 2011d). These data included the amount of diesel fuel consumed by month as recorded by receipts from fuel supplier shipments to each project. Table 7-8 provides the gallons of fuel consumed per WTC site in 2011.

Table 7-8: 2011 Diesel Consumption for WTC Facility by Project

Project	Diesel Gallons
Vehicle Security Center	142,916
Vehicle Security Center 2	40,945
WTC	8,776
Albany & Washington-Dyed Tank	4,789
National 9-11 Memorial Museum	4,250
WTC-Dyed Tank	4,753
WTC-West Vent	319
WTC Tower 1 - Erectors	39,664
Total	**246,411**

[a] Note that diesel consumption reported in Table 7-2 includes diesel fuel consumed by all diesel engines, including those engines of less than 50 horsepower that are not otherwise subject to the WTC emission control and reporting provisions.

Consumption of non-diesel fuels such as gasoline, liquefied petroleum gas (LPG), and CNG were estimated by applying multipliers to the total diesel consumption using the fuel distribution ratio reported by EPA's NONROAD model (EPA, 2009b). NONROAD estimates that close to 97 percent of total fuel consumed by construction equipment can be attributed to diesel fuel, about 2 percent to gasoline, and the remaining portion is LPG and CNG.

Non-WTC Projects

The Port Authority does not track fuel consumption from construction activities of non-WTC projects. Therefore, engineering estimates were developed where work-in-place (WIP) data were used as a surrogate activity data (Port Authority, 2012). These data represent the dollar amounts for contracts with actual construction taking place in 2011, and they also account for WIP associated with security-related contracts at many of the facilities. The total of WIP for 2011 for non-WTC projects was $367,441,301.

Fuel consumption for all non-WTC Port Authority facilities was estimated by multiplying 2011 dollars of WIP by a factor that relates the amount of diesel fuel consumed per dollar of WIP, as calculated from WTC projects. The fuel consumption factor was calculated to be 0.00016 gallons per dollar of WIP. This figure was used to estimate diesel fuel consumption at all non-WTC sites. Consumption of gasoline, LPG, and CNG fuels were estimated based on NONROAD's default fuel distribution.

7.3.2. Emission Factors and Other Parameters

GHG Emission Factors

GHG emissions for construction projects were estimated by multiplying estimates of fuel consumption for construction equipment by the appropriate emission factor for each fuel type. All GHG emission factors were obtained from the "2013 Climate Registry Default Emission Factors" (TCR EF, 2013) and are presented in Table 7-9.

Table 7-9: GHG Emission Factors for Construction Equipment by Fuel Type

Fuel	CO_2 (kg/gal)	CH_4 (kg/gal)	N_20 (kg/gal)
Diesel	10.21	0.0006	0.0003
Gasoline	8.78	0.0005	0.0002
LPG	5.79	0.0003	0.0009
CNG	4.87	0.0097	0.0009

CAP Emission Factors for WTC Projects

Fleet information provided for each WTC project in its June/July 2010 monthly report (Port Authority, 2010) was used to develop CAP emission factors for diesel engines.[7] As part of the Port Authority's WTC Environmental Performance Commitments (TCAP, 2013), contractors must submit an on-site inventory list of the type and number of equipment, engine horsepower, age, tier level, emissions control devices, and other manufacturer information before work commences. The steps used to develop CAP emission factors and associated emissions at each of the WTC project sites are described below.

First, the engines operating at each project site were identified as either EPA Tier 2 or Tier 3 to reflect the emission standards that they have to meet. For all engines assigned to the same tier, the average horsepower of the engines was then determined. Depending on the average engine horsepower, the appropriate emission factor from EPA's NONROAD model (EPA, 2009b) was assigned to each group of Tier 2 and Tier 3 engines. Emission factors for both groups of engines were then weighted by the number of engines within each tier classification.

CAP emission factors in NONROAD are expressed in g/hp-hr and were converted to g/gallon using a brake-specific fuel consumption of 0.367 gallons of diesel fuel per hp-hr. The fuel-based emission factor was then multiplied by diesel fuel consumption to estimate CAP emissions. HC emissions were converted to VOCs, and $PM_{2.5}$ emissions were estimated from PM_{10} emissions based on EPA conversion factors (EPA, 2009b).

The CAP emissions for gasoline, LPG, and CNG, as well as SO_2 emissions for diesel, are based on 2010 national average emission factors developed in support of EPA's MARKAL database (Pechan, 2010). These emission

[7] Equipment operating in June and July 2010 was chosen to represent the year-round average fleet as a simplifying assumption.

factors were back-calculated from national 2010 NONROAD model construction emissions and activity reported by Source Classification Code, tier level, and horsepower, then weighted by fuel consumption for each engine record. National average emission factors were reported in g/hp-hr and, similar to diesel engine emission factors, were converted to g/gallon using EPA brake-specific fuel consumption estimates (EPA, 2009b).

CAP Emission Factors for Non-WTC Projects

Since information to adequately characterize the construction fleet operating at all of these sites was not readily available, CAP emissions estimates were based on fuel consumption multiplied by national average emission factors as derived from the EPA MARKAL database (Pechan, 2010) for all fuel types, including diesel. Similar to the process for WTC projects, adjustments to the average CAP emission factors, available in g/hp-hr, were made to provide the emission factors in g/gallon.

7.3.3. Emissions Estimates

The GHG emissions estimates by facility for construction equipment activity are shown in Table 7-10. The WTC facility contributes a large majority of the total GHG emissions (81 percent), with EWR sites combined being the second most significant contributor (~5 percent). The volume of non-WTC emissions was significantly lower in 2011 than in 2010, primarily because the factor used to convert WIP dollars to gallons of diesel combusted was smaller (on the order of 0.00016 gallons per WIP dollar). In 2010, this conversion factor was calculated as 0.0009 gallons per WIP dollar. It is possible that this conversion factor will continue to decrease as WTC construction winds down.

Table 7-10: 2011 GHG Emissions for Construction Facilities (Metric Tons)				
Facility Name	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
WTC	2,578.7	0.1660	0.0679	2,603.2
Newark Liberty Airport (EWR-80)	46.8	0.0030	0.0012	47.2
Newark Liberty Airport (EWR-CTA)	75.3	0.0048	0.0020	76.0
Newark Liberty Airport (EWR-TEB)	27.5	0.0018	0.0007	27.8
JFK Airport (JFK)	66.3	0.0043	0.0017	66.9
JFK Airport (JFK-LRS)	0.1	0.0000	0.0000	0.1
LGA	35.6	0.0023	0.0009	35.9
SWF	7.4	0.0005	0.0002	7.5
New Jersey Marine Terminal	70.1	0.0045	0.0018	70.7
New York Marine Terminal	17.4	0.0011	0.0005	17.5
Port Jersey	0.9	0.0001	0.0000	0.9
PATH	95.2	0.0061	0.0025	96.1
Construction Management/General Contracts Security	24.8	0.0016	0.0007	25.1
Bus Terminal	42.6	0.0027	0.0011	43.0
George Washington Bridge	51.5	0.0033	0.0014	52.0
Holland Tunnel	18.7	0.0012	0.0005	18.9
Lincoln Tunnel	27.4	0.0018	0.0007	27.6
Staten Island Bridges	10.1	0.0007	0.0003	10.2
Total	3,196.3	0.2057	0.0842	3,226.7

Emissions estimates for select CAPs by facility for construction activity are shown in Table 7-11. WTC accounts for 78 percent of total NO_x and 80 percent of total SO_x. The volume of non-WTC emissions is significant lower in 2011 than in 2010, primarily because the factor used to convert WIP dollars to gallons of diesel fuel combusted was much lower.

Table 7-11: 2011 CAP Emissions for Construction Facilities, Metric Tons				
Facility Name	**NO_X**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
WTC	2.4243	0.0536	0.1681	0.1598
Newark Liberty Airport (EWR-80)	0.0606	0.0010	0.0057	0.0055
Newark Liberty Airport (EWR-CTA)	0.0976	0.0016	0.0092	0.0089
Newark Liberty Airport (EWR-TEB)	0.0357	0.0006	0.0034	0.0032
JFK Airport (JFK)	0.0860	0.0014	0.0081	0.0078
JFK Airport (JFK-LRS)	0.0001	0.0000	0.0000	0.0000
LGA	0.0461	0.0007	0.0044	0.0042
SWF	0.0096	0.0002	0.0009	0.0009
New Jersey Marine Terminal	0.0908	0.0015	0.0086	0.0083
New York Marine Terminal	0.0225	0.0004	0.0021	0.0020
Port Jersey	0.0012	0.0000	0.0001	0.0001
PATH	0.1235	0.0020	0.0117	0.0112
Construction Management/General Contracts Security	0.0322	0.0005	0.0031	0.0029
Bus Terminal	0.0552	0.0009	0.0052	0.0050
George Washington Bridge	0.0667	0.0011	0.0063	0.0061
Holland Tunnel	0.0242	0.0004	0.0023	0.0022
Lincoln Tunnel	0.0355	0.0006	0.0034	0.0032
Staten Island Bridges	0.0131	0.0002	0.0012	0.0012
Total	3.2250	0.0664	0.2440	0.2325

8.0 REFERENCES

Calpine, 2013: File prepared by Wayne Goonan, Calpine, "PAGHGReport2011 2012.xlsx," sent to J. Maldonado, TranSystems, April 2, 2013.

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

EPA, 1997: "Emission Factor Documentation for AP-42 Section 2.4: Municipal Solid Waste Landfills (Revised)." Office of Air Quality Planning and Standards, August 1997.

EPA. 2005: U.S. Environmental Protection Agency. Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide. Publication No. 600/R-05/047

EPA, 2009a: U.S. Environmental Protection Agency, "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories," April 2009.

EPA, 2009b: U.S. Environmental Protection Agency, *NONROAD2008* [computer software], available at http://www.epa.gov/otaq/nonrdmdl.htm#model, Office of Transportation and Air Quality, July 2009.

EPA, 2010: U.S. Environmental Protection Agency, "eGRID Subregion Representational Map," December 2010, available at http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010_eGRID_subregions.jpg.

EPA, 2012a: U.S. Environmental Protection Agency, "eGRID Year 2009 Summary Tables – Version 1.0," April 2012, available at http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_SummaryTables.pdf.

EPA, 2012b: U.S. Environmental Protection Agency, "Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES 2010b," EPA-420-B-12-0016, June 2012.

EPA, 2013a: U.S. Environmental Protection Agency, "2008 National Emissions Inventory Data – Version 3," available at http://www.epa.gov/ttn/chief/net/2008inventory.html, accessed November 14, 2013.

EPA 2013b: U.S., Environmental Protection Agency, "Air Markets Program Data," available in the web at http://ampd.epa.gov/ampd/

FAA, 2013: Federal Aviation Administration, Air Traffic Activity System, Total Flights, SWF [Web database], https://aspm.faa.gov/opsnet/sys/Airport.asp, accessed March 11, 2013.

IPCC, 1996: Intergovernmental Panel on Climate Change. "Working Group I: the Science of Climate Change", Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 1996.

IPCC, 2001: "Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change" [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.

IPCC, 2007: "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

McAllister, 2013: "Fleet Location" [Web Page], http://www.mcallistertowing.com/FleetLocation.aspx, accessed November 14, 2013.

Pechan, 2010: "Documentation of MARKAL Emission Factor Updates," Draft Memorandum prepared by E.H. Pechan & Associates, Inc., to Dan Loughlin, EPA Office of Research and Development, Contract No. EP-D-07-097, Work Assignment 4-07, December 1, 2010.

Port Authority, 1974: "Elizabeth Port Authority Marine Terminal Annex, Area West of Kapkowski Road, Geological Profiles," Drawing No. EPAMT-SL-068, January 3, 1974.

Port Authority, 2008: Port Authority of New York and New Jersey, "Environmental Sustainability Policy". 2008.

Port Authority, 2009: "Greenhouse Gas Emission Inventory for Port Authority of New York & New Jersey, Calendar Year 2006 (Revised)," prepared by Southern Research Institute and E.H. Pechan & Associates, Feburary 2009.

Port Authority, 2010. "EPC Equipment Inventory," email communication from D. Bailey, Port Authority, to K. Thesing, E.H. Pechan & Associates.

Port Authority, 2011: "Greenhouse Gas and Criteria Air Pollutant Emission Inventory for the Port Authority of New York & New Jersey, Calendar Year 2010," prepared by Southern Research Institute and E.H. Pechan & Associates, December, 2011.

Port Authority, 2011d: Multiple files provided by D. Bailey, K. Mitchell, and W. Lipke, Port Authority, to J. Maldonado, TranSystems, September through October 2012.

Port Authority, 2012a: "RE: GHG Inventory Verification Question," email communication from Rubi Rajbanshi, Port Authority, to Juan Maldonado, TranSystems, December 19, 2012.

Port Authority, 2012b: File provided by Gary Ziegler, Port Authority, "CY2011 WIP Activity Data.xlsx," to J. Maldonado, TranSystems, September 2012.

Port Authority, 2012c: "RE: Data Request for 2011 PANYNJ GHG Inventory" email communication from Evelyn Shapiro, Port Authority, to Jackson Schreiber, TranSystems, December 21, 2012.

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

TCAP, 2010: Port Authority of New York New Jersey, "Tenant Construction and Alteration Process Manual," January 2010.

TCAP, 2013: Port Authority of New York New Jersey, "Tenant Construction and Alteration Process Manual," July 2013, p. 65.

TCR, 2010: The Climate Registry, "Local Government Operations Protocol," Version 1.1., May 2010.

TCR, 2013: The Climate Registry, "General Reporting Protocol – Version 2.0," March 2013, available at http://www.theclimateregistry.org/downloads/2013/03/TCR_GRP_Version_2.0.pdf.

TCR EF, 2013: "2013 Climate Registry Default Emission Factors," updated April 2, 2013, available at http://www.theclimateregistry.org/downloads/2013/04/2013-Climate-Registry-Default-Emissions-Factors.pdf.

WeldingWeb, 2012: "Acetylene Prices," retrieved on December, 20, 2012 from http://www.weldingweb.com/showthread.php?t=62953

Wiley, 2002: Wiley III, Joseph B., "Redevelopment Potential of Landfills: A Case Study of Six New Jersey Projects," presented to Federation of New York Solid Waste Associations, Solid Waste/Recycling Conference, Lake George, NY, May 6, 2002.