SCOPE 1, SCOPE 2, & SCOPE 3 (ENERGY PRODUCTION, TENANT ENERGY CONSUMPTION, CONSTRUCTION EQUIPMENT, AVIATION) GREENHOUSE GAS AND CRITERIA AIR POLLUTANT EMISSIONS INVENTORY FOR THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

Calendar Year 2013

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

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ACRONYMS AND ABBREVIATIONS

AC	air conditioning
ACY	Atlantic City International Airport
B20	20 percent biodiesel
Btus	British thermal units
CAD	Central Automotive Division
CAP	criteria air pollutant
ccf	100 cubic feet
CEMS	continuous emission monitoring system
CFCs	chlorofluorocarbons
CFR	Code of Federal Regulations
CH_4	methane
CHP	combined heat and power
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
Con Edison	Consolidated Edison Co. of N.Y., Inc.
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ECRR	Essex County Resource Recovery
eGRID	Emissions & Generation Resource Integrated Database
E10	10 percent ethanol
E85	85 percent ethanol
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FLIGHT	EPA’s Facility Level Information on GreenHouse gases Tool
g	gram(s)
g CO_2e/kWh	grams carbon dioxide equivalent per kilowatt hour
gal	gallon
GGRP	Greenhouse Gas Reporting Program
GHG	greenhouse gas
GRP	General Reporting Protocol
G.W. Bridge	George Washington Bridge
GWBBS	George Washington Bridge Bus Station
GWP	global warming potential
HCs	hydrocarbons
HCFC	hydrochlorofluorocarbon
HFCs	hydrofluorocarbons
hp	horsepower
hr	hour
HSRG	heat recovery steam generator
IPCC	Intergovernmental Panel on Climate Change
JFK	John F. Kennedy International Airport
kg	kilogram
KIAC	Kennedy International Airport Cogeneration
kWh	kilowatt hour
LandGEM	EPA’s Landfill Gas Emissions Model
lbs	pounds
LGA	LaGuardia Airport
MARKAL	EPA’s MARKet ALlocation database

MMBtu	million British thermal units
MOVES	EPA's Motor Vehicle Emissions Simulator
MSW	municipal solid waste
$MTCO_2e$	metric tons of carbon dioxide equivalent
MWh	megawatt hour(s)
National Grid	National Grid USA Service Company, Inc.
N_2O	nitrous oxide
NA	not applicable
NG	natural gas
No.	number
NO_x	oxides of nitrogen
NPCC	Northeast Power Coordinating Council
NQ	not quantified
NYC	New York City
NYCW	NPCC NYC/Westchester
NYMTC	New York Metropolitan Transportation Council
NYUP	NPCC Upstate NY
ODS	ozone-depleting substance
PABT	Port Authority Bus Terminal
PAS	Park Avenue South
PATC	Port Authority Technical Center
PATH	Port Authority Trans-Hudson
PCNJ	Port Commerce, New Jersey
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
ppm	parts per million
PSEG	Public Service Electric and Gas
RFCE	Reliable First Corporation East
scf	standard cubic foot
SEM	Simplified Estimation Method
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SO_x	sulfur oxides
Southern	Southern Research
SWF	Stewart International Airport
TCAP	Tenant Construction and Alteration Process manual
TCR	The Climate Registry
TEB	Teterboro Airport
The Registry	The Climate Registry
TPY	tons per year of pollutant
VOCs	volatile organic compounds
WIP	work in place
WTC	World Trade Center

EXECUTIVE SUMMARY

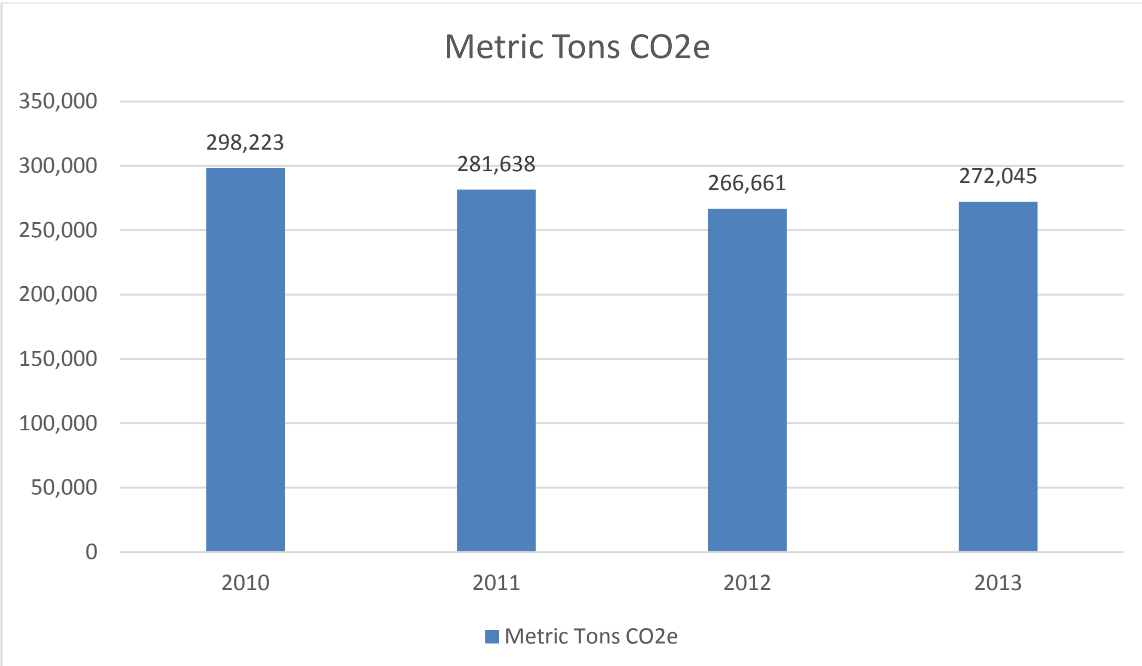
The Port Authority of New York and New Jersey (Port Authority) owns, manages, and maintains bridges, tunnels, bus terminals, airports, the Port Authority Trans-Hudson (PATH) commuter rail system, and marine terminals that are critical to the metropolitan New York and New Jersey region's trade and transportation 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 additional inventories for emission years 2007, 2008, 2010, 2011, and 2012.

The completion of the 2013 inventory documented in this report represents an important milestone for the Port Authority. This report describes the development and results of the Scope 1, 2, and 3 GHG emissions estimates for 2013. The use of a consistent and high-quality protocol for the 2010 through 2013 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 (Scope 1 and Scope 2) in 2013 were 272,045 metric tons of carbon dioxide equivalent (CO_2e) gases. This compares with the following previous years' estimates:



The Port Authority's Scope 1 and Scope 2 carbon footprint has decreased since 2010 at an annual average rate of 2.3 percent. Sustained electricity consumption savings every year are driving this declining emission trend (see Table 1-9). However, in 2013, an uptake in natural gas consumption attributed to variations in weather and operating conditions resulted in a slight increase of total GHG emissions of 1.85 percent.

In 2013, the largest contributor to Port Authority Scope 1 and Scope 2 emissions was purchased electricity, comprising 71.5 percent of all emissions. Other important Port Authority activities in terms of GHG emissions were fuel combustion for heating buildings (14.3 percent of GHGs) and motor vehicle fuel combustion (5.0 percent of GHGs).

The final portion of this report describes the development and results of the GHG emissions estimates for Scope 3 energy production, tenant emissions, and construction emissions. Energy production occurred in two facilities: Kennedy International Airport Cogeneration (KIAC) and Essex County Resource Recovery. Tenant emissions are those emissions from electricity, natural gas and thermal energy that were used by Port Authority tenants on Port Authority property. Construction emissions account for all construction projects funded by the Port Authority.

1.0 INTRODUCTION

1.1. BACKGROUND

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

As a cornerstone of its broader sustainability program, the Port Authority implemented a program to reduce greenhouse gas (GHG) emissions by 80 percent from 2006 levels by 2050. Emissions to be reduced include both those under its operational control (Scope 1 and Scope 2[1]) and those produced by its tenants and customers (Scope 3[2]). The Port Authority used the services of Southern Research (Southern) and SC&A, Inc. (formerly TranSystems|E.H. Pechan & Associates) to conduct a GHG and criteria air pollutant (CAP) emissions inventory of Port Authority facilities and operations for calendar year 2006 to establish the initial baseline required for monitoring progress toward this goal (Port Authority, 2009). The same consulting team later developed GHG and CAP emissions inventories for 2007, 2008, 2010, 2011, 2012, as well as for this 2013 inventory.

The GHG emissions in this report were developed in conformance with The Climate Registry's (The Registry's) "General Reporting Protocol – Version 2.0" (GRP) (TCR, 2013a), although the Port Authority has chosen to release information to CDP as part of its membership. CDP is an international, not-for-profit organization that provides a global system for companies and cities to measure, disclose, manage and share vital environmental information. Scope 1 and Scope 2 emissions were calculated using standardized methods based on objective and verifiable evidence. When systems are not in place to determine emissions based on complete and accurate records, simplified

[1] Scope 1 emissions encompass an organization's direct GHG emissions from stationary and mobile fuel combustion, as well as fugitive emissions from air conditioning units. Scope 2 emissions account for energy acquisitions, such as purchased electricity, steam, heating, or cooling.
[2] Scope 3 emissions come from emitting activities that occur outside the operational boundaries of an organization. Typical Scope 3 emitting activities at the Port Authority include tenant energy consumption, employee commuting, and attracted travel to Port Authority installations.

estimation methods (SEMs) may be employed, provided that SEM emissions do not exceed 5 percent of total emissions. In this report, emissions estimates using SEMs amounted to 3.2% of total Port Authority emissions.

This report also documents the development of a 2013 emission inventory of Scope 3 energy production, tenant emissions, and construction emissions. Energy production occurred in two facilities: Kennedy International Airport Cogeneration (KIAC) and the Essex County Resource Recovery (ECRR). Tenant emissions are those emissions from electricity, natural gas, and thermal energy that were used by Port Authority tenants on Port Authority property. Construction emissions account for all construction projects funded by the Port Authority.

1.2. INVENTORY ARCHITECTURE

1.2.1. Scope 1 and Scope 2 Boundary

In order to ensure the highest quality carbon data, consistent and transparent standards are used to calculate, verify, and publicly report GHG emissions into a single registry. The 2013 GHG inventory was developed according to the following specifications:

- Scope

Emission Year:	2013
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 2013 were developed using The Registry's GRP Version 2.0 and "2013 Climate Registry Default Emission Factors," updated April 2, 2013 (TCR, 2013b).

- Materiality

  An 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 5 percent.

Table 1-1 presents the facilities included in the inventory. It 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. Electricity Usage includes all uses of electricity; major uses are lighting and heating, ventilation, and air conditioning (AC). This inventory structure applied to both GHG and CAP emissions estimates. Note that the Port Authority leases a great deal of space. GHG and CAP emissions associated with tenant energy usage are outside of Port Authority operational control and are not counted as Scope 1 or Scope 2 emissions. Emissions from sources not expressly affiliated with one department, such as emissions from electricity and heating at the Port Authority's Park Avenue offices or fleet vehicles in the New York motor pool, are assigned to Central Administration Functions in lieu of a department. Buildings and properties that the Port Authority manages and leases as property manager are assigned to Real Estate. The Port Authority's Park Avenue offices are considered part of Central Administration Functions, as they 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.

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

Facility	Emitting Activity	Scope 1	Scope 2
Central Administration Functions			
Central Administration Buildings[a]	Electricity Usage	✓	✓
Central Automotive Division	Fleet Vehicles	✓	
Aviation			
John F. Kennedy International Airport (JFK)	Electricity Usage	✓	✓
	Refrigerants	✓	
AirTrain JFK	Terminal and Trains	✓	✓
LaGuardia Airport (LGA)	Electricity Usage	✓	✓
	Refrigerants	✓	
Newark Liberty International Airport (EWR)	Electricity Usage	✓	✓
	Refrigerants	✓	
AirTrain EWR	Terminals and Trains		✓
Stewart International Airport (SWF)	Electricity Usage	✓	✓
	Refrigerants	✓	
Teterboro Airport (TEB)	Electricity Usage	✓	✓
	Refrigerants	✓	
Port Commerce			
Brooklyn Marine Terminal	Electricity Usage	✓	✓
Port Jersey	Electricity Usage	✓	✓
Port Newark	Electricity Usage	✓	✓
Elizabeth Port Authority Marine Terminal	Electricity Usage		✓
Elizabeth Landfill	Fugitive Emissions	✓	
Howland Hook Marine Terminal	Electricity Usage	✓	✓
Tunnels and Bridges			
Holland Tunnel	Electricity Usage	✓	✓
Lincoln Tunnel	Electricity Usage	✓	✓
George Washington Bridge	Electricity Usage	✓	✓
Bayonne Bridge	Electricity Usage		✓
Goethals Bridge	Electricity Usage	✓	✓
Outerbridge Crossing	Electricity Usage	✓	✓

Table 1-1: Scope 1 & Scope 2 Emitting Activities by Facility and Department			
Facility	**Emitting Activity**	**Scope 1**	**Scope 2**
Bus Terminals			
Port Authority Bus Terminal	Electricity Usage	✓	✓
George Washington Bridge Bus Station	Electricity Usage	✓	✓
PATH			
PATH Rail Transit System	Trains		✓
	Utility Track Vehicles	✓	
	Maintenance Vehicles	✓	
	Electricity Usage	✓	✓
Journal Square Transportation Center	Electricity Usage		✓
Real Estate			
Bathgate Industrial Park	Electricity Usage	✓	✓
The Teleport	Electricity Usage	✓	✓
	Fleet Vehicles	✓	
The Legal Center	Fleet Vehicles	✓	
World Trade Center	Fleet Vehicles	✓	
Multi-Department			
Various facilities	Emergency Generators and Fire Pumps	✓	
	Welding Gases	✓	

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

1.2.2. Scope 3 Boundary

In addition to assessing emissions under the Port Authority's control (i.e., Scope 1 and Scope 2), the Port Authority assesses GHG and CAP emissions from tenant and customer activities that occur within or in immediate proximity to its facilities. The Scope 3 inventory is organized according to the emission source categories shown in Table 1-2. Given the breadth of the Scope 3 inventory, emissions assessments are not conducted annually but are developed regularly on a 2- or 3-year cycle. For the 2013 inventory, the emission source categories that were assessed and are presented in this report include: Energy Production, Tenant Energy Consumption, and Construction Activities.

Table 1-2: Scope 3 Inventory by Emission Category Source	
Emission Category Source	**Description**
Attracted Travel	Ground vehicles that access Port Authority facilities, including drayage trucks, movement of cargo, and airport passenger access
Airline Operations	Movement of aircrafts up to 3,000 feet, use of auxiliary power units, and ground support equipment at Port Authority airports
Energy Production	Electricity and thermal energy production from Port Authority assets
Tenant Energy Consumption	Natural gas, electricity, and thermal energy consumption in Port Authority facilities by tenants
Marine Terminals	All marine vessels that call on Port Authority ports within the 3-mile demarcation line off the eastern coast of the United States
Employee Commuting	Movement of Port Authority employees to and from work in private vehicles and public transportation

Table 1-2: Scope 3 Inventory by Emission Category Source	
Emission Category Source	**Description**
Construction Activities	Construction equipment rated higher than 50 horsepower used in Port Authority capital projects

1.2.2.1. Scope 3 Energy Production Boundary

The Port Authority owns two power generation plants: the KIAC facility located within JFK property and the ECRR facility located in Newark, New Jersey. These emissions include emissions from electricity and thermal energy generation at the KIAC facility and electricity generation from municipal solid waste (MSW) combustion at the ECRR.

1.2.2.2. Scope 3 Tenant Energy Consumption Boundary

The Port Authority owns infrastructure and facilities that are entirely or partially leased to Port Authority tenants. While energy consumption of Port Authority-controlled operations is Scope 2 and is covered in Chapter 5, Scope 3 tenant energy consumption represents the energy use of Port Authority tenants within Port Authority facilities. Typically, tenants consume energy in the form of electricity, natural gas, and thermal energy applied for heating and cooling. Tenant energy consumption was assessed for all departments within the organization, including Aviation, Tunnels, Bridges and Terminals, PATH, Port Commerce, Real Estate and Planning.

1.2.2.3. Scope 3 Construction Emissions Boundary

Combustion emissions from construction equipment used during 2013 in Port Authority capital projects are included in this emissions inventory. Construction equipment activity and associated emissions were estimated for all Port Authority-funded construction projects that received payment for work in place (WIP) in 2013. Although the Port Authority is not operationally or financially liable for the equipment used by contractors, it 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 inventory.

1.2.3. 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 the requirements of The Registry's General Reporting Protocol, GWP values from the Second Assessment Report were used and are presented in Table 1-3.

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

Table 1-3: Global Warming Potential Factors for Reportable GHGs

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

Table 1-3: Global Warming Potential Factors for Reportable GHGs			
Common Name	**Formula**	**Chemical Name**	**GWP**

Source: IPCC, 1996.

1.3. SUMMARY OF EMISSIONS RESULTS

1.3.1. Scope 1 and Scope 2 Summary Results

Total Scope 1 and Scope 2 emissions for 2013 are presented in Table 1-4, which summarizes results at the department level. Emissions from sources not expressly affiliated with one department are assigned to Central Administration in lieu of a department. Emission sources grouped under Central Administration include, but are not limited to, electricity purchases at the Port Authority's Park Avenue offices and fleet vehicles in the New York motor pool. Additionally, electricity consumption and natural gas consumption at properties not owned but leased by the Port Authority and occupied by Port Authority were assigned to the Real Estate category.

Table 1-4: Port Authority 2013 Scope 1 & Scope 2 GHG Emissions		
Department	**Metric Tons CO_2e**	**Contribution**
Aviation	151,556	55.71%
PATH	54,205	19.92%
Central Administration	22,281	8.19%
Tunnels and Bridges	16,512	6.07%
Bus Terminals	14,621	5.37%
Port Commerce	11,138	4.09%
Real Estate	1,428	0.52%
Multi-Department	304	0.11%
Total	**272,045**	**100.00%**

Note: Totals may not match the column sums due to rounding

As Table 1-4 shows, reportable emissions for facilities under operational control of the Aviation department account for a majority of Port Authority emissions (55.71 percent). Although the Port Commerce department also administers large maritime properties, most of the maritime terminal facilities are leased to and operated by tenants. Emissions from PATH are the second highest at 19.92 percent, primarily from electricity used as traction power for the rail system (see Section 3.2.1). Central Administration functions contribute another 8.19 percent, primarily due to fuel combustion by the Port Authority fleet. Tunnels and Bridges contribute 6.07 percent as a result of indirect emissions from purchased electricity and steam.

In 2013, 76.3 percent of the Port Authority's total emissions were Scope 2, and 23.7 percent were Scope 1. Figure 1-1 shows emissions by scope per department. For Aviation and PATH, Scope 2 emissions are substantially larger than Scope 1. These Scope 2 emissions are primarily from electricity and steam purchases that serve large public spaces (i.e., airport terminals, PATH stations).

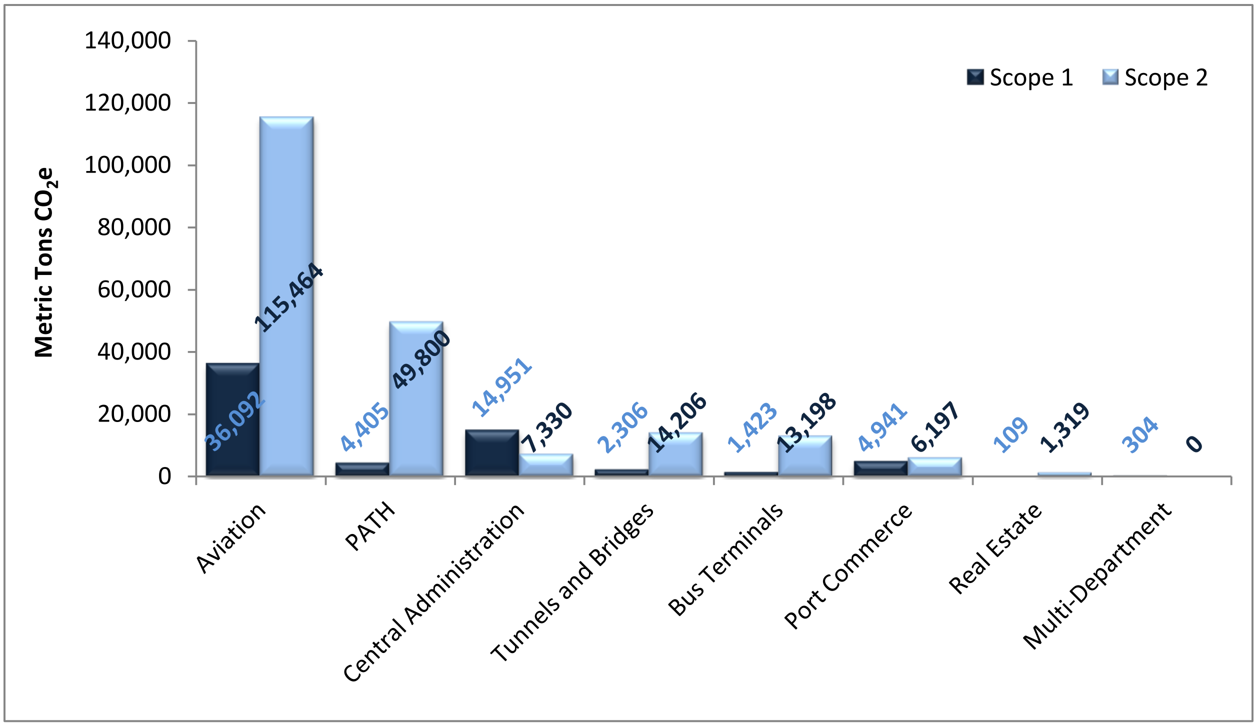


Figure 1-1: 2013 Scope 1 & Scope 2 GHG Emissions by Department and Scope

Figure 1-2 shows which emitting activities make the largest contributions to Port Authority GHG emissions. Purchased electricity contributes 71.5 percent of total emissions, followed by fuel combustion (used for heating facilities) at 14.3 percent, and vehicle fleet fuel combustion, at 5.0 percent. Emissions caused by leaks in AC systems (e.g., refrigeration) and discharges from specialized fire suppression systems contribute 2.8 percent of Port Authority emissions.

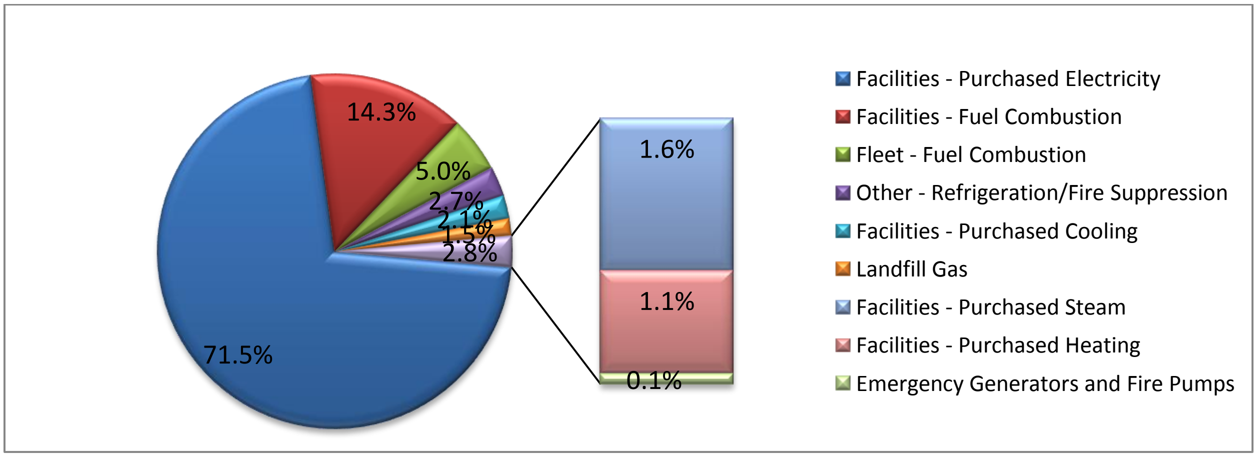


Figure 1-2: Distribution of 2013 Scope 1 & Scope 2 GHG Emissions by Emitting Activity

Table 1-5 shows a detailed summary of the Scope 1 and Scope 2 GHG emissions by department and emitting activity. In general, indirect emissions from electricity purchases comprise the majority of GHG emissions in each department. A few notable exceptions do exist, however. 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 Scope 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 in the Multi-Department group.

Table 1-5: Port Authority 2013 Scope 1 & 2 GHG Emissions by Department and Emitting Activity

Department – Emitting Activity	Scope 1 (metric tons CO_2e)	Scope 2 (metric tons CO_2e)	Total (metric tons CO_2e)
Aviation	**36,092.0**	**115,464.0**	**151,556.0**
Facilities – Fuel Combustion	31,327.2		31,327.2
Facilities – Purchased Cooling		5,825.7	5,825.7
Facilities – Purchased Electricity		106,703.5	106,703.5
Facilities – Purchased Heating		2,934.7	2,934.7
Other – Refrigeration/Fire Suppression	4,764.8		4,764.8
PATH	**4,404.6**	**49,800.2**	**54,204.8**
Facilities – Fuel Combustion	2,491.8		2,491.8
Facilities – Purchased Electricity		49,800.2	49,800.2
Fleet – Fuel Combustion	318.6		318.6
Other – Refrigeration/Fire Suppression	1,594.2		1,594.2
Tunnels, Bridges and Terminals	**3,728.9**	**27,404.0**	**31,132.9**
Facilities – Fuel Combustion	3,132.6		3,132.6
Facilities – Purchased Electricity		23,048.7	23,048.7
Facilities – Purchased Steam		4,355.3	4,355.3
Other – Refrigeration/Fire Suppression	596.3		596.3
Central Administration	**14,950.7**	**7,330.3**	**22,281.0**
Facilities – Fuel Combustion	1,367.9		1,367.9
Facilities – Purchased Electricity		7,330.3	7,330.3
Fleet – Fuel Combustion	13,319.9		13,319.9
Other – Refrigeration/Fire Suppression	262.9		262.9
Port Commerce	**4,940.8**	**6,197.4**	**11,138.2**
Facilities – Fuel Combustion	538.0		538.0
Facilities – Purchased Electricity		6,197.4	6,197.4
Landfill Gas	4,141.0		4,141.0
Other – Refrigeration/Fire Suppression	261.8		261.8
Real Estate	**108.7**	**1,318.8**	**1,427.5**
Facilities – Fuel Combustion	108.7		108.7
Facilities – Purchased Electricity		1,318.8	1,318.8
Multi-Department	**304.1**		**304.1**

Table 1-5: Port Authority 2013 Scope 1 & 2 GHG Emissions by Department and Emitting Activity			
Department – Emitting Activity	**Scope 1 (metric tons CO_2e)**	**Scope 2 (metric tons CO_2e)**	**Total (metric tons CO_2e)**
Emergency Generators and Fire Pumps	303.6		303.6
Welding Gasses	0.5		0.5

Note: Totals may not match the column sums due to rounding.

A number of emitting activities were calculated using SEMs, such as refrigerant losses from AC units, fuel usage by emergency generators, and electricity purchases interpolated from available billing statements. Emissions estimates using SEMs were 3.2 percent of total Port Authority emissions. Table 1-6 presents a department-level summary of emissions estimated using SEMs.

Table 1-6: Port Authority 2013 Scope 1 & Scope 2 GHG Emissions Using SEMs		
Department	**Emitting Activity**	**Metric Tons CO_2e**
Aviation	Facilities – Fuel Combustion	9.3
	Facilities – Purchased Electricity	26.8
	Other – Refrigeration/Fire Suppression	4,764.8
Bus Terminals	Other – Refrigeration/Fire Suppression	596.0
Central Administration	Fleet – Fuel Combustion	533.1
	Other – Refrigeration/Fire Suppression	262.9
PATH	Facilities – Fuel Combustion	9.6
	Facilities – Purchased Electricity	38.9
	Fleet – Fuel Combustion	318.6
	Other – Refrigeration/Fire Suppression	1,594.2
Port Commerce	Facilities – Fuel Combustion	31.2
	Facilities – Purchased Electricity	3.4
	Other – Refrigeration/Fire Suppression	261.8
Tunnels and Bridges	Facilities – Fuel Combustion	1.7
	Facilities – Purchased Electricity	1.7
	Other – Refrigeration/Fire Suppression	0.2
Multi-Department	Emergency Generators and Fire Pumps	303.6
	Other – Refrigeration/Fire Suppression	0.5
Total		**8,760.2**

Note: Totals may not match the column sum due to rounding

1.3.2. Scope 1 and Scope 2 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 Scope 2 emissions), as well as key tenant and customer activities (Scope 3 emissions). The Port Authority commissioned additional GHG studies, culminating with the 2010 inventory (Port Authority, 2011), 2011 inventory (Port Authority, 2014a), 2012 inventory (Port Authority, 2015e), and this 2013 inventory, all of which were developed in conformance with The Registry's guidelines. Third-party verification was obtained for the 2010, 2011, and 2012 inventories but was not pursued for 2013. Verification is both time-consuming for PANYNJ staff and monetarily costly, given the need to hire third-party auditors for this process.

Figure 1-3 compares 2010 through 2013 emissions with the base year (2006). As the 2006 inventory was conducted on the basis of best available data and methodology, 2006 results are not expected to meet the same standard of accuracy as the 2010, 2011, and 2012 inventories. For that reason, comparison of recent inventory results with the 2006 base year should be conducted only to infer the general direction of emission trends prior to 2010.

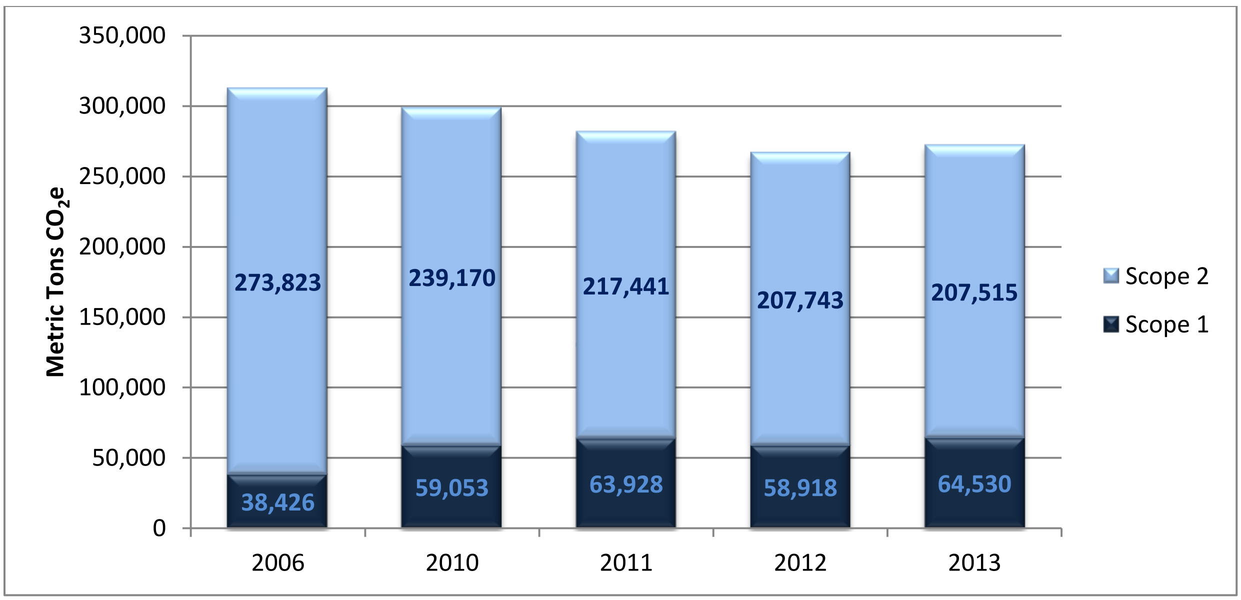


Figure 1-3: Comparison of 2010 through 2013 Emissions with Base Year 2006 (metric tons CO_2e)

Table 1-7 compares 2012 and 2013 direct (Scope 1) emissions by emitting activity and department. Port Authority Scope 1 GHG emissions increased by approximately 5,000 metric tons of CO_2e (8.8 percent) between 2012 and 2013, primarily due to increased consumptions at LGA, EWR, and JFK. An increase in stationary fuel combustion emissions was investigated for Aviation, and it was found that the reason for such increase was greater stationary fuel consumption (i.e., natural gas consumption for heating) at LGA and EWR.

Table 1-7: Comparison of 2012 and 2013 Port Authority Scope 1 GHG Emissions

Emitting Activity/Department	2012	2013	Difference (metric tons CO_2e)	Difference (%)
Facilities – Fuel Combustion	**33,112**	**38,966**	**5,854.2**	**17.68%**
Aviation	26,158	31,327	5,168.9	19.76%
Bus Terminals	573	827	253.6	44.25%
Port Commerce	298	538	239.9	80.45%
Real Estate	123	109	-14.7	-11.92%
Tunnels and Bridges	2,325	2,306	-19.5	-0.84%

Table 1-7: Comparison of 2012 and 2013 Port Authority Scope 1 GHG Emissions				
Emitting Activity/Department	**2012**	**2013**	**Difference (metric tons CO_2e)**	**Difference (%)**
PATH	2,538	2,492	-45.8	-1.80%
Central Administration	1,096	1,368	271.7	24.79%
Fleet – Fuel Combustion	**13,139**	**13,639**	**499.1**	**3.80%**
PATH	267	319	51.6	19.31%
Central Administration	12,872	13,320	447.5	3.48%
Landfill Gas	**4,384**	**4,141**	**-243.0**	**-5.54%**
Port Commerce	4,384	4,141	-243.0	-5.54%
Other – Refrigeration/Fire Suppression	**7,480**	**7,481**	**0.5**	**0.01%**
Aviation	4,765	4,765	0.0	0.00%
Bus Terminals	596	596	0.0	0.00%
Multi-Department	N/A	0	N/A	N/A
Port Commerce	262	262	0.0	0.00%
Tunnels and Bridges	0	0	0.0	0.00%
PATH	1,594	1,594	0.0	0.00%
Central Administration	263	263	0.0	0.00%
Emergency Generators and Fire Pumps	**802**	**304**	**-498.4**	**-62.14%**
Multi-Department	802	304	-498.4	-62.14%
Total	**58,918**	**64,086**	**5,167.7**	**8.77%**

Note: Totals may not match the column sum due to rounding

Table 1-8 compares 2012 and 2013 indirect (Scope 2) emissions by emitting activity and department. Overall, the Port Authority reduced Scope 2 emissions by 228 metric tons of CO_2e (0.11 percent) between 2012 and 2013. Increased electricity consumption relative to 2012 was investigated for Port Commerce and Airtrain Newark (aggregated under the Aviation Department). Increased usages of purchased heating and purchased steam were investigated at JFK and the Port Authority Bus Terminal, respectively. In all cases, the increases were confirmed to be legitimate and correct.

Table 1-8: Comparison of 2012 and 2013 Port Authority Scope 2 GHG Emissions				
Emitting Activity/Department	**2012**	**2013**	**Difference (metric tons CO_2e)**	**Difference (%)**
Facilities – Purchased Electricity	**196,677**	**194,399**	**-2,278.5**	**-1.16%**
Aviation	112,167	106,704	-5,463.4	-4.87%
Bus Terminals	8,204	8,843	639.1	7.79%
Port Commerce	4,861	6,197	1,336.1	27.48%
Real Estate	1,464	1,319	-145.6	-9.94%
Tunnels and Bridges	13,533	14,206	672.9	4.97%
PATH	49,192	49,800	608.7	1.24%
Central Administration	7,257	7,330	73.8	1.02%
Facilities – Purchased Cooling	**5,537**	**5,826**	**288.8**	**5.22%**
Aviation	5,537	5,826	288.8	5.22%
Facilities – Purchased Steam	**2,973**	**4,355**	**1,382.2**	**46.49%**
Bus Terminals	2,973	4,355	1,382.2	46.49%
Facilities – Purchased Heating	**2,555**	**2,935**	**379.5**	**14.85%**

Table 1-8: Comparison of 2012 and 2013 Port Authority Scope 2 GHG Emissions				
Emitting Activity/Department	**2012**	**2013**	**Difference (metric tons CO_2e)**	**Difference (%)**
Aviation	2,555	2,935	379.5	14.85%
Total	**207,743**	**207,515**	**-228.0**	**-0.11%**

Note: Totals may not match the column sum due to rounding

As evidenced in Table 1-8, 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 1-9. The data in Table 1-9 indicate that Port Authority electricity consumption decreased by 0.5 percent between 2012 (497,352 MWh) and 2013 (494,761 MWh). Comparisons with the base year should note that the 2006 inventory made more extensive use of surrogate data and engineering calculations than later inventories because GHG data tracking and management systems were still being built at that time. Since then, the Port Authority has implemented an account-level tracking system for electricity and natural gas purchases that captured energy acquisitions and distributions more accurately for 2010, 2011, and 2012 than was possible with the systems in place in 2006. Note that there are some spaces that toggle between Port Authority (Scope 2) and tenant (Scope 3) usage. When under Port Authority control, these tenant spaces are unoccupied and electricity usage is considered minimal. Future inventories may investigate the significance of this issue.

Table 1-9: Electricity Consumption by Department, 2006 to present (MWh)					
Department	**2006**	**2010**	**2011**	**2012**	**2013**
Aviation	419,208	310,856	289,801	281,573	269,726
Bus Terminals	30,552	30,848	37,310	29,543	31,844
Central Administration	9,940	18,065	15,180	18,536	19,221
PATH	106,394	119,667	124,613	113,812	115,220
Port Commerce	0	6,204	7,415	11,567	14,655
Real Estate	22,821	2,969	3,159	5,274	4.749
Tunnels and Bridges	54,435	37,873	36,968	37,048	39,347
Total	**643,350**	**526,483**	**514,446**	**497,352**	**494,761**

1.3.3. Scope 3 Summary Results

The Scope 3 emissions inventory for calendar year 2013 includes estimates for Port Authority energy production, tenant energy consumption, and construction activities. Table 1-10 presents GHG emissions by emission source category. CAP Emissions are summarized in Table 1-11.

Table 1-10: Port Authority 2013 Scope 3 GHG Emissions (metric tons)	
Emission Source Category	**CO_2e**
Energy Production	649,506
Tenant Energy Consumption	341,946

Construction	15,849
Total	**1,007,301**

Table 1-11: Port Authority 2013 Scope 3 CAP Emissions (metric tons)			
Emission Source Category	**SO_2**	**NO_x**	**PM_{10}**
Energy Production	666	2,597	61
Tenant Energy Consumption	389	207	68
Construction	0	197	16
Total	**1,055**	**3,001**	**145**

To place the 2013 energy production, tenant energy consumption, and construction activities emissions in the context of the entire Scope 3 inventory, a comprehensive summary was compiled from the most recent inventory studies as shown in Table 1-12. Energy production accounts for 10.2 percent of total Scope 3 emissions, followed by tenant energy consumption (5.4 percent) and construction activities (0.2 percent).

Table 1-12: Port Authority Scope 3 Comprehensive GHG Summary (metric tons)			
Emission Category Source		**Metric Tons CO_2e**	**Latest Year of Estimate**
Attracted Travel	Aviation	1,046,814	2013
	Port Commerce	1,023,358	2012
	Tunnels, Bridges and Terminals	546,025	2012
	PATH	60,064	2012
Airline Operations [a]		1,912,551	2013
Energy Production		649,506	2013
Tenant Energy Consumption		341,946	2013
Marine Terminals		289,197	2012
Employee Commuting		23,065	2013
Construction		15,849	2013
Total Scope 3		**5,908,375**	

[a] Movement of aircrafts up to 3,000 feet, use of auxiliary power units and ground support equipment at Port Authority airports.

In support of Port Authority programmatic goals, Table 1-13 organizes Scope 3 emissions according to three emissions classes, namely, customer, tenant, and Port Authority.

Table 1-13: Port Authority Scope 3 GHG Emissions by Class (metric tons)			
Emission Category Source		**Class**	**Metric Tons CO_2e**
Attracted Travel	Aviation	Customer	1,046,814
	Port Commerce	Customer	1,023,358
	Tunnels, Bridges and Terminals	Customer	546,025
	PATH	Customer	60,064

Airline Operations [a]	Tenant	1,912,551
Energy Production	Tenant	649,506
Tenant Energy Consumption	Tenant	341,946
Marine Terminals	Tenant	289,197
Employee Commuting	Port Authority	23,065
Construction	Tenant	15,849
Total Scope 3		**5,908,375**

[a] Movement of aircrafts up to 3,000 feet, use of auxiliary power units and ground support equipment at Port Authority airports.

2.0 STATIONARY COMBUSTION (SCOPE 1)

2.1. BUILDINGS

The 2013 inventory considered buildings (including, but not limited to, Port Authority Central Administration Buildings) where fuel was combusted to produce electricity, heat, or motive power using equipment in a fixed location. Both natural gas and Number (No.) 2 fuel oil were used as heating sources. The consumption of No. 2 fuel oil as a heating source is an addition since the 2012 inventory. 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 2013.

Table 2-1: Port Authority Facilities with Stationary Combustion

Facility	Fuel Types Used	Natural Gas Service Provider
225 PAS	Natural Gas	Consolidated Edison Co. of N.Y., Inc. (Con Edison)
777 Jersey Ave	Natural Gas	Public Service Electric and Gas (PSEG)
AirTrain JFK	Natural Gas	National Grid USA Service Company, Inc. (National Grid)
Bayonne Bridge	Natural Gas	National Grid
Brooklyn Marine Terminal	Natural Gas	Hess Corporation and National Grid
EWR	Natural Gas No. 2 Fuel Oil	PSEG
George Washington Bridge	Natural Gas	PSEG
George Washington Bridge Terminal	Natural Gas	Con Edison
Goethals Bridge	Natural Gas	National Grid
Holland Tunnel	Natural Gas	PSEG and Con Edison
JFK	Natural Gas No. 2 Fuel Oil	National Grid
LGA	Natural Gas No. 2 Fuel Oil	National Grid
Lincoln Tunnel	Natural Gas	PSEG and Con Edison
Outerbridge Crossing	Natural Gas	National Grid
PATC	Natural Gas	Hess Corporation and PSEG
PATH Buildings	Natural Gas	PSEG
PCNJ	Natural Gas	PSEG
SWF	Natural Gas	Central Hudson Energy Group
TEB	Natural Gas	PSEG
The Teleport	Natural Gas	National Grid

Note: Many facilities include multiple buildings. Fuel oil suppliers were not identified by the Port Authority.

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). In rare cases where there were gaps in the data provided by the Port Authority's consumption summary files, Southern either 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 a Microsoft Excel® workbook.

Data on the use of No. 2 Fuel Oil was provided by the Port Authority in the form of gallons of fuel oil consumed, by month, for each building.

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 and No. 2 Fuel Oil. In order to maintain consistency with the CAP emission factors in Table 2-3, an average high heating value of 1,020 British thermal units (Btus) per standard cubic foot was taken from the U.S. Environmental Protection Agency's (EPA's) "AP-42 Compilation of Air Pollutant Emission Factors" (EPA, 1995; hereafter referred to as "EPA AP-42"), Section 1.4. The emission factors for CO_2 were then taken from GRP Table 12.1, and the emission factors for CH_4 and N_2O were taken from GRP Table 12.9 (TCR, 2013a), using the heating value from EPA's AP-42. The GHG emission factors for No. 2 fuel oil were taken directly from GRP Tables 12.1 and 12.9.

Table 2-2: Stationary Combustion GHG Emission Factors

Units	CO_2	CH_4	N_2O
Kilograms (kg)/ccf of natural gas (NG)	5.40	5.10×10^{-4}	1.02×10^{-5}
kg/therm of NG	5.29	5.00×10^{-4}	1.00×10^{-5}
kg/gallon of No. 2 Fuel Oil	10.21	1.38×10^{-3}	8.28×10^{e}

Source: TCR, 2013a.

The CAP emission factors are based on values recommended by EPA AP-42, Chapters 1.3, "Fuel Oil Combustion" and 1.4, "Natural Gas Combustion" (EPA, 1995). The SO_2 emission factor is based on assuming a 100 percent fuel sulfur conversion. The NO_x and particulate matter (PM) emission factors are based on the assumption that the natural gas was combusted in a small [<100 million Btus (MMBtu) per 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	2.67×10^{-5}	4.45×10^{-3}	3.38×10^{-4}
kg/gallon of No. 2 Fuel Oil	1.29×10^{-2}	9.07×10^{-3}	1.50×10^{-3}

2.1.3. Emissions Estimates

Emissions estimates were developed in accordance with GRP Chapter 12, "Direct Emissions from Stationary Combustion" (TCR, 2013a), using the emission factors presented in Section 2.1.2. In a small number of cases, stationary combustion data were not available from the energy provider as natural gas bills, meter readings, or purchase records. For example, if no records existed for a given month, the 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 2012. In accordance with GRP guidelines, emissions developed from engineering calculations are reported separately as SEMs and aggregated with the estimates from all other emission sources. Stationary combustion emissions assessed using SEMs are presented in Table 1-6.

Table 2-4 summarizes stationary combustion emissions by department, and Figure 2-1 presents the percentage of these emissions by department. The Aviation department is the primary emitter of CO2e related to stationary combustion because the Port Authority assumes responsibility for heating large portions of terminal space. Table 2-5 identifies stationary combustion emissions by facility. CAP emissions totals are given by department and facility in Table 2-6 and Table 2-7, respectively.

Table 2-4: 2013 GHG Emissions from Stationary Combustion by Department (metric tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	31,234	2.9984	0.0662	31,318
Bus Terminals	825	0.0779	0.0016	827
Central Administration	1,365	0.1289	0.0026	1,368
PATH	2,475	0.2477	0.0068	2,482
Port Commerce	506	0.0478	0.0010	507
Real Estate	108	0.0102	0.0002	109
Tunnels and Bridges	2,298	0.2172	0.0043	2,304
Total	**38,811**	**3.7282**	**0.0826**	**38,914**

Note: totals may not match the column sums due to rounding.

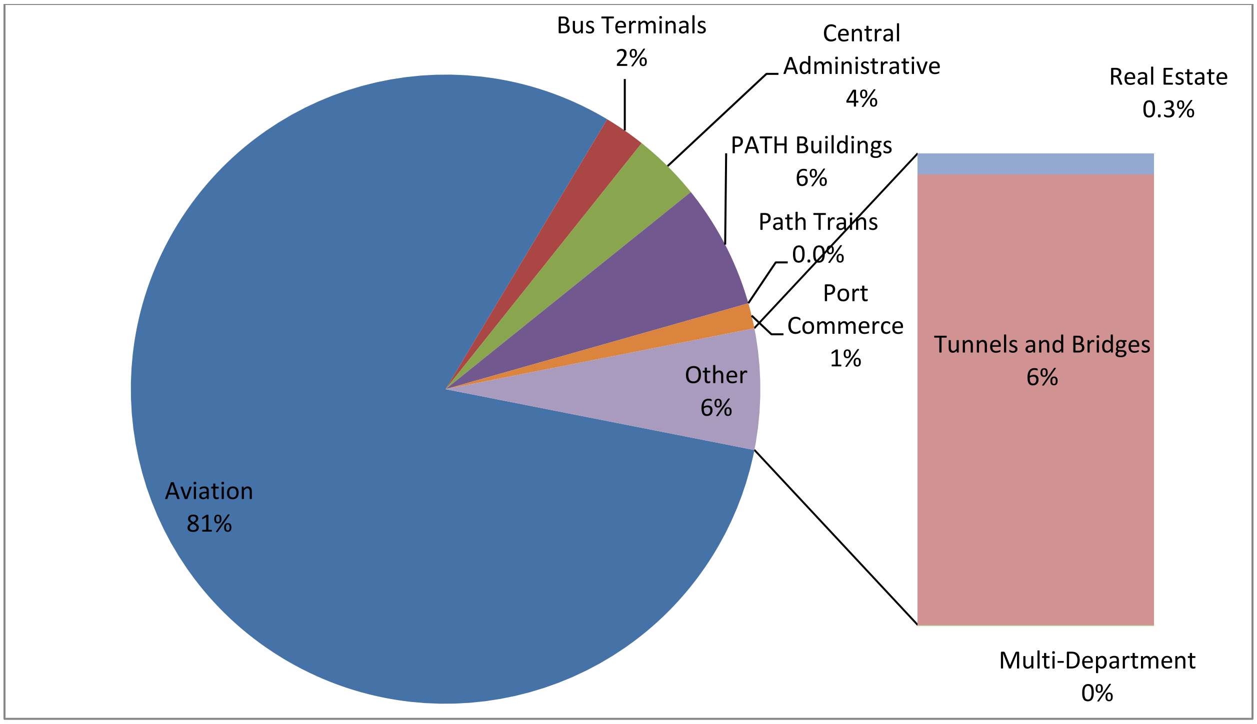


Figure 2-1: 2013 GHG Emissions Distribution from Stationary Combustion by Department

Table 2-5: 2013 GHG Emissions from Stationary Combustion by Facility (metric tons)

Building/Facility	CO_2	CH_4	N_2O	CO_2e
225 PAS	54	0.0051	0.0001	54
777 Jersey	265	0.0250	0.0005	266
AirTrain JFK	414	0.0391	0.0008	415
Bayonne Bridge	37	0.0035	0.0001	37
Brooklyn Marine Terminal	231	0.0218	0.0004	231
EWR	13,622	1.2927	0.0266	13,657
George Washington Bridge	788	0.0744	0.0015	790
George Washington Bridge Terminal	825	0.0779	0.0016	827
Goethals Bridge	443	0.0419	0.0008	444
Holland Tunnel	465	0.0440	0.0009	466
Howland Hook	47	0.0045	0.0001	47
JFK	11,079	1.0744	0.0251	11,109
LGA	4,543	0.4432	0.0107	4,556
Lincoln Tunnel	410	0.0388	0.0008	411
Outerbridge Crossing	155	0.0147	0.0003	156
PATC	1,046	0.0988	0.0020	1,049
PATH Buildings	2,475	0.2477	0.0068	2,482
PCNJ	228	0.0215	0.0004	229

Table 2-5: 2013 GHG Emissions from Stationary Combustion by Facility (metric tons)				
Building/Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
SWF	1,190	0.1125	0.0022	1,193
TEB	387	0.0365	0.0007	388
The Teleport	108	0.0102	0.0002	109
Total	**38,811**	**3.7282**	**0.0826**	**38,914**

Note: totals may not match the column sums due to rounding.

Table 2-6: 2013 CAP Emissions from Stationary Combustion by Department (metric tons)			
Department	**SO_2 (kg)**	**NO_x (kg)**	**PM (kg)**
Aviation	1.6014	26.3149	2.0908
Bus Terminals	0.0042	0.6933	0.0527
Central Administrative	0.0069	1.1472	0.0872
PATH Buildings	0.4409	2.0971	0.1863
Port Commerce	0.0025	0.4250	0.0323
Real Estate	0.0005	0.0911	0.0069
Tunnels and Bridges	0.0116	1.9321	0.1468
Total	**2.0681**	**32.7008**	**2.6031**

Note: totals may not match the column sums due to rounding.

Table 2-7: 2013 CAP Emissions from Stationary Combustion by Facility (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
225 PAS	0.0003	0.0451	0.0034
777 Jersey	0.0013	0.2228	0.0169
AirTrain JFK	0.0021	0.3479	0.0264
Bayonne Bridge	0.0002	0.0310	0.0024
Brooklyn Marine Terminal	0.0012	0.1941	0.0147
EWR	0.2377	11.4584	0.8815
George Washington Bridge	0.0040	0.6621	0.0503
George Washington Bridge Terminal	0.0042	0.6933	0.0527
Goethals Bridge	0.0022	0.3724	0.0283
Holland Tunnel	0.0023	0.3913	0.0297
Howland Hook	0.0002	0.0398	0.0030
JFK	0.9028	9.3469	0.7637
LGA	0.4510	3.8361	0.3185
Lincoln Tunnel	0.0021	0.3450	0.0262
Outerbridge Crossing	0.0008	0.1306	0.0099
PATC	0.0053	0.8793	0.0668
PATH Buildings	0.4409	2.0971	0.1863
PCNJ	0.0012	0.1917	0.0146
SWF	0.0060	1.0006	0.0760

Table 2-7: 2013 CAP Emissions from Stationary Combustion by Facility (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
TEB	0.0020	0.3250	0.0247
The Teleport	0.0005	0.0911	0.0069
Total	**2.0681**	**32.7008**	**2.6031**

Note: totals may not match the column sums due to rounding.

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 the analysts with Microsoft Excel spreadsheets containing actual annual runtime and/or fuel usage data for emergency generators and fire pumps. Information on typical fuel consumption (in terms of gallons per hour of operation) was determined for the specific engine/generator make and model and used to estimate the total annual fuel consumption for the equipment. Based on these data and using the emission factors from GRP Chapter 12, “Direct Emissions from Stationary Combustion” (TCR, 2013a), and EPA AP-42, Section 3.3, “Gasoline and Diesel Industrial Engines” (EPA, 1995), surrogate GHG and CAP emission factors were developed based on each facility’s electricity usage (in tons per year of pollutant (TPY) per MWh). However, actual annual runtime or fuel usage data for emergency generators and fire pumps were not available for all facilities. For these facilities, estimated emissions were calculated using the surrogate emission factors described above and applying them against the electricity usages for each facility. Because these methodologies are based on engineering estimates as opposed to calibrated measurements, all of the emissions associated with emergency generators and fire pumps are reported as SEM (see Table 1-6).

2.2.2. Emission Factors

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

Table 2-8: Emergency Generator and Fire Pump GHG and CAP Emissions Factors		
Pollutant	**Emergency Generator (TPY/MWh)**	**Fire Pump (TPY/MWh)**
CO_2	1.64×10^{-2}	1.60×10^{-1}
CH_4	2.40×10^{-6}	2.38×10^{-5}
N_2O	1.31×10^{-7}	1.30×10^{-6}
NO_x	4.43×10^{-4}	4.32×10^{-3}
SO_x	2.87×10^{-5}	2.84×10^{-4}

Table 2-8: Emergency Generator and Fire Pump GHG and CAP Emissions Factors		
Pollutant	**Emergency Generator (TPY/MWh)**	**Fire Pump (TPY/MWh)**
PM	3.08×10^{-5}	3.04×10^{-4}

2.2.3. GHG Emissions Estimates

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

Table 2-9: 2013 GHG Emissions from Emergency Generators and Fire Pumps (metric tons)		
Pollutant	**Emergency Generators**	**Fire Pumps**
CO_2	234.5	67.4
CH_4	0.0343	0.0100
N_2O	0.0019	0.0005
CO_2e	235.76	67.83

2.2.4. CAP Emissions Estimates

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

Table 2-10: 2013 CAP Emissions from Emergency Generators (metric tons)		
Pollutant	**Emergency Generators**	**Fire Pumps**
NO_x	6.3327	1.8243
SO_x	0.4100	0.1200
PM	0.4407	0.1282

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. The same engineering emission estimate (or SEM, in The Registry's terminology) was ascribed to calendar year 2013.

3.0 MOBILE COMBUSTION (SCOPE 1)

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

3.1. CENTRAL AUTOMOTIVE DIVISION FLEET

The CAD is in charge of purchasing and maintaining the Port Authority's fleet of vehicles. The 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. Table 3-1 presents total fleet consumption by fuel type in 2013.

Table 3-1: Main Fleet Fuel Consumption in 2013

Fuel	Consumption	Units
Gasoline (E10)	1,048,029	Gallons
#2 Diesel	16,004	Gallons
Biodiesel (B20)	280,524	Gallons
E85	103,097	Gallons
CNG	47,010	CCF
Propane	1,295	Gallons

3.1.1. Activity Data

The CAD is responsible for two fleets, as shown in Figure 3-1. The main fleet of 2,688 vehicles refuels either on site at Port Authority service stations or at Sprague retail sites. Every month, Sprague invoices the Port Authority for the volume of fuel dispensed on site and Sprague retail sites, and this information is used to estimate CO_2 emissions from the main fleet.

On the other hand, fuel consumption for the smaller fleets is tracked by the Port Authority Office of the Treasury. This includes 25 vehicles designated as the executive fleet, 35 security vehicles associated with the Port

Authority's Inspector General's office, and two vehicles used in association with training activities in Morris County, New Jersey. These fuel purchases are for vehicles within the CAD's total fleet but are not tracked by Sprague records; instead, they are accounted for separately by means of branded fuel cards (e.g., Shell Fuel Card). Port Authority records did not specify the gallons of fuel purchased through these branded fuel cards, only fuel expenditures. To convert fuel expenditures to fuel volume, the 2013 annual average fuel price of $3.61 per gallon for the middle Atlantic region was applied (EIA, 2015). This analysis also assumed that the 2013 proportions of gasoline and diesel consumption (99.9 percent gasoline and 0.1 percent diesel) were the same as in 2012, when information on fuel volume by fuel type was available.

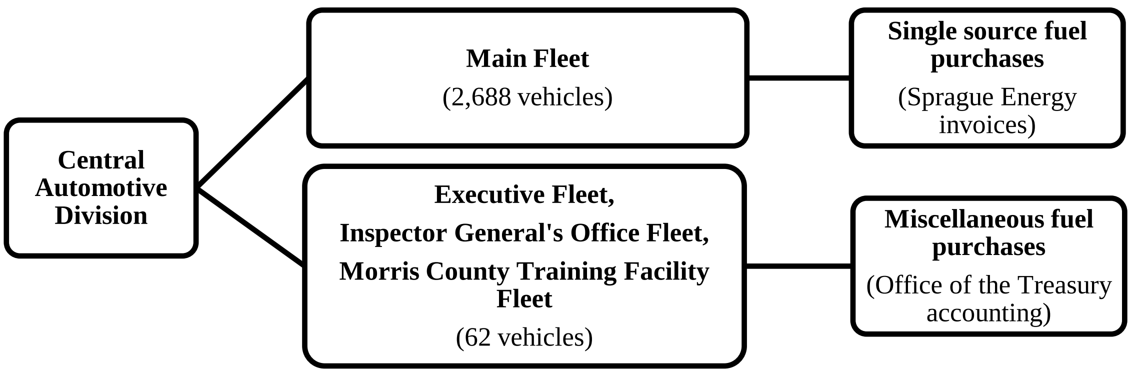


Figure 3-1: Recordkeeping for CAD Fleets

3.1.2. GHG Emission Factors and Other Parameters

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

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

For all fuel types, CH_4 and N_2O emissions were estimated using SEMs, based on the ratio of CO_2 to CH_4 and

N_2O emissions taken from GRP Table 13.9 (TCR, 2013a). The emission factors used to calculate the emissions are presented in Table 3-2.

Table 3-2: Standard Emission Factors for 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
Propane	0%	5.59	0	0.000062	0.000070

Because a number of commercial transportation fuels combine petroleum and biofuel products, it is necessary to adjust the standard emissions factors to differentiate between anthropogenic and biogenic mobile combustion emissions. The latter corresponds to the combustion of the biofuel volume in a given commercial fuel blend. For instance, commercial gasoline (E90) is a mixture of a petroleum product (90 percent) and bioethanol (10 percent); therefore, the effective biogenic emission factor for commercial gasoline was calculated as the product of the ethanol carbon content and the concentration of ethanol in the commercial fuel blend as follows: 10% × 5.75 kg CO_2/gal = 0.575 kg CO_2/gal. Table 3-3 shows the effective CO_2 emissions factors for petroleum and biofuel blends consumed by the CAD fleet.

Table 3-3: Effective CO_2 Emission Factors for the CAD Fleet			
Fuel Type	**Percentage Biofuels**	**CO_2 (kg/gal)**	**Biogenic CO_2 (kg/gal)**
Gasoline (E10)	10%	7.90	0.58
Biodiesel (B20)	20%	8.17	1.89
E85	85%	1.32	4.89

3.1.3. GHG Emissions Estimates

The estimate of GHG emissions for the CAD main fleet is displayed in Table 3-4. Both anthropogenic and biogenic CO_2 emissions use the standard methodology, while the CH_4 and N_2O emissions use SEMs.

Table 3-4: 2013 GHG Emissions for Main Fleet (metric tons)				
Fuel Type	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
Gasoline (E10)	8,281.5	602.6	5.5×10^{-1}	6.2×10^{-1}
#2 Diesel	163.4	0.0	1.0×10^{-2}	1.1×10^{-2}
Biodiesel (B20)	2,291.3	530.2	1.8×10^{-1}	2.0×10^{-1}

Table 3-4: 2013 GHG Emissions for Main Fleet (metric tons)				
Fuel Type	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
E85	135.8	503.9	4.0×10^{-2}	4.5×10^{-2}
CNG	253.9	0.0	1.6×10^{-2}	1.8×10^{-2}
Propane	7.2	0.0	4.5×10^{-4}	5.0×10^{-4}
Total	11,133.1	1,636.7	8.0×10^{-1}	8.9×10^{-1}

Table 3-5 shows the emissions estimated from the rest of the fleet, tracked by the Office of the Treasury.

Table 3-5: 2013 GHG Emissions for Executive Fleet, Security, and Training Vehicles (metric tons)				
Department	**CO_2**	**Biogenic CO_2**	**CH_4**	**N_2O**
Gasoline (E10)	234.3	17.1	0.016	0.018
#2 Diesel	0.3	0.0	0.000	0.000
Total	234.7	17.1	0.016	0.018

Table 3-6 shows the total CAD emissions estimated for each pollutant based on calculation methodology.

Table 3-6: 2013 GHG Emissions from the CAD Fleet (metric tons)				
Emission Method	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Standard Estimation Method	11,133	0.0	0.0	11,133
SEM	235	0.8	0.9	533
Biogenic Emissions	1,654	0.0	0.0	1,654
Total	**13,022**	**0.8**	**0.9**	**13,320**

3.1.4. CAP Activity Data

The vehicle activity provided by CAD came in different units of measurement according the specific segments of the fleet. For most highway vehicles, activity data consisted of recorded miles traveled. For smaller segments of the fleet such as the executive fleet and non-highway vehicles (e.g., forklifts), the activity data consisted of fuel consumed. The selection of the best emission factor based on available activity data is discussed in section 3.1.5 below for each fleet segment.

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 2014) (EPA, 2014a). These emission factors are expressed as grams per mile based on model year and vehicle type for the 2013 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 2013 estimates of mileage per vehicle provided by the CAD to calculate total CAP emissions per vehicle.

Non-highway emissions were calculated by multiplying total per-vehicle fuel consumption by the national average emission factors from EPA's MARKet ALlocation (MARKAL) model database (Pechan, 2010).

There were many cases in which vehicles reported zero fuel consumption but had significant mileage recorded for the vehicle. In these cases, the MOVES 2014 per mile emission factors for that model year and vehicle type were multiplied by the vehicle's annual mileage driven to estimate CAP emissions.

CAP emissions for bulk CNG and propane were estimated by multiplying total fuel consumption by the appropriate MARKAL emission factors.

The CAP estimates for the executive fleet and the security and training vehicles were based on the per-gallon emission factors from EPA's MARKAL database (Pechan, 2010), because no information on mileage per vehicle was available.

3.1.6. CAP Emissions Estimates

Table 3-7 shows the CAP emissions estimates for the entire CAD fleet.

Table 3-7: 2013 CAP Emissions for the CAD Fleet (metric tons)

Vehicle Type	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Highway Vehicles	4.92	0.19	1.95	0.48
Non-highway Vehicles	0.47	0.01	0.04	0.04
Zero Fuel Recorded	2.14	0.03	0.49	0.18
Bulk CNG	0.05	0.01	0.05	0.05
Propane	0.02	0.00	0.00	0.00
Executive/Security Fleet	1.48	0.09	0.41	0.38
Total	**9.08**	**0.33**	**2.94**	**1.14**

3.2. PATH DIESEL EQUIPMENT

3.2.1. Activity Data

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

3.2.2. GHG Emission Factors and Other Parameters

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

3.2.3. GHG Emissions Estimates

Total GHG emissions for PATH diesel equipment are shown in Table 3-8.

Table 3-8: 2013 GHG Emissions from PATH Diesel Equipment (metric tons)

CO_2	CH_4	N_2O	CO_2e
315.73	1.79×10^{-2}	8.04×10^{-3}	318.60

3.2.4. CAP Emission Factors

The emission factors for CAP for diesel equipment used in the PATH system were calculated based on the national average emission factors from the EPA MARKAL database.

3.2.5. CAP Emission Estimates

Table 3-9 reports CAP emissions for diesel equipment used in the PATH system.

Table 3-9: 2013 CAP Emissions from PATH Diesel Equipment (metric tons)

NO_x	SO_x	PM_{10}	$PM_{2.5}$
0.37	0.005	0.03	0.03

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. The 2013 inventory is consistent with the 2012 assessment, which was developed according to the decision tree shown in Figure 4-1. The 2013 inventory continues this inventory effort to get survey information wherever possible. Although most of the information was eventually gathered using a survey, in some cases surrogate data were used to develop a rough and conservative emissions estimate. The decision tree for the selection of methods to quantify fugitive emissions from AC equipment (both stationary and mobile) is shown in Figure 4-1.

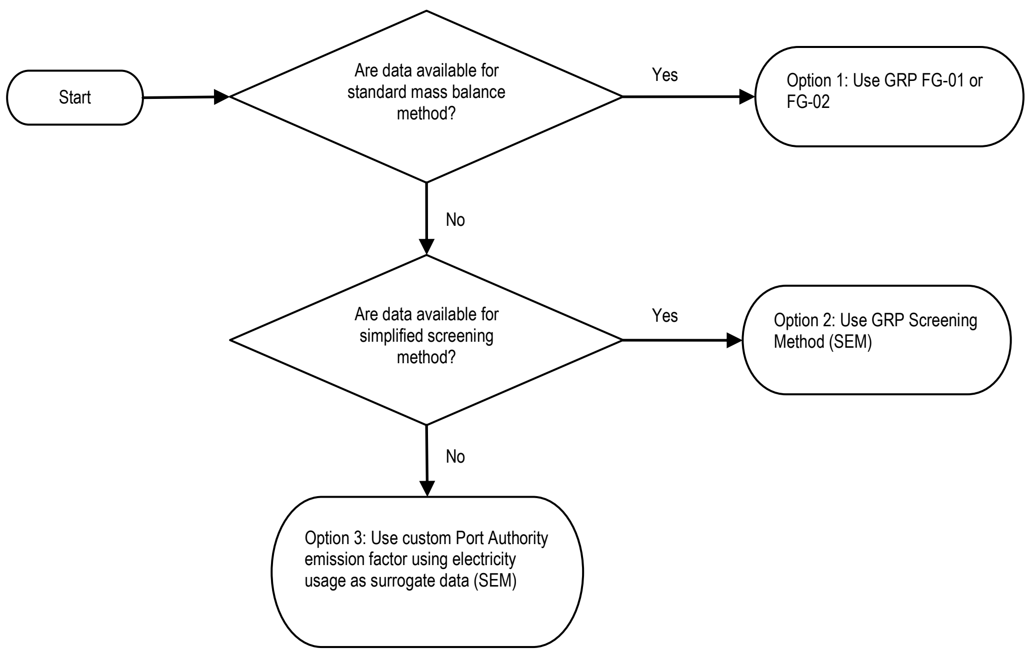


Figure 4-1: Selection of Method to Quantify Fugitive Emissions from AC Equipment

Option 1

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 2013 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 (e.g., additions, removals) to the baseline equipment list. This method is incorporated into the GRP as an approved SEM (TCR, 2013a).

Option 3

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

4.1.1. Activity Data

Whenever AC equipment lists were available, the analysis follows the Option 2 methodology. 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 best available activity data.

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

Facility Description		Method
Fleet (CAD)	CAD	Option 2
JFK	JFK	Option 3
LGA	LGA	Option 3
SWF	SWF	Option 2
EWR	EWR	Option 2
TEB	TEB	Option 3
Port Commerce Facilities NY	Brooklyn Cruise Terminal	Option 2
	Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)	Option 2
	Howland Hook Marine Terminal	Option 2

Table 4-1: Selection of Refrigerant Methodology Option by Facility		
Facility Description		**Method**
Port Commerce Facilities NJ	Elizabeth Port Authority Marine Terminal	Option 3
	Port Jersey	Option 3
	Port Newark Marine Terminal	Option 3
Tunnels & Bridges	George Washington Bridge	Option 2
	Holland Tunnel	Option 2
	Lincoln Tunnel	Option 2
Bus Terminals NY	George Washington Bridge Bus Terminal	Option 3
	PABT	Option 2
AirTrain JFK	AirTrain JFK	Option 3
AirTrain EWR	AirTrain EWR	Option 3
PATH	PATH	Option 2
PATH Buildings	PATH Buildings	Option 2
	PATH Buildings (54 window units)	Option 3

4.1.2. Emission Factors and Other Parameters

Emissions of HFCs and PFCs from refrigeration and AC equipment result from the manufacturing process, leakage over the operational life of the equipment, and disposal at the end of the useful life of the equipment. Common refrigerants, such as R-22, R-12, and R-11, are not part of the GHGs required to be reported to The 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). The resulting emissions estimates for each HFC and PFC were converted to units of CO_2e using the appropriate GWP factors 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 method 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 ($g\ CO_2e/kWh$)**
John F. Kennedy International Airport	Airport Facilities	15.8
LaGuardia Airport	Airport Facilities	15.8
Teterboro Airport	Airport Facilities	15.8
Port Commerce Facilities NJ	Airport Facilities	15.8
G.W. Bridge Bus Terminal	Port Authority Bus Terminal	18.5
AirTrain JFK	PATH Trains	11.3
AirTrain Newark	PATH Trains	11.3
PATH Buildings	Airport Facilities	15.8

4.1.3. GHG Emissions Estimates

GHG emissions estimates for refrigerants used by the Port Authority during 2013 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: 2013 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			301.2				301.2
JFK						1,297.4	1,297.4
LGA						618.8	618.8
SWF	36.1			2.0			38.1
EWR	1,705.5	7.2			168.3		1,881.0
TEB						40.0	40.0
Brooklyn Cruise Terminal						0.0	0.0
Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)				2.8			2.8
Howland Hook Marine Terminal				2.9			2.9
Elizabeth Port Authority Marine Terminal						67.2	67.2
Port Jersey						6.5	6.5
Port Newark Marine Terminal						143.2	143.2
George Washington Bridge	0.1						0.1
Holland Tunnel	0.0						0.0
Lincoln Tunnel	0.2						0.2
G. W. Bridge Bus Terminal						103.5	103.5
PABT	485.2						485.2
AirTrain JFK						461.1	461.1
AirTrain EWR						202.0	202.0
PATH			1,104.6				1,104.6
PATH Buildings	322.5					109.6	432.1
Total	**2,549.5**	**7.2**	**1,405.8**	**7.7**	**168.3**	**3,049.2**	**7,187.7**

4.1.3.1. 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, 2013a), the default capacity of mobile AC units was conservatively estimated to be 1.5 kg. This figure was multiplied by the average leakage per year (also from GRP Table 16.2) and the total number of vehicles in the CAD fleet. The CAD fleet included 2,688 vehicles in the main fleet in 2013 (1,369 highway vehicles, 108 non-highway vehicles, and 1,211 “other” vehicles) and 62 vehicles in the executive/security fleet, for a total of 2,750 vehicles. “Other” vehicles include 1,019 vehicles with no fuel consumption reported and 192 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 because very few vehicles are expected to be used so heavily each year.

4.1.3.2. Airports

ODS substitutes were estimated for the five airport facilities based on the data available. SWF and EWR reported their equipment inventories with sufficient detail to estimate refrigerant leaks at the equipment level. JFK, LGA, and TEB did not report. Therefore, the project team calculated an average emission factor of 15.8 grams of CO_2e per kilowatt hour (g CO_2e/kWh) based on the CO_2e emissions from SWF and EWR divided by the electricity consumption for these two airports. This emission factor was applied to the electricity consumption at JFK, LGA, and TEB to estimate overall CO_2e emissions from ODS substitutes. The electricity consumption used in this estimate did not include tenant electricity use if that electricity usage could be identified and removed. The analysis conservatively assumed that chillers and other AC units were used 50 percent of the time in 2013, which is likely an overestimate.

4.1.3.3. Other Facilities

Tunnels and Bridges reported information on refrigerant equipment, and emissions were estimated from these equipment inventories based on default use and leakage. Sufficient equipment-level information was available to estimate emissions from Real Estate – NY. There was also equipment-level information available for the New Jersey Bridges and Tunnels, as well as PABT and some equipment in PATH buildings. The Option 2 methodology was used wherever possible to estimate emissions from ODS substitute refrigerants. 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 facility managers requesting a list of fire protection equipment (e.g., centralized system, hand-held devices), the nature of the fire suppressant used to charge such equipment, and the amount of fire suppressant purchased for equipment recharge (as a proxy for GHG releases). Based on the survey responses, CO_2 and FM-200® are the latent GHGs to be reported in the event of equipment discharge. According to the GRP (TCR, 2013a), FM-200 fire suppression systems in communication rooms for the transit sector may be disclosed as excluded minuscule sources without the need to quantify actual fire suppressant releases. Facility use of latent GHGs in fire protection equipment is summarized in Table 4-4.

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

Facility Description	Type of Fire Suppressant			
	CO_2	FM-200	No GHG	Unknown
JFK			X	
LGA		X		
SWF	X		X	
EWR				X
TEB			X	
Brooklyn Cruise Terminal			X	
Brooklyn Marine Terminal (Red Hook/Brooklyn Piers)			X	
Howland Hook Marine Terminal			X	
Elizabeth Port Authority Marine Terminal				X
Port Jersey				X
Port Newark Marine Terminal				X
George Washington Bridge				X
Holland Tunnel				X
Lincoln Tunnel				X
Staten Island Bridges				X
G. W. Bridge Bus Terminal				X
PABT			X	
PATH Buildings	X	X	X	
Bathgate Industrial Park			X	
The Teleport			X	

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 relatively low utilization of these systems and infrequent occurrence of fire events are factors that may explain why the inventory shows no reportable activity related to fire suppressants in 2013. Port Authority indicated that there were no releases from fire events, and only a tiny release (approximately 0.1 tons of CO_2) that occurred as a result of equipment testing.

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 for a total surface area of 178 acres.

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

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

4.3.2. Emission Factors and Other Parameters

Emissions estimates were developed in accordance with "Local Government Operations Protocol," Chapter 9, "Solid Waste Management," as prescribed by The Registry (TCR, 2010). The project team used the default values from the model for the percentage of waste that is anaerobically degradable organic carbon, as no specific information was available on the waste disposal rates. The model was also run with the assumptions 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

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

atmosphere. The decay constant (i.e., k-value) was set at 0.057, corresponding to areas that regularly receive more than 40 inches of annual rainfall. CO_2 emissions that are calculated by the model are reported in Table 4-5, but they are classified as biogenic and not included in the CO_2e emissions total for the site.

4.3.3. Emissions Estimates

The 2013 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: 2013 GHG Emissions from the Historic Elizabeth Landfill

Biogenic CO_2 (metric tons)	CH_4 (metric tons)	CH_4 (metric tons CO_2e)
661	197	4,141

In addition to GHG emissions, the historic Elizabeth Landfill also emits VOCs, a precursor to CAP. In 2013, the historic Elizabeth Landfill emitted 0.832 metric tons of VOCs.

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 to be Scope 2 emissions. Table 5-1 lists the facilities and rail systems where electricity was consumed by the Port Authority.

Table 5-1: Port Authority Facilities with Electricity Consumption

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

Note: Facilities may include multiple buildings.

5.1. BUILDINGS

This inventory considers all buildings where electricity was consumed by the Port Authority. For a total of five facilities (JFK, LGA, SWF, PABT, and Teleport), total electricity consumption was shared by the Port Authority and its tenants; therefore, the total electricity consumption was split between the Port Authority and the tenant. For facilities where total dollars spent on electricity through lease agreements were not available, consumption was divided based on 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. All GHGs associated with the consumption of electricity by tenants are considered Scope 3 emissions for the Port Authority, and are found in Section 8.0 of this report.

5.1.1. Activity Data

The Port Authority provided data on electricity consumption by month for each building in kilowatt hours (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 the analysts downloaded data from the provider's website in the form of screen shots converted to PDF or transcribed data from the website into an Excel workbook.

5.1.2. Emission Factors and Other Parameters

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

Table 5-2: Electricity Consumption GHG Emission Factors

Emissions & Generation Resource Integrated Database (eGRID) 2012 Subregion/Provider	CO_2 (kg/kWh)	CH_4 (kg/kWh)	N_2O (kg/kWh)
NYCW (NPCC NYC/Westchester)	0.277	1.08×10^{-5}	1.27×10^{-6}
NYUP (NPCC Upstate NY)	0.226	7.23×10^{-6}	3.07×10^{-6}
RFCE (RFC East)	0.430	1.22×10^{-5}	6.79×10^{-6}
KIAC Facility (Kennedy International Airport Cogeneration)	0.412	2.95×10^{-5}	6.99×10^{-6}

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

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, 2012). Because more GHGs are associated with coal combustion than with natural gas combustion, the emission factors in the Reliable First Corporation East subregion are higher than those in NPCC – NYC/Westchester.

The electricity metrics for KIAC were determined as the ratio of distributed emissions over net electricity generation. Energy inputs (natural gas) and net electricity generation were provided by Calpine Corporation (Calpine, 2014). KIAC GHG emissions were determined based on natural gas consumption by the plant and GRP emission factors (TCR, 2013a). Similarly, emissions of PM_{10} and $PM_{2.5}$ were determined on the basis of fuel consumption using EPA AP-42 emission factors (EPA, 1995). Plant emissions of NO_x and SO_2 were taken from EPA's "Air Markets Program Data" (EPA, 2013b). Emissions were then distributed to electricity generation using the efficiency method as described in GRP Equation 12k (TCR, 2013a). The resulting KIAC electricity metrics are presented in Table 5-2 for GHGs and Table 5-3 for CAPs. Note that electricity purchases from KIAC are limited to two service locations: JFK and AirTrain JFK.

For CAP emission factors associated with eGRID regions, SO_2 and NO_x emission factors were obtained from the EPA eGRID for each subregion (EPA, 2012). Emission factors for PM were calculated in proportion to the SO_2 emissions based on values derived from the 2008 EPA National Emissions Inventory (EPA, 2013a). This is a valid approach because the electricity comes from a variety of power plant sources, and the major factor that contributes to the difference in PM emissions is the control device(s) used. In order to find the proportion to use, total emissions from all electric generating processes were summed for plants in each state for SO_2, $PM_{2.5}$, and PM_{10}. These proportions were different because the percentage of plant types is different in the two states. PM emission factors were calculated as the product of statewide PM emissions and the SO_2 emission factor divided by the sum of statewide SO_2 emissions, as shown in Equation 5-1:

$$Ef_{PM} = Ef_{SO_2} x \frac{\sum_{State} PM}{\sum_{State} SO_2} \quad (5\text{-}1)$$

where

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

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

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

SO_2 = value of sulfur dioxide state emissions

Table 5-3 shows the CAP emission factors used for the 2013 electricity emissions estimates.

Table 5-3: Electricity Consumption CAP Emission Factors

eGRID 2012 Subregion/Provider	SO_2 (kg/kWh)	NO_x (kg/kWh)	$PM_{2.5}$ (kg/kWh)	PM_{10} (kg/kWh)
NPCC NYC/Westchester	4.67×10^{-5}	1.27×10^{-4}	2.00×10^{-6}	3.05×10^{-6}
NPCC Upstate NY	4.47×10^{-4}	1.79×10^{-4}	1.91×10^{-5}	2.91×10^{-5}
Reliable First Corporation East	2.09×10^{-3}	3.69×10^{-4}	3.52×10^{-4}	3.55×10^{-4}
KIAC	2.60×10^{-6}	8.26×10^{-5}	2.63×10^{-5}	2.63×10^{-5}

5.1.3. Emissions Estimates

Emissions estimates were developed in accordance with GRP Chapter 14, "Indirect Emissions from Electricity" (TCR, 2013a). In a small number of cases, when electricity consumption measurements were not available, engineering estimates were developed. For example, if no records existed for a given month, the electricity consumption was estimated by averaging the consumption for the previous and subsequent months. Additionally, if no records existed for a period of several months, electricity consumption was estimated using historical data from 2012. In accordance with GRP guidelines, emissions developed from engineering calculations are reported separately as SEM and aggregated with the estimates from all other emission sources. Indirect emissions from electricity purchases that were assessed using SEMs are presented in Table 1-6.

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

Table 5-4: 2013 GHG Emissions from Electricity Consumption in Buildings by Department (metric tons)

Department	CO_2	CH_4	N_2O	CO_2e
Aviation	82,323	3.921	1.216	82,782
Tunnels and Bridges	14,144	0.454	0.167	14,206
Bus Terminals	8,823	0.343	0.041	8,843
PATH Buildings	7,481	0.212	0.118	7,522
Central Administrative	7,294	0.219	0.102	7,330
Port Commerce	6,164	0.177	0.095	6,197
Real Estate	1,316	0.051	0.006	1,319
Totals	**127,546**	**5.378**	**1.745**	**128,199**

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 the operation of common areas at its terminals.

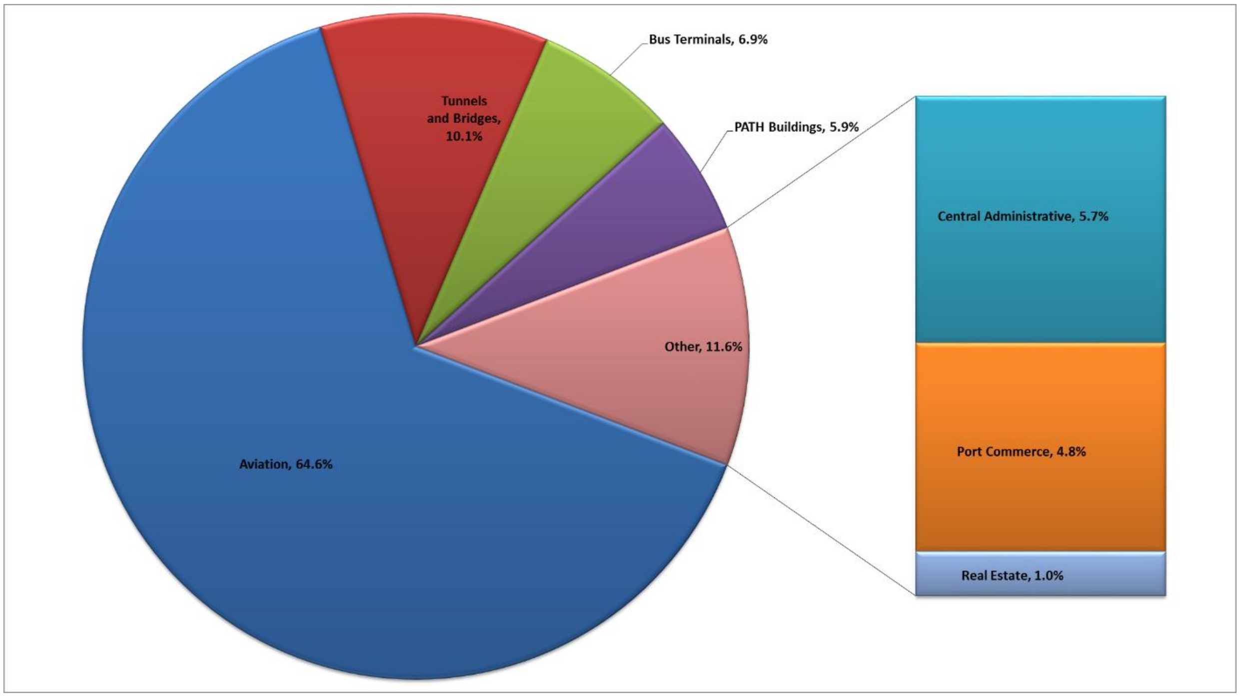


Figure 5-1: 2013 CO_2e Emissions from Electricity Consumption by Department

Table 5-5 shows the emissions estimates by facility. Electricity consumed in New Jersey has higher emission factors, due to the specific fuel mix used to generate the electricity. This results in higher levels of CO_2e when compared to a similar quantity of electricity consumed in New York.

Table 5-5: 2013 GHG Emissions from Electricity Consumption in Buildings by Facility (metric tons)

Facility	CO_2	CH_4	N_2O	CO_2e
JFK	33,929	2.432	0.576	34,158
EWR	35,424	1.004	0.559	35,618
LGA	10,887	0.423	0.050	10,912
PATH Buildings	7,481	0.212	0.118	7,522
Port Authority Bus Terminal	7,272	0.283	0.033	7,288
Lincoln Tunnel	6,555	0.210	0.078	6,583
PATC	5,010	0.142	0.079	5,037
PCNJ	5,919	0.168	0.093	5,952
Holland Tunnel	3,796	0.125	0.041	3,811
George Washington Bridge	2,525	0.072	0.040	2,539
George Washington Bridge Terminal	1,551	0.060	0.007	1,555
The Teleport	1,278	0.050	0.006	1,281
TEB	1,091	0.031	0.017	1,097
225 PAS	737	0.029	0.003	739
Goethals Bridge	692	0.025	0.005	694
777 Jersey	609	0.017	0.010	612
Gateway Newark	494	0.014	0.008	497
Outerbridge Crossing	411	0.015	0.003	413
Bayonne Bridge	165	0.006	0.001	166

Table 5-5: 2013 GHG Emissions from Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
233 PAS	41	0.002	0.000	41
96/100 Broadway	210	0.008	0.001	211
SWF	992	0.032	0.013	997
Brooklyn Marine Terminal	134	0.005	0.001	135
115 Broadway	136	0.005	0.001	137
Howland Hook	111	0.004	0.001	111
Bathgate Industrial Park	38	0.001	0.000	38
116 Nassau St.	56	0.002	0.000	56
Totals	**127,546**	**5.378**	**1.745**	**128,199**

CAP emissions totals are presented by department and by facility in Table 5-6 and Table 5-7, respectively.

Table 5-6: 2013 CAP Emissions for Electricity Consumption by Department (metric tons)				
Department	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Aviation	181.486	43.904	32.231	32.561
Tunnels and Bridges	45.183	10.124	7.507	7.588
PATH Buildings	36.356	6.419	6.126	6.177
Central Administrative	29.909	5.786	5.015	5.060
Port Commerce	28.811	5.191	4.850	4.890
Bus Terminals	1.488	4.034	0.064	0.097
Real Estate	0.222	0.602	0.009	0.014
Totals	**323.5**	**76.1**	**55.8**	**56.4**

Table 5-7: 2013 CAP Emissions for Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
EWR	172.2	30.4	29.0	29.3
PATH Buildings	36.4	6.4	6.1	6.2
PATC	24.3	4.3	4.1	4.1
PCNJ	28.8	5.1	4.8	4.9
Lincoln Tunnel	21.0	4.7	3.5	3.5
George Washington Bridge	12.3	2.2	2.1	2.1
Holland Tunnel	10.6	2.6	1.7	1.8
TEB	5.3	0.9	0.9	0.9
777 Jersey	3.0	0.5	0.5	0.5
Gateway Newark	2.4	0.4	0.4	0.4
LGA	1.8	5.0	0.1	0.1
Bayonne Bridge	0.0	0.1	0.0	0.0
Port Authority Bus Terminal	1.2	3.3	0.1	0.1
Outerbridge Crossing	0.5	0.2	0.1	0.1
SWF	2.0	0.8	0.1	0.1
George Washington Bridge Terminal	0.3	0.7	0.0	0.0
JFK	0.2	6.8	2.2	2.2
The Teleport	0.2	0.6	0.0	0.0
225 PAS	0.1	0.3	0.0	0.0
Goethals Bridge	0.8	0.4	0.1	0.1
233 PAS	0.0	0.0	0.0	0.0

Table 5-7: 2013 CAP Emissions for Electricity Consumption in Buildings by Facility (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
96/100 Broadway	0.0	0.1	0.0	0.0
Brooklyn Marine Terminal	0.0	0.1	0.0	0.0
115 Broadway	0.0	0.1	0.0	0.0
Howland Hook	0.0	0.1	0.0	0.0
Bathgate Industrial Park	0.0	0.0	0.0	0.0
116 Nassau St.	0.0	0.0	0.0	0.0
Totals	**323.5**	**76.1**	**55.8**	**56.4**

5.2. RAIL SYSTEMS

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

5.2.1. Activity Data

For electricity consumption for the PATH, AirTrain EWR, and AirTrain JFK, the Port Authority provided consumption data by month for each building in kWh. It transcribed some of the data directly from the utility's website into a Microsoft Excel workbook and provided additional data in the form of copies of bills from the utility. In some cases, data were not immediately available, so the analysts 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 GRP 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, in order to conservatively capture all emissions.

5.2.2. Emission Factors and Other Parameters

As described in Section 5.1.3, emissions estimates are developed in accordance with GRP Chapter 14, "Indirect Emissions from Electricity" (TCR, 2013a). The GHG emission factors used to calculate the GHGs associated with electricity consumption are shown in Table 5-2.

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

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

5.2.3. Emissions Estimates

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

Table 5-8: 2013 GHG Emissions from Electricity Consumption by Train System (metric tons)

Train	CO_2	CH_4	N_2O	CO_2e
PATH Rail System	42,047	1.19	0.66	42,278
AirTrain JFK	16,090	1.10	0.25	16,192
AirTrain Newark	7,687	0.22	0.12	7,730
Total	65,824	2.51	1.04	66,200

Table 5-9: 2013 CAP Emissions from Electricity Consumption by Train System (metric tons)

Train	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PATH Rail System	204.36	36.08	34.44	34.72
AirTrain Newark	37.36	6.60	6.30	6.35
AirTrain JFK	0.34	3.61	0.94	0.95
Total	242.07	46.29	41.68	42.01

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

This chapter discusses emissions associated with energy purchases in the form of steam, heating, and cooling from the KIAC facility 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, 2014). KIAC GHG emissions were determined based on natural gas consumption by the plant and GRP emission factors (TCR, 2013a); similarly, PM_{10} and $PM_{2.5}$ emissions were determined on the basis of fuel consumption using EPA AP-42 emission factors (EPA, 1995). Plant emissions of NO_x and SO_2 were taken from EPA's "Air Markets Program Data" (EPA, 2013b). Emissions were then distributed to heating and cooling using the efficiency method as described in GRP Equation 12k (TCR, 2013a). The resulting heating and cooling emission factors are presented in Table 6-1 for GHGs and Table 6-2 for CAPs.

Table 6-1: KIAC GHG Emission Factors

Product	CO_2	CH_4	N_2O
Heating (kg/MMBtu)	61.08	4.38×10^{-3}	1.04×10^{-3}
Cooling (kg/MMBtu)	61.08	4.38×10^{-3}	1.04×10^{-3}

Table 6-2: KIAC CAP Emission Factors				
Product	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Heating (kg/MMBtu)	3.85×10^{-4}	1.22×10^{-2}	3.89×10^{-3}	3.89×10^{-3}
Cooling (kg/MMBtu)	3.85×10^{-4}	1.22×10^{-2}	3.89×10^{-3}	3.89×10^{-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: 2013 GHG Emissions from KIAC Energy Purchases (metric tons)				
Energy Use	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
JFK Heating	2,231	0.160	0.038	2,246
JFK Cooling	5,023	0.360	0.085	5,057
JFK Total	**7,254**	**0.520**	**0.123**	**7,303**
AirTrain Heating	634	0.049	0.012	689
AirTrain Cooling	763	0.055	0.013	769
AirTrain Total	**1,447**	**0.104**	**0.025**	**1,457**

Table 6-4: 2013 CAP Emissions from KIAC Energy Purchases (metric tons)				
Energy Use	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
JFK Heating	0.0141	0.4474	0.1422	0.1422
JFK Cooling	0.0317	1.0074	0.3202	0.3202
JFK Total	**0.0457**	**1.4548**	**0.4624**	**0.4624**
AirTrain Heating	0.0043	0.01371	0.0436	0.0436
AirTrain Cooling	0.0048	0.1531	0.0487	0.0487
AirTrain Total	**0.0091**	**0.2902**	**0.0923**	**0.0923**

6.2. PORT AUTHORITY BUS TERMINAL

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

6.2.1. Activity Data

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

6.2.2. Emission Factors and Other Parameters

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

Table 6-5: 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}	$6.22\ 10^{-2}$	6.69×10^{-3}

6.2.3. Emissions Estimates

Because 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. It should be noted that the increase in emissions from 2012 at PABT was directly caused by extensive testing performed on the Sovaloid System, which is the bus terminal ramp snow melting system. During the testing, the Sovaloid System had to be operated at 150 degrees to ensure proper oil flow & simulate system operation during a storm.

Table 6-6: 2013 PABT GHG Emissions from Con Edison Steam Purchases (metric tons)

Building	CO_2	CH_4	N_2O	CO_2e
PABT	4,339	0.4896	0.0204	4,355.33

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

Table 6-7: 2013 PABT CAP Emissions from Con Edison Steam Purchases (metric tons)

Building	SO_2	NO_x	$PM_{2.5}$	PM_{10}
PABT	2.4501	4.0303	0.2091	0.2239

7.0 ENERGY PRODUCTION (SCOPE 3)

This chapter discusses the emitting activities associated with two power generation plants owned by the Port Authority: the KIAC facility located in New York, and the ECRR facility located in New Jersey.

7.1. KENNEDY INTERNATIONAL AIRPORT COGENERATION

The Port Authority leases the KIAC facility to KIAC Partners, a partnership wholly owned by the Calpine Corporation, pursuant to a long-term lease agreement expiring on January 31, 2020. KIAC Partners is responsible for the operation and maintenance of the KIAC facility. The current business model features an energy purchase agreement with the Port Authority for electricity and thermal energy required by JFK in which excess electricity is sold to the electricity market and excess thermal energy is resold to JFK tenants (Port Authority, 2014b).

This section describes how plant-level operational data were used to assess plant-level emissions, as well as the steps taken for distributing these emissions between Port Authority and JFK airport tenant energy consumption.

7.1.1. Activity Data

The KIAC facility is a combined-cycle power plant equipped with two identical gas combustion turbines and one steam generator fed by two heat recovery steam generators (HRSGs). The gas combustion turbines and HRSGs run on natural gas. The KIAC facility produces both electricity and thermal energy.

The plant operator, Calpine Corporation, provided all necessary information to assess plant-specific electricity and thermal production metrics in terms of mass of air pollutants over electricity or thermal energy sold. Key operational data included fuel input, electric power output, and thermal production output (Calpine, 2014).

7.1.2. Plant Emissions Methodology

This analysis used a fuel-based methodology, whereby the natural gas fuel input was converted to emissions using default emission factors. The CO_2 emission factor is fuel specific to natural gas, and the N_2O and CH_4 emission factors are fuel type and power generation technology specific (e.g., combined cycle, natural gas combustion). PM emission factors were obtained from EPA AP-42, Chapter 1 Table 1.4-2 (EPA, 1995), where the industry-average emission rate is expressed in terms of PM mass per volume of natural gas combusted. Note that PM_{10} and $PM_{2.5}$ emissions were assumed to be the same as a conservative measure. Emission factors used in the assessment are presented in Table 7-1.

Table 7-1: Emission Factors for Natural Gas Combustion at Combined Cycle Power Plant			
Pollutant	**Value**	**Units**	**Source**
CO_2	53.02	kg/MMBtu	TCR, 2013a, Table 12.1
CH_4	3.8	g/MMBtu	TCR, 2013a, Table 12.5
N_2O	0.9	g/MMBtu	TCR, 2013a, Table 12.5
$PM_{2.5}$	7.6	lbs/10^6 scf	EPA, 1995
PM_{10}	7.6	lbs/10^6 scf	EPA, 1995

NO_x and SO_2 emissions were obtained from environmental compliance public records (EPA, 2013b).

7.1.3. Distributed Emissions Methodology

To determine the portion of emissions attributable to electricity and thermal energy generation, it was necessary to back-calculate energy input from energy outputs using typical system efficiency values. The efficiency of electricity process was calculated from operation records as 40 percent; a default value (80 percent) was adopted in the case of thermal production. This assessment adopted the distributed emissions methodology of The Registry, an excerpt of which is presented in Figure 7-1 (TCR, 2013a).

Equation 12k | **Allocating CHP Emissions to Steam and Electricity**

Step 1: $E_H = (H \div e_H) \div [(H \div e_H) + (P \div e_P)] \times E_T$

Step 2: $E_P = E_T - E_H$

Where:

E_H = Emissions allocated to steam production
H = Total steam (or heat) output (MMBtu)
e_H = Efficiency of steam (or heat) production
P = Total electricity output (MMBtu)
e_P = Efficiency of electricity generation
E_T = Total direct emissions of the CHP system
E_P = Emissions allocated to electricity production

Source: TCR, 2013a.

Figure 7-1: Distributed Emissions Methodology

7.1.4. Electricity and Thermal Energy Metrics

KIAC facility emissions were distributed to electricity and thermal (heating and cooling) energy using the methodology described in Section 7.1.2. The resulting plant metrics are presented in Table 7-2 for each type of energy production and pollutant. These plant metrics were used to estimate Port Authority indirect emissions from electricity and thermal energy purchases, as described in Chapters 5 and 6, respectively.

Table 7-2: KIAC Electricity and Thermal Energy Metrics by Pollutant							
Metric	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
Heating (kg Pollutant/MMBtu	61.08	0.0044	0.0010	0.0122	0.0004	0.0039	0.0039
Cooling (kg Pollutant/MMBtu	61.08	0.0044	0.0010	0.0122	0.0004	0.0039	0.0039
Electricity (kg Pollutant/MWh)	411.83	0.0295	0.0070	0.0826	0.0026	0.0263	0.0263

7.1.5. Results

KIAC facility GHG emissions are presented in Table 7-3, and CAP emissions are summarized in Table 7-4.

Table 7-3: KIAC GHG Emissions Summary (metric tons)			
CO_2	**CH_4**	**N_2O**	**CO_2e**
299,986	21.50	5.09	302,016

Table 7-4: KIAC CAP Emissions Summary (metric tons)			
NO_x	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
60.16	1.89	19.12	19.12

7.2. ESSEX COUNTY RESOURCE RECOVERY FACILITY

At the ECRR facility, GHG and CAP emissions result from energy recovery activities, primarily the combustion of MSW as the primary source of energy for electricity generation, with diesel fuel combustion as an auxiliary energy source. The emission boundary includes emissions from electricity generation activities and excludes emissions associated with hauling and tipping of waste. The ECRR facility consists of three mass-fired boilers with two turbine generators.

7.2.1. GHG Emissions Methodology

Under EPA's Greenhouse Gas Reporting Program (GGRP), defined under Title 40 of the Code of Federal Regulations (40 CFR) Part 98, large electricity producers must report general combustion CO_2 emissions, as well as biogenic CO_2, CH_4, and N_2O emissions. The ECRR facility is subject to 40 CFR Part 98 reporting and annually submits to EPA quality-assured data from continuous emission monitoring systems (CEMSs). Part 98 reporting data were accessed through EPA's Facility Level Information on GreenHouse gases Tool (FLIGHT) database (EPA, 2014b). A CEMS is the total equipment necessary for the determination of an emission rate using pollutant analyzer measurements at the stack. Emission estimates using CEMSs are verified by the EPA and meet the highest standard of accuracy under the GGRP. For that reason, the GHG emissions, heat rating, and hours of operation data collected under EPA's GGRP served as the basis of the GHG analysis presented in this chapter (EPA, 2014b).

7.2.2. CAP Emissions Methodology

NO_x and SO_2 emissions are directly proportional to the facility's heat input. Using EPA's GGRP information, the analysis assessed heat input as the product of each combustor's maximum heat input rating and the unit's annual hours of operation. The sum of each unit's heat input was converted to NO_x and SO_2 emissions using the emissions factors published by eGRID (EPA, 2012). The eGRID database provides emissions rates specific to ECRR operations in terms of mass of pollutant per unit of heat input.

PM emission factors were obtained from EPA AP-42, Chapter 2 Table 2.1-8 (EPA, 1995), where the industry-average emission rate is expressed in terms of PM mass per unit mass of MSW combusted for a given control technology. The selection of the emission factors from AP-42 reflects the control equipment installed at ECRR, consisting of electrostatic precipitators and spray dry scrubber systems. PM_{10} and $PM_{2.5}$ emissions were assumed to be the same as a conservative measure.

The actual mass of MSW combusted at the ECCR facility was not available but was derived from available information as follows. MSW components, as characterized by EPA (EPA, 2014d), were multiplied by their respective average energy content from the U.S. Energy Information Administration (EIA) (EIA, 2007) in order to get an estimated average MSW energy content of 8.99 MMBtu per short ton. This was divided by the aforementioned estimate of facility heat input to get the estimated annual tonnage of MSW of 920,000 short tons. MSW tonnage was then multiplied by the corresponding PM emission factors. Table 7-5 presents the emission rates for criteria pollutants.

Table 7-5: CAP Emission Factors for MSW Combustion

Pollutant	Value	Units	Source
NO_x	0.16	(lb/MMBtu)	EPA, 2014c, "Covanta Essex Company" Profile, Plant Sequence Number 3519
SO_2	0.69	(lb/MMBtu)	
PM_{10}	0.1	(lbs/short ton)	EPA, 1995, AP-42, Table 2.1-8, Spray Dryer/ESP Emission Factors
$PM_{2.5}$	0.1	(lbs/short ton)	

In addition to MSW, a small volume of distillate No. 2 fuel oil was used as auxiliary fuel. The quantity of distillate fuel oil combusted at the facility was not included in the FLIGHT database and, therefore, was back-calculated using the reported CH_4 emissions from distillate fuel. Using Registry emissions factor of 0.0014 kg of CH_4 per gallon of diesel fuel (TCR, 2013b) results in an estimate that 121,000 gallons of distillate No. 2 fuel oil were combusted in 2013. These estimated gallons of diesel fuel were multiplied by the CAP emission factors for No. 2 fuel oil (see Table 7-6) obtained from EPA AP-42, Chapter 1, Table 1.3-1 (EPA, 2010b).

Table 7-6: CAP Emission Factors for No. 2 Fuel Oil Combustion	
Pollutant[a]	**Emission Factor (Short Tons/Gallon)**
NO_x	0.0000108863
SO_2	0.0000644108
PM_{10}	0.0000010796
$PM_{2.5}$	0.0000009662

[a] It was assumed that the PM_{10} emission factor is the sum of the PM_{10} - Filterable and PM Condensable emission factors and that the $PM_{2.5}$ emission factor is the sum of the $PM_{2.5}$-Filterable and PM Condensable emission factors.
Source: EPA, 2010b.

7.2.3. Results

GHG emissions results from the ECRR facility are presented in Table 7-7, where emissions are broken down by combustor unit. The ECCR facility uses MSW as primary fuel and No. 2 fuel oil as an auxiliary fuel. Emissions come almost exclusively from MSW combustion, with less than 0.5 percent resulting from No. 2 fuel oil combustion. CAP emissions estimates are summarized in Table 7-8.

Table 7-7: Essex County Resource Recovery Facility GHG Emissions, 2013 (metric tons)						
Fuel Type	**Combustor Unit**	**Biogenic CO_2**	**Non-Biogenic CO_2**	**CH_4**	**N_2O**	**CO_2e**
MSW	1	168,952	109,895	94.06	12.35	116,338
Distillate No. 2 Fuel Oil	1	0	413	0.06	0.01	5
MSW	2	166,677	108,415	94.68	12.43	114,892
Distillate No. 2 Fuel Oil	2	0	407	0.06	0.01	5
MSW	3	168,677	109,716	95.42	12.52	116,246
Distillate No. 2 Fuel Oil	3	0	412	0.05	0.01	4
Total		**504,306**	**329,258**	**284.33**	**37.33**	**347,490**

Table 7-8: Essex County Resource Recovery Facility 2013 CAP Emissions (metric tons)				
Source	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
MSW Combustion	667	2,853	46	46
No. 2 Fuel Oil Combustion	1.3	7.8	0.1	0.1
Totals	**668**	**2,861**	**46**	**46**

Note: Totals may not match the column sums due to rounding.

The 2013 anthropogenic CO_2e emissions due to combustion of MSW and fuel usage were 347,490 metric tons. This nets a 26 percent decrease in overall emissions from the facility during the 2006–2013 period. It is important to underscore that the introduction of EPA's GGRP has had the result of improving the quality of the 2013 GHG estimates because this recent program mandates an uncertainty range of less than 5 percent. This may explain some of the decrease between 2013 estimates and those from earlier years. Table 7-9 shows the difference between 2006 and 2013 estimated CO_2e emissions.

Table 7-9: CO_2e Emissions for Essex County Resource Recovery Facility, 2006–2013				
Essex County Resource Recovery Facility	**CO_2 Equivalent (metric tons)**			**Percentage Difference (2006 vs. 2013)**
	2006	**2008**	**2013**	
Waste combusted	466,379	478,970	346,243	-25.8%
Diesel fuel combusted	2,148	1,826	1,247	-41.9%
Total	**468,527**	**480,796**	**347,490**	-25.8%

8.0 TENANT ENERGY CONSUMPTION (SCOPE 3)

The Port Authority owns infrastructure and facilities that are entirely or partially leased to Port Authority tenants. The energy consumption of Port Authority-controlled operations is covered in Chapter 5; this chapter presents the energy consumption of Port Authority tenants within Port Authority facilities. The assessment of tenant energy consumption includes electricity, natural gas, and tenant thermal energy consumption.

Table 8-1 presents Port Authority facilities in which tenant energy consumption is known to occur or has the potential to occur. Energy consumption and associated emissions assessments were conducted for all facilities except when noted as "not quantified" (NQ) in Table 8-1. Specifically, energy consumption was not assessed for Atlantic City International Airport (ACY). Additionally, energy consumption for Midtown Properties and the Portfields Initiative was assessed as null until future redevelopment.

Table 8-1: Port Authority Facilities with Tenant Energy Consumption

Department/Facility	Type of Energy Consumption		
	Electricity	Natural Gas	Thermal
Airports			
ACY	√ (NQ)	√ (NQ)	
EWR	√	√	
JFK	√	√	√
LGA	√	√	
SWF	√	√	
TEB	√	√	
Tunnels, Bridges, and Terminals			
G.W. Bridge Bus Station	√	√	
Port Authority Bus Terminal	√	√	
PATH			
Journal Square Transportation Center	√	√	
Port Commerce			
New Jersey Marine Terminals	√	√	
New York Marine Terminals	√	√	
Real Estate			
Bathgate Industrial Park	√	√	
Industrial Park at Elizabeth	√	√	
Midtown Properties	√	√	
Portfields Initiative	√	√	
Queens West Waterfront Development	√	√	
The Legal Center	√	√	
The South Waterfront	√	√	
The Teleport	√	√	
WTC One	√	√	
Planning Department			
Vesey Street Ferry Terminal	√	√	

8.1. ELECTRICITY

8.1.1. Activity Data

Energy consumption was either compiled from metered electricity consumption statements or assessed from the share of building space corresponding to tenant occupancy. Electricity consumption statements were provided by the Port Authority for five facilities located in New York State: JFK, LGA, Port Authority Bus Terminal, Teleport, WTC Buildings, and Vesey Street Ferry Terminal (Port Authority, 2015c). For facilities where metered electricity consumption was not available, information relating to tenant building occupancy was gathered from contacts within the Real Estate Department. Table 8-2 presents a summary of tenant electricity consumption.

Table 8-2: Tenant Electricity Consumption by Facility

Facility	Electricity Usage (kWh)
Airports	**413,191,497**
JFK	257,680,464
LGA	56,678,183
ACY	NQ
EWR	54,494,749
SWF	29,614,436
TEB	14,723,665
Tunnels, Bridges, and Terminals	**7,285,298**
Port Authority Bus Terminal	5,617,023
G.W. Bridge Bus Station	1,668,275
PATH	**161,163**
Journal Square Transportation Center	161,163
Port Commerce	**18,910,294**
Real Estate	**330,321,941**
The Teleport	75,713,949
WTC One	6,868,303
Queens West Waterfront Development	167,229,569
Bathgate Industrial Park	453,159
Industrial Park at Elizabeth	9,793,194
The South Waterfront	63,285,797
The Legal Center	6,977,970
Midtown Properties	0
Portfields Initiative	0
Planning Department	**441,760**
Vesey Street Ferry Terminal	441,760
Total	**770,311,953**

8.1.2. Methodology

Electricity consumption emissions were calculated as the product of energy consumption (*C*) and emission per unit of energy consumed for any given pollutant (i.e., the emission factor, EF_i), as shown in Equation 8-1. The GHG emission factors utilized with Equation 8-1 are shown in Table 8-3 (EPA, 2012). The CAP emission factors are shown in Table 8-4. These emission factors correspond to those used for the estimation of Scope 2 purchased electricity emissions as described in Chapter 5.

$$Emissions = C \times EF_i \tag{8-1}$$

where

C = consumption of electricity (kWh)

EF_i = electricity emission factor for pollutant *i* (kg pollutant/kWh)

i = GHG or CAP pollutant

Table 8-3: Electricity Consumption GHG Emission Factors

eGRID 2012 (2009 Data) 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}

Source: EPA, 2012.

Table 8-4: Electricity Consumption CAP Emission Factors

eGRID 2012 (2009 Data) 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}
Port Commerce	1.70×10^{-3}	3.23×10^{-4}	2.85×10^{-4}	2.88×10^{-4}

Source: EPA, 2012.

In the absence of metered electricity statements, tenant electricity consumption (*C* in Equation 8-1) was assessed as the product of tenant occupancy in terms of square footage, the energy consumption intensity per unit area of occupied space, and the fraction of energy consumption attributable to electricity consumption (EIA, 2003).Note that information relating to tenant building occupancy was gathered from contacts within the Real Estate Department. This approach is presented in Equation 8-2. The values used for energy consumption intensity (I_j) and fraction of total energy consumption attributable to electricity usage (S_j) are summarized in Table 8-5. The electricity consumption estimates from Equation 8-2 are then used in Equation 8-1.

$$C = \left(\sum_J A_j \times I_j \times S_j\right) \times K \tag{8-2}$$

where

C = consumption of electricity (kWh)

A = tenant occupancy area specific to building activity *j* (square foot)

I_j = total energy consumption intensity for building activity *j* (Btu/square foot)

S_j = share of total energy consumption attributable to electricity usage specific to building activity *j* (unitless)

K = conversion factor from Btu to kWh

Table 8-5: Fuel Energy Intensities by Building Activity		
Principal Building Activity (*j*)	**Fuel Energy Intensity In thousand Btu/square foot (I_j)**	**Share of Electricity Use (S_j)**
Education	83.1	0.45
Food Sales	199.7	0.80
Food Service	258.3	0.43
Health Care	187.7	0.45
Inpatient	249.2	0.41
Outpatient	94.6	0.57
Lodging	100.0	0.43
Retail	73.9	0.64
Office	92.9	0.62
Public Assembly	93.9	0.45
Public Order and Safety	115.8	0.44
Religious Worship	43.5	0.36
Service	77.0	0.52
Warehouse and Storage	45.2	0.56
Other	164.4	0.50
Vacant	20.9	0.31

Source: SRI/SC&A with information from EIA, 2003.

8.1.3. Results

Table 8-6 shows the GHG emissions estimates from electricity broken down by facility. CAP emissions totals are presented by facility in Table 8-7.

Table 8-6: 2013 GHG Emissions from Tenant Electricity Consumption in Buildings (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Airports	**123,534**	**4.331**	**0.946**	**123,918**
JFK	71,377	2.783	0.327	71,537
LGA	15,700	0.490	0.058	15,728
ACY	0	0.000	0.000	0
EWR	23,433	0.665	0.370	23,561
SWF	6,693	0.214	0.091	6,726
TEB	6,331	0.180	0.100	6,366
Tunnels, Bridges, and Terminals	**2,273**	**0.081**	**0.018**	**2,281**
Port Authority Bus Terminal	1,556	0.061	0.007	1,559
G.W. Bridge Bus Station	717	0.020	0.011	721

Table 8-6: 2013 GHG Emissions from Tenant Electricity Consumption in Buildings (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
PATH	**69**	**0.002**	**0.001**	**70**
Journal Square Transportation Center	69	0.002	0.001	70
Port Commerce	**7,577**	**0.226**	**0.108**	**7,615**
Real Estate	**103,817**	**3.680**	**0.864**	**104,162**
The Teleport	20,973	0.818	0.096	21,020
WTC One	1,903	0.074	0.009	1,907
Queens West Waterfront Development	46,323	1.806	0.212	46,426
Bathgate Industrial Park	195	0.006	0.003	196
Industrial Park at Elizabeth	4,211	0.119	0.066	4,234
The South Waterfront	27,213	0.772	0.430	27,362
The Legal Center	3,001	0.085	0.047	3,017
Midtown Properties	0	0.000	0.000	0
Portfields Initiative	0	0.000	0.000	0
Planning Department	**122**	**0.005**	**0.001**	**123**
Vesey Street Ferry Terminal	122	0.005	0.001	123
TOTAL	**237,393**	**8.325**	**1.938**	**238,169**

Note: Totals may not match the column sums due to rounding.

Table 8-7: 2013 CAP Emissions from Tenant Electricity Consumption in Buildings (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
Airports	**172.056**	**69.329**	**25.537**	**26.359**
JFK	12.034	32.725	0.515	0.786
LGA	2.119	5.761	0.091	0.138
ACY	0.000	0.000	0.000	0.000
EWR	113.894	20.109	19.182	19.346
SWF	13.238	5.301	0.566	0.862
TEB	30.772	5.433	5.183	5.227
Tunnels, Bridges, and Terminals	**3.749**	**1.329**	**0.598**	**0.609**
Port Authority Bus Terminal	0.262	0.713	0.011	0.017
G.W. Bridge Bus Station	3.487	0.616	0.587	0.592
PATH	**0.337**	**0.059**	**0.057**	**0.057**
Journal Square Transportation Center	0.337	0.059	0.057	0.057
Port Commerce	32.114	6.100	5.387	5.437
Real Estate	**179.932**	**61.434**	**28.839**	**29.343**
The Teleport	3.536	9.616	0.151	0.231
WTC One	0.321	0.872	0.014	0.021
Queens West Waterfront Development	7.810	21.238	0.334	0.510
Bathgate Industrial Park	0.947	0.167	0.160	0.161
Industrial Park at Elizabeth	20.468	3.614	3.447	3.477

Table 8-7: 2013 CAP Emissions from Tenant Electricity Consumption in Buildings (metric tons)				
Facility	**SO_2**	**NO_x**	**$PM_{2.5}$**	**PM_{10}**
The South Waterfront	132.267	23.352	22.277	22.466
The Legal Center	14.584	2.575	2.456	2.477
Midtown Properties	0.000	0.000	0.000	0.000
Portfields Initiative	0.000	0.000	0.000	0.000
Planning Department	**0.021**	**0.056**	**0.001**	**0.001**
Vesey Street Ferry Terminal	0.021	0.056	0.001	0.001
TOTAL	**388.209**	**138.309**	**60.419**	**61.807**

Note: Totals may not match the column sums due to rounding.

8.2. NATURAL GAS

8.2.1. Activity Data

The tenant emissions from natural gas consumption were estimated from best available information, consisting of the amount of space occupied by tenants in Port Authority-owned facilities. In most cases, tenant square footage data for each facility were provided by the Port Authority. In some instances, tenant-occupied space was retrieved from Internet sources (Port Authority, 2015d). Table 8-8 summarizes tenant occupancy data for selected activities.

Table 8-8: Tenant Occupancy by Facility for Selected Building Activities (square foot)						
Facility	**Food Sales**	**Retail**	**Office**	**Warehouse**	**All Other**	**Total**
Airports	**404,425**	**1,123,76**	**421,801**	**2,541,658**	**5,060,431**	**9,552,076**
JFK	145,772	165,255	-	-	-	311,027
LGA	-	-	-	-	1,865,805	1,865,805
ACY	-	-	-	-	-	0
EWR	238,653	958,506	-	1,750,817	1,190,583	4,138,559
SWF	20,000	-	65,010	790,841	1,208,727	2,084,578
TEB	-	-	356,791	-	795,316	1,152,107
Tunnels, Bridges, and	**26,378**	**174,287**	**13,943**	**0**	**11,766**	**226,374**
Port Authority Bus Terminal	26,378	54,287	13,943	-	11,766	106,374
G.W. Bridge Bus Station	-	120,000	-	-	-	120,000
PATH	**9,419**	**13,713**	**17,649**	**1,401**	**8,536**	**50,718**
Journal Square Transportation	9,419	13,713	17,649	1,401	8,536	50,718
Port Commerce	**-**	**-**	**342,769**	**4,735,465**	**88,705,308**	**93,783,542**
Real Estate	**358,000**	**236,325**	**3,762,617**	**0**	**6,314,840**	**10,671,782**
The Teleport	-	-	700,000	-	-	700,000
WTC One	-	-	1,197,000	-	703,000	1,900,000
Queens West Waterfront	-	174,325	-	-	4,427,000	4,601,325
Bathgate Industrial Park	58,000	-	-	-	400,840	458,840
Industrial Park at Elizabeth	300,000	-	-	-	-	300,000
The South Waterfront	-	62,000	1,454,000	-	784,000	2,300,000
The Legal Center	-	-	411,617	-	-	411,617

Table 8-8: Tenant Occupancy by Facility for Selected Building Activities (square foot)						
Facility	**Food Sales**	**Retail**	**Office**	**Warehouse**	**All Other**	**Total**
Midtown Properties	-	-	-	-	-	0
Portfields Initiative	-	-	-	-	-	0
Planning Department	**0**	**0**	**0**	**0**	**22,000**	**22,000**
Vesey Street Ferry Terminal					22,000	22,000
Total	**798,222**	**1,548,08**	**4,558,779**	**7,278,524**	**100,122,88**	**114,306,49**

8.2.2. Methodology

Natural gas consumption was assessed as the product of tenant occupancy in terms of square footage, the energy consumption intensity per unit area of occupied space, and the fraction of energy consumption attributable to natural gas consumption (EIA, 2003). This methodology assumes that energy use not attributable to electricity consumption pertains to natural gas consumption. This assumption is informed by the energy supply profile of Port Authority facilities where the Port Authority has operational control. The methodology is summarized in Equation 8-3. The values used for energy consumption intensity (I_j) and share of total energy consumption attributable to electricity usage (S_j) are summarized in Table 8-5.

$$G = \left(\sum_j A_j \times I_j \times [1 - S_j]\right) \times L \quad (8\text{-}3)$$

where

G = consumption of natural gas (MMBtu)

A = tenant occupancy area specific to building activity j (square foot)

I_j = total energy consumption intensity for building activity j (Btu/square foot)

S_j = share of total energy consumption attributable to electricity usage specific to building activity j (unitless)

L = conversion factor from Btu to MMBtu

The GHG emission factors used to calculate the GHGs associated with tenant natural gas consumption are shown in Table 8-9. The CAP emission factors are based on values recommended by EPA AP-42, Chapter 1.4, "Natural Gas Combustion" (EPA, 1998), and are presented in Table 8-10.

Table 8-9: Natural Gas Combustion GHG Emission Factors			
Units	**CO_2**	**CH_4**	**N_2O**
kg/MMBtu	53.02	5.00×10^{-3}	1.00×10^{-4}

Source: TCR, 2013a.

Table 8-10: Natural Gas Combustion CAP Emission Factors			
Units	**SO_2**	**NO_x**	**PM total**
kg/therm	2.65×10^{-5}	0.00441	0.000335

Source: EPA, 1998.

8.2.3. Results

Table 8-11 and Table 8-12, respectively, show the GHG and CAP emissions estimates from natural gas broken down by facility.

Table 8-11: 2013 GHG Emissions from Tenant Natural Gas Consumption (metric tons)				
Facility	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Airports	**25,935**	**2.4467**	**0.0489**	**26,001**
JFK	1,368	0.1290	0.0026	1,371
LGA	8,059	0.7603	0.0152	8,080
ACY	0	0.0000	0.0000	0
EWR	9,069	0.8556	0.0171	9,092
SWF	5,234	0.4937	0.0099	5,247
TEB	2,205	0.2080	0.0042	2,211
Tunnels, Bridges, and Terminals	**363**	**0.0342**	**0.0007**	**364**
Port Authority Bus Terminal	194	0.0183	0.0004	195
G.W. Bridge Bus Station	169	0.0159	0.0003	169
PATH	**3,278**	**0.3092**	**0.0062**	**3,286**
Journal Square Transportation Center	30	0.0028	0.0001	30
Port Commerce	**3,248**	**0.3064**	**0.0061**	**3,257**
Real Estate	**47,404**	**4.4720**	**0.0894**	**47,525**
The Teleport	1,302	0.1229	0.0025	1,306
WTC One	3,147	0.2969	0.0059	3,155
Queens West Waterfront Development	30,628	2.8894	0.0578	30,707
Bathgate Industrial Park	100	0.0094	0.0002	100
Industrial Park at Elizabeth	2,337	0.2205	0.0044	2,343
The South Waterfront	9,124	0.8608	0.0172	9,148
The Legal Center	766	0.0722	0.0014	768
Midtown Properties	0	0.0000	0.0000	0
Portfields Initiative	0	0.0000	0.0000	0
Planning Department	**49**	**0.0047**	**0.0001**	**50**
Vesey Street Ferry Terminal	49	0.0047	0.0001	50
TOTAL	**80,276**	**7.5733**	**0.1515**	**80,482**

Note: Totals may not match the column sums due to rounding.

Table 8-12: 2013 CAP Emissions from Tenant Electricity Consumption (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
Airports	**0.130**	**21.580**	**1.639**
JFK	0.007	1.138	0.086
LGA	0.040	6.706	0.509
ACY	0.000	0.000	0.000
EWR	0.045	7.546	0.573

Table 8-12: 2013 CAP Emissions from Tenant Electricity Consumption (metric tons)			
Facility	**SO_2**	**NO_x**	**PM**
SWF	0.026	4.355	0.331
TEB	0.011	1.835	0.139
Tunnels, Bridges, and Terminals	**0.002**	**0.302**	**0.023**
Port Authority Bus Terminal	0.001	0.162	0.012
G.W. Bridge Bus Station	0.001	0.140	0.011
PATH	**0.000**	**0.025**	**0.002**
Journal Square Transportation Center	0.000	0.025	0.002
Port Commerce	**0.016**	**2.703**	**0.205**
Real Estate	**0.237**	**39.443**	**2.996**
The Teleport	0.007	1.084	0.082
WTC One	0.016	2.618	0.199
Queens West Waterfront Development	0.153	25.485	1.936
Bathgate Industrial Park	0.000	0.083	0.006
Industrial Park at Elizabeth	0.012	1.945	0.148
The South Waterfront	0.046	7.592	0.577
The Legal Center	0.004	0.637	0.048
Midtown Properties	0.000	0.000	0.000
Portfields Initiative	0.000	0.000	0.000
Planning Department	0.000	0.041	0.003
Vesey Street Ferry Terminal	0.000	0.041	0.003
TOTAL	**0.385**	**64.052**	**4.866**

Note: Totals may not match the column sums due to rounding.

8.3. THERMAL ENERGY

8.3.1. Activity Data

JFK is the only location where tenant thermal energy consumption occurs for heating and cooling applications. Tenant thermal energy consumption information was available from Port Authority sub-billing records (Port Authority, 2015a).

8.3.2. Methodology

Emissions from thermal energy consumption were estimated as the product of energy consumption and the pollutant intensity of the thermal energy delivered (i.e., the emission factor). The emission factors are specific to the KIAC facility, which is the supplier of thermal energy. The derivation of these emission factors is discussed in detail in Chapter 7 (see Table 7-2). These emission factors are shown in Table 8-13 and Table 8-14 for GHG and criteria pollutants, respectively.

Table 8-13: KIAC Thermal Energy GHG Emission Factors			
Units	**CO_2**	**CH_4**	**N_2O**
Heating (kg Pollutant/MMBtu)	61.08	0.0044	0.0010
Cooling (kg Pollutant/MMBtu)	61.08	0.0044	0.0010

Table 8-14: KIAC Thermal Energy CAP Emission Factors				
Units	**NO_x**	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
Heating (kg Pollutant/MMBtu)	0.0122	0.0004	0.0039	0.0039
Cooling (kg Pollutant/MMBtu)	0.0122	0.0004	0.0039	0.0039

8.3.3. Results

Port Authority records indicate that there were just over 163,000 MMBtu of thermal heating and nearly 216,000 MMBtu of thermal cooling consumed by JFK tenants. Associated GHG and CAP emissions are shown in Table 8-15 and Table 8-16, respectively.

Table 8-15: 2013 GHG Emissions from Tenant Thermal Energy (metric tons)				
Units	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
KIAC Heating	9,963	0.71	0.17	10,031
KIAC Cooling	13,175	0.94	0.22	13,265

Table 8-16: 2013 Thermal Energy CAP Emissions (metric tons)				
Units	**NO_x**	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
KIAC Heating	2.00	0.06	0.64	0.64
KIAC Cooling	2.64	0.08	0.84	0.84

9.0 CONSTRUCTION ACTIVITIES (SCOPE 3)

This category represents combustion emissions from construction equipment used during 2013 in Port Authority capital projects. Construction equipment includes non-road construction equipment such as excavators and crawlers as well as electricity generators and air compressors. Construction equipment activity and associated emissions were estimated for all Port Authority-funded construction projects that received payment for WIP in 2013 (Port Authority, 2015b).

Although the Port Authority is not operationally or financially liable for the equipment used by contractors, it 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 inventory.

9.1. ACTIVITY DATA

The Port Authority administers the Green Construction Equipment program intended to reduce air pollution by requiring construction contractors to retrofit non-road diesel engines, reduce engine idling, and report on the number of equipment used on site, their technical specifications, and their utilization. Records from the Green Construction Equipment program served as the basis for the assessment of fuel combustion emissions from non-road construction equipment. The key operational data for the assessment of GHG and SO_2 emissions were diesel fuel use. When these were not specified for a given piece of equipment, an estimate of diesel fuel use was calculated on the basis of equipment utilization and the rate of fuel consumption. The key operational data for assessment of the other CAP emissions were equipment-specific characteristics, including engine power rating, engine performance standard, operating hours, and equipment type.

Table 9-1 shows the data that SC&A received from Port Authority contractors on the types of equipment that were used on construction projects in 2013. This information is broken down by engine power rating and engine performance standards and includes the count of equipment in each category and the sum of all operating hours reported. The most common equipment power ratings were 100–175 horsepower (hp) (29 percent of all equipment) and 25–50 hp (16 percent).

Table 9-1: Construction Equipment Distribution by Engine Size and Regulatory Tier

Engine Power Rating (hp)	Engine Performance Standard	Equipment Count	Operating Hours
<11	Tier 4	1	1,824
	Other[a]	4	3,696
≥11 to <25	Tier 1	1	1,824
	Tier 4	1	1,824
	Other[a]	2	2,058
≥25 to <50	Tier 2	18	17,392
	Tier 4i	24	20,434
	Tier 4f	1	312
	Other[a]	39	27,285
≥50 to <75	Tier 2	13	10,344
	Tier 3	11	3,341
	Tier 4i	31	20,992
	Tier 4f	6	3280
	Other[a]	9	10,036
≥75 to <100	Tier 1	7	1,964
	Tier 2	12	5,619
	Tier 3	10	7,152
	Tier 4i	16	11,072
	Other[a]	15	5,938
≥100 to <175	Tier 1	9	2,196
	Tier 2	31	15,855
	Tier 3	62	29,098
	Tier 4i	11	2,674
	Other[a]	39	12,601
≥175 to <300	Tier 1	3	546
	Tier 2	9	4,249
	Tier 3	29	10,169
	Tier 4i	15	3,782
	Tier 4f	1	8
	Other[a]	11	2,799
≥300 to <600	Tier 2	8	3,456
	Tier 3	29	21,243
	Tier 4i	20	17,680
	Other[a]	5	764
≥600 to ≤750	Tier 2	2	482
	Tier 3	5	4,696
>750 except generator sets	Tier 1	1	16
	Tier 2	2	77

Table 9-1: Construction Equipment Distribution by Engine Size and Regulatory Tier			
Engine Power Rating (hp)	**Engine Performance Standard**	**Equipment Count**	**Operating Hours**
	Tier 4i	3	244
	Other[a]	3	125
Generator sets >750 to ≤1200	Tier 2	2	672
Total		521	289,818

[a] When the Port Authority contractors provided engine power rating without providing enough data to determine the applicable engine performance standards, SC&A assigned the pieces of equipment to an "Other" category. Equipment in the "Other" category is assumed to have an emissions profile of the average of the different tiers.

Table 9-2 shows the distribution of construction equipment by engine size and equipment type, as provided by Port Authority contractors. There were 521 pieces of equipment reported in 2013. The most common equipment types were lifts (118) and loader/backhoe/bulldozer material handler (83 pieces of equipment).

Table 9-2: Construction Equipment Distribution by Engine Size and Equipment Type		
Engine Power Rating (hp)	**Equipment Type**	**Count**
<11	Lift	1
	Loader/Backhoe/Bulldozer/Material Handler	1
	Roller	1
	Traffic Arrow/Light Tower	2
≥11 to <25	Roller	1
	Shuttle Buggy	1
	Traffic Arrow/Light Tower	2
≥25 to <50	Air Compressor	15
	Crane	3
	Excavator	4
	Generator	8
	Hammer/Drill	1
	Indeterminate	1
	Lift	35
	Pump	2
	Roller	4
	Shuttle Buggy	3
	Traffic Arrow/Light Tower	4
	Welder	2
≥50 to <75	Air Compressor	1
	Excavator	6
	Generator	1
	Lift	49
	Loader/Backhoe/Bulldozer/Material Handler	6
	Pump	1

Table 9-2: Construction Equipment Distribution by Engine Size and Equipment Type

Engine Power Rating (hp)	Equipment Type	Count
	Roller	5
	Shuttle Buggy	1
≥75 to <100	Air Compressor	3
	Excavator	8
	Hammer/Drill	1
	Lift	13
	Loader/Backhoe/Bulldozer/Material Handler	29
	Milling/Cutting	1
	Roller	2
	Shuttle Buggy	1
	Vacuum/Dust Collector	2
≥100 to <175	Air Compressor	10
	Crane	3
	Excavator	40
	Generator	2
	Lift	12
	Loader/Backhoe/Bulldozer/Material Handler	33
	Milling/Cutting	2
	Paver	6
	Pump	1
	Roller	37
	Vacuum/Dust Collector	6
≥175 to <300	Air Compressor	2
	Crane	9
	Excavator	10
	Generator	1
	Hammer/Drill	2
	Lift	1
	Loader/Backhoe/Bulldozer/Material Handler	13
	Paver	24
	Roller	3
	Vacuum/Dust Collector	3
≥300 to <600	Air Compressor	20
	Crane	5
	Excavator	4
	Generator	7
	Grit Unit	1
	Hammer/Drill	5
	Lift	7
	Loader/Backhoe/Bulldozer/Material Handler	1
	Milling/Cutting	4
	Pump	3
	Shuttle Buggy	3
	Vacuum/Dust Collector	1
	Welder	1
≥600 to ≤750	Air Compressor	1
	Crane	2

Table 9-2: Construction Equipment Distribution by Engine Size and Equipment Type		
Engine Power Rating (hp)	**Equipment Type**	**Count**
	Generator	1
	Milling/Cutting	1
	Pump	2
>750 except generator sets	Milling/Cutting	9
Generator sets >750 to ≤1200	Generator	2

Table 9-3 shows the 2013 estimated diesel fuel consumption used on all construction projects and gasoline consumption reported from the WTC construction sites. This estimate is based on both diesel consumption figures provided by Port Authority contractors and diesel gallons estimated based on WIP spending.

Table 9-3: 2013 Fuel Used in Construction, by Facility Type (gallons)		
Facility Type	**Diesel**	**Gasoline**
Aviation	499,877	No data
Ports	223,424	No data
Rail	67,138	No data
Security	82,878	No data
Tunnels, Bridges and Terminals	585,110	No data
WTC	71,038	10,301
Total	**1,529,466**	**10,301**

Note: Totals may not match the column sums due to rounding.

9.2. METHODOLOGY

The assessment of GHG and SO_2 emission follows a fuel-based method, in which the emissions are directly proportional to the volume of fuel combusted as shown in Equation 9-1. The GHG emission factors were taken from The Registry (TCR, 2013a). Using the EPA NONROAD model to calculate SO_2 emissions was considered, but it was determined to be outdated because the SO_2 estimate is based on fuel sulfur contents of 339 parts per million (ppm), which is no longer allowable by regulation. The current federal gasoline sulfur standard is 30 ppm (EPA, 2013c). However, the Green Construction Equipment program requires the use of ultra-low sulfur diesel at Port Authority land construction sites; for that reason, a diesel sulfur content of 15 ppm was used when deriving the corresponding emission factor.

$$Emissions = V \times EF_p \qquad (9\text{-}1)$$

where

V = fuel volume (gallons; diesel only for SO_2, diesel and gasoline for GHG)

EF = emissions factor for pollutant p (kilograms/gallon)

p = GHG or SO_2 pollutant

CAP emissions, with the exception of SO_2, were estimated as a function of equipment type, engine type (i.e., a combination of engine power rating, model year, and engine performance standard), and hours of operation. CAP emission estimates were further adjusted to account for losses in engine performance over the engine's life span using a deterioration factor. This method is presented in Equation 9-2.

$$Emissions = P_i \times T_i \times EF_{i,q,e} \times DF_j \tag{9-2}$$

where

P = engine power rating (hp) of engine type i (hp)

T = annual hours of operation of equipment with engine type i (hours)

EF = emission factor specific to pollutant "q" for engine type i (g/hp-hours)

DF = deterioration factor specific to age of service j (unitless)

i = engine type

j = age of service

q = pollutant

e = equipment type

Emissions factors for hydrocarbons (HC), carbon monoxide (CO), NO_x, and PM_{10} used in this analysis are calculated by multiplying the steady-state engine emission factors (which are specific to engine power rating and engine performance standard) by the transient adjustment factors (which are equipment-type specific), both of which come from EPA's NONROAD2008a model (EPA, 2010c). The steady-state emissions factors are specific to the engine performance standard and power-rating categories that are presented in Table 9-1. Thus, the emission factor is specific to each type of pollutant, engine performance standard, engine power rating, and equipment type. HC emissions were converted to VOC emissions, and $PM_{2.5}$ emissions were estimated from PM_{10} emissions based on EPA conversion factors (EPA, 2010e and 2010c).

These emission factors are then multiplied by a deterioration factor to account for increasing emissions as engines age. This deterioration factor was calculated as the product of the relative deterioration factor (R), the average hours of use per year for a given engine (H), and estimated engine age (A) divided by average lifetime of non-road diesel engines (L), as shown in Equation 9-3 (EPA, 2010d).

$$Deterioration\ Factor = R \times H \times A/L \tag{9-3}$$

where

R = Relative deterioration factor (unitless)

H = Average hours of use per year for a given engine power rating (hours per year)

A = Age of equipment (years)

L = Average lifetime of non-road diesel equipment of this size (hours)

The relative deterioration factor shows the increase in emissions in an engine that is at the end of its lifespan as compared to a brand-new engine. This varies by engine performance standard and pollutant type and results in an increase of only a few percent for VOC and NO_x but an increase of 47 percent for PM for all engine standards. The relative deterioration factor and average lifetime of non-road diesel equipment came from EPA's NONROAD model documentation (EPA, 2010d). Average engine use per year for a given horsepower rating was estimated based on those projects that provided hourly engine usage and engine power ratings. Some horsepower categories were not represented in this data set, so average hours per year were estimated based on three horsepower groups: 0–100 hp, 100–175 hp, and greater than 175 hp.

Activity data were either compiled or derived from the Green Construction Equipment program records. These records accounted for 63 funded projects representing 82 percent of all 2013 WIP expenditures. Moreover, projects for which construction equipment information was available featured varying degrees of data completion. For that reason, a three-level classification was developed to frame the relative level of uncertainty associated with the activity data used in the analysis. These three levels are described as follows:

- Category 1 corresponds to low-uncertainty activity data where records provided an equipment list and either equipment operational hours or time period of equipment use on site (or both). Category 1 also includes all records for which contractors confirmed their exempt status from disclosing equipment information; that is, they did not operate equipment over 50 hp for more than 20 days. In this case, the calculation assumes emissions were negligible.
- Category 2 corresponds to medium-uncertainty activity data for which the contractor provided an equipment list but neither equipment operational hours nor the time period of equipment use on site.
- Category 3 corresponds to high-uncertainty activity data. WIP expenditures were used as surrogate data to estimate GHG and CAP emissions, by multiplying Category 3 WIP expenditures with the ratio of diesel use and CAP emissions per dollar of WIP expenditures for Category 1 and Category 2.

In general, records from the Green Construction Equipment program were used as they were provided. We must assume that these records provided by Port Authority contractors are representative of all Port Authority construction projects. Any gaps in the records provided were filled in using the following assumptions:

- Default operating schedule: 8-hour work day and Monday–Friday work week with no work on holidays; this equates to 251 work days in 2013.
- Default construction equipment fuel consumption rates (i.e., gallons per hour) and engine power ratings were

deduced from available records or supplemented with fuel consumption rates gathered from a literature review.

- Construction equipment operating hours per day were based on an average profile from complete records.
- When model year information was not available, emission factors were calculated by averaging the emission factors of all engine performance standards within that horsepower rating.
- In situations where equipment use time was known or could be estimated but a default average fuel consumption value was not available (either engine horsepower could not be determined or the equipment fell into one of the categories without provided fuel consumption data), the total diesel fuel consumed by the rest of the equipment in that contract was adjusted upward proportional to the number of equipment use hours that were unaccounted for. That is, if 5 percent of the equipment use hours did not have associated fuel use information, the total available fuel use would be assumed to account for 95 percent of the total fuel use and adjusted upward to reach 100 percent.

9.3. RESULTS

The GHG emissions for 2013 Port Authority-funded construction projects are summarized in Table 9-4. About half of total GHG emissions were estimated primarily from operational records, that is, the sum of Category 1 and Category 2 emissions. This represents a significant improvement from previous assessments that use proxy data to estimate all non-WTC construction emissions. Greater availability of construction equipment profiles and equipment utilization stems from full implementation of the Port Authority's construction emissions reduction program; this program requires all construction contracts to use ultra-low sulfur diesel in non-road diesel powered construction equipment, retrofit equipment of 50 horsepower or more, and observe a three-minute idling limit. As discussed in Section 9.2, Category 3 emissions were estimated as the product of the average pollution intensity of Category 1 and Category 2 projects (i.e., mass of pollutant per WIP expenditure dollar) and the WIP expenditure of a given capital project.

Table 9-4: GHG Emissions from Construction, by Estimation Method (metric tons)

Estimation Method	Site	CO_2	CH_4	N_2O	CO_2e	CO_2e Distribution by Estimation Method
Category 1	Non-WTC	4,821	0.27	0.12	4,865	36%
	WTC	816	0.05	0.02	823	
Category 2	Non-WTC	2,126	0.12	0.05	2,146	13%
Category 3	Non-WTC	7,943	0.45	0.20	8,015	51%
Total		**15,707**	**0.90**	**0.40**	**15,849**	**100%**

Note: Totals may not match the column sums due to rounding.

The CAP emissions for 2013 Port Authority-funded construction projects are summarized in Table 9-5.

Table 9-5: CAP Emissions from Construction, by Estimation Method (metric tons)						
Estimation Method	**VOCs**	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Category 1: Non-WTC	3.56	17.48	36.66	0.01	3.01	2.92
Category 1: WTC	6.42	34.64	79.67	0.00	6.10	5.92
Category 2	1.81	9.81	17.85	0.01	1.76	1.71
Category 3	6.14	31.20	62.33	0.02	5.45	5.29
Total	**17.92**	**93.14**	**196.52**	**0.04**	**16.32**	**15.83**

Note: Totals may not match the column sums due to rounding.

2013 construction-related emissions and WIP spending are compared to values reported for previous years and summarized in Table 9-6. Note: no construction estimate was performed for the years 2009 and 2012. In general, WIP spending increased significantly between 2006 and 2010 due to the huge increase in WTC construction spending, which was nearly complete by 2013.

Table 9-6: WIP Spending and Emissions from Port Authority Construction, 2006–2013						
	2006	**2007**	**2008**	**2010**	**2011**	**2013**
Total WIP Spending	$531,508,923	$960,135,102	$1,323,802,471	$1,722,823,817	$1,901,441,301	$1,643,024,781
GHG ($MTCO_2e$)	48,436	54,448	62,586	17,291	3,227	15,849

The methodology to estimate 2013 construction emissions improved significantly relative to similar estimates in previous years. This is especially the case for non-WTC construction sites, for which the Port Authority is now requiring contractors to maintain construction equipment and utilization records. For that reason, historical construction emission trends may not only reflect changes in the breath and intensity of construction activities but also, to some extent, improvements in emission quantification methods. As background, previous construction emissions assessments relied on WTC financial and operational data (i.e., fuel logs) to determine the general ratio of fuel consumption to WIP dollars spent; this ratio was then applied to all non-WTC sites in proportion to the WIP expenditure (i.e., proxy data). This methodology was used because WTC was the only Port Authority construction site for which operational data were systematically collected. In contrast, operational data were more widely available for construction activity at WTC and non-WTC sites in 2013, which in turn minimized the need to develop emission estimates from proxy data.

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APPENDIX A: AVIATION MEMORANDUM

This memorandum was prepared for Port Authority's Aviation Department to summarize 2013 greenhouse gas and criteria air pollutant emissions. The objective of the memorandum was to outline the methodology used to estimate 2013 emissions.

MEMORANDUM

To:	Rubi Rajbanshi, Nathaniel Kimball (Port Authority of New York & New Jersey)
From:	Juan Maldonado, Jackson Schreiber (SC&A) Brandon Cline (SRI)
Date:	July 31, 2015
Subject:	2013 Greenhouse Gas (GHG) and Criteria Air Pollutant (CAP) Emissions Inventory for the Aviation Department of the Port Authority of New York & New Jersey

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This memo provides an overview of the methodologies used to prepare the calendar year (CY) 2013 Greenhouse Gas (GHG) and Criteria Air Pollutant (CAP) emissions inventory for the Aviation Department of the Port Authority of New York & New Jersey. In general, SC&A applied the methodologies developed for the CY2011 Aviation Department GHG and CAP Emissions Inventory (or 2011 Aviation Department Inventory) to ensure comparability of inventory results. However, some adjustments to past methodologies were made to take advantage of available activity data or improve the quality of emissions estimates; these are explicitly noted in the discussion below.

Port Authority Fleet

The Aviation Department provided an inventory of vehicles of the Port Authority Fleet for CY2013, referred to as the *Master Vehicle List* (Port Authority, 2015). SC&A reviewed this inventory for accuracy by cross checking against the CY2013 Central Automotive Division (CAD) database and past Shadow Fleet inventories. Some inaccuracies were found in the *Master Vehicle List* for TEB and SWF, where 96 vehicles owned by the Port Authority, but operated by contractors, were moved to the Shadow Fleet category.

The most accurate source of CY2013 vehicle fuel consumption information comes from CAD fuel purchasing records. These fuel data reflect aggregate consumption of the entire CAD fleet. In order to assess the share of fuel use by airport, SC&A allocated fuel consumption using less accurate, but more detailed, fuel records maintained by CAD in the *Master Vehicle List*. This allocation step was necessary to ensure that the sum of allocated fuel consumption matches the financial records of fuel purchases and thus ensure that emission results conform to the materiality threshold of The Climate Registry (TCR) program (i.e., error margin of ±5%). Carbon dioxide (CO_2) emissions by airport were calculated based on the allocated fuel consumption multiplied by the per gallon CO_2 emission factors from TCR. Emissions for all other pollutants were estimated proportionately to CO_2 emissions at each airport.

Terminal Purchased Electricity, Natural Gas and Thermal Energy

Terminal-purchased electricity (in kWh) and natural gas consumption (in therms) for CY2013 were provided by the Aviation Department. This consumption information was then multiplied by TCR emission factors to estimate total GHG emissions. CAP emissions were estimated using emission factors from AP-42 for natural gas consumption, and eGRID2012 emission factors for electricity (EPA, 2012). As specified by the Aviation Department, energy consumption emissions account for all energy metered and invoiced to the Port Authority. This reflects energy consumption of Port Authority operations for all airports (scope 2), and, in the case of JFK and LGA, it also includes electricity and thermal energy consumption of tenants (scope 3 emissions).

Aircraft
The primary modeling tool for analysis was the Federal Aviation Administration's (FAA's), Emission and Dispersion Modeling System (EDMS), Version 5.1.4.1 released in August 2013, which represents an update from Version 5.1.3 utilized for the 2011 Aviation Department Inventory (FAA, 2013). EDMS Version 5.1.4.1 features a more extensive list of aircraft types which, in turn, enhances direct correspondence of airport operations data to EDMS aircraft categories.

Landing and take-off (LTO) data were provided for the five airports by the Aviation Department. EDMS was used to estimate CO_2 and CAP emissions as follows:

- Used a crosswalk to correlate operations, which are provided by International Civil Aviation Organization (ICAO) aircraft codes to the proper EDMS aircraft codes. The direct correlation rate was as high as 99.9% or as low as 95% for TEB. Operations that were not directly correlated were distributed proportionately across the aircraft mix. The crosswalk between ICAO and EDMS aircraft codes is included as Appendix A-1.
- Applied an adjustment factor to match operations with the FAA's Air Traffic Activity System (ATADS) database. For example, at JFK airport, the Aviation Department recorded 401,057 landing or takeoff operations in 2013. However, the ATADS database shows 411,776 landing and takeoff operations. Because the ATADS is considered the most reliable estimate of total operations, an adjustment factor was applied to all operations in order to get the total to match ATADS. In the case of JFK airport, this is 411,776 divided by 401,057, or 1.0267.
- Entered operations by aircraft category into the EDMS model, as well as airport-specific taxi times to generate CO_2 and CAP emission estimates. Airport-specific taxi times were provided by the Aviation Department.
- Methane (CH_4) and nitrous oxide (N_2O) emissions were estimated outside of the model, using aircraft-specific emission factors in terms of mass of pollution per LTO from the 2006 IPCC Guidelines (IPCC, 2006).

Auxiliary Power Units
Auxiliary Power Units (APUs) CAP emissions were modeled in EDMS as a function of operations and default APU assignation to aircraft categories. GHG emissions for APUs are not included in EDMS, and therefore were estimated by SC&A outside of the model. CO_2 emissions were estimated using the CO_2/SO_2 stoichiometric ratio. CH_4 and N_2O emissions were estimated based on typical CO_2 to CH_4/CO_2 and N_2O/CO_2 ratios for aircraft engine emissions.

Based on guidance from the Federal Aviation Administration (FAA) Voluntary Airport Low Emissions Program (VALE), 2013 APU estimates were revised downward in cases where PCA and gate electrification are available, and unchanged from EDMS default runs in all other cases (FAA, 2010). This VALE guidance is discussed in Table A-1, whereas the percentage availability of PCA and gate electrification at each airport was provided by Port Authority, and is displayed in Table A-2 below.

Table A-1: Methodology to Determine Default APU Run Time

Gates without power and/or gates without PCA	no emission reduction; therefore, use EDMS default APU run time (26 minutes per LTO)
Gates with power and with PCA	Emission reductions are achieved, where APU run time is 7 minutes per LTO (i.e., the sum of 2 minutes on connection + 5 minutes on departure).

Table A-2. Gate Electrification and PCA Available at Port Authority Airports, 2013

Airport	Percentage of gates with gate power (400hz)	Percentage of gates with preconditioned air
JFK	98%	92%
EWR	100%	75%
LGA	95%	47%
SWF	100%	100%
TEB	0%	0%

Note that EDMS Version 5.1.4.1 assigned less frequent APU activity to the aircraft mix than Version 5.1.3. For instance, the newer version assigned no APU activity to Gulfstream IV-SP, whereas APU activity was assigned to this aircraft type under EDMS Version 5.1.3.

Ground Support Equipment

The Aviation Department provided an updated and expanded inventory of ground support equipment (GSE) for JFK, EWR and LGA (Port Authority, 2015). This equipment inventory was combined with EDMS default utilization rates to generate CAP emission estimates. EDMS does not use the most current version of EPA's NONROAD model, so the SO_2 emission factor was revised to account for the effects of fuel sulfur limits. GSE emission factors used by EDMS are derived from EPA's NONROAD2005 model, which has been superseded by NONROAD2008. The GSE gasoline sulfur content used by EDMS from NONROAD2005 is constant over time at 339 ppm (EDMS, 2013). This is no longer accurate as the current federal gasoline sulfur standard is 30 ppm (EPA, 2013). Therefore, EDMS overestimates SO_2 emissions from gasoline combustion for inventory years after CY2005. For that reason, SO_2 estimates from EDMS were adjusted by a factor of 0.08 to reflect the current 30 ppm federal gasoline sulfur standard (EPA, 2013).

Note that EDMS does not model GHG emissions; for that reason, CO_2 emissions were estimated using the CO_2/SO_2 stoichiometric ratio. CH_4 and N_2O emissions were estimated based on typical CO_2 to CH_4/CO_2 and N_2O/CO_2 ratios for internal combustion engines.

As was done in the 2011 Aviation Department Inventory, deicer emissions were estimated separately because default emissions from deicers in EDMS created an unreliably high estimate (larger than all other ground support equipment combined for some airports). These deicers were assumed to be used at the same levels seen in the 2011 analysis, or 211 hours/month for the four winter months. These activity data were then used to estimate total fuel consumption, and then GHG and CAP emissions. With this methodology, deicer emissions are less than 1 percent of total airport GSE emissions for all pollutants.

Attracted Travel

The data inputs to the attracted travel analysis were the 2013 passenger survey data (Port Authority, 2015), 2013 total passenger data (Port Authority, 2014) and data on average travel party size to match the 2012 attracted travel methodology (Parsons Brinckerhoff et al., 2006; Excellent et al., 2008; Airlink et al., 2008). The most significant change in methodology pertains to the volume of passengers counted towards the attracted travel analysis. The volume of passengers was adjusted down to exclude in-transit passengers, who do not induce attracted travel. The Port Authority provided the percentage of connecting flights by airport used to adjust total passenger volumes (see Table A-3).

Table A-3. Percentage of Total Passengers on Connecting Flights, 2013

JFK	35%
EWR	40%
LGA	22%
SWF	4%
TEB	0%

This change in methodology significantly reduces the estimated passenger volumes at the three major airports. Other factors contributing to the differences between the 2012 and 2013 results include variance in annual passenger survey answers (for example, the percentage of passengers arriving by mass transit went up for JFK, EWR and LGA between 2012 and 2013), as well as better fuel efficiency of the vehicle fleet in the New York/New Jersey area as old and inefficient vehicles retire and more fuel efficient and electric vehicles enter the market.

For TEB, the number of passengers was estimated as the number of aircraft movements. TEB's attracted travel vehicle-miles traveled (VMT) were estimated assuming an average trip length of 16.2 miles, based on the distance from TEB to Manhattan, with all trips assigned to personal cars at a vehicle occupancy rate of 1.0. This matches the methodology used in the revised 2012 results.

Cargo Trucks
Data detailing cargo trips by route and vehicle type were available from a 2002 air cargo truck movement study for JFK (URS, 2002). VMT for cargo-related travel was derived by multiplying the number of cargo trips by the estimated trip length of the access and egress routes. Trip length by origin was estimated using Google Maps, while the number of cargo trips at JFK in 2013 was estimated by scaling the number of trips estimated from the 2002 study, using cargo tonnage statistics as a proxy. The resulting 2013 cargo VMT for JFK by vehicle type was then apportioned to other airports, using the 2013 ratio of cargo tons from JFK to the cargo tons at LGA, EWR, and SWF airports. Note that no cargo traffic was allocated to TEB.

Shadow Fleet
The shadow fleet is comprised of shuttle buses, fuel trucks, and assorted smaller vehicles. The shuttle buses and fuel trucks operate at the three major airports (JFK, EWR and LGA), while the smaller vehicles operate in TEB and SWF.

Emissions from all three vehicle categories were estimated based on the fuel consumption provided by the Aviation Department. In all three cases, fuel consumption totals were multiplied with TCR emission factors to estimate GHG emissions. CAP emissions were estimated based on per gallon MARKAL emission factors multiplied by gasoline and diesel fuel consumption.

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Appendix A-1. ICAO and EDMS Aircraft Code Crosswalk

ICAO Aircraft Code	ICAO Aircraft Description	EDMS Aircraft Code	EDMS Aircraft Description
560XL		CNA560-XL	Cessna 560 Citation Excel
737-823		B737-8	Boeing 737-800 Series
737-832		B737-8	Boeing 737-800 Series
747-47UF		B747-4F	Boeing 747-400 Freighter
757-222		B757-2	Boeing 757-200 Series
757-223		B757-2	Boeing 757-200 Series
757-231		B757-2	Boeing 757-200 Series
757-232		B757-2	Boeing 757-200 Series
757-28A		B757-2	Boeing 757-200 Series
767-223		B767-2	Boeing 767-200 Series
767-323		B767-3	Boeing 767-300 Series
767-332		B767-3	Boeing 767-300 Series
A109	AGUSTA, MH-68 Stingray	A109	Agusta A-109
A119	AGUSTA, AW-119 Koala	A109	Agusta A-109
A139	AGUSTA, AB-139	A109	Agusta A-109
A300	AIRBUS, A-300	A300B2-1	Airbus A300B2-100 Series
A306	AIRBUS, A-300F4-600	A300B4-6	Airbus A300B4-600 Series
A308	AIRBUS, A-300,800 series	A300B4-6	Airbus A300B4-600 Series
A310	AIRBUS, A-310	A310-2	Airbus A310-200 Series
A318	AIRBUS, A-318	A318-1	Airbus A318-100 Series
A319	AIRBUS, A-319	A319-1	Airbus A319-100 Series
A320	AIRBUS, A-320	A320-1	Airbus A320-100 Series
A321	AIRBUS, A-321	A321-1	Airbus A321-100 Series
A330	AIRBUS, A-330	A330-2	Airbus A330-200 Series
A332	AIRBUS, A-330-200	A330-2	Airbus A330-200 Series
A333	AIRBUS, A-330-300	A330-3	Airbus A330-300 Series
A340	AIRBUS, A-340	A340-2	Airbus A340-200 Series
A343	AIRBUS, A-340-300	A340-3	Airbus A340-300 Series
A345	AIRBUS, A-340-500	A340-5	Airbus A340-500 Series
A346	AIRBUS, A-340-600	A340-6	Airbus A340-600 Series
AC50	NORTH AMERICAN ROCKWELL, Commander 500	COMMANDER500	Rockwell Commander 500
AC69	Rockwell Turbo Commander	COMMANDER690	Rockwell Commander 690
AC90	GULFSTREAM AEROSPACE, Jetprop AC90 Commander 900, ROCKWELL, 690 Jetprop Commander 840	COMMANDER690	Rockwell Commander 690

AEST	AEROSTAR (1), 600	AEROSTAR	Aerostar PA-60
ASTR	GULFSTREAM AEROSPACE, Gulfstream G100 / IAI, 1125 Astra	GULF100	Gulfstream G100
AT42	ATR, ATR-42	ATR42-2	ATR 42-200
AT43	ATR, ATR-42-320	ATR42-3	ATR 42-300
AT72	ATR, ATR-72-200	ATR72-2	ATR 72-200
B190	BEECH, 1900 / RAYTHEON, 1900	BEECH1900-C	Raytheon Beech 1900-C
B340	HAWKER BEECHCRAFT, King Air 350 / RAYTHEON, LR-2 Super King Air 350	BEECH300	Raytheon Super King Air 300
B350	HAWKER BEECHCRAFT, King Air 350 / RAYTHEON, LR-2 Super King Air 350	BEECH300	Raytheon Super King Air 300
B365	HAWKER BEECHCRAFT, King Air 350 / RAYTHEON, LR-2 Super King Air 350	BEECH300	Raytheon Super King Air 300
B407	BELL, 407	B407	Bell 407
B412	BELL, 412 / AGUSTA, AB-412	B407	Bell 407
B712	BOEING, 717-200	B717-2	Boeing 717-200 Series
B717	BOEING, 717-200	B717-2	Boeing 717-200 Series
B721	BOEING, C-22 / BOEING, 727-100	B727-1	Boeing 727-100 Series
B722	BOEING, 727-200	B727-2	Boeing 727-200 Series
B727	BOEING, 727-200	B727-2	Boeing 727-200 Series
B728	BOEING, 727-800	B727-2	Boeing 727-200 Series
B732	BOEING, 737-200	B737-2	Boeing 737-200 Series
B733	BOEING, 737-300	B737-3	Boeing 737-300 Series
B734	BOEING, 737-400	B737-4	Boeing 737-400 Series
B735	BOEING, 737-500	B737-5	Boeing 737-500 Series
B736	BOEING, 737-600	B737-6	Boeing 737-600 Series
B737	BOEING, 737-700 / BOEING, C-40 Clipper	B737-7	Boeing 737-700 Series
B738	BOEING, 737-800 BBJ2	B737-8-BBJ2	Boeing Business Jet II
B739	BOEING, 737-900 BBJ3	B737-8-BBJ2	Boeing Business Jet II
B742	BOEING, 747-200 / Boeing E-4 / VC - 25	B747-2	Boeing 747-200 Series
B744	BOEING, 747-400 / YAL-1	B747-4	Boeing 747-400 Series
B747	BOEING, 747	B747-1	Boeing 747-100 Series
B74S	BOEING, 747SP	B747-SP	Boeing 747-SP
B752	BOEING, 757-200 / C-32	B757-2	Boeing 757-200 Series

B753	BOEING, 757-300	B757-3	Boeing 757-300 Series
B757	BOEING, 757	B757-2	Boeing 757-200 Series
B762	BOEING, 767-200	B767-2	Boeing 767-200 Series
B763	BOEING, 767-300	B767-3	Boeing 767-300 Series
B764	BOEING, 767-400	B767-4	Boeing 767-400
B767	BOEING, 767	B767-2	Boeing 767-200 Series
B772	BOEING, 777-200ER	B777-2ER	Boeing 777-200-ER
B774	BOEING, 777-400	B777-3	Boeing 777-300 Series
B777	BOEING, 777	B777-2	Boeing 777-200 Series
B77L	BOEING, 777-F / 200LR	B777-2LR	Boeing 777-200-LR
B77W	BOEING, 777-300ER	B777-3ER	Boeing 777-300 ER
BE10	BEECH, U-21F Ute / 100 King Air	BEECH100	Raytheon King Air 100
BE20	BEECH, C-12C Huron / BEECH, 1300 Commuter	MIL-C12	Raytheon C-12 Huron
BE23	BEECH, 23 Musketeer / Sundowner	BEECH18	Raytheon Beech 18
BE30	BEECH, Super King Air (300) / Raytheon 300	BEECH300	Raytheon Super King Air 300
BE33	BEECH, 33 Debonair / RAYTHEON, 33 Bonanza	BEECH36	Raytheon Beech Bonanza 36
BE35	BEECH, 35 Bonanza	BEECH36	Raytheon Beech Bonanza 36
BE36	BEECH, 36 Bonanza (piston)	BEECH36	Raytheon Beech Bonanza 36
BE40	BEECH, 400 Beechjet / RAYTHEON, Jayhawk	BEECH400	Raytheon Beechjet 400
BE55	BEECH, C-55 Baron / T42 Cochise / Colemill President 600 / Baron 55	BEECH55	Raytheon Beech 55 Baron
BE58	BEECH, 58 Baron	BEECH58	Raytheon Beech Baron 58
BE60	BEECH, 60 Duke	BEECH60	Raytheon Beech 60 Duke
BE90	BEECH, 90 Queen Air	BEECH90	Raytheon King Air 90
BE99	BEECH, 99 Airliner	BEECH99	Raytheon Beech 99
BE9L	BEECH, 90 (E90) King Air / Taurus 90	BEECH90	Raytheon King Air 90
BE9T	BEECH, King Air (F90)	BEECH90	Raytheon King Air 90
C130	LOCKHEED, EC-130H Hercules	MIL-C130	Lockheed C-130 Hercules
C17	BOEING, C-17 Globemaster 3	MIL-C17A	Boeing C-17A
C170	CESSNA, 170	CNA150	Cessna 150 Series
C172	CESSNA, 172 Cutlass / Mescalero / skyhawk	CNA172	Cessna 172 Skyhawk

C182	CESSNA, 182 Skylane / Wren 460	CNA182	Cessna 182
C206	CESSNA, Skywagon 206 / Stationair	CNA206	Cessna 206
C208	CESSNA, 208 Grand Caravan / Cargomaster	CNA208	Cessna 208 Caravan
C210	CESSNA, 210 Centurion	CNA210	Cessna 210 Centurion
C25	CESSNA, Citation CJ	CNA525	Cessna 525 CitationJet
C25A	CESSNA, Citation CJ2	CNA525	Cessna 525 CitationJet
C25B	CESSNA, Citation CJ3	CNA525	Cessna 525 CitationJet
C25C	CESSNA, Citation CJ4	CNA525	Cessna 525 CitationJet
C30J	LOCKHEED MARTIN, CC-130J Hercules	MIL-C130	Lockheed C-130 Hercules
C310	CESSNA, 310 / U-3 / L-27 / T310	CNA310	Cessna 310
C337	CESSNA, 337 Super Skymaster / REIMS, FT337E Turbo Super Skymaster / Summit Sentry	CNA337	Cessna 337 Skymaster
C340	CESSNA, 340	CNA340	Cessna 340
C402	CESSNA, 402 Businessliner / 401	CNA402	Cessna 402
C414	CESSNA, 414 Chancellor L2P L	CNA414	Cessna 414
C421	CESSNA, 421 Golden Eagle / Executive Commuter	CNA421	Cessna 421 Golden Eagle
C425	CESSNA, 425 Corsair	CNA425	Cessna 425 Conquest I
C441	CESSNA, 441 Conquest	CNA441	Cessna 441 Conquest II
C5	LOCKHEED, C-5 Galaxy	MIL-C5	Lockheed C-5 Galaxy
C500	CESSNA, 500 Citation	CNA500	Cessna 500 Citation I
C501	CESSNA, 501 Citation 1SP	CNA501	Cessna 501 Citation ISP
C525	CESSNA, 525 Citation CJ4	CNA525	Cessna 525 CitationJet
C550	CESSNA, 550 Citation Bravo	CNA550	Cessna 550 Citation II
C551	CESSNA, 551 Citation 2SP	CNA551	Cessna 551 Citation IISP
C560	CESSNA, 560 Citation Ultra / UC-35 Citation Encore	CNA560	Cessna 560 Citation V
C56X	CESSNA, 560XL Citation XLS	CNA560-XL	Cessna 560 Citation Excel
C650	CESSNA, 650 Citation 3	CNA650	Cessna 650 Citation III
C680	CESSNA, 680 Citation Sovereign	CNA680	Cessna 680 Citation Sovereign
C72R	CESSNA, 172RG Cutlass RG	CNA172	Cessna 172 Skyhawk
C750	CESSNA, 750 Citation 10	CNA750	Cessna 750 Citation X A
CL30	BOMBARDIER, Challenger 300	CL300	Bombardier Challenger 300
CL60	CANADAIR, Challenger 600	CL600	Bombardier Challenger 600
CL65	CANADAIR, Challenger 600	CL600	Bombardier Challenger 600

CRJ	CANADAIR, Regional Jet CRJ-100	CRJ1	Bombardier CRJ-100
CRJ1	CANADAIR, Regional Jet CRJ-100	CRJ1	Bombardier CRJ-100
CRJ2	CANADAIR, CL-600 Challenger 800 / Regional Jet CRJ-200	CRJ2	Bombardier CRJ-200
CRJ5	CANADAIR, CL-600 Challenger 800 / Regional Jet CRJ-200	CRJ4	Bombardier CRJ-400
CRJ7	CANADAIR, Challenger 870 / Regional Jet CRJ-701 / CRJ-700	CRJ7	Bombardier CRJ-700
CRJ9	CANADAIR, CL-600 Regional Jet CRJ-900	CRJ9	Bombardier CRJ-900
CVLT	CANADAIR, CV-580 / CV-640 / CV- 600 / KELOWNA CV-5800	CV640	Convair CV-640
D328	FAIRCHILD DORNIER, 328	DO328JET	Dornier 328 Jet
DC10	MCDONNELL DOUGLAS, MD-10	MD10-1	Boeing MD-10-1
DC8	DOUGLAS, DC-8	DC8-5	Boeing DC-8 Series 50
DC86	DOUGLAS, DC-8-60	DC8-6	Boeing DC-8 Series 60
DC87	DOUGLAS, DC-8-70	DC8-7	Boeing DC-8 Series 70
DC9	DOUGLAS, DC-9	DC9-1	Boeing DC-9-10 Series
DC91	MCDONNELL DOUGLAS, DC-9-10	DC9-1	Boeing DC-9-10 Series
DC93	MCDONNELL DOUGLAS, DC-9-30 / Nightingale / Skytrain 2	DC9-3	Boeing DC-9-30 Series
DC95	DOUGLAS, DC-9-50	DC9-5	Boeing DC-9-50 Series
DCH8	DOUGLAS, DC-8	DC8-5	Boeing DC-8 Series 50
DH08	DE HAVILLAND CANADA, CT-142 Dash 8	DHC8-1	DeHavilland DHC-8-100
DH6B	??	DHC6-1	DeHavilland DHC-6-100 Twin Otter
DH8	DE HAVILLAND CANADA, CT-142 Dash 8	DHC8-1	DeHavilland DHC-8-100
DH8A	DE HAVILLAND CANADA, CT-142 Dash 8	DHC8-1	DeHavilland DHC-8-100
DH8B	DE HAVILLAND CANADA, Dash 8 (200)	DHC8-2	DeHavilland DHC-8-200
DH8C	DE HAVILLAND CANADA, Dash 8 (300)	DHC8-3	DeHavilland DHC-8-300
DH8D	DE HAVILLAND CANADA, Dash 8 (400)	DHC8-3	DeHavilland DHC-8-300
DHC8	DE HAVILLAND CANADA, Dash 8	DHC8-1	DeHavilland DHC-8-100

DHCB	DE HAVILLAND CANADA, Dash 8	DHC8-1	DeHavilland DHC-8-100
E135	EMBRAER, EMB-135	ERJ135	Embraer ERJ135 A
E140	EMBRAER, ERJ-140	ERJ140	Embraer ERJ140 A
E145	EMBRAER, ERJ-145LR	ERJ140-LR	Embraer ERJ140-LR
E170	EMBRAER, 170	ERJ170	Embraer ERJ170
E175	EMBRAER, 175	ERJ175	Embraer ERJ175
E190	EMBRAER, 190	ERJ190	Embraer ERJ190
E45	EMBRAER, EMB-145XR	ERJ145	Embraer ERJ145 A
E45X	EMBRAER, EMB-145XR	ERJ145-XR	Embraer ERJ145-XR
EMB-135KL		ERJ135	Embraer ERJ135 A
EMB-145LR		ERJ145-LR	Embraer ERJ145-LR A
ERJ 190-100 IGW		ERJ190	Embraer ERJ190
F2TH	DASSAULT, Falcon 2000	FAL2000	Dassault Falcon 2000
F900	DASSAULT, Mystère 900	FAL900	Dassault Falcon 900
FA10	DASSAULT, Mystère 10 / Falcon 10	FAL10	Dassault Falcon 10
FA20	DASSAULT, Falcon 20 / Guardian	FAL20-C	Dassault Falcon 20-C
FA50	DASSAULT, Falcon 50 / Mystere	FAL50	Dassault Falcon 50
FA7X	DASSAULT, Falcon 7X	FAL7X	Falcon 7X
G150	GULFSTREAM AEROSPACE, Gulfstream G150 / IAI G150	GULF150	Gulfstream G150
G280	GULFSTREAM AEROSPACE, Gulfstream G280	G-280	Gulfstream G280
GALX	GULFSTREAM AEROSPACE, Gulfstream G200 / IAI, Gulfstream G200	GULF200	Gulfstream G200
GL5T	BOMBARDIER, BD-700 Global 5000	GLOBAL5000	Bombardier Global Express 5000
GLEX	BOMBARDIER, BD-700 Global Express / Sentinel	GLOBALEXPRESS	Bombardier Global Express
GLF1	VC-11 Gulfstream 1	GULF1	Gulfstream I
GLF2	GRUMMAN, VC-11 Gulfstream 2	GULF2	Gulfstream II
GLF3		GULF3	Gulfstream G300
GLF4	GULFSTREAM AEROSPACE, Gulfstream 4	GULF4	Gulfstream G400
GLF5	GULFSTREAM AEROSPACE, G-5SP Gulfstream G550	GULF550	Gulfstream G550
H25A	HAWKER SIDDELEY, HS-125-3	HS125-3	Hawker HS-125 Series 3
H25B	BRITISH AEROSPACE, BAe-125-800 / Hawker Beechcraft Hawker 800	HS125-8	Raytheon Hawker 800

H25C	RAYTHEON, Hawker 1000	HS125-1000	Raytheon Hawker 1000
HA4T	HAWKER BEECHCRAFT, Hawker 4000 / RAYTHEON, 4000 Hawker 4000	H4000	Raytheon Hawker 4000 Horizon
J328	FAIRCHILD DORNIER, 328JET	DO328JET	Dornier 328 Jet
JS31	BRITISH AEROSPACE, Jetstream 31	J31	BAE Jetstream 31
LJ24	GATES LEARJET, 24	LEAR24	Bombardier Learjet 24
LJ25	GATES LEARJET, 25	LEAR25	Bombardier Learjet 25
LJ31	GATES LEARJET, 31	LEAR31	Bombardier Learjet 31
LJ35	GATES LEARJET, 35	LEAR35	Bombardier Learjet 35
LJ40	GATES LEARJET, 40	LEAR40	Bombardier Learjet 40
LJ45	GATES LEARJET, 45	LEAR45	Bombardier Learjet 45
LJ55	GATES LEARJET, 55	LEAR55	Bombardier Learjet 55
LJ60	GATES LEARJET, 60	LEAR60	Bombardier Learjet 60
M20P	AEROSTAR (1), 202 / Mooney M-20J / Chapparal / Mark / Range / Executive / Eagle/ Ovation / Super 21 / Allegro / Statesman	MOONEY-M20K	Mooney M20-K
M20T	MOONEY, 252TSE / Bravo / Acclaim / Encore	MOONEY-M20K	Mooney M20-K
MD10	BOEING, MD-10	MD10-1	Boeing MD-10-1
MD11	Mcdonnell Douglas / BOEING, MD-11	MD11	Boeing MD-11
MD82	MCDONNELL DOUGLAS, MD-82	MD82	Boeing MD-82
MD83	MCDONNELL DOUGLAS, MD-83	MD83	Boeing MD-83
MD87	MCDONNELL DOUGLAS, MD-87	MD87	Boeing MD-87
MD88	MCDONNELL DOUGLAS, MD-88	MD88	Boeing MD-88
MD90	MCDONNELL DOUGLAS, MD-90	MD90	Boeing MD-90
MU2	MITSUBISHI, MU-2 Marquise / Soiltaire	MU2	Mitsubishi MU-2
MU30	MITSUBISHI, MU-300 Diamond	MU300	Mitsubishi MU-300 Diamond
P180	PIAGGIO, P-180 Avanti	P180	Piaggio P.180 Avanti
P210	CESSNA, P210 Pressurized Centurion / riley P210	CNA210	Cessna 210 Centurion
P28A	PIPER, PA-28-150 Cherokee / Archer / Tupi	PA28	Piper PA-28 Cherokee Series
P28B	AICSA, PA-28-236 Dakota / Pathfinder/charger / PIPER	PA28	Piper PA-28 Cherokee Series

P28R	AICSA, Turbo Arrow 3 / EMBRAER, EMB-711B Corisco / PIPER, PA-28R-201T Turbo Cherokee Arrow 3	PA28	Piper PA-28 Cherokee Series
P46T	PIPER, PA-46-500TP Malibu Meridian	PA46-500	Piper PA-46 500TP
PA23		PA23	Piper PA-23 Apache/Aztec
PA24	PIPER, PA-24 Comanche	PA24	Piper PA-24 Comanche
PA27	PIPER, PA-23-250 Aztec	PA27	Piper PA-27 Aztec
PA28	PIPER, PA-23-250 Aztec	PA28	Piper PA-28 Cherokee Series
PA30	PIPER, PA-30 Twin Comanche	PA30	Piper PA-30 Twin Comanche
PA31	AICSA, PA-31-350 Navajo Chieftain / PIPER, PA-31-350 Chieftain	PA31	Piper PA-31 Navajo
PA32	AICSA, PA-32 Turbo Saratoga / PIPER, Cherokee Six	PA32	Piper PA-32 Cherokee Six
PA34	AICSA, PA-34 Seneca / PIPER / PZL-MIELEC, Mewa	PA34	Piper PA-34 Seneca
PA46	PIPER, PA-46R-350T Malibu Matrix / Mirage	PA46-500	Piper PA-46 500TP
PAY1	CHINCUL, Cheyenne 1 / Piper	PA42	Piper PA-42 Cheyenne Series
PAY2	AICSA, Cheyenne 2 / PIPER, Cheyenne 2XL	PA42	Piper PA-42 Cheyenne Series
PAY3	PIPER, Cheyenne 3 / AICSA	PA42	Piper PA-42 Cheyenne Series
PC12	PILATUS, PC-12 Eagle	PC12	Pilatus PC-12
PE12	PILATUS, PC-12 Eagle	PC12	Pilatus PC-12
PRM1	HAWKER BEECHCRAFT, 390 Premier 1 / RAYTHEON, Premier 1	PREMIER	Raytheon Premier I
R22L	ROBINSON, R-22 Mariner	R22	Robinson R22
R22R	ROBINSON, R-22 Mariner	R22	Robinson R22
R44	ROBINSON, R-44 Raven / Astro / Clipper	R44	Robinson R44 Raven
RJ	AI(R), RJ-100 Avroliner	AVRORJ100	Avro RJ-100
RY11	RYAN, ST-R	ST3KR	Ryan ST3KR A
RY22	RYAN, ST-R	ST3KR	Ryan ST3KR A
RY29	RYAN, ST-R	ST3KR	Ryan ST3KR A

RY4L	RYAN, ST-R	ST3KR	Ryan ST3KR A
S76	SIKORSKY, S-76 Spirit	S76	Sikorsky S-76 Spirit
SBR1	NORTH AMERICAN, T-39 Sabreliner / Rockwell Sabre 40	SABR40	Rockwell Sabreliner 40
SF34	SAAB, S100 Argus / S340	SAAB340-A	Saab 340-A
SR20	CIRRUS, SR-20 SRV	SR20	Cirrus SR20
SR22	CIRRUS, SR-22	SR22	Cirrus SR22
SW3	Fairchild Swearingen Merlin 3	SA226	Fairchild SA 226-T Merlin III
SW4	FAIRCHILD (1), UC-26 Merlin 4 / FAIRCHILD SWEARINGEN, SA-227PC Metro	SA26	Fairchild SA-26-T Merlin II
T204	TUPOLEV, Tu-204	TU204	Tupolev 204
TBM7	SOCATA, TBM-700	TBM700	EADS Socata TBM-700
TBM8	SOCATA, TBM-850	TBM-850	EADS Socata TBM-850
WW24	IAI, 1124 Westwind 1	IAI1124	Israel IAI-1124 Westwind I